Waikato Regional Council Technical Report 2017/31

Waikato Region greenhouse gas inventory - July 2015 to June 2016

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

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November 2017

Document #: 11070355

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Acknowledgement

The development of this emissions inventory was possible due to contributions from numerous organisations and individuals who have helped by providing data, reviewing data accuracy and giving feedback on some of the assumptions made.

Special thanks to staff at Waikato Regional Council, Waikato TLAs, Ministry for the Environment, Ministry of Primary Industries and Landcare Research for their feedback and support throughout the preparation of the inventory.

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Abstract

Acronyms and abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EF	Emissions factor
GDP	Gross domestic product
GHG	Greenhouse gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories
GWP	Global warming potential
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
MfE	Ministry for the Environment
MBIE	Ministry of Business, Innovation and Employment
N_2O	Nitrous oxide
NF_3	Nitrogen trifluoride
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride

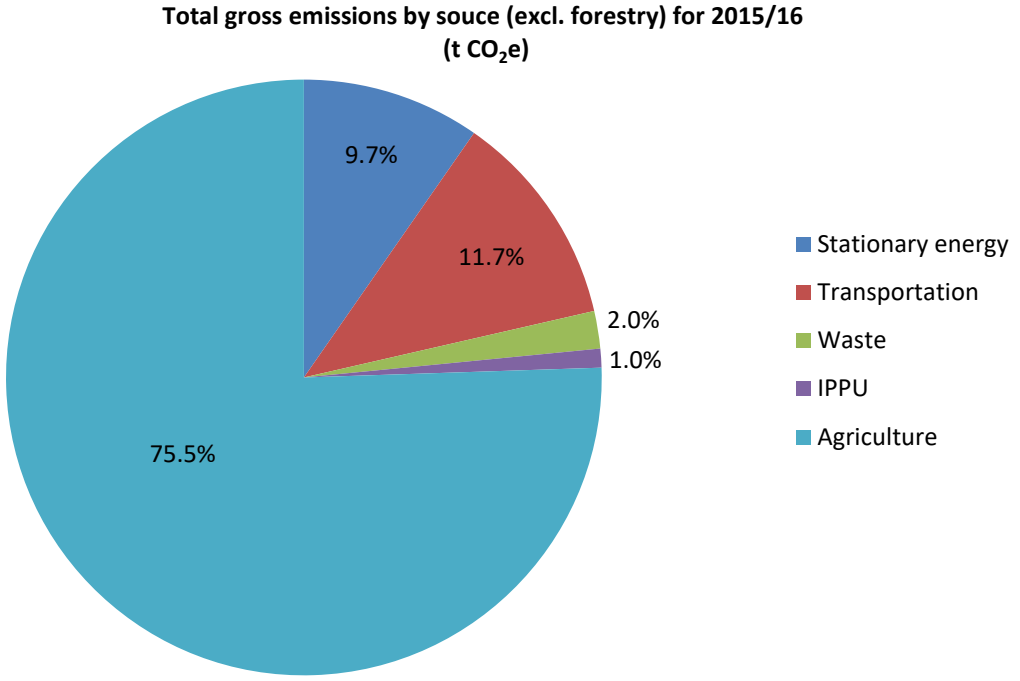
Glossary

Emission factor(s)	A factor that converts activity data into GHG emissions data (e.g., kg CO_2e emitted per litre of fuel consumed, kg CO_2e emitted per kilometer travelled, etc.).
Scope 1 emissions	GHG emissions from sources located within the Waikato region boundary.
Scope 2 emissions	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the Waikato region boundary.
Scope 3 emissions	All other GHG emissions that occur outside the Waikato region boundary as a result of activities taking place within the Waikato boundary.
BASIC	An inventory reporting level that includes all scope 1 sources except from energy generation, imported waste, IPPU, and AFOLU, as well as all scope 2 sources.
BASIC+	An inventory reporting level that covers all BASIC sources, plus scope 1 AFOLU and IPPU, and scope 3 in the Stationary Energy and Transportation sectors.

Executive summary

This represents the first baseline report for Waikato Region's Community-scale Greenhouse Gas (GHG) Emissions Inventory. The inventory was compiled following the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC), which is considered best practice for community based inventories.

Activities within Waikato Region's boundaries generated 13,797,097 metric tonnes of carbon dioxide equivalent (t CO_2e) between July 2015 and June 2016. When forestry is included, the total net emissions are 8,201,706 t CO_2e. This represents about 14.5% of New Zealand's total net emissions.



Agricultural activities generate the largest amount of the gross emissions (75.5%) for Waikato, followed by transportation (11.7%) and stationary energy (9.7%). Forestry removes a net volume of 5,595,391 t CO_2e (41% of the total gross emissions).

As expected, Scope 1 emissions (GHG emissions from sources located within the Waikato region boundary) make up the majority of emissions in Waikato Region. In future inventories, improvements in accuracy and completeness of data will lead to a better understanding of Scope 3 emissions (GHG emissions that are happening outside the Region but are driven by activities within the Region).

Sector		Total by scope ($t CO_2e$)				Reporting level ($t CO_2e$)	
		Scope 1	Scope 2	Scope 3 included in BASIC/ BASIC+[1]	Other Scope 3		
Stationary Energy	Energy use	902,608	392,968	38,332	NE	1,295,576	1,333,908
	Energy generation supplied to the grid	NO					
Transportation (all II emissions)		1,604,698	1,818	13,203	NE	1,604,698	1,619,540
Waste	Generated in the Region	280,963		IE	NE	280,963	280,963
	Generated outside Region	NO					
IPPU (all IV emissions)		141,334			NE		141,334
AFOLU (all V emissions)		4,825,961			NE		4,825,961
Total		All territorial[2] emissions				**3,181,237**	**8,201,706**

Note: NO – not occurring; NE – not estimated

On a per capita basis, Waikato's agricultural emissions are almost three times higher than the national per capita average (23.2 vs 8.5 t CO_2/cap) while the forestry sector removes more than double the national average (-12.5 vs -5.3 t CO_2/cap). Stationary energy, waste and IPPU emissions are below the national averages.

Due to its emissions profile, Waikato Region would need to focus its reduction efforts on agriculture as well as consider options for maintaining or increasing its carbon removal potential (forestry). Within agriculture, a focus on methane emissions reduction is needed since it makes up about 70% of agricultural emissions.

Transport and Stationary Energy sectors also contribute significant emissions to the overall regional carbon footprint and represent significant emission reduction potential, e.g. by reducing electricity, petrol, diesel and natural gas consumption as well as fugitive emissions from coal mining.

As this is the first comprehensive inventory for Waikato Region, it is recommended that a repeat emissions inventory is carried out in three years' time. This would enable an enhancement of inventory completeness as well ability to track changes in emissions generation/removal.

In addition, Waikato Regional Council (WRC) can focus on cooperation with the individual territorial authorities within the Region to develop a low carbon policy and action plans. WRC is already a signatory of the Local Government New Zealand' 2017 Leaders Climate Change Declaration[3]. Signing up to the Global Covenant of Mayors for Energy and Climate also presents an opportunity to maintain momentum and focus on emission reductions, as well as being able to learn from other cities and communities internationally and in New Zealand.

[1] Explanations on BASIC and BASIC + reporting levels are provided in section 2.2.

[2] Territorial emissions refer to scope 1 emissions as per GPC reporting system terminology.

[3] The declaration can be accessed at http://www.lgnz.co.nz/our-work/publications/local-government-leaders-climate-change-declaration-2017/.

Waikato Region's GHG emissions: key facts

- Waikato Region's per capita net emissions are 50% higher than the national average (18.3 vs 12.5 t CO_2/cap).
- Agricultural activities generate 75.5% of all emissions. On a per capita basis, Waikato's agricultural emissions are almost three times higher than the national average (23.2 vs 8.5 t CO_2/cap).
- Forestry sector removes about 41% of the Waikato's total gross emissions, more than double the national average (-12.5 vs -5.3 t CO_2/cap). Over 90% of carbon sequestration comes from exotic forest.

1 Introduction and context

The New Zealand government ratified the Paris Agreement in April 2017, which is an international commitment to limit global warming to below two degrees. 196 countries are parties to this agreement which ultimately needs to lead to emissions reductions of 60-80% if global warming is to stay below two degrees.

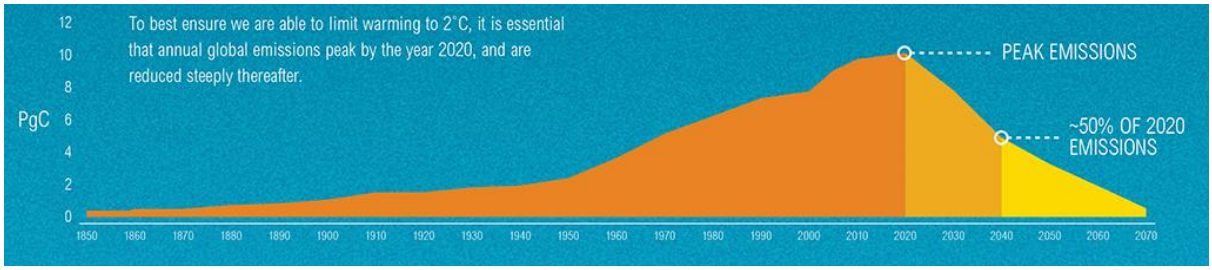


Figure 1: Global Carbon Budget (Source: World Resources Institute)

To achieve this goal and make a fair contribution to global emissions reductions, the New Zealand government has set short and long term unconditional national targets for New Zealand's greenhouse gas emissions:

- a 5 per cent reduction target below 1990 greenhouse gas emissions levels by 2020;
- a 30 per cent reduction target below the 2005 greenhouse gas emissions levels by 2030 (this target is equivalent to 11 per cent below 1990 levels by 2030); and
- a 50 per cent reduction target below the 1990 greenhouse gas emissions levels by 2050.

It is recognised that solutions to climate change and transition to a low carbon economy cannot be pursued by central government without the involvement and actions of local government – for adaptation as well as mitigation. Globally more than 7,500 cities and local governments have signed up to the Global Covenant of Mayors for Energy and Climate (www.globalcovenantofmayors.org) reporting on their community greenhouse gas emission and emission reduction measures.

To develop their carbon reduction strategies and measures, regional and local governments need as a first step to have a good understanding of their emissions profile i.e. what are the sources of emissions by sectors and gases.

1.1 Role of regional councils

In New Zealand, regional councils have statutory responsibilities regarding climate adaptation, particularly with a view to natural hazards, infrastructure and assets management. In addition, it has been recognised that regional and local councils can also contribute to climate mitigation and transition to a low carbon economy, and address the opportunities and risks that climate change presents.

The Mayors and Chairs of New Zealand have recently re-confirmed the 2015 Climate Change Declaration and the key commitments and actions that Councils plan to undertake. WRC is a signatory to this declaration which covers all member agencies activities, roles and functions of the sector and specifically identifies how local government will act and what it requires of central government to support action on climate change.

Local Government New Zealand has also just launched a project to help mitigate climate change and prepare for adaptation.[4]

[4] Detailed project plan is available here: http://www.lgnz.co.nz/assets/Uploads/Climate-Change-A3-LGNZ-Sep2017.pdf; document accessed on 22 September 2017.

1.2 Waikato region's context

To date, the Waikato Region has not developed a greenhouse gas inventory apart from early attempts over a decade ago when inventory practices and tools were not yet applied.

A 2001 high level inventory shows that the Waikato Region produced approximately 21% of New Zealand's total greenhouse gas emissions whereas the population of the Region at the time represented only 12% of the national population.

Existing emissions data captured and reported through the NZ Greenhouse Gas Inventory (GHGI) do not give a complete picture that is useful for regions to inform targeted policy action to mitigate emissions – particularly when agriculture emissions and sinks are concerned, as these are specific to each region and particularly important for the Waikato Region.

This project will enable Waikato Regional Council (WRC) to enhance its understanding of the Region's carbon profile and hotspots, and facilitate initial discussions regarding options and pathways for a low carbon transition.

The insights provided by a carbon inventory will also be useful to inform the positions and responses by the WRC to future government policies to meet Paris Agreement targets – beyond the role of the Emissions Trading Scheme (ETS) which to date has been a key emissions reduction tool deployed by the government.

The project to develop a greenhouse gas inventory for the Region is linked to several initiatives and long-term planning by WRC seeking to support environmental enhancements and sustainable economic growth for the Region, and the pre-requisite to transition to a low carbon economy, including:

- Understanding the implications of COP 21 Paris Agreement for the Region.
- The development of progress indicators to benchmark the sustainable development of the Region.
- Exploring the current state and opportunities to promote green growth for the Region.
- Waikato Region Strategic Direction 2016-2019[5]
- Waikato Regional Council Freshwater Strategy[6]

WRC has developed WISE (Waikato Integrated Scenario Explorer) which includes energy and CO_2 emissions for 48 sectors that can be used in the inventory.

1.3 Purpose of this report

This report provides the Waikato Region with a snapshot of its emission profile for the 2015/16 financial year reporting period. The report identifies key emission sources and their relative contribution.

The principal aim of this report is to:

- Help the Regional Council and its stakeholders understand their local emissions profile;
- Enable informed decision making and policy development; and
- Support the Council with information and evidence to actively work with key emission sectors and stakeholders towards reducing local emissions.

The emission estimates are a reflection of the local economy and particular circumstances Waikato Region. This makes it difficult to compare the Region to other regions in New Zealand or

[5] For more information, see https://www.waikatoregion.govt.nz/assets/PageFiles/19184-strategic-direction/5304-Strategic-Direction-SUMMARY-DR.pdf.

[6] For more information, see https://www.waikatoregion.govt.nz/assets/PageFiles/40487-lets-talk-water/Fresh-water-strategy-2017-COMBINED-web.pdf

against the national average. We have however attempted to normalise the respective emissions on a per capita basis to provide some context and relative scale.

Regionally, and for New Zealand in general, agricultural and forestry related activities play a significant role in terms of emissions generation, but also mitigation options. Globally emissions will need to reduce significantly over the next 30 years. Cooperating and working with stakeholders in each emission sector will be crucial to achieving this target.

This document summarises the findings from the data collection and calculations and also outlines the underlying assumptions and limitations.

2 Methodology

2.1 The Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories

This inventory report follows the methodology outlined in the Global Protocol for Community Scale Greenhouse Gas Emissions Inventory (GPC), published by the World Resources Institute (WRI 2015) and includes emissions from stationary energy, transport, waste, industry, agriculture and forestry activities within the regional (administrative) boundary. The inventory covers seven greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

This is the same methodology used for other community scale GHG inventories around New Zealand (e.g. Auckland, Dunedin and Wellington) and internationally.

2.2 Emissions calculations and reporting

This inventory assesses both direct (production-based) emission sources within the geographic area (Scope 1) and indirect (consumption-based) emission sources associated with goods and services imported into the geographic area. Examples of indirect emission sources include electricity from the national grid (Scope 2), transport into the area that originates or terminates outside the area e.g. aviation (Scope 3). The GPC methodology represents international best practice for city and community level greenhouse gas (GHG) emissions reporting.

The following aspects are worth noting in reviewing the inventory:

- Emissions are expressed on a carbon dioxide-equivalent basis including climate change feedbacks using the 100-year GWP (Global Warming Potential) values including climate-carbon feedback from the Intergovernmental Panel on Climate Change Fifth Assessment Report: Climate Change 2013;
- Emissions are calculated by multiplying activity data by an emission factor associated with the activity;
- Total emissions are reported for gross emissions (excluding forestry) and net emissions (including forestry);
- In line with the GPC, activity data for the various emission sources includes data from bottom up sources (locally provided measures or estimates) and top down sources (based on national information), depending on data availability;
- GPC requires that total emissions are reported at the BASIC or BASIC+ levels. This inventory reports at the BASIC+ level (which includes scope 1 and scope 2 emissions from stationary energy and transport, scope 1 and scope 3 emissions from waste, and emissions from IPPU and AFOLU and transboundary transport);
- Following GPC guidance and requirements, notation keys (IE, NE, NO and C) have been used in the emissions report and data quality for each activity/sector assessed (see Appendix 12.1 for a description of data quality assessment).

2.3 Assumptions, limitations and uncertainties

Emissions inventories of this nature involve a range of assumptions, limitations and uncertainties. Examples of data limitations are:

- Emissions from industrial product use by scaling national emissions from industrial product use on a population basis;
- This inventory estimates solid waste emissions from both open and closed landfills and national inventory figures on a population basis;

- This inventory estimates emissions from waste water treatment by scaling national emissions from these sources on a population basis.
- Uncertainties also exist where data is missing or has been estimated based on limited information.

As well as activity-related assumptions and uncertainties, the GPC methodology includes a number of assumptions in terms of calculations of sector emissions. For example:

- This inventory accounts for forest carbon stock changes from afforestation, reforestation, deforestation and forest management (i.e. it applies land-use accounting conventions under the UN 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.

A full listing of assumptions and limitations are included in the Appendix 12.2. Data sources and identified data gaps are listed in section 12.3. Where helpful, specific information on assumptions, limitations and uncertainties are included along with the sector results.

3 Results overview and discussion

3.1 Main sources of emissions

The inventory results show that activities within the Region's boundaries generated 13,797,097 metric tonnes of carbon dioxide equivalent (t CO_2e) between July 2015 and June 2016. When forestry is included, the total net emissions are 8,201,706 t CO_2e.

Agriculture is the greatest emissions generator (75.5%) of total gross emissions for Waikato, followed by transportation (11.7%) and stationary energy (9.7%). Forestry removes a net volume of 5,595,391 t CO_2e (41% of the total gross emissions).

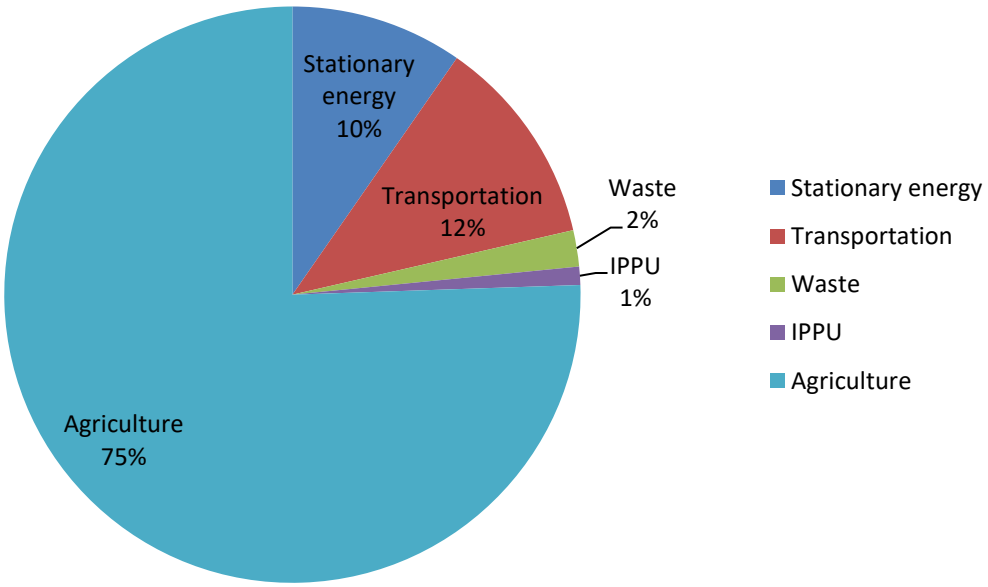


Figure 2: Total gross emissions by source (excl. forestry) for 2015/16

On a per capita basis, Waikato's agriculture emissions are significantly higher than national per capita average (23.2 vs 8.5 t CO_2/cap) while forestry sector removes more than double the national average (-12.5 vs -5.3 t CO_2/cap). Stationary energy, waste and IPPU emissions are below the national averages.

Table 1 Summary of per capital emissions, Waikato vs New Zealand 2015/16

	Waikato Region emissions 2015/16	**New Zealand emissions in 2015**	**Unit**
Population	449,200	4,509,700	People
Per capita gross emissions	30.7	17.77	tCO_2e/cap
Per capita net emissions	18.3	12.50	tCO_2e/cap
Per capita gross emissions (excluding agriculture and forestry)	7.5	9.25	tCO_2e/cap
Total net (including forestry)	8,201,706	56,372,519	tCO_2e
Total gross (excluding forestry)	13,797,097	80,155,149	tCO_2e

Due to its emissions profile, Waikato Region would need to focus its reduction efforts on agriculture as well as consider options for maintaining its carbon removal potential (forestry). Within agriculture, a focus on methane reduction is needed since it makes up about 70% of agricultural emissions.

Forestry provides for significant sequestration of carbon emissions, however, over 90% of sequestration comes from exotic forest with a limited amount from natives. It is therefore important that impact from forest harvesting cycles are understood so that mitigation actions can respond to fluctuations in removals.

Table 2 Overview of transportation emissions by fuel type, 2015/16

FUEL TYPES		**Reporting year 2015/16 t CO_2e**
Transportation	Petrol	683,107
	Diesel	879,477
	Rail diesel	37,598
	Rail electricity	1,818
	Jet Kerosene	10,487
	Av Gas	2,536
	Marine Diesel	-
	Light Fuel Oil	-
	LPG	4,516
	Bitumen	NA
	Lubricants	NA
Total CO_2e emissions		**1,619,540**

Transport sector is the second biggest emitter of emissions in Waikato Region, and diesel and petrol use (for on-road transport) are responsible for over 90% of emissions.

3.2 Comparison to other regions or municipalities & NZ averages

To provide a perspective into the Waikato Region's emissions profile in relation to other cities or regions of New Zealand, a summary overview is presented in the tables below. The most recent inventories for Wellington city and the Wellington Greater Region, Wairarapa and Auckland City have all been prepared using GPC and therefore it allows for credible benchmarking. The national inventory figures for New Zealand are also included.

It should be noted that the emissions profile of all other organisations are different than that of Waikato Region and therefore their mitigation strategies and actions plans would be different too.

Table 3 Overview of Waikato Region's emissions against other entities (t CO_2e)

	Waikato 2015/16	Wairarapa 2012/13	Wellington greater Region, 2015	Auckland City, 2014	New Zealand, 2015
	449,200	41,559	494,000	1,526,900	4,509,700
Stationary energy	1,333,908	46,116	627,705	3,689,000	17,693,324
Transportation	1,619,540	155,961	1,393,725	4,669,000	14,761,855
Waste	280,963	25,799	195,326	793,000	4,000,660
IPPU	141,334	12,162	154,883	2,336,000	5,279,680
Agriculture	10,421,352	1,150,466	1,190,850	646,386*	38,419,630
Forestry	-5,595,391	-1,796,632	-1,483,490	-953,879*	-23,782,630

*estimates calculated on the basis of published inventory report for Auckland City, 2000-2015

For further insights, sector emissions have also been calculated on a per capita basis.

Table 4 Overview of emissions per capita, Waikato Region and others (t CO_2e/cap)

	Waikato Region 2015/16	Wairarapa 2012/13	Wellington greater Region 2015	Auckland City 2014	New Zealand, 2015
Population	449,200	41,559	494,000	1,526,900	4,509,700
Stationary energy	2.97	1.11	1.27	2.42	3.92
Transportation	3.61	3.75	2.82	3.06	3.27
Waste	0.63	0.62	0.40	0.52	0.89
IPPU	0.31	0.29	0.31	1.53	1.17
Agriculture	23.20	27.68	2.41	0.42	8.52
Forestry	-12.46	-43.23	-3.00	-0.62	-5.27

4 Stationary energy

Stationary energy use in the Region is responsible for 1,333,908 t CO_2e in 2015/16, representing 9.7% of the gross emissions.

The main source of emissions from stationary energy is natural gas consumption, contributing 38% of the stationary energy emissions, with natural gas transmission and distribution losses contributing (T&D Losses) an additional 2 %. Electricity consumption (Scope 2) and electricity T&D Losses from electricity contribute approximately 30% and 3% respectively. Fugitive emissions (Scope 1) from coal mining contribute almost a quarter of stationary energy emissions.

Emissions from electricity consumption are based on the national average emissions factor for electricity generation. The emissions from electricity generation have not been included in the Waikato carbon footprint, as these are part of the national emissions inventory for electricity generation. It is not possible to say with certainty where electricity generated in Waikato is distributed to. Waikato Region, however, is a net generator of electricity; from the total amount of 17,236.4 GWh electricity generated within the region, only 3,392.2 GWh is consumed locally. The balance of 13,844.2 GWh is consumed elsewhere, with Auckland likely to be a significant beneficiary of that.

A detailed breakdown of the stationary energy emission sources is provided in the table below.

Table 5 Summary of Stationary Energy Emissions by Source, 2015/16

Sector/Category Source		**Emissions (tCO_2e)**		**Sector Percentage Contribution**
Stationary Energy	Electricity	392,968	1,333,908	29.5%
	Electricity T&D Loss	38,332		2.9%
	Natural Gas	506,416		38.0%
	Natural Gas T&D Loss	27,001		2.0%
	LPG	30,387		2.3%
	Coal	28,661		2.1%
	Biofuel use	7		0.0%
	Fugitive Emissions (coal mining)	310,136		23.3%

4.1 Residential stationary energy

Emissions from residential use (201,711 t CO_2e) represent 15% of the total stationary energy related emissions or 1.4% of the overall regional gross emissions.

Residential energy use emissions are dominated by emissions from electricity generation, contributing 64% of the overall residential energy use emissions, with an additional 6% being emitted through electricity T&D losses. Natural gas use represents the second largest emission source (21%) for residential energy use. A complete breakdown of residential stationary energy related emissions is provided in the graphic below.

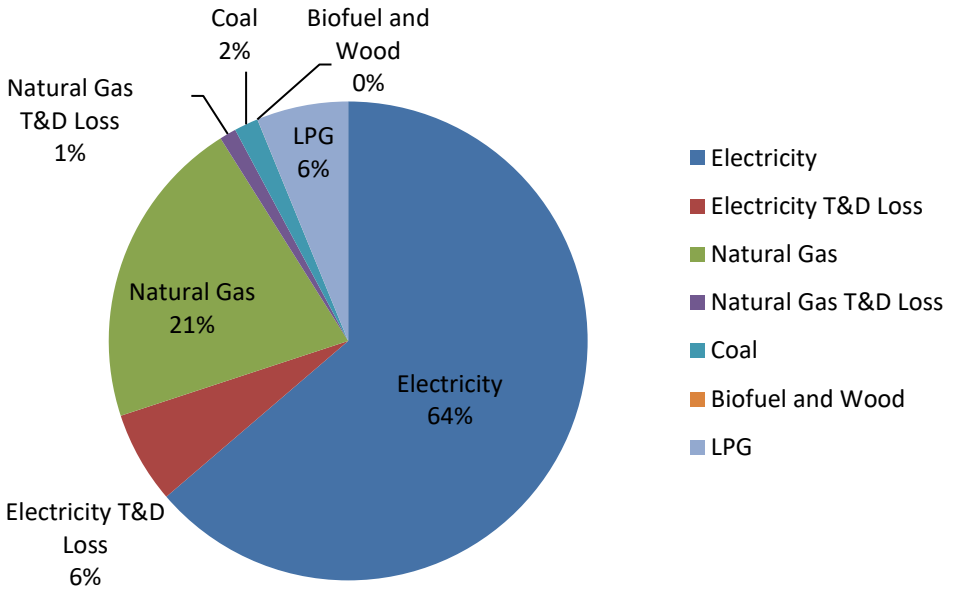


Figure 3: Waikato Region Residential Stationary Energy Emissions, 2015/16

4.2 Commercial stationary energy

Emissions from commercial use (187,190 t CO2e) represent 13% of the total stationary energy related emissions or 1.3% of the overall regional gross emissions.

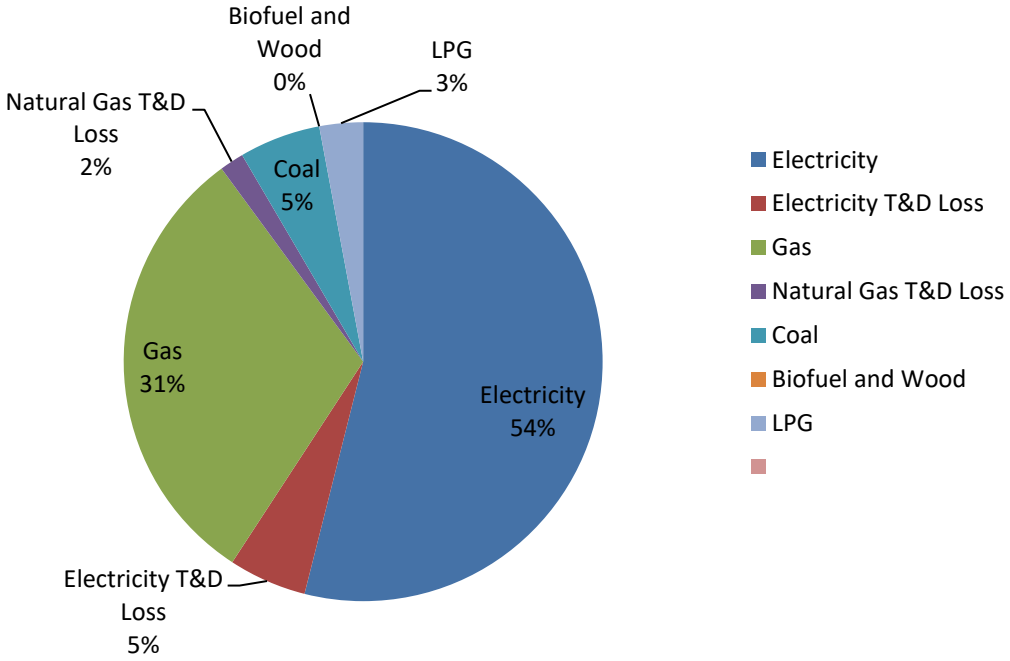


Figure 4: Waikato Region Commercial Stationary Energy Emissions 2015/16

Commercial energy use emissions are also dominated by emissions from electricity generation, contributing 54% of the overall commercial energy use emissions, with an additional 5% being emitted through electricity T&D losses. Natural gas use represents the second largest emission source (31%) for commercial energy use. A complete breakdown of commercial stationary energy related emissions is provided in Figure 5 .

4.3 Industrial stationary energy

Industrial use is responsible for majority of the stationary energy related emissions for the Waikato Region (945,006 t CO_2e), contributing 72% of the total stationary energy related emissions or 7% of the overall regional gross emissions.

Natural gas use is contributed the majority (43%) of the industrial stationary energy related emissions. This excludes the coal and gas used for the Huntly Power station, as this is already included in the national electricity emissions factor. Fugitive emissions from coal mining (310,136 t CO2e) represent the second largest emission source (32%) for the industrial stationary energy sector. Electricity consumption represents the third largest emission source (18%) for industrial stationary energy use. A complete breakdown of industrial stationary energy related emissions is provided in the graphic below.

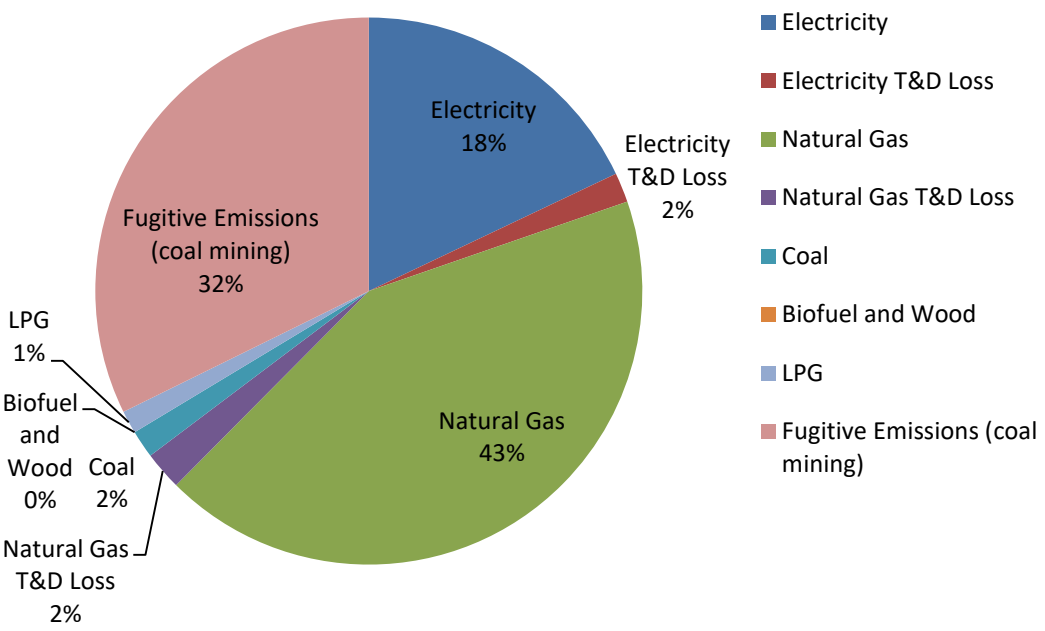


Figure 5: Waikato Region Industrial Stationary Energy Emissions 2015/16

Industrial stationary energy use includes energy used for agriculture, forestry and fishing. No emissions have been estimated for fugitive emission from oil and natural gas systems. These were considered to be insignificant, as there is limited storage and processing of oil and gas within the Region. Emissions from transmission and distribution of natural gas have been included.

5 Transportation

In 2015/16 transportation sources contributed 1,619,540 tCO_2e, representing 12% of the Waikato Region's overall gross emissions. Transportation was the second highest sector contributor to regional GHG emissions, albeit significantly lower than contributions from Agriculture.

The emissions profile for transportation sources is dominated by on-road transport (predominantly Scope 1 emissions), contributing approximately 97% of the transportation emissions during the reporting period (see Table 6). A detailed breakdown of the transportation emission sources is provided in the table below. Figure 7 provides a breakdown of the emissions generated by individual fuel types.

Table 6 Summary of Waikato Region transportation emissions by sector, 2015/16

Sector/Category		Emissions (t CO_2e)		Sector Percentage Contribution
Transportation	On-road	1,567,100	t CO_2e	97%
	Railway	39,416		2%
	Aviation	13,023		<1%

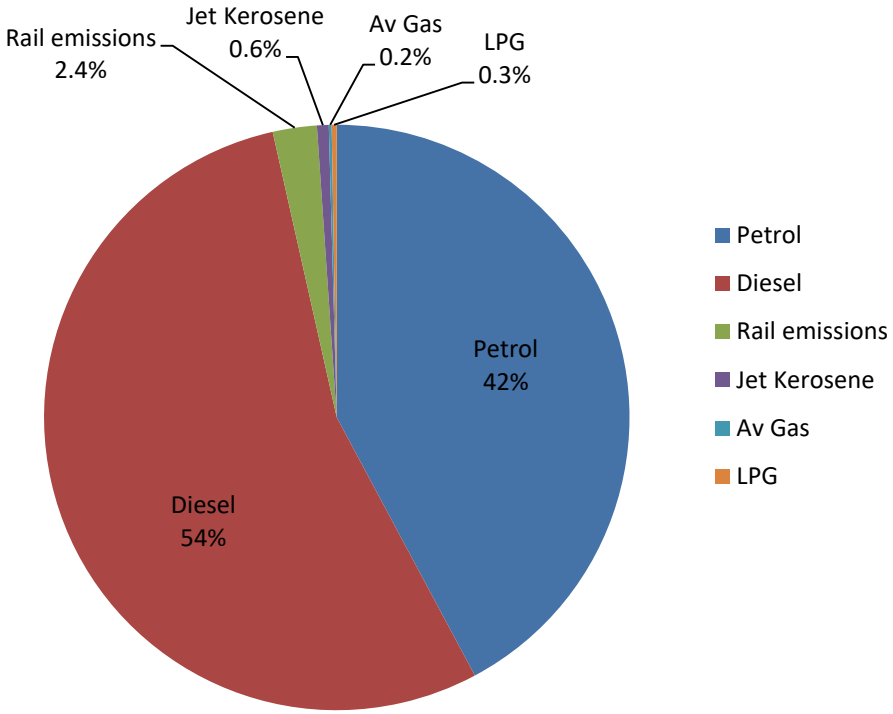


Figure 6 Summary of Waikato Region Transportation Emissions by fuel type 2015/16

For transport occurring within the Auckland region, emissions from combustion of fuels are reported in scope 1 and emissions from grid-supplied electricity are included in scope 2. Scope 3 reports the emissions from a portion of transboundary journeys occurring outside the Auckland region, and transmission and distribution losses from grid-supplied electricity. The emissions are calculated for on-road vehicles, railways, water transport, aviation and off-road transport, respectively.

5.1 On-road transportation

On-road transportation contributed approximately 97% of the total transportation emissions for the Region during the reporting period. Road transport emissions (from petrol, diesel and LPG)

were estimated based on fuel sales figures. Diesel fuel use is responsible for 56% of the on-road transport emissions, with petrol use contributing 44%. LPG use is responsible for 0.3% of the on-road emissions.

On-road transport emissions have been estimated using fuel sales data (top-down approach). This data does, however, not allow for a break-down of off-road transport and small/private maritime fuel use. These are assumed to be included in the on-road fuel use data.

No data was available to estimate cross boundary road transport under Scope 3. It was assumed that fuel purchased within the Region and used for transport outside the Region is equal to the amount of fuel purchased outside the Region and used within the regional boundaries.

These aspects will need to be addressed in future inventories. Given Waikato's location relative to Auckland and potential impacts of a fuel tax[7], there are likely to be significant emissions from cross boundary travel and potential increases in fuel purchases for use outside the Waikato Region. More data will be required to estimate the extent of transboundary emissions (e.g. through travel surveys or vehicle kilometre travel models) or fuel exporting.

5.2 Railway

The rail network in the Waikato Region used both electricity and diesel. The estimated emissions from diesel use for rail is 37,598 t CO_2e representing 2.3% of the transport related emissions. Electricity use for rail contributes 1,818 t CO_2e (scope 2 emissions) or 0.1% of the transport related emissions.

5.3 Water transport

No major port is operating in the Region and as a result there is no significant maritime navigation within the Region. There are, however, small tourism water taxis operating in the Region (e.g. Coromandel). These are assumed to be included in the on-road diesel fuel figures. Similarly, private and small fishing vessels are also assumed to be included in the on-road transport diesel use figures.

5.4 Aviation

The Waikato Region has two airports in Hamilton and Taupo that support domestic flights. The estimated emissions from aviation gas and jet kerosene consumption is 13,023 t CO_2e representing 0.8% of the total transport related emissions for the Region. This represents Scope 3 emissions, accounting for all the departing flights at the two regional airports.

5.5 Off-road transportation

Off-road fuel consumption (for example farm, forestry or airport vehicles) is assumed to be included in the data reported for road transport. Due to lack of specific data this could not be reported separately.

A 2005 study by Ministry of Transport assumed that approximately 3-4% of the national transport fuel was used for off-road transport. MfE have initiated a project to disaggregate energy consumption activities for fisheries and off-road activities. It is understood that the outcomes will be reported in 2018.

[7] Auckland Council has been considering a fuel tax and the central government has indicated its support for such tax to fund transport infrastructure.

6 Waste

In 2015/16 emissions associated to waste contributed 280,963 t CO_2e, representing 2.1% of the Region's overall gross emissions. Waste emissions are dominated by solid waste disposal contributing approximately 87% of the waste related emissions.

Combustion of landfill gas (LFG) and sludge incineration was estimated to generate approximately 4,916 t CO_2 (biogenic[8]).

Table 7 Summary of Waikato Region waste emissions by source 2015/16

Sector/Category Source		Emissions (t CO_2e)		Sector Percentage Contribution
Waste	Solid Waste Disposal	245,316	280,963	87.3%
	Waste Water	35,647		12.7%

6.1 Solid waste

Solid waste emissions were estimated using a 1st-order decay model that requires waste volume estimates for the last 50 years. Historical waste volumes sent to landfill were estimated using the average waste generated per person per year, as reported by Ministry for the Environment (MfE), and historical national population figures as reported by Stats New Zealand.

During the 2015/16 reporting period, the majority of municipal solid waste generated within Waikato was mostly disposed of at the Hampton Downs and Tirohia Landfill (Scope 1), 18% and 63% respectively, the remaining solid waste is deposited at a number of smaller landfills (19%).

The majority of solid waste emissions (65%) were released from landfills without landfill gas collection. These are predominantly from closed landfills that have been used in the past but are still emitting landfill gas. The calculations assume all waste sent to landfills other than Hampton Downs and Tirohia was sent to landfill without LFG collection systems, including historic waste sent to landfill prior to the opening of these two landfills.

Emissions from landfills with landfill gas collection systems (i.e. Hampton Downs and Tirohia Landfills) are responsible for 35% of the regional emissions from solid waste. Details of Landfill Gas (LFG) collection and efficiency were unable to be obtained for any of the operating landfills. Therefore, the NZ average was used, as reported by the MfE 2017.

6.2 Waste water

Waste water treatment generated 35,647 t CO_2e or approximately 0.5% of the total gross emissions for the Waikato.

No data for the specific type of waste water treatment methods or number of individuals in the Region using different waste water treatment methods was available for the Waikato Region at the time of deriving the waste water emissions. Therefore, national waste water emissions data and the New Zealand and Waikato Region population data were used to calculate the per capita waste water treatment and disposal emissions, and the total waste water emissions from the Waikato Region.

Most urban waste water treatment systems in New Zealand use advanced treatment methods resulting in relatively few GHG emissions. The majority of waste water treatment related emissions arise from the use of septic tanks. Overall, emissions from waste water treatment are

[8] Biogenic CO_2 emissions, such as the combustion or digestion of biological materials, are part of the natural carbon cycle and do not directly contribute to climate change. The GPC Standard recommends reporting these emissions outside of the total greenhouse gas emissions.

considered not to be material across New Zealand. Further, to obtain an accurate representation of waste water related emissions requires a significant amount of data from each waste water treatment plant, as well as an accurate number of septic tanks being used.

The top down approach adopted for the Waikato Region can therefore be regarded as sufficient to provide an estimate of the likely order of magnitude and the expected emissions. This approach also confirmed that at approximately 0.5 %, these emissions are not material for the overall regional carbon footprint.

7 Industrial processes and product use (IPPU)

7.1 Industrial processes

Stationary energy emissions from industrial processes using coal, natural gas and electricity for production and operation processes have been estimated within the respective emission categories (Stationary Energy - Section 4).

7.2 Product use

In 2015/16 industrial GHG emissions contributed 141,334 tCO_2e (1%) towards regional gross emissions. The emissions for industrial product use include emissions from hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (Scope 1). Nitrogen trifluoride emissions do not occur in New Zealand, and therefore are not included in this report.

Industry and solvent related emissions are estimated based on data provided in the New Zealand Greenhouse Gas Emissions 1990-2015 report (MfE 2017). Emissions from industrial product use (refer Table **8**) were estimated based on New Zealand's average emissions per capita for the Waikato Region population.

Table 8 Summary of industrial product use emissions for Waikato Region

Industry and solvent Waikato	**Reporting year 2015/16**	**Unit**
Refrigerants	**130,612**	t CO2e
Foam Blowing	**393**	t CO2e
Fire extinguishers	**228**	t CO2e
Aerosols & MDI*	**8,345**	t CO2e
SF6	**1,755**	t CO2e
Total	**141,334**	**t CO2e**

* metered dose inhalers

8 Agriculture

Agriculture generated an estimated 10,421,352 tCO_2e in Scope 1 emissions in 2015/16. This represents approximately 77% of the total gross emissions for the Region. A breakdown of agricultural emissions by source is provided below (Table 9).

The majority of emissions (71% or 7,450,000 t CO2e) were generated by methane (CH4) emitted from enteric fermentation and manure management of farmed animals (see Figure 8: **Agricultural emissions for 2015/16**
. Overall, beef and dairy cattle are responsible for approximately 80% of all agricultural emissions, with about 2.3 million cattle farmed in the Region in 2015/16.

Table 9 Summary of agricultural emissions sources and gases (t CO_2e), 2015/16

Emission source	Reporting year 2015/2016	Unit
Enteric fermentation (CH_4)	7,044.5	kt CO_2e
Manure Management (CH_4)	405.5	kt CO_2e
Total CH_4 (in tCO_2e)	**7,450.0**	kt CO_2e
Manure Management (N_2O)	1,292.1	kt CO_2e
Agricultural Soils (N_2O)	181.4	kt CO_2e
Grazing animals (N_2O)	1,285.3	kt CO_2e
Leaching (N_2O)	52.5	kt CO_2e
Atmosphere deposition (N_2O)	160.2	kt CO_2e
Total N_2O (in tCO_2e)	**2,971.4**	kt CO_2e
Total emissions CO_2e	**10,421,352.5**	**t CO_2e**

Waikato's agriculture emissions represent 77% of all gross emissions for the Region (excluding forestry sector). Half of the Region's emissions are therefore related to methane, which is a short-lived gas that it is not associated strongly with co-benefits like water quality as is the case with N_2O reduction. The Region will need to consider these aspects when choosing reduction pathways, and decide whether it should focus on methane reduction in the short term irrespective of central government policy in this area.

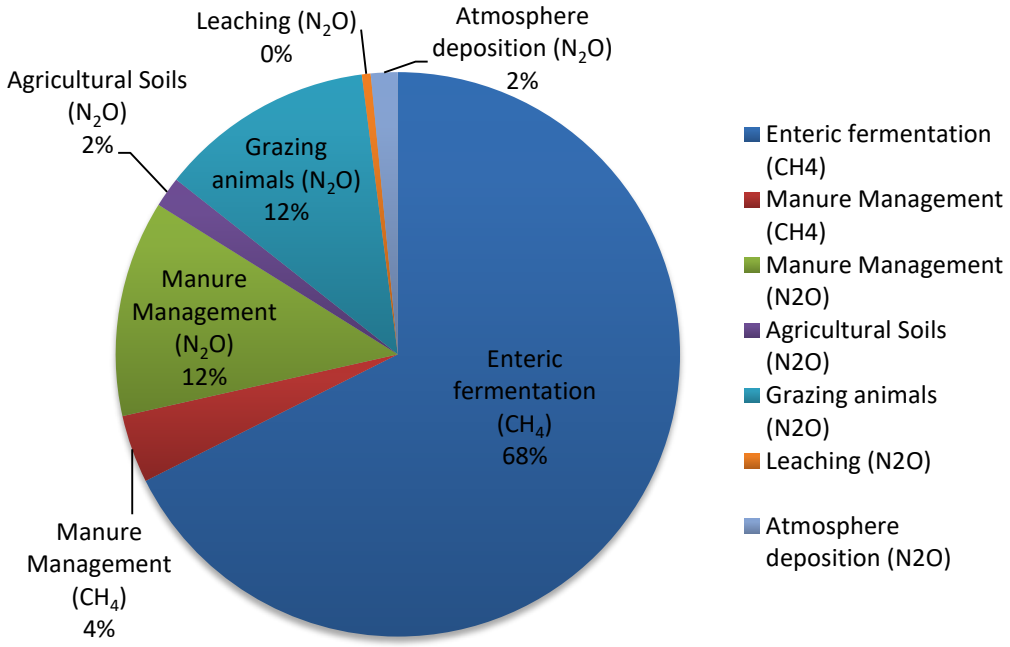


Figure 7: Agricultural emissions for 2015/16

8.1 Agricultural emissions trends

While this GHG inventory is a baseline assessment to be used for reporting and tracking trends from this point forward, this section focuses on changes in stock numbers (Figure 9) and the related greenhouse gas emissions (Figure 10) between 2002 and 2015 in Waikato Region - using data from Statistics NZ Agricultural Production Survey. This information is intended to help start discussions and dialogue about climate mitigation strategies.

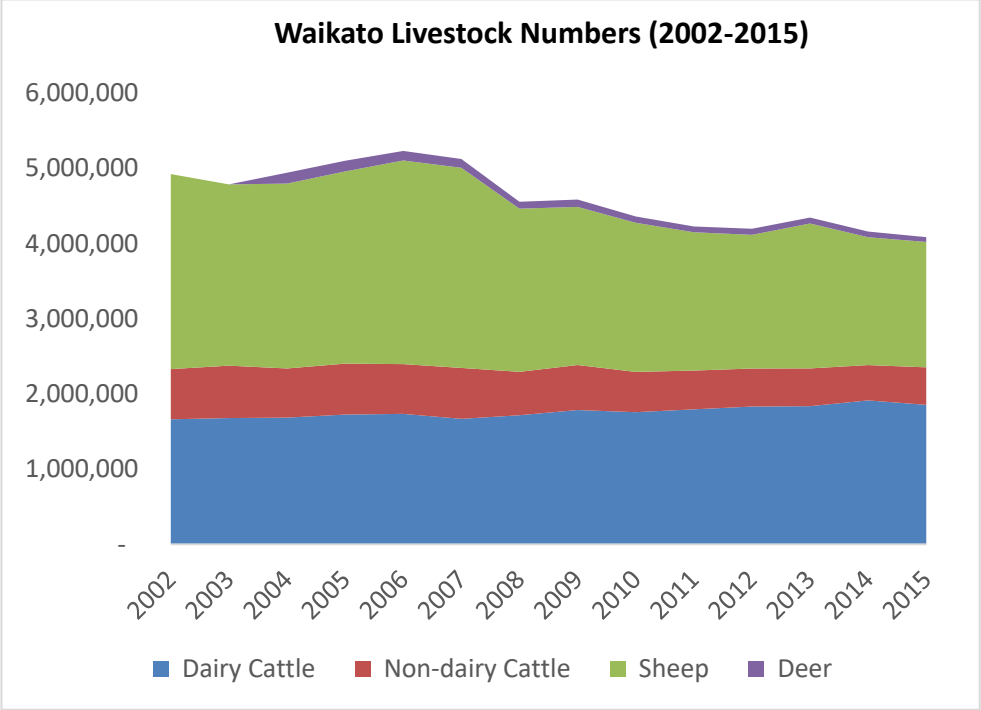


Figure 8: Changes in livestock numbers in the Waikato Region (2002- 2015)

In net terms, the number of livestock in the Region decreased from 2002 to 2015 with a relatively small shift from non-dairy to dairy cattle.

In line with livestock numbers and the higher impact of beef and dairy cattle, total emissions from livestock do not change much from 2002 to 2015[9]. In the same period, sheep and non-dairy cattle emissions have reduced slightly while dairy emissions have increased (Figure 9).

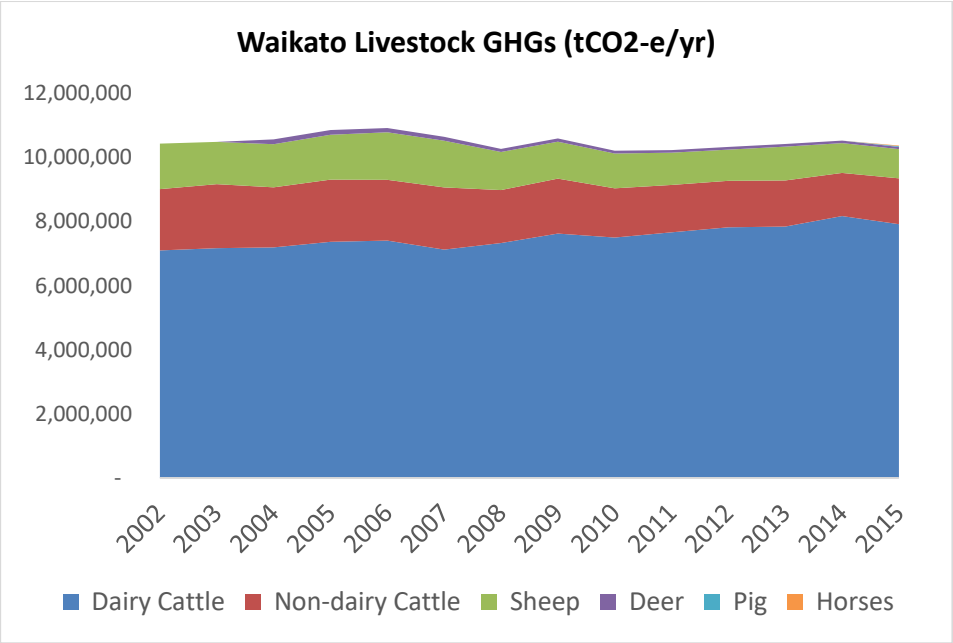


Figure 9: Greenhouse gas emissions (tCO2e) from stock in the Waikato Region (2002-2012)

However, where changes are noticed is in their spatial distribution across the Region.

To create the spatial representation maps (Figure 12 & 10a), the agricultural production data used to calculate agricultural emissions (from StatsNZ), was 'downscaled' and applied to the land use map for Waikato Region to 'spread' the emissions across the Waikato spatially (with factors for pastoral farm also varying by stocking rate). The land use maps are based on Agribase databases for 2011 and 2015. The areas that are dark red also have more cows/ha; the grey areas are trees and water, which do not produce emissions.

This is a crude method for spatial representation of emissions intensity and their purpose is to help start discussions and dialogue about mitigation within the council as well as the farming community. Further improvements can be made to ensure that the maps are robust when actual mitigation measures are considered.

[9] Emissions factors are sourced from NIR 2017 and NIR 2015 - MfE 2017, Table 5.3.6.

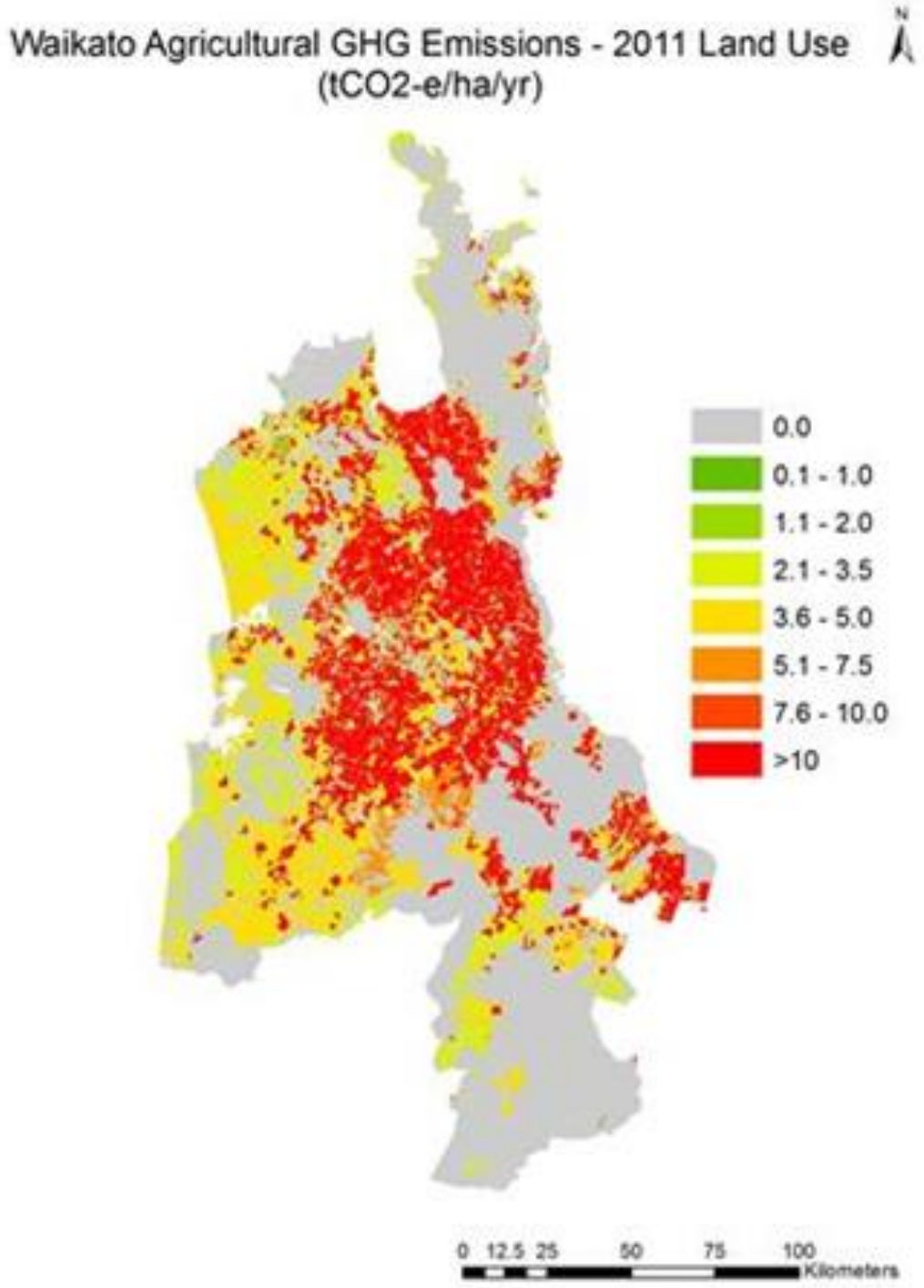


Figure 10: Spatial distribution of agricultural emissions, 2011

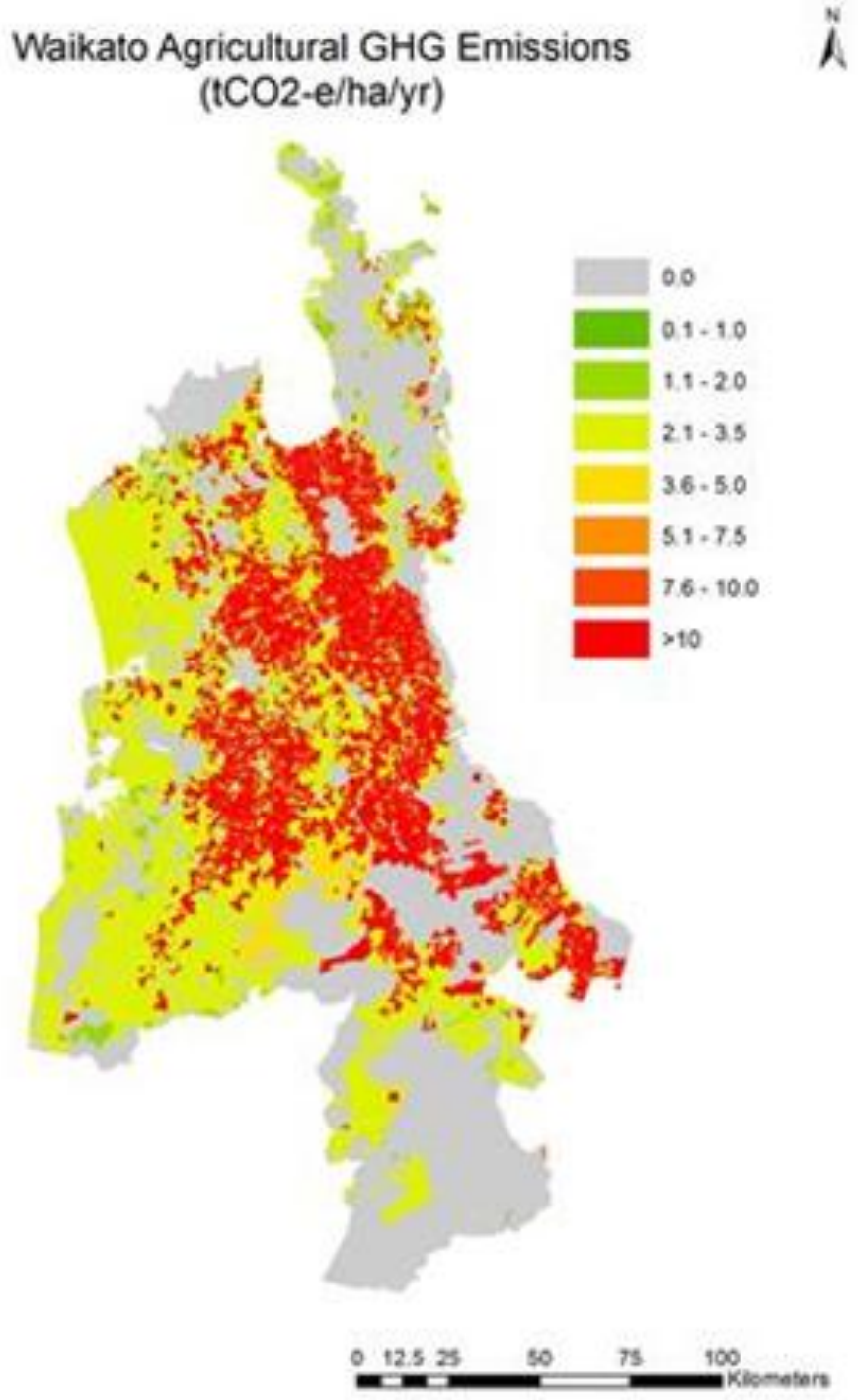


Figure 11: Spatial distribution of agricultural emissions, 2015

Soil organic carbon

Soil carbon is considered important for climate regulation as it represents the largest land-based sink for carbon. There are many factors that influence carbon levels in soils, including the type of soil, land use, management practices or weather. Recent research suggests that globally, the potential for soils to sequester carbon to mitigate climate change has been overestimated by as much as 40% due to the fact that cycling of carbon in soils takes much longer than initially thought[10].

[10] Yujje Ha et al.(2016). "Radiocarbon constraints imply reduced carbon uptake by soils during the 21st century." *Science,* 23 Sep 2016: Vol. 353, Issue 6306.

In New Zealand, the national Greenhouse Gas Inventory is prepared on the assumption that soil carbon does not change when land use is constant, and changes in carbon are only taken into account when there is a change in land-use. A 2017 national review about soil carbon change determined that the different data sets available suggest either no change or a gain in carbon, large uncertainties notwithstanding[11].

Management of the carbon currently stored in Waikato soils could support or undermine the efforts to reduce emissions, depending whether soils release or soak up carbon. Research on a Waikato dairy farm on peat soils estimates the carbon change, i.e. loss, at 2.9 C t per year. Whereas this is a single site measurement and more sites are required for statistical validity, there is a potentially significant carbon liability for Waikato Region given the 94,000 ha of organic soils present in Waikato.[12]

Significant research is still required to better understand changes in soil carbon (specifically within the same land use) and how to measure in a verifiable manner specific sequestration practices – particularly when the information is intended for use in GHG emissions inventory.

[11] Schipper, L. A., P. L. Mudge, et al. (2017). "A review of soil carbon change in New Zealand's grazed grasslands." New Zealand Journal of Agricultural Research 60(2): 93-118.

[12]

9 Forestry carbon sequestration and emissions

Forestry activities in Waikato Region in 2015/16 contributed an estimated -5,595,391 t CO_2e. Most sequestration was generated by exotic forest, with about 6% contribution from native forest.

Table 10 Summary of forest emissions/removals by source 2015/16

Emission source/category	**Emissions (t CO_2e)**	
Forest area: sequestration		
Exotic forest sequestration	-12,386,068	13,167,701
Native forest sequestration	-781,633	
Forest area: removal		
Exotic Wood harvested (round wood removal)	3,907,516	7,572,310
Exotic Wood harvested (remaining on site)	1,674,650	
Exotic wood harvested (below ground, dead wood and litter)	1,990,144	
Net forestry emissions	**-5,595,391**	**t CO_2e**

The forestry sector emissions include carbon sequestered through growing trees, and carbon lost through harvesting. In 2015/2016 emissions from sequestration were greater than those for harvesting, resulting in net negative emissions for the Waikato Region forestry sector.

It is however important to understand harvest rates over the near and medium term as this may result into significant increase in net emissions for the Region through loss of sinks.

Trees sequester carbon over a long period (approximately 30 years for exotic forest plantations and up to 100 years for indigenous forests). The GPC methodology applied for the Waikato Regional carbon footprint assumes that all carbon stored in trees is released in the year the trees are harvested. Figure **13** indicates the carbon yield over multiple forest rotations, demonstrating the impact of the harvesting cycle. It is likely that the overall carbon balance of the Region is relatively stable over a 50-100 year period (depending on planting rates). However, as illustrated in Figure **13**, on an annual basis the emissions and sequestration values will vary significantly depending on the level of harvesting taking place.

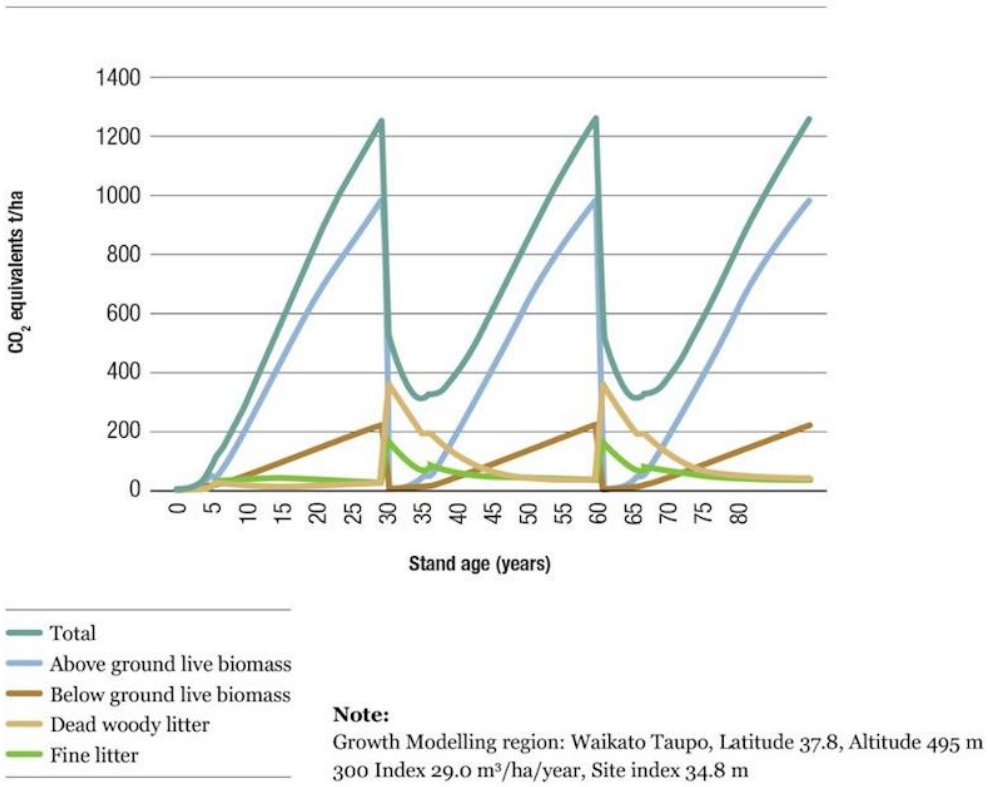


Figure 12 Carbon yield - multiple rotations (Source: Forest Ownership Association, Facts & Figures, 2014)

Figure **14** below outlines the forest areas planted and harvested in the Waikato Region over the last 15 years. This indicates that over the last 10 years more land has been harvested than replanted and newly planted, resulting in significant emissions from harvesting and a loss of sinks within the Region. This planting and harvesting activity will have potential impacts on Waikato's forestry emissions and overall emissions profile in the future.

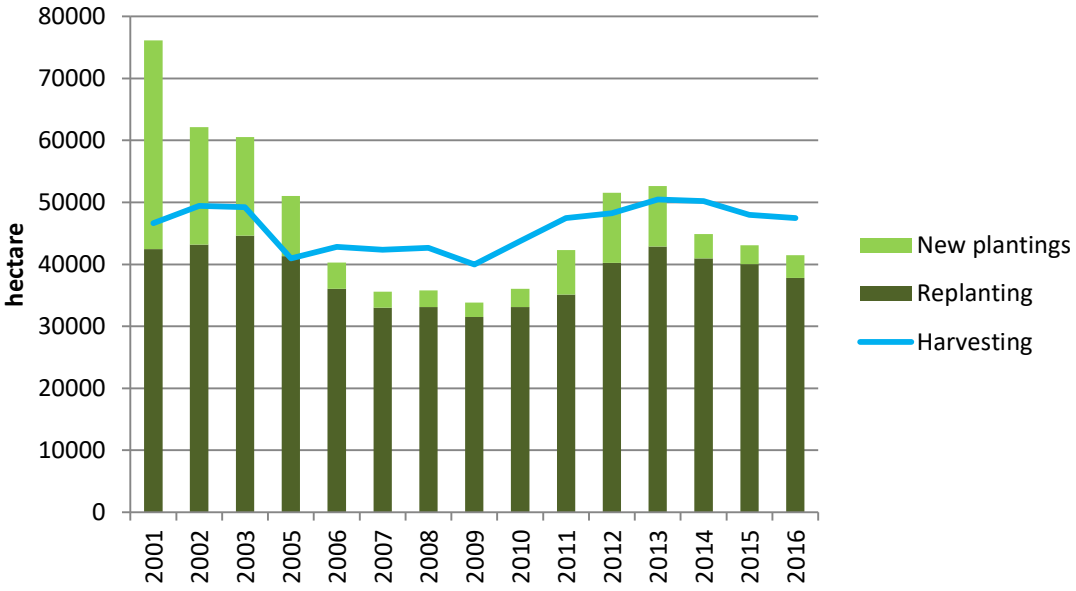


Figure 13 Forest planting and harvesting rates in the Waikato Region

An increased focus on riparian and marginal hill land planting that involves long-life species that can meet sequestration standards may be a viable solution for Waikato Region to enhance

sequestration rates while also reducing nutrient leaching and sedimentation as required by the Healthy River Plan Change.

10 Conclusions and recommendations

The GPC is considered the most comprehensive GHG accounting and reporting framework for cities and wider communities around the globe. It is increasingly used by local and regional governments to inform emission reduction targets, track performance and to develop GHG inventories that are credible and compatible with international standards (incl. the IPCC national reporting guidelines). The GPC also enables organisations to benchmark their performance against similar organisations.

10.1 Inventory preparation and data collection

This emissions inventory was prepared with the best available data at this time. For preparation of future inventories, WRC may consider the following recommendations to improve the quality of the inventory but also for accessing, managing and reporting the inventory results in a way that is credible and integrated into other processes at WRC to reduce the efforts required to produce such inventories but also enable action on the data.

Recommendation 1: Reporting intervals

It is recommended that WRC considers the preparation and update of the regional inventory at three-year intervals.

A three-year interval is considered adequate for the development of an emission inventory taking into account the resource intensiveness of such process and the value that an updated inventory can provide to managing emissions. If Waikato Region was to join international platforms such as CDP, this may require annual inventory update and disclosure.

In New Zealand, some of the regional councils produce yearly emissions inventory (particularly when they are party to platforms such as or C40 Cities, for instance Auckland City). Given that Waikato Region has not identified reduction targets and that there are other platforms such as the Waikato Progress Indicators that provide an overview on the performance of the Region as a whole in terms of community well-being, a three-year interval for developing a comprehensive and GPC-compliant inventory is considered appropriate. Three-year intervals also coincide with the electoral cycle in New Zealand and the long-term planning processes within councils.

Recommendation 2: Data management

Explore the feasibility of using specific software tools to assist with data collection, analysis and reporting using the same underlying data.

Data collected for this inventory has been logged into custom designed templates by AECOM, reflective GPC requirements. The World Bank (CURB) and C40 (CIRIS) have developed custom GPC tools to help with data management and reporting. In New Zealand, organisations such as Foundation Footprint or Eco-Portal have developed platforms that integrate data needed for carbon inventories with other data collection efforts by councils (for instance environmental compliance or sustainability reporting) to generate timely and actionable reports for sustainability performance improvement.

The Council may consider the use of such software while also seeking synergies for instance with the Waikato Progress Indicators development.

Recommendation 3: Data quality and availability

Overall, data quality is considered to be robust. The majority of the material emission sources have been estimated using bottom up data (e.g. forestry, agriculture and fuel sales). However, there are a number of data sets that have been estimated using a top down approach and applying national average emissions (e.g. industrial product use and waste water treatment emissions). A detailed overview of data gaps is provided in section 12.3.

Overall, the data quality is considered to be adequate for this level of emissions reporting. Data sets that can be enhanced in future inventories include:

- Emissions from off-road transport, stationary diesel use (for generators) and recreational marine travel are not included in the road transport emission estimates, due to lack of data allowing for a more detailed breakdown of the fuel sales data. No data was available to estimate cross boundary road and rail transport emissions (Scope 3). Given Waikato's location relative to Auckland and potential impacts of a fuel tax, there are likely to be significant emissions from cross boundary travel or increases in fuel purchases for use outside the Waikato Region. More data will be required to estimate the extent of transboundary emissions (e.g. through travel surveys or vehicle kilometre travel models) or fuel exporting.
- Emissions from aviation have been estimated based on the number of flights recorded over one week. These were extrapolated to represent a 12 months period. Fuel sales data of flight movement data will be required to get a more accurate understanding of the aviation related emissions.
- No data has been available for the tourism and shipping industry (e.g. Coromandel area). Although these are likely to only contribute a small amount of the regional emissions, we recommend this to be investigated to assess if the emissions are material (i.e. >1%).
- Forestry sector emissions have a significant impact on the regional emissions profile. The approach used in this inventory differs from the approach used for the national level reporting, due to lack of regional specific data at the national level. We encourage Waikato Region to work with MfE to obtain regional level land-use and land-use change data in line with the national reporting.[13]
- The same is true for changes in carbon stock and harvested wood products. The approach used in this report differs from the national approach. Aligning the Region to the national emissions reporting is likely to provide a more accurate picture of the net carbon changes over the long term, compared to the potential variations on a year to year basis due to the carbon accounting method used for this report.

10.2 Setting reduction goals

There are various approaches to setting up reduction goals. The GPC suggests four different approaches to setting emissions reduction targets as follows:

- Base year emissions goals
- Fixed level goals
- Base year intensity goals
- Baseline scenario goal

For example, Auckland City and Wellington greater Region have set up base year net emissions reduction goals (which assumes reduction to an historical date considered the baseline year). Internationally, some cities have set carbon neutral goals as long term aspirations.

Recommendation 4: Setting reduction goals

Dialogue with key stakeholders within the Council as well as outside (TLAs, industry, farming and community groups) should commence to explore level of ambition and preferred approach to setting emissions reduction goals. Careful considerations need to be given to sectors not currently covered by ETS but likely to be included in the future i.e. agriculture, and gases like methane that may not have strong environmental co-benefits i.e. nexus water quality vs carbon reduction.

Overall, agriculture and forestry will require specific attention in setting up reduction targets and understanding the dynamics with carbon removals, recognising that:

[13] Dialogue with MfE staff has already commenced as result of this project and there is interest to support WRC in their future efforts to enhance inventory activity data.

- Half of the Region's emissions are from methane, which is a short-lived gas that it is not associated strongly with co-benefits like water quality as is the case with N_2O reduction.
- Majority of carbon removals in Waikato are due to exotic forestry, which becomes a carbon liability if/when harvested.
- Soil carbon and soil management regimes will have a material impact on the carbon balance, presenting either opportunities for sequestration or liabilities for the Region.

The Region will need to consider all these aspects when choosing reduction pathways, including the gaps in knowledge that need to be addressed to effectively pursue emissions reductions.

A base year reduction goal approach may be considered, with 2015 as a base year for which inventory data exists.

Recommendation 5: **Take** a **long term strategic outlook to emissions reduction**

Waikato Regional Council has already explored green growth pathways and is strategically looking at win-win solutions for the people and environment. Responding to climate change and building climate resilience requires a long-term outlook for Waikato – as transformation of sectors like agriculture will require new technical solutions (including research) and sustained effort and collaboration with farming community and other stakeholders. Collaboration with other councils (particularly those with a similar emissions profile i.e. significant agricultural emissions) in New Zealand is also important in order to exchange ideas and benchmark performance, and the Local Government NZ provides a strong platform in that respect.

This inventory is only a first step in the process of understanding and building capability to respond to climate change.

11 References/Bibliography

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12 Appendices

12.1 Data Quality Assessment

Data management	Data collection		
	Measured	**Derived**	**Estimated**
Robust	M1	D1	E1
Satisfactory	M2	D2	E2
Questionable	M3	D3	E3
Measured = Data directly provided by a service provider, contractor or directly obtained from a monitoring device. For example electricity invoices, contractor receipts, emissions monitoring equipment, incident reports, consultant reports etc.			
Derived = Data obtained from calculations, mass balances, use of physical/chemical properties, use of coefficients and emission factors etc. For example converting cubic meters of waste into tonnes			
Estimated = Usually where there is no other available method for obtaining the data. Such data could be prorated on previous results, use of precedents or historical data, or even a calculated guess			
Robust = Evidence of sound, mature and right reporting system, where room for error is negligible. Examples would include use of spread sheets, databases and on-line reporting			
Satisfactory = Examples would include manual, but structured keeping of records, files and results. Some potential for error or loss of data.			
Questionable = No logical or structured approach to data or record keeping. High potential for error &/or loss of data. Data may appear to differ from those initially reported.			

12.2 Assumptions and limitations

Sector/Category	Assumptions and Exclusions
Stationary Energy Emissions	
Residential, commercial and industrial stationary energy emissions	• Coal and biomass related emissions have been estimated using a top down approach, applying the national average consumption for commercial and residential coal use, estimated based on population figures. • Consumption of natural gas and electricity data are based on total energy distributed to grid exit points within the Region. The energy provided to these grid exit points have then been allocated to the entire Region. This may in some instances mean that energy used outside the Region may be counted as part of the Region's Footprint, depending on the distribution network for gas and electricity, which may not fully match the Region's boundaries in all cases. • Emission per user group (i.e. residential, commercial and industrial) was estimated based on national average energy use split between these groups as reported by MBIE (2017a). • Coal and natural gas consumption for the Huntley Power Station have been excluded from the regional emissions estimates, as this is already reflected in the national emissions factor for electricity generation.
Electricity Generation	• National emission factor for electricity generation was estimated based on data published by MBIE in their quarterly electricity and liquid fuel emissions table (MBIE 2017b). • It is understood from the Electricity Authority's 'Generating Station List' (September 2012) that more electricity is generated in the Region than is consumed. • The emissions from stationary energy generation (e.g. from the Huntly Power Station) occurring within the region have not been included in the Waikato Region carbon footprint, as these are part of the national emissions calculations for electricity generation. Waikato's share of the emissions from stationary energy generation is already accounted for as part of the emissions estimated for the region's electricity consumption.
Electricity Consumption	• Consumption of electricity data is based on total energy distributed to grid exit points within the Transpower Network. • The electricity consumption figure used for the Waikato Region is likely to be conservative, as the total energy distributed to the exit-grid points does not follow regional boundaries. However, it is likely that the affected population/area is relatively small and therefore the impact to the energy consumption to the Waikato Region is not likely to be significant.
LPG	• LPG consumption in the Waikato Region is based on the total amount of LPG supplied to the North Island and calculated on a per capita basis using 2016 population estimates.

	• LPG stationary energy estimates are based on the national share of 9kg and 45kg gas bottles, and bulk sales as outlined in New Zealand's GHG Inventory 1990-2015.
Natural Gas	• Natural gas consumption is based on total gas distributed to exit grid points within the Waikato Region as supplied by First Gas (excludes sites that have direct connections to the transmission network) as well as the direct gas volumes for Fonterra Te Rapa and Lichfield Dairy Factory. • Natural gas used by Huntly Power station has not been included as these are already reflected in the national emissions factor for electricity generation. • The natural gas distribution network does not follow regional boundaries and may include some of the surrounding rural areas. However, it is assumed that the population in these areas is relatively small and therefore the impact to the regional natural gas consumption is not likely to be significant. • Assumes distribution loss emissions of 6.36 $kgCO_2e/GJ$ during distribution based on the national average reported for distribution loss of reticulated natural gas (MfE 2016 - voluntary GHG reporting guidelines).
Industrial Stationary Energy Emissions	• No specific data was available for industrial stationary energy consumption with the exception of natural gas use for co-generation plants at the Fonterra Te Rapa & Lichfield Dairy plants and fugitive emissions from mining. • Emissions from industrial consumption of coal and LPG, and have been estimated based on a top-down approach allocating national emissions on a per capita basis. • No other emissions (e.g. diesel) have been estimated from industrial stationary energy consumption, due to lack of data.
Fugitive Emissions	• Not included in the Inventory as there is no production of oil or gas within the Waikato Region. • Fugitive emissions from coal have been included in industrial stationary energy emissions.
Coal	• Emissions relating to the use of coal from residential, commercial, as well as from agriculture, forestry and fishery activities have been included for the Waikato Region. • Fugitive emissions from coal mining have been included under Stationary Energy (industrial emissions), based on the national average emissions factor for fugitive emissions from sub-bituminous coal mining reported by MfE.
Transportation Emissions	
Road	• Total volume of fuel sold within the Waikato Region in FY2015/2016 was provided by Hamilton City Council. • Fuel consumption figures (petrol and diesel) also include fuel used for off-road transport and recreational water transport, as these are sold through the same network. Due to lack of data these could not be reported separately.

Rail	• Emissions from rail transport are estimated based on length of rail network and average fuel consumption per tonne km and freight volume as provided by Kiwi Rail for the 2015/16 financial year. • The rail network in the Waikato is electric and diesel. • Rail diesel use is estimated based on the average fuel consumption per tkm travelled within the Region. Due to lack of more detailed data it is not possible to estimate what portion of the rail related diesel use was purchased in- or outside the Region. • It was assumed that Diesel sold for rail transport is not included in the Waikato fuel sales data for road transport. • Electricity emissions are estimated based on the total kWh consumed by KiwiRail and the national emissions factor for electricity generation, and transmission and distribution losses.
Aviation	• Aviation fuel data sold/pumped at Hamilton and Taupo Airport could not be obtained during the data collection. • Aviation emissions, from Jet Kerosene, have been estimated using the average number of Air New Zealand movements understood to take place via the FlightAware.com website. The number of flights estimated is likely to be conservative as it only includes Air NZ movements. It is understood that other aircrafts operating from Hamilton and Taupo airport are also using JetA1. These have not been estimated. • The estimated aviation emissions represent 50% of aviation related emissions associated with Air NZ movements at Hamilton and Taupo Airport, in line with the GPC framework. • Aviation gas fuel consumption for smaller aircraft and helicopters were estimated based on conversation with aviation fuel experts.
LPG	• LPG consumption in the Waikato Region is based on the total amount of LPG supplied to the North Island and calculated on a per capita basis using 2016 population estimates. • LPG transportation energy estimates are based on the national share of automotive and forklift sales as outlined in New Zealand's GHG Inventory 1990-2015. • LPG consumption estimate does not take into account automotive and forklift sales in the Region that may then be taken out of the Region or individual district boundaries.
Off-Road	• Off-road fuel consumption is assumed to be included in the data reported for road transport. Due to lack of specific data this could not be reported separately.
Waste Emissions	
Solid Waste Disposal	• Solid waste emissions were estimated using a 1st-order decay model (which requires waste volume estimates for the last 50 years). • Reliable historic population figures, provided by StatsNZ, only go back to 1986 therefore 30 years of data has been estimated for the Waikato Region Solid Municipal Waste emissions. • Due to limited specific current and/or historic data for the Region, waste volumes sent to landfill for the Waikato Region have been estimated by applying the New Zealand national average waste

	generation per capita (reported by MfE, 2017) and using historic population figures reported by StatsNZ. • Landfill gas emissions were estimated for landfills with and without landfill gas capturing systems. • Data on specific waste composition was not available therefore this data has been modelled based on the national average waste composition reported by MfE (2017). • Waikato District, Hamilton City and Waipa District send all their waste to landfill at Hampton Downs, and Thames District, Hauraki District and Matamata-Piako District send all their waste to landfill at Tirohia. • Hampton Downs has been collecting landfill gas since 2006 and Tirohia has been collecting landfill gas since 2001.
Incineration	• Emissions from waste incineration have not been included, as only small quantities of clinical and hazardous waste is incinerated in New Zealand. Emissions from these sources are assumed to be insignificant[14].
Waste Water Treatment	• No data for the specific type of waste water treatment methods or number of individuals in the Region using different waste water treatment methods was available for the Waikato Region at the time of deriving the waste water emissions. • National Waste Water emissions from 2015 and population data from 2016 were used to calculate the per capita waste water treatment and disposal emissions, and the total waste water emissions from the Waikato Region. 2015 data was the most up to date information available from the New Zealand Greenhouse Gas Inventory 1990-2015.
Industrial Emissions	
Industrial Processes	• No emissions from industrial processes have been included due to the lack of specific activity data. It is understood there are very few large industrial operations resulting in emissions from chemical or physical processes taking place within the Waikato Region.
Product Use including: HFC, PCFs and SF_6	• Emissions for refrigerants, fire extinguishers, foam blowing, aerosols and metered dose inhalers, as well as SF_6 in electrical equipment are estimated based on New Zealand average per capita emissions (MfE 2017).
Agricultural Emissions	
Agriculture	• Agricultural emissions are based on agricultural production data provided by Statistics New Zealand. • Emissions from field burning of agricultural residues have not been included in the calculations above, due to lack of data and methodological guidance by the IPCC 2006 Guidelines. These emissions are assumed to be insignificant.
Forestry Emissions	
Forestry	• Exotic forest volumes are based on data provided in the National Exotic Forest Description published by MPI (MPI 2016 and MPI 2015). The data is provided on a Territorial Authority (TA) level.

[14] Nationally, emissions from incineration of waste represent about 0.1% of the total waste emissions.

	• Carbon sequestration for exotic forests include above ground, below ground, dead wood and litter. • Carbon sequestration rates for exotic forest are based on yield tables provided by MfE, assuming a 50/50 split between pre 1990 and post 1989 forests within the Waikato Region. • Harvest data has been calculated using the Waikato's available regional data. • Due to insufficient data for land use changes, no emissions from land use change of cropland, wetlands, settlements and other land have been estimated. • Maturing native forests (i.e. Manuka and Kanuka), as well as grassland with woody biomass have been included as native forests. • Data for native forests is based on LCDB vol. 4 data. • Sequestration rates for native forest were based on advice from MfE (2017). • Emissions from forest harvesting activities are included in the Inventory as part of the LULUCF emissions. • For the purpose of this report, it was assumed that all carbon stored in tree biomass (above and below ground as well as in dead wood and litter) become an emission in the year of the tree harvest.
Emission Factors	
Emission Factors – Mobile and Stationary Energy	• Emissions factors are based on published New Zealand specific emission factors where possible. Sources include the New Zealand National Greenhouse Gas Inventory (MfE 2017) and Guidance for Voluntary Greenhouse Gas Reporting for Organisations (MfE 2016), National Energy File data (MBIE 2017) and the 5th IPCC Assessment Report (IPCC 2013). A detailed list of emission factors is provided in the individual emissions calculations table in the Excel tables prepared as part of this project. • Advice received by MfE (for a previous report) supported the use of the most recently published emissions factors for all reporting years and emissions calculations. • The Global Warming Potential used to convert CH_4 and N_2O to CO_2e are based on the IPCC Fifths Assessment Report for 100 year GWP including climate-carbon feedbacks.

12.3 Data Sources and Data Gaps

Data for the community carbon footprint was collected from a number of data sources. Key data sources are detailed below:

Table 11 Waikato Region GHG Inventory Data Sources – 2015/16

Emissions Category		Data Source
Stationary Energy		First Gas Limited Transpower Electricity Authority KiwiRail Genesis Energy (Huntley Power Station coal and gas use) LPG Association NZ MBIE (2015) Energy in NZ, Section K MBIE (2015) Data Tables for Coal MfE (2015) National Greenhouse Gas Inventory Report
Transportation		Air travel movements (FlightAware.com) KiwiRail LPG Association NZ Hamilton City Council (fuel sales data for Hauraki, Matamata-Piako, South Waikato, Thames-Coromandel, Waipa and Waikato Districts) Otorohanga District Council (fuel sales data for Otorohanga, Ruapehu and Waitomo Districts) Ministry of Business, Innovation & Employment (fuel properties)
Waste	Solid Waste	Waste Management Envirowaste Individual City and District Councils Internal Waste data
	Waste Water	MfE (2017) 1990-2015 National Greenhouse Gas Inventory Report
Industrial		MfE (2017) 1990-2015 National Greenhouse Gas Inventory Report
Agriculture		MfE (2017) 1990-2015 National Greenhouse Gas Inventory Report Statistics New Zealand (Agricultural production data)
Forestry		MPI (2015, 2016) National Exotic Forest Description Statistics New Zealand

A data gap analysis was undertaken during the data collection stage of the project. The following data gaps and alternative data sources were identified:

Table 12 Waikato Region GHG Inventory Data Gaps – 2015/16

Emissions Category		Data Gap	Alternative Data Source
Stationary Energy		- District specific biofuel (wood) consumption data - District specific coal consumption data	- No alternative data source (assumed to be included in total forest harvest emissions) - National average (on per capita basis)
Transportation		- Public Buses - Airport fuel sales - Off-road fuel use - Maritime fuel use (for small private vessels)	- Assumed to be included in total fuel sales data - Estimated based on flight movements - Assumed to be included in total petrol and diesel sales data for the Region - Assumed to be included in the total diesel sales data for the Region
Waste	Solid Waste	- Landfill gas collection efficiency for Tirohia, Hampton Down - Historic waste volumes	- National average collection efficiency - Assume no landfill collection at any landfills other than Hampton Downs and Tirohia, this includes historic (now closed) landfills - Assume national average waste generation per person (as outlined in the national GHG inventory by MfE)
	Waste Water	- No data available for local waste water treatment systems or number of people connected to these	- Assume national average waste water treatment emissions on a per capita basis
Industrial		- Significant industrial (physical & chemical) process activity resulting in GHG emissions - Industrial product use (e.g. asthma inhaler, aerosols, etc.)	- No sources identified – assumed not to be relevant or significant - Emissions were estimated based on national emissions data on a per capita basis
Agriculture		- No goat numbers reported for Region - No estimates of cultivated organic soils within Region	- Assumed not to be relevant - Not estimated

Forestry	- No data for Harvest Wood Products (i.e. what harvested wood is used for)	- Assumed that all carbon stored in trees is released in the year of harvest
	- insufficient data to estimate annual changes in land use (grassland, cropland, wetland, settlements and other land)	- Not estimated

A more detailed description of the assumptions and limitations associated with the carbon footprint calculations is provided in section12.2.

+ Sources required for BASIC reporting + Sources required for territorial total but not for BASIC/BASIC+ reporting

GPC ref No.	Scope	GHG Emissions Source (By Sector and Sub-sector)	Notation keys	Gases in tonnes									Data Quality	
				CO_2	CH_4	N_2O	HFC**	PFC**	SF_6**	NF_3*	Total CO_2e	CO_2(b)	AD	EF
I		STATIONARY ENERGY												
I.1		Residential buildings												
I.1.1	1	Emissions from fuel combustion within the city boundary		63,692	5.15	0.73	NO	NO	NO	NO	64,085	-	M	H
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary		125,395	IE	IE	NO	NO	IE	NO	125,395	-	M	H
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption		12,232	IE	IE	NO	NO	IE	NO	12,232	-		
I.2		Commercial and institutional buildings and facilities												
I.2.1	1	Emissions from fuel combustion within the city boundary		82,251	6.55	1.00	NO	NO	NO	NO	82,771	-	M	H
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary		95,138	IE	IE	NO	NO	IE	NO	95,138	-	M	H
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption		9,280	IE	IE	NO	NO	IE	NO	9,280	-		
I.3		Manufacturing industries and construction												
I.3.1	1	Emissions from fuel combustion within the city boundary		442,992	35.81	4.72	NO	NO	NO	NO	445,615	-	M	H
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary		172,435	IE	IE	NO	NO	IE	NO	172,435	-	M	H
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption		16,820	IE	IE	NO	NO	IE	NO	16,820	-		
I.4		Energy industries												
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary		NO	NO	NO	NO	NO	IE	NO	-	-		
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary		IE	IE	IE	NO	NO	IE	NO	-	-		
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations		IE	IE	IE	NO	NO	IE	NO	-	-		
I.4.4	1	Emissions from energy generation supplied to the grid		NO	IE	IE	NO	NO	IE	NO	IE	-		
I.5		Agriculture, forestry and fishing activities												
I.5.1	1	Emissions from fuel combustion within the city boundary		IE	IE	IE	NO	NO	NO	NO	-	-		
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary		IE	IE	IE	NO	NO	IE	NO	-	-		
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption		IE	IE	IE	NO	NO	IE	NO	IE	-		
I.6		Non-specified sources												
I.6.1	1	Emissions from fuel combustion within the city boundary		IE	IE	IE	NO	NO	NO	NO	-	-		
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary		IE	IE	IE	NO	NO	IE	NO	-	-		
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption		IE	IE	IE	NO	NO	IE	NO	IE	-		
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal												
I.7.1	1	Emissions from fugitive emissions within the city boundary		NO	9121.66	NO	NO	NO	NO	NO	310,136	-		
I.8		Fugitive emissions from oil and natural gas systems												
I.8.1	1	Emissions from fugitive emissions within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
II		TRANS PORTATION												
II.1		On-road transportation												
II.1.1	1	Emissions from fuel combustion on-road transportation occurring within the city boundary		1,548,141	127.23	49.11	NO	NO	NO	NO	1,567,100	-	H	H
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation		IE	IE	IE	NO	NO	IE	NO	IE	-	H	H
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption		IE	IE	IE	NO	NO	IE	NO	-	-		
II.2		Railways												
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary		37,321	1.57	0.75	NO	NO	NO	NO	37,598	-		
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways		1,818	IE	IE	NO	NO	IE	NO	1,818	-		
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption		C	C	C	NO	NO	IE	NO	-	-	M	H
II.3		Waterborne navigation												
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary		IE	IE	IE	NO	NO	NO	NO	-	-		
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation		NO	NO	NO	NO	NO	NO	NO	-	-		
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption		NO	NO	NO	NO	NO	IE	NO	-	-	M	H
II.4		Aviation												
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary		IE	IE	IE	NO	NO	NO	NO	-	-		
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation		NO	NO	NO	NO	NO	NO	NO	-	-		
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption		12,912	0.09	0.36	NO	NO	IE	NO	13,023	-	M	H
II.5		Off-road transportation												
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary		IE	IE	IE	NO	NO	NO	NO	-	-		
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation		IE	IE	IE	NO	NO	IE	NO	IE	-		
III		WASTE												
III.1		Solid waste disposal												
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary		NO	7,214.64	NO	NO	NO	NO	NO	245,298	-	M	H
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.2		Biological treatment of waste												
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.3		Incineration and open burning												
III.3.1	1	Emissions from solid waste generated and treated within the city boundary		NO	0.45	0.0090	NO	NO	NO	NO	18	-		
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary		NO	No	NO	NO	NO	NO	NO	-	-		
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.4		Wastewater treatment and discharge												
III.4.1	1	Emissions from wastewater generated and treated within the city boundary		NO	1,048.45	NO	NO	NO	NO	NO	35,647	-		
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
III.4.3	1	Emissions from wastewater generated outside the city boundary but treated within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
IV		INDUSTRIAL PROCESSES and PRODUCT USES (IPPU)												
IV.1	1	Emissions from industrial processes occurring within the city boundary		IE	IE	IE	IE	NO	NO	NO	-	-		
IV.2	1	Emissions from product use occurring within the city boundary		NO	NO	NO	139,579	NO	1,755	NO	141,334	-	M	H
V		AGRI CULTURE , FORESTRY and OTHER LAND USE (AFOLU)												
V.1	1	Emissions from livestock within the city boundary		NO	219,116.58	8,648.85	NO	NO	NO	NO	10,027,322	-	M	H
V.2	1	Emissions from land within the city boundary		- 5,595,391	NO	1,322.25	NO	NO	NO	NO	- 5,201,361	-	H	H
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary		NO	NO	NO	NO	NO	NO	NO	-	-		
VI		OTHER SCOPE 3												
VI.1	3	Other Scope 3		NE	NE	NE	NE	NE	NE	NO	-	-		
		Total Emissions by Greenhouse gas and for the whole city as CO_2e.		- 5,543,340	5,684,545	2,971,723	139,579	-	1,755	-	8,201,706			