Mapping Auckland's Food System

Towards a quantification of flows of food, waste, loss, and greenhouse gas emissions

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Glossary of terms

Food waste	'Food waste is any food and inedible parts of food, removed from the supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to the sea' (FUSIONS, 2014).
Food system	A food system refers to all the elements and activities related to producing and consuming food, including economic, health, and environmental outcomes. Our definition, for the purposes of this work, borrows elements of the OECD perspective, but focuses exclusively on waste and GHG emissions as factors of environmental outcomes (OECD, 2023).

Executive summary

This project aims to quantify the flows of food[1] generated in Auckland and consumed by Aucklanders. Our analysis examines, as much as possible, the direct inputs into Auckland's food system and the food waste generated within the food and beverage system in Auckland Council's geographical jurisdiction.

The primary goals of the research are to:

1. generate baseline data on material flows of Auckland's food system and associated greenhouse gas (GHG) emissions, and
2. assist in the identification of intervention points to support Auckland's transition towards a circular and low-carbon food system.

This research is a key component of Auckland Council's statutory obligations under the Waste Minimisation Act (2008) to produce a Waste Assessment and associated Waste Management and Waste Minimisation Plan (WMMP). In addition, the outputs of this research are relevant to the Council's commitments under Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan to be carbon neutral by 2050.

Our approach

Following a desk-top research approach, we gathered and harmonised, to the extent that it was possible, several diverse datasets. Secondary sources such as Stats New Zealand and the Ministry for Primary Industries (MPI) have been utilised. We also contacted food processors and manufacturers seeking relevant data and information, some of which was commercially sensitive. While we drew on a stylised conceptual map of the food system (see Figure 1), we were unable to gather sufficient data for all relevant parts of the system.

Our approach to associated GHG emissions was principally informed by the NZ-Specific Food Emissions Database (Drew et al., 2020).

Our analysis does not cover the entirety of the food system

In 2022, a report from the Office of the Prime Minister's Chief Science Advisor (OPMCSA, 2022) highlighted the acute lack of data concerning food processing, consumption, and waste across the New Zealand food system. Our research has largely been an exercise in navigating and overcoming these limitations. Exhaustive efforts have been made to include all facets of the Auckland food system, but the lack of available data, supported assumptions, and access to some institutions has prohibited us from full coverage of the food system.

[1] References to food are inclusive of beverages and other liquid food products.

Domains not included in our analysis are exports from Auckland to the rest of New Zealand and internationally, imports to Auckland from other parts of New Zealand, distribution and warehousing, and some institutions, such as retirement homes and workplace canteens.

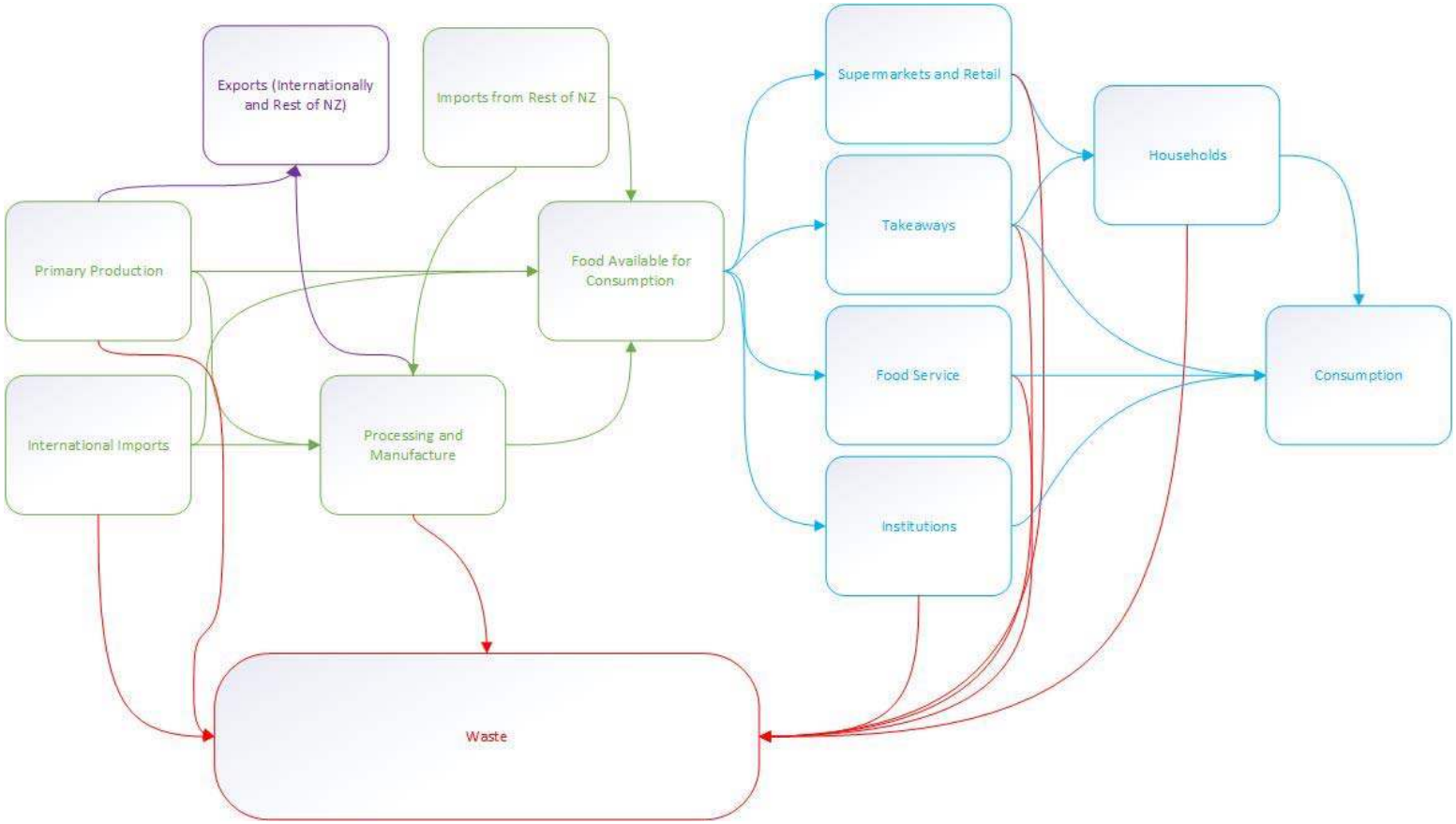
The exclusion of these domains means that we are unable to determine volumes and types of food flowing in and out of Auckland at various stages of the food system. For example, food manufactured in Auckland will be distributed to other parts of New Zealand, and food manufactured elsewhere in New Zealand will be distributed to Auckland.

We suggest that a valuable next step in mapping New Zealand's food systems will involve collecting data on the inflows and outflows of food between different regions on the country. Therefore, this research represents more of a conversation starter around food waste and associated greenhouse gas emissions in Auckland, rather than the final word, as such. This work could be used to identify waste and emissions reduction interventions across the main constituents of the Auckland food system and serve as a basis for further analysis as more data and insights are produced.

Key findings

Conceptual map of Auckland food system

Figure 1: Auckland food system conceptual map



Source: Sapere analysis

- Green denotes inflows of food into Auckland's food system. These are the points of importation, primary production, and food manufacturing which together account for food available for consumption.
- Red denotes food wasted and the sources of food waste in the Auckland food system.
- Purple denotes exports of food products both internationally and to other regions of the country. These are flows out of the Auckland food system.
- Blue denotes the various domains of food purchase and consumption in the Auckland food system.

Quantification of food inflows, outflows, waste volumes, and emissions in the Auckland food system per annum

Table 1: Food inflows, outflows, waste, and emissions volumes

	Inflows		Processing	Outflows			
	International imports	Primary production	Processing and manufacturing	Supermarkets and retail	Food service and takeaways	Households	Institutions
Food volumes[2][3] (tonnes)	810,295	578,507	568,917	716,273	80,138	644,804	5,403
Waste volumes (tonnes)	121,544	90,224	29,943	21,081	17,557	103,950	2,050
Food-waste ratio	0.15	0.16	0.05	0.03	0.22	0.16	0.38
Food emissions[4][5] (tCO2e)	2,173,080	4,343,652	3,076,512	1,980,095	427,607	1,900,452	28,771
Emissions from food wasted (tCO2e)	325,961	149,326	161,921	93,584	90,814	290,727	12,507

[2] By food volumes, we are referring to the volume of food imported, produced, manufactured, sold, or consumed at each stage.
[3] Volumes of food represented at one stage may reflect the inclusion of food volumes at prior stages. For example, volumes of food produced in primary production will be reflected in food volumes present at the processing and manufacturing stage.
[4] By food emissions, we are referring to emissions attributable to foods that are successfully imported, produced, manufactured.
[5] GHG emissions represented at one stage may reflect the inclusion of GHG emissions from prior stages. For example, emissions volumes in supermarkets and retail will reflect GHG emissions from the processing and manufacturing and primary production stages.

Food-waste emissions ratio	0.15	0.03	0.05	0.05	0.21	0.15	0.43

Navigating Table 1

- Table 1 is intended to compare food volumes, food waste, food emissions, and emissions from food wasted at each stage of the Auckland food system.
- Ratios are intended to support the identification of areas with the most significant food waste volumes and emissions from food waste volumes.
- Each stage of the Auckland food system has been analysed in isolation, meaning the table does not demonstrate a flow of food or emissions between different stages of the food system.
- Food volumes at each stage are not cumulative, meaning volumes in one stage reflect the inclusion of volumes detected in earlier stages. For example, a proportion of food tonnages detected in primary production will also be detected in processing and manufacture, as well as various points of consumption.
- Emissions volumes at each stage should not be added to determine an overall total.
- Food waste and emissions from food waste are exclusive to each stage of the food system. As such, they can be considered cumulatively, and addition of each stage will result in a headline figure for food waste and emissions from food waste.

Key takeaways

- At the points of inflow and processing, 810,295 tonnes come from international imports, while 578,507 tonnes come from primary production. 568,917 tonnes of food are processed and manufactured in Auckland.
- 748,754 tonnes of food enter Auckland households for consumption per annum from a combination of supermarkets, retail, and takeaway food venues. However, 103,950 tonnes of this are wasted.
- 62,664 tonnes of food flow through food service venues in Auckland per annum. However, 12,532 tonnes are wasted.
- 1,140,675 tCO2e are attributed to food waste across Auckland's food system. Food waste associated with international imports accounts for 325,961 tCO2e, while households account for 290,727 tCO2e.
- Food manufacturers in Auckland produce 569,000 tonnes of food, and discard 29,941 tonnes, 24 per cent of which goes to landfill, 63 per cent to stock feed and 10 per cent to composting or rendering.
- Supermarkets discard 21,081 tonnes of food each year, with 23 per cent of those food products going to landfill, 15 per cent going to food donation programmes, and 46 per cent to animal feed.

- One of the industries with the highest rates of wastage is the fishing industry, which wastes around 50 per cent (an estimated 5,478 tonnes) of green weight seafood in Auckland each year (10,957 tonnes).

Identified intervention options

Here, we present intervention options for waste and GHG emissions reductions identified throughout our research. Given the prominence of households and the supermarkets and retail sector (see Table 1), some focus is placed on these components. While acknowledging that additional interventions, not identified through this research, may be available to Auckland Council, possibilities include:

- Loosening or removal for cosmetic standards placed on fruits and vegetables by supermarkets.
- Identifying alternative productive uses for fruits and vegetables that do not meet cosmetic standards.
- Collaborating with food processors and manufacturers to further reduce waste volumes directed to landfill.
- Identifying alternative uses for foods directed to landfill by supermarkets and food retailers.
- Creation or promotion of waste management infrastructure for food service and takeaways to divert preparation waste and spoilage to productive destinations, away from landfill.
- Encouraging a reduction in portion sizes serviced in food service and takeaway venues.
- Encouraging Aucklanders to plan meals in advance and adjust food purchasing accordingly.
- Creation or promotion of waste management infrastructure for households to divert food waste away from landfill.
- Improved data collection at all stages of the food system, but especially in food processing and manufacturing as well as food inflows and outflows between regions of New Zealand.

1. Background and context

Auckland Council is seeking to quantify the material flows within Auckland's food system and associated GHG emissions. This project is a core component of the Council's obligations under the Waste Minimisation Act (2008) to produce a Waste Assessment and associated Waste Management and Minimisation Plan (WMMP). Additionally, the project outputs also align with commitments under Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan to be carbon neutral by 2050.

1.1 Objectives

Our task is to quantify the material flows of food in Auckland's food system. Our objectives are to:

- generate baseline data on material flows of Auckland's food system and associated GHG emissions; and
- identify leverage points to support Auckland's transition towards a circular, low-carbon food system.

Of the two objectives, the first has primacy. Leverage points and associated interventions by Auckland Council may be considered further in future work, but the immediate need is for good data upon which to base prospective actions.

1.2 Scope of analysis

When discussing the quantities and flows of food and beverages generated in Auckland and consumed by Aucklanders, we are referring to the chain of supply and production (including international imports) through to consumption that occurs within the geographical boundaries of Auckland Council's jurisdiction.

Figure 2: Auckland Council geographical boundaries

As such, our analysis examines the direct inputs into Auckland's food system and waste generated at any stage of the food and beverage supply chain within Auckland. This also includes an examination of GHG emissions. Water waste and food packaging waste are not in scope. The delineation of Aucklanders from tourists visiting the region is not a priority. As such, for the purposes of our research and analysis, tourists to the Auckland region are considered Aucklanders.

1.3 The key stages we consider in Auckland's food system

- **Imports**: relates to the importation of food into New Zealand from overseas ports.
- **Primary production**: activities relating to the cultivation of plants and animals for food purposes in the Auckland regional boundary.
- **Processing and manufacturing**: activities relating to the processing and manufacturing of food and beverage products, occurring within the Auckland regional boundary.
- **Supermarkets and retail**: activities relating to the sale of food and beverage products directly to the consumer. This encompasses trade carried out through Auckland-based supermarkets.
- **Food service**: activities relating to the service of food and beverage products to Aucklanders away from the household at hospitality venues, such as cafés and restaurants.
- **Households**: the consumption of food and beverage products in Auckland-based households.
- **Institutions**: the consumption of food and beverage products in institutional settings, such as hospitals, schools, and prisons.

1.4 There are three main ways to calculate food waste

Research oriented around the issue of food waste generally adopts one of three methodological approaches:

- **Direct measurement**, which is often achieved via waste audits, typically produces the most accurate and reliable data. However, direct measurement is a time and labour-intensive exercise, and therefore unfavourable to the broader objectives of this project.
- **Self-reporting** relies on food producers, processors, service operators, retailers, and households accurately collecting and reporting their food waste. This approach is subject to a strong degree of reporting bias, where entities, consciously or otherwise, underreport food waste. It also requires extensive and prolonged engagement from various entities across the spectrum of the food system.
- **Inference and extrapolation** call upon multiple data types and sources to construct a broad image of food waste within a given system. In terms of timeframes, this approach is highly favourable. However, estimates emerging from this approach should be treated as indicative only, as they tend to rely on a series of assumptions more so than robust and accurate data.

1.5 Our approach

By necessity, our approach most closely resembles inference and extrapolation. Our approach is a top-down exercise driven by the availability of data and the particulars of each segment of the Auckland

food system. We take a bespoke approach to each part of the food system, rather than employing a uniform method across all stages of analysis.

1.5.1 Data limitations

At a national and regional level, data visibility over the food system is weak (OPMCSA, 2022). Although, some production data is readily available via Stats New Zealand and MPI, commercial sensitivities prohibit deeper probing into food processing and manufacture, retail, and food service. The data used in this study has been obtained from public and private entities. In many cases, we rely on data from previous studies to extrapolate and infer for the Auckland food system. This has involved scaling for Auckland, either by population or industry contributions to GDP.

While a concerted effort has been made to cover all aspects of the food system, data parameters and access – or lack thereof – to key government agencies and entities has frustrated that effort. Additionally, variances in data quality have limited the granularity that we are able to exhibit at various stages of the food system. Areas that would benefit from investigation in subsequent work include, schools, rest homes, food services, takeaways, and food manufacturing. For each of these domains, we analyse and discuss data we were able to acquire and highlight limitations in our approach.

1.5.2 Food waste is a moving target

Food waste has come under the spotlight of public and political scrutiny in recent years, as developed economies seek to move towards models of economic circularity and reduced emissions. Food system entities are at different stages of their waste reduction journeys – some entities do not collect food waste data, while others hold comprehensive waste data and have implemented waste reduction initiatives. We acknowledge the ongoing work from groups such as the Kai Commitment, who seek to better understand the landscape of food waste in Aotearoa New Zealand and believe that more robust and reliable food waste data will be available in three to five years' time.

2. Food imports

In 2020, it was estimated that New Zealand imports around 20 per cent of its food (Olsen, 2020), with the majority of food coming from domestic production. Despite being a minority, imports remain an important source of food inflows into the country. Food imports include products that cannot be grown or cultivated on these islands – certain tropical fruits, for example. Imports also include food products with geographic and cultural affinities, such as pasta from Italy and wine from France. However, food imports also encompass processed foods and food production additives, such as artificial sweeteners and processed sugars. Here, we estimate the volumes and types of food imported into New Zealand. From there, we estimate the proportion of these imports attributable to Auckland.

2.1 Auckland imports around 810,295 tonnes of food per annum

To estimate the volumes of food imported into New Zealand, we utilise annual harmonised import data. This data captures all products imported into the country and breaks down imports by landing port. Importantly, however, landing ports are not a direct indicator of where products are consumed or further manufactured. For example, products landed in Auckland may be consumed or further manufactured in the Waikato region.

As a comprehensive import dataset, considerable cleaning was required to use it for the purposes of analysing food imports. This involved isolating food or food-grade products from the dataset for subsequent analysis.

2.1.1 2,436,035 tonnes of food are imported into New Zealand per annum

Our analysis of food and food-grade products in the harmonised imports data (Stats NZ) suggests that 2.4 million tonnes are imported into New Zealand each year. The largest categories by weight include grains and pastas (986,958 tonnes), sugars and sweets (370,629 tonnes), and fruit including processed fruits (176,483 tonnes).

2.1.2 We use population to extrapolate national data to Auckland

Determining the proportion of the 2.4 million tonnes of food that is attributable to Auckland is challenging. As discussed, food products landed in Auckland ports are not necessarily consumed or further manufactured in Auckland. Likewise, food products landed in ports outside of Auckland may be further manufactured or consumed in Auckland. To extrapolate for Auckland, we apply a population share of 33.4 per cent.[6] We recognise the uncertainty of extrapolating by population, but

[6] https://web.archive.org/web/20140407092912/http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/Pages/censusinaucklandhome.aspx

also acknowledge that without a comprehensive understanding of the final destinations or intended use of imported products, attributing them to regions of New Zealand will continue to be challenging.

By extrapolating for population, we estimate 810.2 thousand tonnes of food are imported into Auckland each year. As with the national level, we estimate that pasta and grains, sugars and sweets, and fruits (including processed fruits) are the three greatest categories of foods imported.

Table 2: Top three food imports by weight

Food type	New Zealand (tonnes)	Auckland (tonnes)
Pasta and grains	986,958	329,644
Sugars and sweets	370,629	123,790
Fruit	176,483	58,945

Source: Stats New Zealand and Sapere analysis

2.1.3 As much as 121,544 tonnes of food are wasted during importation

When discussing food waste related to importation of goods, we are referring to food wastage that occurs during storage and freight. Around 10,000 shipping containers go missing across the globe each year contributing to food waste or loss. Another issue is the failure of refrigerated shipping container units, which affects the integrity of the food, rendering it unsuitable for human consumption. Estimates place food waste during transport to be between 7 per cent and 15 per cent.[7] Taking the lower, upper, and mid-point, we estimate the following range of potential food waste during transport:

Table 3: Importation waste volume estimates

Waste estimate (%)	Waste estimate (tonnes)
7% (low)	56,720
15% (high)	121,544
11% (mid-point)	89,132

Source: Sapere analysis

In most cases this waste will occur outside the jurisdiction of New Zealand. The role for local government could extend to the management of wasted food products as they are unloaded at New Zealand ports.

2.2 2,173,080 tCO2e are attributed to landed food imports

Estimates of tCO2e attributable to imports requires an intimate understanding of farming practices at the point of origin, as well as a comprehensive understanding of the transportation journey food has

[7] https://www.foodengineeringmag.com/articles/101206-food-waste-mitigation-via-transportation

taken from its point of origin to New Zealand. Given that such data is not readily available, we draw our GHG emissions estimates from the *Our World in Data Greenhouse Gas Emissions Across the Supply Chain*[8] dataset, which provides global averages for various food products. We use this data for the sake of completeness and note that our estimate of tCO2e concerning imports should be considered as indicative. Using these global averages, we estimate 2,173,080 tCO2e are attributed to landed food imports.

2.2.1 325,961 tCO2e are attributed to waste during the importation stage

Food waste at the importation stage (121,544 tonnes) comes from a combination of theft, loss due to malfunction of refrigerated shipping containers, and loss due to human error, such as breakage and other accidents. However, we are uncertain of waste volumes attributable to each cause of waste. As such, to calculate tCO2e attributable to waste volumes, we assume a uniform spread across food products imported. As such, we estimate 325,961 tCO2e are attributable to food waste during importation.

[8] https://ourworldindata.org/environmental-impacts-of-food

3. Primary production

Primary production includes horticulture, agriculture, animal agriculture, and seafood. Here, we estimate volumes of food production in the Auckland region. For animal agriculture, 'head counts' of animals, per region, were obtained from Stats New Zealand. For horticultural and agricultural products, either a hectare or square metre value, per region, were also obtained via Stats New Zealand. To estimate volumes of seafood production, an Official Information Act (OIA) request was lodged with MPI.

3.1 There are 204,475 tonnes of agriculture animals in Auckland

Drawing from available Stats New Zealand data, we estimate that there are 1,285,378 animals intended for agricultural purposes in the Auckland region. This includes dairy cattle (123,478), beef cattle (113,340), sheep (180,218), pigs (10,165), chickens (671,059), chicken replacement stock intended for egg production, otherwise known as pullets (184,661), goats (2,019), ostriches and emus (4), and alpacas and llamas (434). It should be noted that there are other animals raised for agriculture reasons, such as deer, but their figures have been suppressed by Stats New Zealand and have therefore not been included in our estimates. A common reason for data suppression is that figures are so low that they compromise confidentiality. As such, it is our view that deer is not a significant domain of primary production in the Auckland region.

3.1.1 Average weights are used to convert animal head counts to tonnage

Using average weights for each of the agriculture animals included in our count, we estimate the total weight of agriculture animals (prior to any form of processing) to be 204,475.16 tonnes.

Table 4: Average agriculture animal weights

Animal	Average weight (kg)
Dairy cattle	770
Beef cattle	800
Sheep	75
Pigs	220
Chickens	4
Pullets	3
Goats	65
Alpacas and llamas	70
Ostriches and emu	120

Source: Sapere analysis

3.1.2 Around 1,704 tonnes of agriculture animals are lost per annum through on-farm mortality

On-farm animal waste is better described as animal mortality rates. Data concerning on-farm mortality rates are not widely collected nor available. According to international literature (Redlingshöfer et al., 2017), rates of on-farm animal mortality vary highly per the variant of species, age, environmental conditions, and animal welfare regulations in different jurisdictions. However, to provide an indication of on-farm mortality, we draw on lessons from animal welfare case studies.

- **On-farm cattle mortality**

A two-year observation of 1,200 beef cattle in Australia identified the on-farm mortality of 56 cattle (Wallach et al., 2017). Most deaths were attributable to disease or husbandry issues. Eight cattle were killed by dingoes. The on-farm mortality rate of cattle (excluding death-by-dingo) is 0.04 per cent over a two-year period, or 0.02 per cent per annum. This equates to an estimated 47 dead cattle (36.89 tonnes) per annum.

- **On-farm lamb mortality**

A longitudinal study by Massey University identified significant on-farm wastage of ewe lambs.[9] Wastage was considered in terms of missing and deceased lambs. Rates of waste varied extensively from 3.5 per cent to 24.8 per cent annually. In most years, however, rates of loss sat between 8 and 12 per cent. Assuming an average loss rate of 10 per cent per annum, applied to lambs and sheep alike, as many as 18,022 (1,351.65 tonnes) sheep and lambs either died or went missing.

- **On-farm pig mortality**

A Finnish study (Bergman et al., 2019) estimated the average on-farm mortality rate of pigs to be 9.7 per cent. This study was specific to piglet-producing farms, so may not be considered ubiquitously across Auckland pig farming. However, as an indication, this implies that 986 pigs (216.92 tonnes) die on farm in Auckland per annum.

- **On-farm poultry mortality**

On-farm poultry mortality rates between 1 and 5 per cent are considered normal. Anything in excess of this figure is considered unusual (Poultry Care, 2020). To take a mid-point of this normal rate (3 per cent), we estimate that around 25,672 (98.7 tonnes) chickens may die on-farm in Auckland per annum.

3.1.3 On-farm animal waste is usually buried or incinerated

According to a food industry expert interviewed for this study, most dead animals remain on farm, and it is not common practice for deceased animals, of any kind, to go beyond the farm gate. Typically, these animals are buried or incinerated if communicable disease is the cause of death. As

[9] https://beeflambnz.com/news-views/study-identifies-ewe-wastage-issue

such, there appears to be little further use for this kind of food waste. Waste reduction in this specific domain would appear to be a broader question of animal health and welfare on farm.

3.2 Around 46 tonnes of dairy solids are produced in Auckland per annum

According to Dairy NZ,[10] a dairy cow in Auckland can be expected to produce 369 kg of milk solids each year. Based 123,478 dairy cows in the Auckland region, we estimate that 45,563,382 kg (45.5 tonnes) of dairy solids are produced in Auckland per annum.

3.2.1 Around 1.5 tonnes of dairy solids are wasted during the production process

Primary production dairy waste occurs via spillage, spoilage, contamination, human error, and machinery malfunction. International literature (Redlingshöfer et al., 2017) suggests that 3.2 per cent of milk products are lost during the primary production phase. Assuming this rate of loss translates to the Auckland dairy sector, we estimate 1,458,028 kg (1.45 tonnes) of milk solids were wasted in Auckland per annum. It not clear if there are any uses for this waste (i.e., waste streams). However, if we assume it is waste arising from on-farm accidents, then further uses seem highly unlikely.

Food waste may also be considered in terms of 'spent' dairy cows that are no longer capable of producing milk. These cows are generally sent to meat processing facilities and used for cheaper portions of beef, such as mince and organ meats. Some may also be used in the production of pet and animal food.

3.3 Around 13,182 tonnes of eggs are produced in Auckland per annum

Auckland accounts for 19.9 per cent of New Zealand's egg production.[11] Applying Auckland's production levels to the totality of New Zealand egg production provides an indication as to how many eggs are produced in the region. We convert egg numbers to tonnes by multiplying by an average egg weight of 60 grams.

Table 3: New Zealand/Auckland egg production

Year	NZ (dozens)	Auckland (dozens)	Tonnes (Auckland)
2022	92,002,928	18,308,583	13,182

Source: Infometrics and Sapere analysis

[10] https://d1r5hvvxe7dolz.cloudfront.net/media/documents/New_Zealand_Dairy_Statistics_2021-22.pdf
[11] https://www.infometrics.co.nz/article/2023-01-scrambling-to-find-eggs-in-2023

3.3.1 Almost 66 tonnes of eggs are wasted during the production process

International literature suggests on-farm egg loss is 0.5 per cent of production (Redlingshöfer et al., 2017). This means approximately 91,543 dozen eggs (65.91 tonnes) were wasted in 2022. The literature also explains that nominally high volumes of egg waste are inevitable because (1) eggs are a highly breakable product, (2) crowded barns or cages increase the chance of breakage, and (3) chickens are known to supplement their diet with the calcium found in eggshells.

3.4 Around 3,477 tonnes of grain agriculture are produced in the Auckland region per annum

According to Stats New Zealand, 1,046 tonnes of barley are harvested in Auckland per annum, and 2,431 tonnes of maize grain (excluding sweetcorn) are harvested in Auckland per annum, making for a total of 3,477 tonnes. There is some degree of wheat production in the Auckland region, but this has been suppressed by Stats New Zealand and is, therefore, not included in our estimate.

3.4.1 70 tonnes of grain agriculture are wasted during the production process

There is no available data on waste volumes of grain crops in Auckland or Aotearoa more broadly. We suspect, as with horticulture, that waste volumes are highly seasonal and waste data is not frequently collected by farmers. However, international literature suggests that grain crops experience a 2 per cent rate of on-farm waste (Redlingshöfer et al., 2017). This would equate to 21 tonnes of wasted barley and 49 tonnes of wasted maize grain.

This estimate cannot explain the causes of on-farm barley waste, nor attribute volumes to each cause. However, crop diseases, such as ramularia, are a common cause of barley loss.[12] On-farm wasted barley and wheat can either be used for compost, soil enrichment, or animal feed.

3.5 309,493 tonnes of horticultural products are produced in Auckland per annum

Based on data from Stats New Zealand, we estimate that 309,493 tonnes of horticultural products are produced in the Auckland region per annum. The figure comprises 52 different categories of different fruits and vegetables. However, data for the following categories has been suppressed and, therefore, is not included in our estimate:

- Plums.
- Grapefruit and gold fruit.
- Macadamia.

[12] https://www.cropscience.bayer.co.nz/pests/diseases/ramularia-leaf-spot

- Vegetable seeds (intended for subsequent growing).

3.5.1 81,448 tonnes horticultural products are wasted during the production process

Quantifying on-farm horticultural waste is challenging because (1) waste is subject to a strong degree of seasonality, and (2) famers tend not to collect food waste data (Beausang et al., 2017). On-farm horticultural waste is, however, consistently highest during the middle of the growing season.

- **The start of the season** is characterised by high levels of demand, low yields, good quality produce and, consequently, low levels of waste.
- **The middle of the season** is characterised by significant variances in demand, high yields, mixed produce quality and, consequently, high levels of waste.
- **The end of the season** is characterised by a better match between supply and demand, low yields, deteriorating produce quality, and a medium level of waste.

We use high-level assumptions informed by insights from Australia[13] to estimate horticultural food waste in Auckland. These estimates are based on the following on-farm waste proportions:

- Apples and pears: 18.5 per cent.
- Olives: 29.4 per cent.
- Grapes: 19 per cent.
- Orchard and other fruits: 24.1 per cent.
- Vegetables: 27.3 per cent.

By applying waste percentages from the Australian literature, we estimate 81,448 tonnes of horticultural products are wasted before leaving the farm gate. According to the Australian literature, much of the waste occurs pre-harvest due to weather conditions or invasive species. Waste during and post-harvest is often the result of human error, such as breakage and spillage, or quality issues.

3.5.2 What happens to on-farm horticultural food waste?

According to the Australian Department of Agriculture, Fisheries, and Forestry, no horticulture food waste is sent to landfill sites. Most waste in this domain is either left on the ground or ploughed into the ground.

Table 5: On-farm horticulture waste streams

On-farm waste streams (Australia)[14]	
Left on ground	44%
Ploughed into ground	26%
Recovered for compost	18%

[13] https://www.agriculture.gov.au/abares/research-topics/surveys/horticulture-crop-loss#key-points
[14] Total percentages exceed 100 as farmers could provide multiple responses.

Other	13%
Recovered for animal feed	10%
Buried on farm	5%
Recovered for use in products	4%

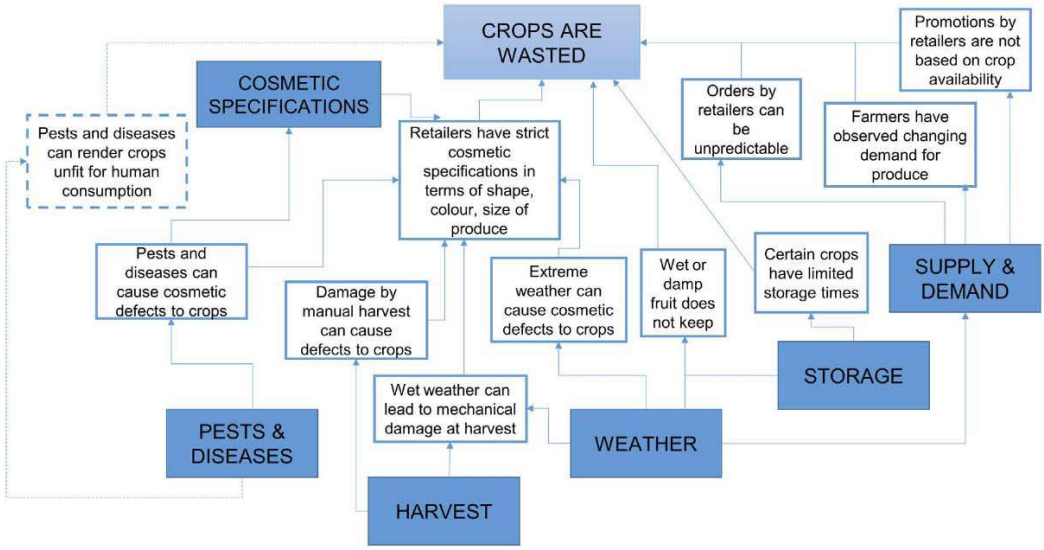
Source: Australian Department of Agriculture, Fisheries, and Forestry

Applying these proportions to our estimated waste volumes in Auckland horticulture, we find that 35,837 tonnes are left on the ground, 21,176 tonnes are ploughed into the ground, 14,661 tonnes are recovered from compost, 8,145 tonnes are recovered for animal feed, 4,072 tonnes are buried on farm, 3,258 are recovered for use in products, and 10,588 would be designated as 'other'. This assumes Australian horticultural practices are replicated in the Auckland region[15].

3.5.3 Causes of on-farm horticultural food waste

Food waste in primary production can be attributed to six main causes (Beausang et al., 2017):

Figure 3: Causal map of food waste in primary production



Source: Beausang et al. (2017)

- **Pests and diseases** are the cause of cosmetic damage to fruits and vegetables, meaning they cannot be sold to retailers that follow strict cosmetic specifications. However, other damage caused by pests and disease can render the fruit or vegetable unfit for human consumption.
- **Cosmetic specifications** imposed by retailers can render fruits and vegetables as waste if they are too big, too small, do not meet colour specifications, or are unusually shaped.

[15] We acknowledge that there are unique aspects to New Zealand and Australian horticulture. However, given the broad similarities in climate and farming practices between the two countries we have determined they are comparable for this exercise.

- **Weather** can cause cosmetic damage to fruits and vegetables, meaning they may not be sold by retailers. Weather events such as hail and heavy rain can split the skins on some fruits and vegetables, leading them to decay.
- **Supply and demand** can create a production challenge for farmers. Farmers have reported unpredictable orders from retailers. Weather can dictate how much produce a farmer has available to sell, but also the quantities of produce demanded. For example, demand for broccoli tends to drop when the weather is warmer, while demand for soft fruits increases. Unpredictable weather patterns can therefore lead to oversupply and subsequent waste of certain crops.
- **Harvesting**, both mechanical and manual, can cause damage to crops. Wet weather can make mechanical harvesting more difficult and increase rates of loss. Human error in manual harvesting can also lead to damage, causing retailers to reject the produce.
- **Access to storage and processing** facilities may also engender waste. The length of time fruit and vegetables can be held in storage can be weather-dependent. Crops harvested during wet weather tend not to last as long in storage. Likewise, access to processing facilities or lack thereof, such as commercial freezing, can lead to the loss of certain vegetable crops.
- **Changing consumer demands** can be rapid and unpredictable. Farmers may find themselves with an excess of produce that is no longer widely demanded by consumers.

3.6 Around 10,957 tonnes of green weight seafood are landed in Auckland per annum

We lodged an OIA request with MPI to release the estimated catch totals (green weight) in areas relevant to Auckland's geographical boundaries. Due to section s9(2)(b)(ii)[16] and section s9(2)(ba)(i)[17] of the OIA, granularity of data is suppressed, meaning we are not privy to volume of catch per species, nor where exactly seafood was landed. Furthermore, all catch related to scallops is suppressed, due to the low number of permit holders for this species in the region. As such, scallops are not included in the estimated total. However, we were advised that these figures do not include pāua, as there is no commercial fishing for this species in the Auckland region.

It is important to note that our estimate (10,957.35 tonnes), based on MPI figures, covers the green weight of seafood. This is the weight prior to any processing, such as gutting, that occurs at sea.

3.6.1 Seafood waste volumes are elusive, but we estimate around 5,478 tonnes are wasted

Since our data from MPI does not provide a comprehensive breakdown of green weight attributable to different species, is difficult to arrive at an informed estimate of seafood waste that occurs during

[16] To protect information where the making available of the information would be likely unreasonably to prejudice the commercial position of the person who supplied or who is the subject of the information.

[17] To protect information which is subject to an obligation of confidence or which any person has been or could be compelled to provide under the authority of any enactment, where the making available of the information would be likely to prejudice the supply of similar information, or information from the same source, and it is in the public interest that such information should continue to be supplied.

processing on boats. Seafood waste volumes have been described as "enormous" (Venugopal, 2021), arising from the discard of shells, bones, innards, and skins, as well as by-catch, which accounts for about one-third of total seafood waste. Determining these waste volumes accurately would require a fuller understanding of the species caught in the Auckland region, which will need significant buy-in from commercial fishing entities and MPI. However, existing literature (Coppola et al., 2021) suggests waste from processing green weight can range from 20 to 80 per cent. Taking 50 per cent as a mid-point, we estimate seafood waste to be 5,478.5 tonnes.

3.7 4,343,652 tCO2e are attributed to primary production and a further 149,326 tCO2e are attributed to primary production waste

To estimate tCO2e at the primary production, or pre-farm gate stage, we followed the NZ-specific food emissions database (Drew et al., 2020). This dataset aggregates GHG emissions from farming with GHG emissions from processing. To disaggregate farming from processing, we obtained proportions of GHG emissions attributable to farming for products in primary production from *Our World in Data Greenhouse Gas Emissions Across the Supply Chain*. We applied these proportions to emissions factors found in the NZ-specific food emissions database. On this basis, we estimate 4,343,652 tCO2e are attributed to primary production and a further 149,326 tCO2e are attributed to primary production waste.

3.7.1 Agriculture animals account for 3,961,552 tCO2e of primary production

Of the 4,343,652 tCO2e for primary production, 3,961,552 tCO2e comes from animal agriculture, around 91 per cent. Moreover, 3,741,042 tCO2e is attributable to cattle alone. However, of the 149,326 tCO2e attributable to primary production waste, 24,235 comes from animals, most of which (21,214 tCO2e) is attributable to sheep and lamb. A higher proportion tCO2e is attributable to wasted horticultural products and seafood due to the comparatively high waste volumes in these categories.

4. Food manufacture

Several Auckland-based food manufacturers were contacted and asked to participate in our research. Although there was a general interest in our work, food manufacturers were not comfortable sharing data due to commercial sensitivities. Consequently, we have taken a top-down, inference-based approach using existing literature.

Without the direct involvement of food manufacturers in Auckland, we are unable to precisely determine the volumes and types of food they produce per annum. We can, however, infer from waste volumes a high-level estimate of the weight and type of food produced in the Auckland region by manufacturers and processors. This is achieved using an inverse, or reverse, calculation, which involves estimating the total volume of food, by estimating the per centage of food typically wasted during food processing and manufacture.

4.1 Around 29,943 tonnes of food manufacture waste are produced in Auckland per annum

Prior research found that in 2011, 80,606 tonnes of food waste was attributable to the New Zealand food manufacturing and processing sector (Reynolds et al., 2016). To bring these waste volumes into the contemporary food processing and manufacturing sector, we scale for growth in GDP in manufacturing between 2011 and 2021 (9 per cent).[18] This approach assumes no changes to production processes or practices that may have increased efficiency and reduced waste. Our estimates indicate that during 2021, food processing waste from food processors and manufacturers accounted for 88,068 tonnes of food waste. To extrapolate these figures for Auckland food processing and manufacture, we scale for Auckland's proportion of the New Zealand food and beverage sector (34 per cent),[19] resulting in a food processing waste estimate of 29,943.12 for Auckland.

Following existing literature, we estimate that these waste volumes emanate mainly from various forms of meat and dairy processing. However, waste is prevalent in other domains of food processing, such as seafood.

Table 6: Auckland commercial and industrial food waste types and quantities 2021

Food type	Tonnes in 2021 (Auckland)
Meat processing waste	6,383
Poultry processing waste	1,935
Bacon, ham and small-good waste	2,772
Dairy product waste	8,630
Fruit and vegetable, oil and fat, cereal waste	2,660

[18] https://ecoprofile.infometrics.co.nz/Auckland/Gdp/GrowthIndustries
[19] https://www.aucklandnz.com/invest/focus-sectors/food-beverage

Food type	Tonnes in 2021 (Auckland)
Bakery, sugar and confectionery waste	2342
Seafood processing waste	2965
Other food waste (processed foods)	2257

Source: Reynolds et al., (2016), and Sapere analysis

4.1.1 Most food from manufacturers waste ends up as stock feed

In 2017, the Sustainable Business Network conducted research into food waste volumes from Auckland-based food manufacturers (Sustainable Business Network, 2017). Their research followed a self-reporting methodology – where manufacturers audited and reported their waste volumes. Manufacturers were also asked to report how food waste was disposed of.

Twenty-eight businesses and 34 manufacturing sites were reviewed for the research. In total 40,800 tonnes of waste were generated per annum from these businesses. Around 45 per cent of businesses were producing more than 10 tonnes of food waste per month, with almost one third producing over 50 tonnes per month.

Forty-seven per cent of food waste was collected by stock feed companies, 28 per cent by general waste companies, 5 per cent to renderers, 8 per cent to independent farmers, and 12 per cent to other domains.

Of waste collected, 63 per cent went to stock feed, while 24 per cent went to landfill. Composting (6 per cent), rendering (4 per cent), and other (3 per cent) were less significant waste stream destinations.

Guided by these proportions, we estimate the following food waste volumes and destinations attributable to Auckland-based food manufacturers and processors:

Table 7: Waste destinations and volumes from Auckland manufacturers and processors

Waste destinations	Percentage	Tonnes
Stock feed	63%	18,864.09
Landfill	24%	7,186.32
Composting	6%	1,796.58
Rendering	4%	1,197.72
Other	3%	898.29

Source: Sustainable Business Network (2017) and Sapere analysis

4.2 Almost 569,000 tonnes of food are manufactured in Auckland in addition to the almost 30,000 tonnes wasted

To run our inverse calculation[20], we follow an estimate from the UK,[21] which suggests that food manufacturers will 'tolerate'[22] 5 per cent food waste within their processes. This means to estimate total food volumes, we apply a multiplier of 20 to our waste figures.

Following our multiplier, based on an assumed waste rate of 5 per cent, we estimate 598,860 tonnes of food are processed by Auckland-based manufacturers per annum (29,943 tonnes of which are waste). Applying the same multiplier across different waste categories, we assume the following volumes of production by food type:

Table 8: Food manufacture estimates by food type

Food type	Total tonnage	Wasted tonnage	Total produced (output tonnes)
Meat processing	127,653	6,383	121,270
Poultry processing	38,708	1,935	36,772
Bacon, ham and small-good	55,439	2,772	52,666
Dairy product	172,594	8,630	163,964
Fruit and vegetable, oil and fat, cereal	53,195	2,660	50,535
Bakery, sugar and confectionery	46,843	2,342	44,500
Seafood processing	59,295	2,965	56,329
Other food (processed foods)	45,134	2,257	42,877

Source: Sapere analysis

4.3 3,076,512 tCO2e are attributed to processing and manufacturing food, while 161,921 tCO2e are attributed to processing and manufacturing waste

We estimate tCO2e attributable to food processing and manufacture using emissions factors for farming and processing from the NZ-specific food emissions database (Drew et al., 2020). Given we are unaware of the exact food types processing and manufactured in Auckland facilities, we developed

[20] We acknowledge the sensitivity of our inverse calculation, and application of inverse calculations more broadly. In this case, we have adopted an inverse calculation in lieu of any other data. As such, our estimates arising from inverse calculations should be considered as indicative only.

[21] https://theconversation.com/enormous-amounts-of-food-are-wasted-during-manufacturing-heres-where-it-occurs-102310

[22] We note that 'tolerate' would suggest 5% to be an upper waste estimate in food manufacturing, meaning our multiplier will produce a total food estimate on the lower end of the scale.

an average kgCO2e/kg figure based on food types that correspond with the categories of food we estimate are processed and manufactured in Auckland. We then used these averages to estimate tCO2e attributable to food processed and manufacture and food waste.

Table 9: tCO2e food processing and manufacture and food process and manufacture waste

Food type	tCO2e processing and manufacture	tCO2e processing and manufacture waste
Meat processing	1,241,375.34	65,335.54
Poultry processing	86,231.68	4,538.51
Bacon, ham and small-good	477,688.57	25,151.50
Dairy product	508,160.96	26,745.31
Fruit and vegetable, oil and fat, cereal	67,717.38	3,564.07
Bakery, sugar and confectionery	116,433.95	6,128.10
Seafood processing	363,533.23	19,133.33
Other food (processed foods)	215,371.50	11,335.34
Total	3,076,512.61	161,921.72

Source: (Drew et al., 2020) and Sapere analysis

5. Supermarkets and retail

Here, we attempt to estimate the volumes of food coming through New Zealand supermarkets and retailers. We did not have access to supermarkets or retailers as part of our research. However, insights were obtained via a dataset acquired from GS1 New Zealand.[23] This dataset provides a comprehensive breakdown of barcoded foods sold across supermarkets in New Zealand. Supermarkets included in the dataset are as follows:

- New World
- Countdown
- Pak'nSave
- Fresh Choice
- SuperValue.

Consequently, the dataset does not have full coverage of supermarkets and food retailers across the country. However, a 2021 report from the Commerce Commission[24] estimates that supermarkets represent around 85 per cent of total of food retail purchases in New Zealand. As such, we apply a multiplier (1.1764) to the GS1 dataset to estimate food purchases across the entirety of the market.

It is also important to note that the GS1 dataset only captures barcoded and weighted foods. This means that loose items are not included – these items may include, but are not necessarily limited to bulk items, fresh fruits, and vegetables, unpackaged fish, butcher meats, and deli items. This means these items are not included in our calculations.

Finally, the dataset captures retail food purchases at a national level. This means we have extrapolated for Auckland by population share (33.4 per cent). We are aware Auckland spends more, on average, on food than the rest of the country. However, increased food expenditure does not necessarily translate to greater volumes of food purchased. Higher levels of dollar spend on food more often translate to the purchase of higher quality versions of the same foods.

5.1 Over 716,273 tonnes of barcoded food items are purchased via Auckland retailers per annum

We estimate, 716,273.87 tonnes of barcoded foods are sold via Auckland retailers per annum. The top 10 food categories by weight account for over half of the total weight of purchased barcoded food items (418,587.08 tonnes). These include:

[23] https://www.gs1nz.org/?gclid=Cj0KCQjwtamIBhD3ARIsAARoaEyHWxxCgfpPSZDI-z5xy2775A0scpL8UuKxfVUDpwwDJOQDQOBT7LAaAqcoEALw_wcB

[24] https://comcom.govt.nz/__data/assets/pdf_file/0024/260376/Market-study-into-the-retail-grocery-sector-Draft-report-Executive-summary-29-July-2021.pdf

Table 10: Top 10 food purchases by weight

Food type	Purchase weight (tonnes)
Carbonated beverages	80,568
Milk & cream	68,460
Fresh vegetables	54,280
Beer	45,767
Water	36,446
Bread	32,529
Juice/drinks	28,417
Wine	19,707
Grocery milk	19,672
Fresh meat	16,955
Yoghurt & dairy desserts	15,781

Source: GS1 and Sapere analysis

Within the category of fresh meat, which includes processed some processed meats, chicken products account for around 66 per cent of total weight. Chicken is distantly followed by beef, pork, and lamb in terms of purchase weight.

Table 11: Top meat purchases by weight

Meat type	Purchase weight (tonnes)
Fresh meat chicken value add	8,015.46
Fresh meat sausage	4,066.23
Fresh meat chicken whole bird	3,175.78
Fresh meat bgr/mball/rsle-bf	490.13
Fresh meat beef	394.62
Fresh meat pork	328.12
Fresh meat bgr/mball/rsle-oth	246.39
Fresh meat chicken random weight	66.22
Fresh meat kebab chicken	54.98
Fresh meat other poultry	51.96
Fresh meat alternative	50.23
Fresh meat other meat	15.09
Fresh meat beef random weight	0.051
Fresh meat lamb random weight	0.036
Fresh meat lamb	0.004

Source: GS1 and Sapere analysis

5.1.1 Auckland supermarkets and retailers waste 21,081 tonnes of food per annum

We did not have direct access to supermarket food waste data as part of our study. Instead, inferences and extrapolations of current levels of food waste have been made by drawing on insights from an earlier study conducted in 2017.

In a national audit of New Zealand supermarkets (Goodman-Smith et al., 2020), it was estimated that the volume of supermarket food waste was 60,500 tonnes per annum. At the time of the study this equated to 160 tonnes per store per annum. It was found that most food waste was repurposed:

- 46 per cent of food waste went to animal feed.
- 23 per cent of food waste went to landfill.
- 15 per cent of food waste went to protein reprocessing.
- 15 per cent of food waste went to food donation programmes.
- 1 per cent of food waste went to composting.

The Goodman-Smith study was conducted on a national level. It provided a per-store average of annual waste volumes (160 tonnes). We have taken this average, with the assumption that there have been no material changes to supermarket food waste volumes since 2017 and applied it to the number of relevant supermarket outlets in the Auckland region. At the time of writing, there are 112 supermarkets operating in the region.

Assuming 160 tonnes of waste per store, these supermarkets produce **17,920 tonnes** of waste per annum. To extrapolate up for the rest of the supermarket and food retail sector in Auckland, we apply the same multiplier used in our estimate of barcoded food purchases (1.1764). On this basis, we estimate Auckland based supermarkets and food retailers produce **21,081 tonnes** of food waste per annum.

Assuming waste proportions have remained unchanged since 2017, waste streams from Auckland supermarkets and food retailers are as follows:

- 9,697 tonnes to animal feed.
- 4,848 tonnes to landfill.
- 3,162 to protein reprocessing.
- 3,162 to food donation programmes.
- 210 tonnes to composting.

5.1.2 Vegetables, bakery items, meat, and fish are among the most wasted food items in supermarkets and retail

Goodman-Smith found that vegetables (27 per cent) and bakery items (23 per cent) were the most wasted food type, followed by meat and fish (19 per cent), fruit (17 per cent), dairy (6 per cent), staple foods (4 per cent), non-dairy drinks (2 per cent), and other (2 per cent).

Following those proportions, we estimate the following volumes of food waste, by food type, in Auckland supermarkets to be:

- 5,691 tonnes of vegetables
- 4,848 tonnes of bakery items
- 4,005 tonnes of meat and fish
- 3,583 tonnes of fruit
- 1,264 tonnes of dairy
- 843 tonnes of staple foods
- 421 tonnes of non-dairy drinks
- 421 tonnes of other products.

5.1.3 Dairy is the most common food waste item directed to landfill

The Goodman-Smith study also found that, of the foods directed to landfill, 23 per cent were dairy, 21 per cent were bakery items, and 21 per cent were meat and fish. Using these proportions, we estimate the volumes of food sent to landfill from Auckland supermarkets is as follows:

Table 12: Estimates of types of food sent to landfill from Auckland supermarkets

Food sent to landfill	Tonnes of waste
Dairy	1,115
Bakery	1,018
Meat and fish	1,018
Other	1,697

Source: Goodman-Smith et al., (2020) and Sapere analysis

5.2 1,980,095 tCO2e are attributed to food sold by supermarkets and food retailers

To arrive at our GHG emissions estimate for foods sold by supermarkets and retailers we cross-referenced the GS1 dataset with the New Zealand-specific food emissions database (Drew et al., 2020). This involved attributing an emissions factor to all foods in the GS1 dataset. Not all foods in the GS1 dataset correspond perfectly with foods described in the New Zealand-specific food emissions database. In such cases, discretion was exercised to determine the closest match. Based on this exercise, 1,980,095 tCO2e were attributed to products sold by supermarkets and retailers.

5.2.1 93,584 tCO2e are attributed to food waste in the supermarket and retail setting

As we do not have a comprehensive list, comparable to the GS1 dataset, of food wasted in supermarkets and retail, it was necessary to determine an average kgCO2e/kg for high-level types of food wasted in supermarkets and food retail outlets from the NZ-specific food emissions database (Drew et al., 2020). Using these averages, we estimate 93,584 tCO2e are attributable to food waste in supermarkets and retailers.

Table 13: tCO2e from food waste in supermarkets and retailers

Food type	tCO2e from food waste
Vegetables	12,332
Bakery items	21,844
Meat and fish	37,617
Fruit	6,387
Dairy	10,253
Staple foods	2,914
Non-dairy drinks	405
Other	1,829

Source: (Drew et al., 2020) and Sapere analysis

6. Food service and takeaways

Food service encompasses food and beverage consumption outside the home environment in places such as restaurants, cafés, bars, and pubs. We did not have access to any food service providers, or relevant data, to quantify the volumes or weights of food purchased, sold, consumed, or wasted. However, we can estimate food waste volumes by extrapolating from existing literature and use these waste volumes to run an inverse calculation. This means first quantifying waste volumes, then estimating total food volumes on that basis.

6.1 12,532 tonnes of food waste are attributed to food service venues in Auckland

It is important to note that our reference to food service venues here covers cafés, restaurants, pubs and taverns, and members' clubs. Takeaway venues are calculated under a separate cover.

To obtain insights into the food service sector, we extrapolated insights from audits of New Zealand's cafés and restaurants in the North (WasteMINZ, 2018) and South (Chisnall, 2018; Jones, 2018) Islands. These audits calculated the quantities of waste produced and the sources of waste. Disposal routes, i.e., volumes of waste sent to landfill, compost, or animal feed, were not accounted for.

24,366 tonnes for food waste were generated by cafés and restaurants in New Zealand in 2017/18. The average café and restaurant generate roughly **2.8 tonnes of food waste per annum**, of which 61 per cent, or 14,863 tonnes, was considered 'avoidable' food waste. Food waste from cafés and restaurants can be organised into three categories:

- **Spoilage (7 per cent)** – occurs with the over-ordering of ingredients or poor stock rotation practices that lead to foods to spoil and be discarded before use.
- **Preparation waste (60 per cent)** – occurs in the kitchen and includes unused food by-products, such as eggshells, vegetable peelings, or overcooked items that cannot be sold. This also includes any unsold food left at the close of the business day that cannot be sold the following day.
- **Plate waste (33 per cent)** – refers to the uneaten food items left by customers.

In lieu of evidence to the contrary, we assume the average café or restaurant produces **2.8 tonnes of food waste** today, as it did in the studies conducted in 2018. According to Business Demography Statistics,[25] there were **4,476 food service outlets** operating in the Auckland region in 2022. On this basis, we estimate 12,532 tonnes of food waste are produced by Auckland food service venues per annum. The sources of this food waste are:

- 7,519 tonnes of preparation waste
- 4,135 tonnes of on-plate waste
- 877 tonnes of spoilage.

[25] https://nzdotstat.stats.govt.nz/WBOS/Index.aspx?DataSetCode=TABLECODE7601#

6.1.1 Vegetables are the most wasted food item by food service venues

Continuing to follow the literature (Chisnall, 2018; Jones, 2018; WasteMINZ, 2018), we assume that the proportions of food wasted in cafés and restaurants is as follows:

- Vegetables – 28 per cent.
- Bakery items – 26 per cent.
- Meat – 13 per cent.
- Fruit – 9 per cent.
- Other – 24 per cent.

Table 14: Estimates of food waste by type

Types of food wasted	Waste volumes (tonnes)
Vegetables	3,509
Bakery	3,258
Meat	1,629
Fruit	1,127
Other	3,007

Source: (Chisnall, 2018; Jones, 2018; WasteMINZ, 2018) and Sapere analysis

6.1.2 Food service waste disposal routes remain elusive

Unfortunately, existing literature in this domain (Chisnall, 2018; Jones, 2018; WasteMINZ, 2018) did not seek to quantify the volume of waste streams stemming from cafés and restaurants. As such, we have no proportionate breakdown to apply to our total waste estimates. A discussion was held with one author of the aforementioned studies who advised that all cafés and restaurants included in their studies were independently owned and sent all of their waste to landfill. This perspective was compounded when speaking to a representative of a North Shore business organisation, who advised that most cafés dispose of their food waste to landfill in lieu of adequate infrastructure to channel it elsewhere. However, the same representative also advised that he was operating a scheme with a large private waste collector to convert café food waste into compost, signalling evolving approaches to food waste.

6.2 Almost 63,000 tonnes of food flow through food service venues in Auckland per annum

International research suggests that 20 per cent of all food in food service venues is wasted (Silvennoinen et al., 2015). Following that logic, we adopt a five times multiplier to estimate the total volume of food, wasted and consumed, in Auckland food service venues. Based on our estimate of 12,532 tonnes of food waste, this results in a total of 62,664 tonnes of food, of which 50,132 tonnes are not wasted.

6.3 290,760 tCO2e are attributed to food service venues in Auckland

Without full knowledge of the types of foods served in Auckland food service venues, we arrive at an estimated average of 4.64 kg of CO_2 per kilogram of food, based on a sample of food types frequently served in food service venues from the NZ-Specific Food Emissions Database.

Of the 62,664 tonnes of food flowing through Auckland food service venues, 54,267 tonnes are prepared for consumption and account for 251,798 tCO2e. However, 4,135 tonnes of prepared food go uneaten, and are considered on-plate waste – this accounts for 19,190 tonnes of the almost 252,000 tonnes of CO_2 estimated above. A further 34,891 tonnes of CO_2 are attributed to the 7,519 tonnes of food wasted during preparation, and an additional 4,070 tonnes of CO_2 are attributed to the 877 tonnes of spoiled food.

6.4 Around 5,025 tonnes of food waste are attributed to takeaway food services in Auckland

According to the Business Demography Statistics, there are 2,679 takeaway food outlets operating in the Auckland region. Assuming an average annual waste figure of 2.8 tonnes per outlet, as per other food services venues, we estimate a total of 7,501 tonnes of food waste per annum from takeaways in Auckland. However, we acknowledge that on-plate waste for takeaways does not occur onsite. Instead, it occurs away from the outlet, most likely in households, workplaces, or outdoors. We estimate takeaways on plate waste (33 per cent) to be 2,475 tonnes per annum and note that this weight should be applied to household waste, rather than food service. The remaining 5,025 tonnes of food waste is made up of 525 tonnes of spoilage and 4,500 tonnes of preparation waste.

6.5 Around 38,000 tonnes of food flow through Auckland takeaways per annum

As with food service venues, we apply a five times multiplier to takeaway waste volumes to estimate the total volume of food. As such, we estimate a total of 37,506 tonnes of food flow through Auckland takeaways. Minus spoilage (525 tonnes) and preparation waste (4,500 tonnes), 32,481 tonnes are sold to consumers. A further 2,475 tonnes are wasted at the point of consumption, meaning we estimate 30,006 tonnes of takeaway food are consumed, i.e., not wasted. Again, however, we cannot meaningfully disaggregate this into weight by food types based on this estimate alone.

6.6 243,746 tCO2e stem from takeaway food services

As with food service, we are unaware of the complexion of food types served by takeaways in Auckland. Thus, we follow the same approach of estimating an average CO_2 emissions kg value by analysing foods from the NZ-Specific Food Emissions Database that would typically be served at a takeaway premises, some of these include, pizza, burgers, hot dogs, stir-fries, pies, and sausage rolls, as well as dairy and non-dairy beverages. We are of the view that takeaways reflect higher average

CO_2 emissions than food service, as takeaways generally serve a greater proportion of processed – and therefore more emissions-intense – foods.

6.6.1 Consumption of takeaway food accounts for 194,997 tCO2e

Of the 243,746 tonnes of emissions attributed to takeaway food service, 194,997 represents consumption of food and 16,087 tonnes of emissions arise due to on-plate food waste. On-plate waste GHG emissions are attributed to households, where takeaway foods might typically be consumed. 29,249 tonnes come from preparation waste, and a further 3,412 tonnes come from food spoilage.

7. Households

Households, or household consumption, encompasses the consumption of food and beverage products from all sources within Auckland-based residences. We estimate household food consumption by looking to retail purchase volumes (as contained in the GS1 dataset) and purchases from takeaway food venues.

7.1 Around 748,754 tonnes of food enter Auckland households per annum

Guided by our previous estimates of food retail purchases (716,273 tonnes) and takeaway food purchases (32,481 tonnes), we estimate 748,754[26] tonnes of food enter Auckland households per annum. The table below details the types of volumes of food, by food type entering Auckland households per annum:

Table 15: Food types by weight, from supermarket/retail purchases, entering Auckland households

Food type	Purchase weight (tonnes)
Carbonated beverages	80,568.82
Milk & cream	68,460.18
Fresh vegetables	54,280.79
Beer	45,767.12
Water	36,446.89
Bread	32,529.33
Juice/drinks	28,417.09
Wine	19,707.30
Grocery milk	19,672.79
Fresh meat	16,955.36
Yoghurt & dairy desserts	15,781.41

Source: GS1 and Sapere analysis

7.1.1 Almost 104,000 tonnes of food are wasted by Auckland households per annum

There have been two audits of household food waste completed in New Zealand during the past decade, one in 2014-15 and another in 2018, both completed for WasteMINZ (Sunshine Yates, 2018). In the 2014-15 study, it was found that 33.5 per cent of kerbside refuse comprised of food waste,

[26] As this relies on the use of the GS1 dataset, our estimate does not include food items without a barcode, i.e., loose fruit and vegetables, meat from the butcher counter, or fish from the fish counter.

equating to 3.17 kg per household per week. The 2018 study found that 34.1 per cent of kerbside waste comprised of food waste, equating to 3.15 kg per household per week. In the three years between each of the studies, there was no statistically significant shift in food waste proportions.

In the 2014-2015 study, 49.7 per cent of household waste was considered avoidable food waste (food that could have been eaten). Similarly, the 2018 study found 48.8 per cent of food waste was considered avoidable – again, a difference without statistical significance.

In 2018, households threw away 164 kg of food, meaning 86 kg was avoidable food waste. Per person, this equates to 61 kg of food waste, 32 kg of which was avoidable.

Given there was no statistically significant jump in the proportion of food waste in kerbside collections between the years of 2015 and 2018, we assume that there has been no statistically significant change in this proportion since 2018. We do, however, acknowledge that food waste proportions would likely have been higher during the years Auckland was subject to COVID-19 lockdown restrictions. During this time, food waste attributable to food service would have been likely diverted to households to some extent. We treat COVID-19 lockdown periods as an anomaly, and assume proportions found in 2018 remain relevant, at present.

We extrapolate for Auckland by applying per person food waste figures to the estimated 2021 Auckland population (1,704,100). On that basis, around 103,950 tonnes of food waste were collected from households in 2021, with 54.5 thousand tonnes being classified as avoidable waste.

Types of food wasted in Auckland households

The 2018 study (Sunshine Yates, 2018) identifies the top 20 types of food wasted and the proportion they account for in all food waste and avoidable food waste. Applying these proportions to Auckland food waste volumes we can estimate the tonnage of was attributable to food types.

Table 16: Estimates types of food wasted by weight

All food wasted (tonnes)	2021
Bananas	7,661.12
Oranges	6,226.61
Bread	6,174.64
Poultry	5,831.60
Leftovers	4,501.04
Potatoes	4,189.19
Lemons	2,858.63
Apples	2,661.12
Tea and teabags	2,515.59
Mixed vegetables	2,432.43
Beef	2,318.09
Gunge	2,224.53

All food wasted (tonnes)	2021
Broccoli	1,923.08
Pumpkin	1,871.10
Eggs	1,860.71
Carrots	1,850.31
Lettuces	1,725.57
Onions	1,559.25
Rice	1,424.12
Sweetcorn	1,372.14

Source: Sunshine Yates (2018) and Sapere analysis

Eleven of the 20 most wasted food types are fruits and vegetables, while meat waste (poultry and beef) is the second highest category. Wasted bread is the third highest category. The composition of leftovers (wasted prepared meals) is not clear. However, accounting for 4,500 tonnes in 2021, it is a significant source of food waste.

In terms of avoidable food waste, bread accounted for the single greatest source (5,200 tonnes). Combined fruit and vegetable categories were the second highest source of waste, followed by meat and dairy products.

Table 17: Estimates of types of avoidable food waste by weight

All avoidable food waste (tonnes)	2021
Bread	5,235
Leftovers	4,471
Oranges	2,181
Apples	1,799
Bananas	1,690
Potatoes	1,635
Poultry	1,417
Rice	1,417
Lettuces	1,308
Beef	1,090
Yoghurt	981
Pumpkin	927
Takeaway - hot chips	872
Carrots	817

All avoidable food waste (tonnes)	2021
Cheese	763
Grapefruits	763
Tomatoes	708
Lemons	708
Kiwifruit	708
Cabbages	654

Source: Sunshine Yates (2018) and Sapere analysis

7.1.2 Our waste estimates do not have full coverage

The main limitation to consider as part of our estimate is that it only covers food waste detected in kerbside pickup. It does not examine other channels of household food waste; the most likely secondary source being *Insinkerator* units. Another limitation is that we have assumed there have been no changes in waste proportions since 2018. Although no statistically significant change was detected between the 2014-15 and 2018 studies, food prices have experienced significant increases from 2018 and 2022, which may have influenced behaviours, volumes of food purchased, and consumption. Fruits and vegetables have experienced considerable price increases, which may have curbed purchase and thereby food waste volumes.

7.2 Around 435,667 tonnes of retail and supermarket purchases in Auckland are of New Zealand made food

By examining the country-of-origin attribution of food products sold in retail and supermarkets, we estimate 435,667 tonnes of food products purchased in Auckland are New Zealand made. This estimate includes products labelled as "Made in New Zealand from local and imported Ingredients" as well as those labelled "Made in New Zealand from imported ingredients", which account for 233,321 tonnes and 22,048 tonnes respectively. Australia (69,500 tonnes) and Asia (27,505 tonnes). It should be noted, however, that a significant proportion of food purchases (152,438 tonnes) have no clearly attributable place of origin (denoted by NULL).

Table 18: Food purchase volumes by place of origin

Place of origin	Sum of Auckland share (tonnes)
Made in New Zealand from local and imported Ingredients	233,321.46
Made in New Zealand	180,297.53
NULL	152,438.31
Made in Australia	69,500.18
Made in Asia	27,505.37
Made in New Zealand from imported ingredients	22,048.67

Place of origin	Sum of Auckland share (tonnes)
Made in Europe	19,394.62
Made in North, South or Central America	9,381.70
Made in Africa	840.27
Made in Other	506.94
Made in Oceania	251.70

Source: GS1 and Sapere analysis

7.3 1,900,452 tCO2e are attributed to food consumed in households, while 290,727 tCO2e is attributed to food wasted by households

tCO2e is estimated by amalgamating our estimates of supermarket and retail purchases (1,980,095) and takeaway food purchases (211,084). This means a total of 2,191,179 tCO2e are attributable to household food purchases. Following the proportions of food wasted by households, as calculated above, we estimate 290,727 tCO2e are attributable to food waste and 1,900,452 tCO2e is attributed to household consumption.

8. Institutions

In terms of food waste and consumption, an institution is a place where scheduled meals are served to a contingent of the population attending the institution for period. For the purposes of this exercise, institutions include prisons, schools, and hospitals. In each, we attempt to quantify the inflows of food to each institution; where possible, we seek to disaggregate by food type, and estimate associated volumes of food waste.

8.1 Close to two tonnes of food are prepared for Auckland prisoners per annum

Based on a total Auckland prison population of 2,625, broken down as per Table 19, we estimate 1,713.42 tonnes of food are prepared for Auckland-based prisoners each year.

Table 19: Auckland prison populations

Auckland prison populations (December 2022)	Total
Auckland Prison	528
Mount Eden	890
Auckland South Corrections	894
Auckland Region Women's Corrections Facility	313
Total	2,625

Source: Department of Corrections

We estimate that 1,609.58 tonnes are attributable to prisoners who consume meat and animal products, while 103.84 tonnes are attributable to vegan and vegetarian prisoners. This is based on a New Zealand estimate[27] that 6 per cent of a given New Zealand population are either vegetarian or vegan.

8.1.1 We arrive at our estimate by examining prison food menus

Department of Corrections were approached for comment and insight for this research. However, no one was available. This means our analysis cannot account for food management, preparation, or storage practices in Auckland prisons. Our estimate is the result of analysing two weeks of prison food menus: Week 1[28] and Week 2.[29] These menus detail meals throughout the day across a whole week. All prisons in New Zealand are served the same menus on the same week, meaning food prepared for Auckland prisoners is the same regardless of institution.

[27] https://healthify.nz/hauora-wellbeing/v/vegetarianism-veganism/
[28] https://www.corrections.govt.nz/resources/policy_and_legislation/Prison-Operations-Manual/POM-Related-Links/menus/national-menu-week-1
[29] https://www.corrections.govt.nz/resources/policy_and_legislation/Prison-Operations-Manual/POM-Related-Links/menus/national-menu-week-2

Prison menus do not detail the weight or volume of food served to each prisoner for each meal. To estimate the weight served to prisoners, we cross-referenced each meal with the New Zealand Food Composition Database,[30] which accounts for the recommended serving size of various foods. Importantly, prison food menus are options-based for either vegetarians or meat eaters. We proceed on the assumption that a sufficient volume of food vegetarian or vegan food is prepared for our estimated number of vegetarian and vegan prisoners (158),[31] as well as those consuming meat and animal products (2,467).

8.1.2 Dairy products, sandwiches, and fruit rank amongst the highest categories of foods served to prisoners

Here, we break down the food served to Auckland by weight and food type. Further granularity of some categories is limited by a lack of information. For example, menus detail that prisoners are served a portion of fruit, without detailing the type of fruit served.

Table 20: Food prepared for Auckland prisoners by weight and food type

Food type	Annual weight (tonnes) for Auckland prisoners
Sandwiches	284.60
Milk	242.28
Tea (made)	229.32
Fruit	229.32
Vegetables	143.32
Meat dishes	139.82
Potatoes	128.99
Yoghurt	75.07
Toasted bread	66.88
Cakes/muffins	57.33
Jam/margarine	38.22
Breakfast cereal	31.6
Rice	18.42
Pasta	18.42
Vegetarian dishes	9.71

Source: Department of Corrections and Sapere analysis

[30] https://www.foodcomposition.co.nz/
[31] Rounded up from 157.5.

8.2 Food waste in prisons could be as high as 369 tonnes per annum

Again, without input from Department of Corrections, and understanding of its food management practices, it is difficult to fully comprehend the types and weights of food wasted in Auckland prisons. However, an estimate can be obtained by looking to relevant international literature.

In California, it is estimated that somewhere between 0.5 lbs (227 g) to 1.2 lbs (544 g) of food waste is generated per prison inmate per day ('Lowering Prison Costs with Sustainable Food Waste Management', 2021). Taking the mid-point (385.5 g), this would translate to 1.01 tonnes of food waste per day, or 369.35 tonnes per annum.

8.2.1 Most prison food waste likely occurs at the point of preparation

Reflecting on studies of cafés and restaurants in New Zealand[32] (WasteMINZ, 2018), 7 per cent of food waste in a kitchen setting arises from spoilage (pre-preparation), 60 per cent occurs during the preparation of food (in the form of by-products, such as vegetable peels and meat trimmings), and 33 per cent occurs post-preparation as plate waste. Following these proportions, we estimate 25.86 tonnes of food waste occurs in Auckland prisons as a result of spoilage, 221.61 tonnes of waste occur as a result of food preparation, and 121.89 tonnes arise as a result of on-plate waste.

8.2.2 Prison food waste streams are unclear

We are unaware of what food waste management practices, if any, are in place at Auckland's prisons. Anecdotally, we heard that some prisons send all food waste to landfill, lacking sufficient infrastructure to channel it elsewhere. However, we had also heard of trials with the use of worm farms to help decompose food waste and use it for compost at one Auckland prison.

8.3 6,170 tCO2e are attributed to prison food

There are 5,391 tonnes of GHG emissions attributed to prepared food only, the breakdown of which is shown in the table below:

Table 21: GHG emissions per prison foods

Food type	GHG emissions (tCO2e)
Sandwiches	2,234.13
Meat and fish dishes	1,237.49
Milk	365.85

[32] We acknowledge that cafés and restaurant kitchens are likely operationalised differently from prison kitchens, and as such estimates of spoilage and preparation waste may be somewhat higher than what is found in the prison environment.

Food type	GHG emissions (tCO2e)
Vegetables	295.25
Fruit	282.06
Yoghurt	247.00
Cakes/muffins	245.37
Toasted bread	96.98
Jam/margarine	94.40
Rice	75.55
Potatoes	61.92
Breakfast cereal	56.05
Tea (made)	45.86
Pasta	32.06
Vegetarian dishes	21.67
Total	**5,391.66**

Source: Drew et al., (2020) and Sapere analysis

On-plate food waste accounts for 383.55 tCO2e. However, preparation waste (697.37 tonnes of CO_2) and food spoilage (81.36 tonnes of CO_2) need also need to be accounted for, bringing total GHG emissions to 6,170.39 tonnes.

8.4 Around 3,262 tonnes of food are prepared for school children in Auckland via the Ka Ora, Ka Ako programme

Quantifying the volumes of food served to school students across Auckland is challenging, because schools tend to make independent decisions about serving lunches and, in some cases, breakfast. Some schools may serve no food at all, while others may have dedicated kitchens and canteens. Private schools, with a mixture of boarding and non-boarding students may offer a full suite of meals to students, as well as snacks, throughout the day. Altogether, this means that it is not possible to obtain a comprehensive account of food consumption and waste in schools, without an audit of schools across Auckland.

We can, however, shed a spotlight on food volumes served to Auckland school students by examining the Ka Ora, Ka Ako programme[33]. A total of 69,520 student across Auckland participate in the

[33] The Ka Ora, Ka Ako | Healthy School Lunches programme aims to reduce food insecurity by providing access to a nutritious lunch in school every day (Ministry of Education).

programme. According to the programme guidelines[34], students in rolls 0 to 3 are to receive a minimum of 180g for their lunch, while groups 4 to 8 receive 240g, and those in 9 and above receive 300g. A breakdown of the number of students belonging to each roll is shown in the table below:

Table 22: Composition of students participating in Ka Ora, Ka Ako and daily minimum serving weights

Roll	No. Students	Minimum serving weight per day (g)
Roll 0-3	16,447	180
Roll 4-8	28,525	240
Roll 9+	24,547	300
Total	**69,520**	

Source: Ministry of Education

Based on a 190-day school year we, therefore, estimate (based on minimum serving weights) that 3,262.45 tonnes of food are prepared for consumption for Auckland students participating in the programme, per annum. Schools implementing the programmes have some flexibility in the types of food served, prohibiting us from providing a granular attribution of weight to food type. However, by following the nutrition standards for the programme, we estimate breakdown of food served to be as follows:

Table 23: Weights of food types prepared for student rolls per annum

Food category	Roll (0-3)	Roll (4-8)	Roll 9+	Total (tonnes)
Vegetable	117	244	245	606
Grains and Starch	94	325	420	839
Protein	117	271	291	680
Others	234	461	443	1,138
Total (tonnes)	**563**	**1,301**	**1,399**	**3,262**

Source: Ministry of Education and Sapere analysis

Foods falling into the 'other' category are wide ranging and may include:

- Milk, milk products, and milk alternatives
- Fruits
- Cooking sauces and table sauces
- Faits, oils, and spreads
- Liquids (such as water and stocks)
- Herbs and spices
- Pastries, confectionary, and packaged snacks

[34] Nutrition Standards for Ka Ora, Ka Ako menus - Ka Ora, Ka Ako - Healthy School Lunches Programme (education.govt.nz)

8.4.1 Around 260 tonnes of surplus food are produced via the Ka Ora, Ka Ako programme, per annum

A 2023 survey of Auckland schools, provided to us by the Ministry of Education, found that around 8 per cent of meals prepared for students were considered surplus[35]. We assume the surplus rate to be evenly split across the three roll groups. On that basis, we estimate a total of 261 tonnes of surplus lunches are produced. In terms of food types, surplus lunch volumes are comprised of 48 tonnes of vegetables, 67 tonnes of starch and grains, 54 tonnes of protein, and 91 tonnes from foods belonging to the 'other' category.

At the time, there is limited reporting as to how schools manage surplus lunches[36]. Discussions with stakeholders from the Ministry of Education indicate that surplus lunches are given to students to take home for later consumption and donated to foodbanks and homeless shelters. Contracts with lunch suppliers stipulate that surplus lunches must be redistributed. As such, stakeholders expressed a strong view that it is highly unlikely surplus lunches are being sent to landfill.

8.4.2 Around 870 tonnes of on-plate waste are attributed to the Ka Ora, Ka Ako programme in Auckland

Excluding the 261 tonnes of surplus lunches, 3,001.45 tonnes of food is served to Auckland students for consumption per annum. Of the 3,001 served for consumption, we estimate around 29 per cent[37] is uneaten, and considered on-plate waste, translating to 870.42 tonnes of food, Again, there is limited reporting as to how schools manage on-plate food waste. Discussions with stakeholders indicate that, where possible, this waste is diverted for animal feed and composting.

8.4.3 Almost 98 tonnes of food waste are attributed to food preparation in the programme

To make a determination of food waste volumes attributable to food preparation for the programme, we spoke with the manager of the industrial kitchens supplying Auckland schools.

According to the industrial kitchen manager interviewed, his industrial kitchens operate with very low waste volumes, noting that industrial kitchens cannot be fairly compared to kitchens in hospitality, institutions, or even manufacturing. He explained that his industrial kitchens operate with a strong ethos of reuse. For example, he explained that unused sandwich bread is reprocessed back into flour, which is then used to make tortilla wraps, and that unused sandwich meats are often cooked into different hot meals recipes. He conceded that food waste does occur due to preparation errors,

[35] Surplus lunches, as defined by the programme is meal that is fit for redistribution to people.
[36] We have been advised by stakeholders operating the programme that new reporting requirements will be implemented later in 2024.
[37] We arrive at this estimate based on international literature (Getlinger et al., 1996) that finds on-plate food waste in school lunches ranges from 24 to 35 per cent.

breakages, and spoilage, but limited this waste to an estimate of around 3 per cent. He also noted that all this waste is diverted for animal feed.

Based on 3 per cent preparation waste, we estimate around 98 tonnes (97.87) of food waste occurs per annum, as a result of preparing food for the Ka Ora, Ka Ako programme in Auckland. We do not have sufficient information to attribute types of food to this headline food preparation waste estimate.

8.5 Over 25,168 tCO2e are attributed to foods prepared for consumption by the Ka Ora, Ka Ako programme in Auckland

We infer from NZ-Specific Food Emissions Database types of foods served to school children and draw on an average kg of CO2 per kg of food. Some of the foods included in our average are sandwiches, wraps, burgers, stir-fries, casseroles, and sausage. The average kg CO2 per kg of food used is 7.49. From this we estimate the headline tCO2e for food prepared for consumption to be 25,168.83, this includes 773.07 tCO2e attributable to preparation waste.

8.5.1 Over 6,519 tCO2e and 1,954 tCO2e are attributed to on-plate waste and surplus food respectively

We estimate that of the 25,168 tCO2e attributable to food prepared for Auckland students, 6159.46 tCO2e is attributed to on-plate food waste, while 1,954.86 tCO2e is attributed to surplus meals. 15,961.44 tCO2e are attributable to food that students in the Auckland region consume, per annum.

The table below shows an overview of our estimates of food served, consumed, and wasted in Auckland.

Table 24: Overview of food served, wasted, and consumed in Auckland Ka Ora, Ka Ako programme

Waste and consumption	Food (tonnes)	tCO2e
Preparation waste	98	733
Food prepared for consumption	3,262	24,436
Surplus	261	1,955
On-plate waste	870	6,519
Food consumed	2,131	15,961

Source: Sapere Analysis

8.6 Over 2,140 tonnes of food flow through Auckland hospitals per annum

Like schools, hospitals have a degree of autonomy when it comes to food menus, volumes, and food waste management practices. As such, we suggest that the most accurate means to measuring food flows in Auckland hospitals would be via an auditing process. At the time of writing, many hospitals in Auckland are undergoing such an audit. Whenever they become available, these datasets should elucidate precise food consumption and waste tonnages, as well as waste management practices. In absence of this data, however, we have pursued an inference-based approach to estimate food consumption and waste volumes in Auckland hospitals.

According to the Ministry of Health (2023), there is capacity for 3,424 beds across all hospitals in the Auckland region. For the purposes of our estimations, we assume these beds are continually occupied over a 12-month period. Patients are generally served three meals each day and are given options as to the content and size of those meals. Small, medium, and large are the sizes typically offered. The exact weight of each meal will vary depending on the size and foods selected by the patient. However, we have calculated an average meal weight for each size option, based on an examination of various hospital food menus.

Table 25: Hospital meal serving sizes

	Small (g)	Medium (g)	Large (g)
Breakfast	443	534	671
Lunch	456	483	553
Dinner	369	409	496
Total	1,268	1,426	1,720

Source: Sapere analysis

If we assume an even spread of patients across each serving size (1,411 patients), a total of 1,833.57 tonnes are prepared and served to patients across Auckland hospitals each year. 526.71 tonnes are attributable to those selecting the small option, 592.29 tonnes to the medium option, and 714.57 tonnes to those selecting large.

8.6.1 152 tonnes of served food go uneaten, 276 tonnes are wasted during preparation, and 32 tonnes are spoiled prior to preparation

Based on a discussion with a sustainability manager at a large Auckland hospital, our waste estimates assume that an average of 41 grams (40.74) are left uneaten of patients' plates. Across all meals served to patients over a one-year period, we estimate on-plate food waste to be 152.33 tonnes. Following waste proportions found in food service venues (33 per cent from on-plate waste, 60 per cent from preparation waste, and 7 per cent from spoilage), we estimate 276.96 tonnes of food waste

to come from preparation waste, and a further 32.31 tonnes of waste to arise due to spoilage. As such, we estimate total food waste volumes attributable to Auckland hospitals to be 461.61 tonnes.

It is not entirely clear from our research how different hospitals manage their waste volumes. However, interviews we conducted with sustainability managers across three Auckland hospitals indicated that there is recognition of the importance of food waste management. In all cases, hospitals were considering, and trialling, various waste management practices.

8.7 Over 9,940 tCO2e are attributable to food in Auckland hospitals

We estimate tCO2e by first taking an average CO2e per kilogram of food from the NZ-Specific Food Emissions Database (4.64). We then multiply that average by the sum of all food across a one-year period. On this basis, we estimate 7,800 tCO2e are attributable to foods that are consumed. 1,285 tonnes come from preparation waste, 706 tonnes come from on-plate food waste, and a further 149 tCO2e are attributable to spoiled foods.

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