

# NATIONAL FOOD WASTE BASELINE

## Final assessment report

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## GLOSSARY

Term	Definition*
Animal feed	Diverting material grown for human consumption from the food supply chain (directly or after processing) to animals. Material sent to animal feed is not considered food waste.
Bio-based materials / biochemical processing	Converting material into industrial inputs / products. Examples include creating fibres for packaging material; creating bioplastics (e.g. polylactic acid); making traditional materials such as leather or feathers (e.g. for pillows); and rendering fat, oil or grease into a raw material to make products such as soaps, biodiesel or cosmetics. Biochemical processing does not include energy generation through anaerobic digestion or production of bioethanol through fermentation.
Co-digestion / anaerobic digestion	Breaking down material via bacteria in the absence of oxygen to generate energy (typically in the form of biogas) and nutrient-rich matter. Co-digestion refers to the simultaneous anaerobic digestion of food waste and other organic material in one digester. This destination includes fermentation, converting carbohydrates – such as glucose, fructose and sucrose – via microbes into alcohols in the absence of oxygen to create products such as biofuels.
Composting/aerobic processes	Breaking down material via bacteria in oxygen-rich environments to produce organic material (via aerobic processes) that can be used as a soil amendment.
Controlled combustion	Sending material to a facility that is specifically designed for combustion in a controlled manner. In Australia, it is likely to include some form of energy recovery and may also be referred to as energy-from-waste or waste-to-energy.
Destination	A finite set of possible pathways for food material to define food waste and rank resource recovery activities. The potential destination set is established in the Food Loss and Waste Accounting and Reporting Standard (FLW Standard) developed by the international, multi-stakeholder program, the Food Loss and Waste Protocol (FLW Protocol). It has been adapted to the Australian context.
Disposal	Disposal of food waste is defined with reference to the Food Loss and Waste Standard as adapted to the Australian context. It consists of the following destinations for food waste: other disposal, landfill and sewer/wastewater disposal.
Diversion	Generically, this is the process of redirecting food waste from disposal to a higher value and more productive purpose, such as reuse, recycling and recovery.
Food	Any substance – whether processed, semi-processed, or raw – that is intended for human consumption. Includes inedible parts associated with food.
Food waste	<p>The National Food Waste Strategy defines food waste as:</p> <ul style="list-style-type: none"> <li>• Solid or liquid food that is intended for human consumption and is generated across the entire supply and consumption chain but does not reach the consumer, or reaches the consumer but is thrown away. This includes edible food, the parts of food that can be consumed but are disposed of, and inedible food, the parts of food that are not consumed because they are either unable to be consumed or are considered undesirable (such as seeds, bones, coffee grounds, skins, or peels)</li> <li>• Food that is imported into, and disposed of, in Australia</li> <li>• Food that is produced or manufactured for export but does not leave Australia.</li> </ul>

Inedible parts associated with food	Components associated with a food that, in a particular food supply chain, are not intended to be consumed by humans, such as bones, rinds, and pits/stones. It does not include packaging. What is considered inedible varies among users (e.g., chicken feet are consumed in some food supply chains but not others), changes over time. Inedible has been defined in the Australian context.
Land application	Spreading, spraying, injecting or incorporating organic material (including not harvested / ploughed in) onto or below the surface of the land to enhance soil quality.
Landfill	Sending material to an area of land or an excavated site that is specifically designed and built to receive wastes.
Food loss	Food loss is a generic term used in some jurisdictions to differentiate from food waste, either describing where losses occur in the supply chain (e.g. in production and manufacturing) or the reasons why the food is lost (e.g. due to events such as disease or weather). The National Food Waste Strategy adopts 'food waste' as an inclusive term to address both food loss and food waste (see above).
Food rescue	The process of diverting good quality excess food from landfill to charities and other organisations who redistribute food in the form of groceries or meals to Australians in need. Rescued food is considered part of the food supply chain, although the distribution pathway is different from that originally intended. It is not included in the National Food Waste Baseline.
Not harvested / ploughed in	Leaving crops that were ready for harvest in the field or tilling them into the soil. It applies only to the harvestable portion of the crop.
Recycling	Converting materials that would have otherwise been disposed of into new materials. Food waste recycling includes material and / or nutrient recovery that delivers a net environmental benefit post-manufacturing or post-consumption, using processes including bio-based materials / biochemical processing; co-digestion / anaerobic digestion; and composting / aerobic processing.
Resource recovery	A generic category defined in the National Waste Report as "the sum of materials sent to recycling and energy recovery, net of contaminants and residual wastes sent to disposal". The National Food Waste Baseline 2016/17 broadens this to include any activity involving the processing of food waste for diversion from landfill, including recovery of food production by-products such as skins, furs and feathers.
Refuse / discards / litter	Material abandoned on land or disposed at sea. This includes open dumps (i.e., uncovered, unlined), open burn (i.e., not in a controlled facility), the portion of harvested crops eaten by pests, and fish discards (the portion of total catch that is thrown away or 'slipped' from the net before being taken on board). The National Food Waste Baseline does not include this destination.
Sewer / wastewater treatment	Sending material to the sewer (with or without prior treatment), including that which may go to a facility designed to treat wastewater.
Other – Recovery	Sending material to a destination that is not covered in the FLW Protocol standard destinations above, for recovery. This includes treatment of hazardous waste, which due to its characteristics poses a threat of risk to public health, safety or the environment and requires particularly high levels of control. Examples of hazardous food waste in some jurisdictions include biosolids, grease trap sludge and wastes from abattoirs and tanneries.

Other – Disposal

Sending material to a destination that is not covered in the FLW Protocol standard destinations above, for disposal. This includes hazardous food waste that may be treated and disposed at a hazardous waste treatment facility.

\* The definitions are drawn from Food Loss and Waste Protocol, except where the source explicitly noted or the term is flagged as generic.

## EXECUTIVE SUMMARY

Australia generated an estimated 7.3 million tonnes (MT) of food waste in 2016/17 from across the entire supply and consumption chain. The waste was managed in a wide variety of ways depending on its characteristics and the sector that generated it. Across the supply and consumption chain, 1.2 MT was recycled, 2.9 MT was recovered and 3.2 MT was disposed.

The National Food Waste Baseline project is the first detailed quantification of food waste in Australia at the country scale and across the full food supply and consumption chain, from primary production through to consumption and disposal or recovery. It was developed in response to the National Food Waste Strategy (the Strategy) released by the Australian Government in November 2017 to contribute toward global action to reduce food waste and align with the United Nations' Sustainable Development Goal (SDG) Target 12.3<sup>1</sup>, which aims to ensure sustainable consumption and production patterns. The Strategy also helps give effect to Australia's obligations under the United Nations Framework Convention on Climate Change to reduce greenhouse gas emissions, primarily through the diversion of food waste from disposal outcomes.

The Strategy sets the objective to halve food waste along the supply and consumption chain by 2030. The Strategy adopts a circular economy approach that takes into account the food waste hierarchy (Section 1.1) and seeks to capture food waste as a resource.

Total food waste generation of 298 kilograms per capita<sup>2</sup> (7.3MT nationally) constitutes the National Food Waste Baseline.

Generation of food waste is not evenly dispersed along the supply and consumption chain. Households and primary production are the largest waste generating sectors, together accounting for 65% of national food waste. Significant volumes are also generated in food manufacturing (24%) (Figure 1).

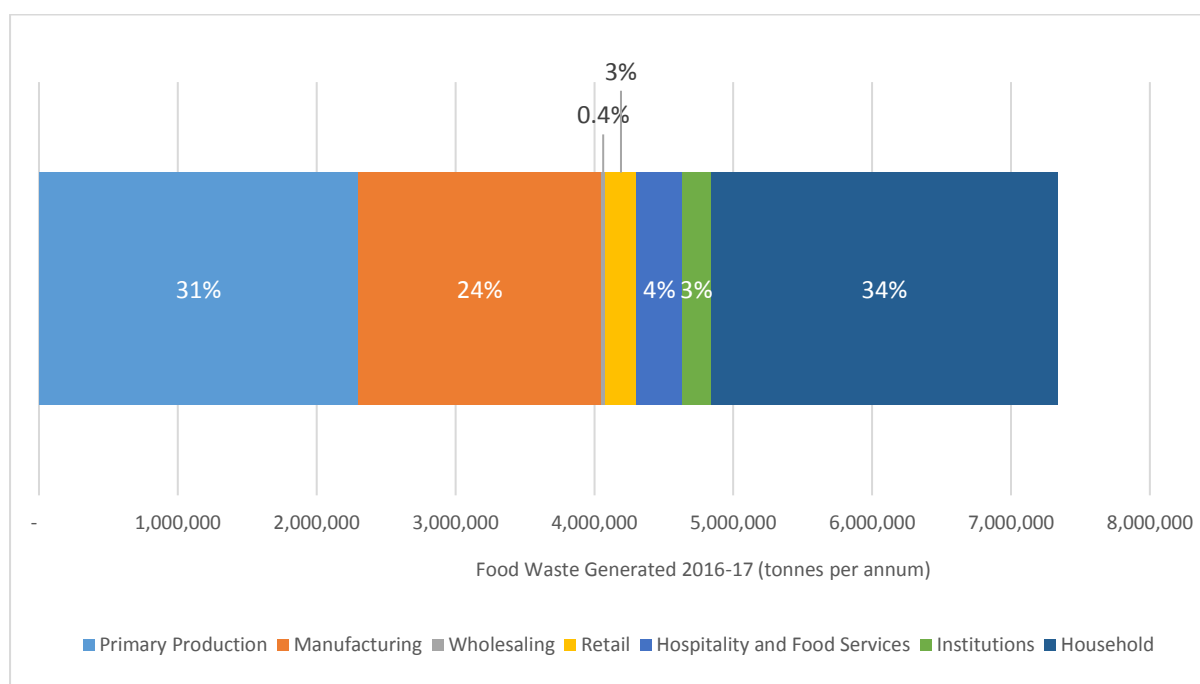


Figure 1: National food waste generation by sector, 2016/17 (Food waste from the transport sector is integrated into these quantities)

<sup>1</sup> Transforming our world: 2030 Agenda for Sustainable Development; [www.un.org/sustainabledevelopment/development-agenda/](http://www.un.org/sustainabledevelopment/development-agenda/)

<sup>2</sup> Australian population on June 30, 2017 – 24.59 million (Australian Bureau of Statistics)

A critical determinant in the baseline estimate of national food waste generation is how food waste is defined in the Strategy. This is more specific than how waste is defined in the Australian Government's 2018 National Waste Policy. Waste is defined as material that has finished initial use and entered a waste stream, including material that is recycled and landfilled<sup>3</sup>. This definition supports most state and territory government waste strategies with the primary aim to divert material from landfill to any productive use.

The Strategy defines food waste as:

- Solid or liquid food that is intended for human consumption and is generated across the entire supply and consumption chain.
- Food that does not reach the consumer, or reaches the consumer but is thrown away. This includes edible food, the parts of food that can be consumed but are disposed of, and inedible food, the parts of food that are not consumed because they are either unable to be consumed or are considered undesirable (such as seeds, bones, coffee grounds, skins, or peels).
- Food that is imported into, and disposed of, in Australia.
- Food that is produced or manufactured for export but does not leave Australia.

While many governments have committed to the United Nations' SDG Target 12.3, each country has developed its own approach to quantifying and defining food waste. The National Food Waste Baseline methodology incorporates leading international approaches – including from the United Kingdom<sup>4</sup>, Europe<sup>5</sup> and the multi-stakeholder initiative Champions 12.3 – and the key Food Loss and Waste (FLW) Accounting and Reporting Standard developed to support SDG Target 12.3.

The centrepiece of the FLW Standard's definitional framework is a finite set of possible destinations for food material and its associated inedible parts, other than going direct to human food. Three modifications were made to the suite of destinations to suit the Australian food and waste context: the 'Other' category was divided into recovery and disposal destinations; Refuse/Litter was deleted given this data is very minimally collected for food waste in Australia; and Food Rescue has been specifically quantified as an area of particular policy and business interest in waste avoidance rather than a waste destination.

To apply the conceptual framework, the Australian Government has designated each of the modified 12 destinations as either a food outcome or a food waste outcome, based on the context of Australia's food industry and the objectives of the Strategy. All destinations have been designated as waste except for Food Rescue and Animal Feed, which in line with practice in the UK<sup>6</sup> and elsewhere have been considered food outcomes as they remain within the human food system.

While all other destinations are considered waste, they are not all equal. The conventional waste hierarchy ranks waste outcomes by preference, with various tiers of resource recovery being clearly preferable to disposal. The food waste hierarchy adds another filter, with priority given to activities that avoid food waste by keeping food in the food system.

Broadly, three types of activities are recognised as avoiding food waste: reduction of food waste through efficiency and optimisation at all points of the supply and consumption chain; repurposing food waste streams into new food products; and redistributing surplus food within the food system (food rescue).

This priority focus does not devalue initiatives to move up the hierarchy any food waste that is generated. Resource recovery activities such as composting, rendering and energy conversion provide significant triple bottom line value as food waste initially destined for disposal is diverted to resource recovery or higher value activities. These activities and outcomes will also continue to be driven and measured by state and territory governments, and at a national scale by the Australian Government's National Waste Policy and the National Waste Report.

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<sup>3</sup> National Waste Policy: Less Waste More Resources, 2018

<sup>4</sup> Food Surplus and Waste Measurement and Reporting, A Reference Document for Suppliers, 2018. WRAP UK

<sup>5</sup> FUSIONS Definitional Framework for Food Waste, 2014

<sup>6</sup> [http://www.wrap.org.uk/sites/files/wrap/Animal\\_feed\\_info\\_sheet.pdf](http://www.wrap.org.uk/sites/files/wrap/Animal_feed_info_sheet.pdf), accessed 05/11/2018

The baseline project has shed light on the Australian food industry and consumer practices by identifying where food waste is being generated at the sector level across the supply and consumption chain, and by state and territory. Arcadis' confidence in the food waste estimates is moderate across the board, with lower confidence in some sectors. The data available for wholesale, retail, hospitality and some food manufacturing sub-sectors is limited, while transport has been separately reported due to data challenges isolating food waste from this sector.

The sector-by-sector analysis indicates households, primary production and manufacturing are the largest generators of food waste, which helps to identify opportunities to reduce food waste at scale (Table 1). It indicates the preferred approaches currently used by the various sectors that comprise the food chain, including households, with each sector typically favouring a small number of pathways based on its individual operating context.

Table 1: A summary of destinations for food waste and surplus, quantified by sector (kT)

Destination	Primary Production	Manufacturing	Wholesale	Retail	Hospitality	Institutions	Households	Total	Total per capita (kg)
Bio-based materials / biochemical processing	–	105	–	–	–	–	–	105	4.3
Co-digestion / anaerobic digestion	–	74	–	8	–	–	–	82	3.3
Composting / aerobic processes	–	716	14	47	17	–	198	992	40.4
Other – Recovery	–	113	–	–	–	–	–	113	4.6
Controlled combustion (energy recovery)	–	7	–	–	–	–	–	7	0.3
Land application	–	487	–	–	–	–	–	487	19.8
Not harvested / ploughed in	2,270	–	–	–	–	–	–	2,270	92.3
Other – Disposal	–	–	–	–	–	–	–	–	–
Landfill	–	62	13	177	307	209	2,302	3,070	124.8
Sewer / Wastewater treatment	–	194	–	–	–	–	–	194	7.0
<b>Total</b>	<b>2,270</b>	<b>1,758</b>	<b>27</b>	<b>232</b>	<b>324</b>	<b>209</b>	<b>2,500</b>	<b>7,320</b>	<b>297.7</b>
Animal feed	337	3,437	25	135	–	–	–	3,934	160.0
Food rescue	11	19	1	17	0.4	–	–	48	2.0

\* Food waste from transport is integrated into these quantities but discussed separately in Section 3.15.

The two largest sources of food waste nationally are household food waste to landfill and harvest-ready produce that is not harvested and / or ploughed in. Other significant streams include food

manufacturing waste disposed to land application or composting and food waste from the hospitality and institution sectors.

Surplus food redistributed to food rescue or diverted to animal feed are considered to remain within the human food system. Significant quantities are sent to animal feed from early in the supply chain, where it predominantly goes to feed animals for subsequent human consumption.

It is worth noting the only specific exclusion within the National Food Waste Baseline, which is sugarcane fibre (bagasse). The bagasse left after sugar refining, which is an inedible part associated with food, accounts for around 28% (by weight) of the raw sugarcane and in 2016/17 totalled 10 MT<sup>7</sup>. The bagasse proportion has also been applied to harvest losses that remain in the field, totalling 1 MT of bagasse in 2016/17. This 11 MT has been excluded from the baseline quantification as it significantly skews the national food waste estimate, particularly in Queensland where the sugar industry is highly concentrated. Removing it from the dataset allows more refined analysis and comparison across the economy, and better reflects the scale of food waste generation in the rest of the food manufacturing sector.

Waste from the sugar industry is already well utilised, with mill-generated bagasse primarily combusted to generate on-site power. The waste stream is a target of various state and Commonwealth government research and grant programs<sup>8</sup> and the Queensland Biofutures 10-Year Roadmap and Action Plan<sup>9</sup>.

Figure 2 illustrates the distribution of food waste generation across Australia, identifying states and territories for priority focus. This follows population as well as specific agricultural and manufacturing sectors concentrated within each jurisdiction.

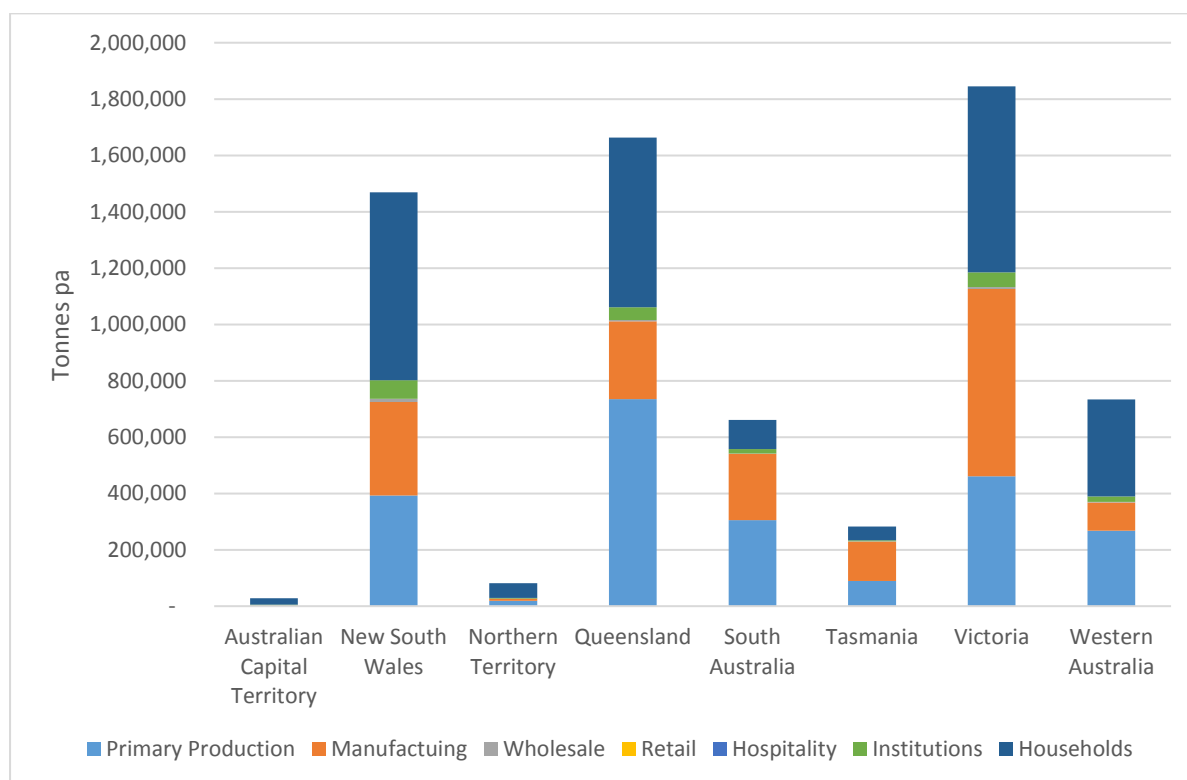


Figure 2: A breakdown of food waste generation by jurisdiction (excluding bagasse)

<sup>7</sup> Estimate by the Sugar Cane Milling Council

<sup>8</sup> [www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/sugar/funding-bodies](http://www.daf.qld.gov.au/business-priorities/plants/field-crops-and-pastures/sugar/funding-bodies)

<sup>9</sup> [www.statedevelopment.qld.gov.au/industry-development/biofutures.html](http://www.statedevelopment.qld.gov.au/industry-development/biofutures.html)

The National Food Waste Baseline provides a benchmark for measuring national performance in implementing activities to avoid and recover food waste, by establishing a consistent framework to quantify food waste generation and to track progress towards the target of halving food waste.

National food waste figures, however, are not particularly useful for international comparison. There are two reasons for this. Firstly, food waste generation is a function of multiple factors unique to each country, including business and consumer practices, economic mix and scale, systems of government, food culture, social demographics, infrastructure, geography and climate. The Australian agricultural base and food context is distinct from cold climate Canada, the compact UK and the food tastes of Asia.

Secondly, country figures cannot be directly compared due to differences in the way food waste is defined, even where similar overall food waste accounting frameworks have been applied, and in the scope of data and the collection methodologies. These differences can be overt, such as the UK excluding primary production or the key US analysis by ReFED defining food waste exclusively as that sent to landfill. Differences can also be hidden in the detail, such as the critical designation of destinations as food or waste, and the position on whether to include the inedible parts of food, which represent a significant proportion of food waste.

Data quality and coverage is also highly variable, all of which inject significant uncertainty into any comparison of food waste performance between countries.

The United Nations SDG Target 12.3 is *by 2030, to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses*<sup>10</sup>. Each country is at liberty to choose how to define their individual baseline estimates based on an internally consistent methodology and recognising the data available within the country and its context. Australia has adopted a broad approach, both to the definition of food waste and the scope of the food supply and consumption chain.

As the first detailed attempt to quantify total food waste generated in Australia, the baseline project has been informed by a large number of data sources and via consultation with a wide range of stakeholders, including:

- Industry groups, which in most cases had limited data on industry-wide generation or typical loss factors, but were useful in setting context and helping engage their sector
- Research organisations, including Commonwealth Scientific and Industrial Research Organisation (CSIRO), Research and Development Corporations (RDCs), Cooperative Research Centres (CRCs) and universities
- State and local government agencies and departments, including variously environment, waste, agriculture and industry, and public sector operating entities such as health, aged care, education and corrections
- Australian Government departments, including environment, defence and agriculture
- The Steering Committee of the National Food Waste Strategy.

The limited prior attention to food waste in Australia and commercial confidentiality constraints resulted in mixed results on data acquisition. Many organisations do not have reporting frameworks in place to track their food waste by volume or economic value. The data collected can be highly variable, with uncertain protocols on data management, food waste definition and transparency on end destinations.

The approach to data collection and modelling was designed to address these issues to the fullest extent possible, including verifying the approach with experienced food waste practitioners in Australia and the UK, assessment of best practice internationally and direct consultation with local stakeholders to gather data and validate assumptions.

More than 300 organisations were engaged through a structured consultation between March and June 2018, based on written survey templates across the community and direct interviews with key stakeholders. Of these, 91 submitted some level of data, while others provided anecdotal and

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<sup>10</sup> <http://www.fao.org/sustainable-development-goals/indicators/1231/en/>



contextual information or informal estimates to help sanity check the results. Analysis of the available waste and industry profile data for each sector informed a “best fit” approach to modelling in order to scale up the data to national level. In some cases, the reliance on indicative waste factors and assumptions was relatively high (Section 5).

There are opportunities to refine the National Food Waste Baseline assessment in future iterations as more data becomes accessible. Over time, targeted research and industry engagement, such as through the work of the Fight Food Waste Cooperative Research Centre and the implementation phase of the National Food Waste Strategy by Food Innovation Australia Limited are expected to support and improve the reach and rigour of food waste datasets and strengthen the reporting framework and its capacity to accurately track performance and identify further opportunities to reduce food waste.

# 1. BACKGROUND

## 1.1. National Food Waste Strategy

The National Food Waste Strategy was released in 2017 to provide the framework to support collective action towards reducing food waste by half by 2030.

The Australian Government committed in 2016 to develop the strategy to contribute to global action on reducing food waste under the United Nations' Sustainable Development Goal Target 12.3 (SDG 12.3), which is part of its 'Transforming our world: 2030 Agenda for Sustainable Development'. By reducing food waste, the Strategy also helps give effect to Australia's obligations under the United Nations Framework Convention on Climate Change to help reduce greenhouse gas emissions.

Food production is one of Australia's largest industries. The food supply and consumption chain in Australia has a combined worth of approximately AUD\$230 billion which comprises \$38 billion in farm and fish production, \$80 billion in food processing and \$112 billion in retail food sales<sup>11</sup>.

The National Food Waste Strategy notes that achieving the reduction in food waste is a shared responsibility and identifies four priority areas:

- **Policy support**, including identifying areas to target investment, establishing a voluntary commitment program to reduce food waste and legislative reform
- **Business improvements**, including identifying areas for improvement, supporting technology adoption, encouraging collaboration and normalising food waste considerations into business practices
- **Market development**, including identifying food waste composition and nutritional value to develop new markets, encourage innovation and connecting food waste sources to users
- **Behaviour change** in both consumers and the food industry workforce.

To inform each of these aspects and to define the target and track performance over time, the Australian Government has commissioned Australia's most detailed assessment of national food waste quantities across the supply chain, from farm to fork to final disposal or recovery.

The National Food Waste Baseline estimates how much food waste is generated in Australia annually, and how much is recycled, recovered and disposed. These headline figures establish the baseline against which performance would be measured.

The baseline assessment also identifies where food waste is produced (both within the food chain and geographically by state / territory), and whether the material is disposed to a no-value destination,

## What is food waste?

Australia's National Food Waste Strategy 2017 adopts a broad and inclusive definition of food waste.

Food waste covers:

- Solid or liquid food that is intended for human consumption and is generated across the entire supply and consumption chain
- Food that does not reach the consumer, or reaches the consumer but is thrown away. This includes edible food (the parts of food that can be consumed but are disposed of) and inedible food (the parts of food that are not consumed because they are either unable to be consumed or are considered undesirable, such as seeds, bones, coffee grounds, skins or peels)
- Food that is imported into, and disposed of, in Australia
- Food that is produced or manufactured for export but the waste occurs in Australia.

<sup>11</sup> PMSEIC (2010) Australia and Food Security in a Changing World. The Prime Minister's Science, Engineering and Innovation Council. [http://www.chiefscientist.gov.au/wp-content/uploads/FoodSecurity\\_web.pdf](http://www.chiefscientist.gov.au/wp-content/uploads/FoodSecurity_web.pdf). Accessed 1 June 2018.

subject to some form of resource recovery or avoided as food waste through diversion to animal feed or redistribution to food rescue. This more granular level of data helps to identify the highest impact opportunities for food waste prevention and reduction, for example by targeting the sectors and regions generating the most food waste or by moving up the waste hierarchy of preferred options (Figure 3).

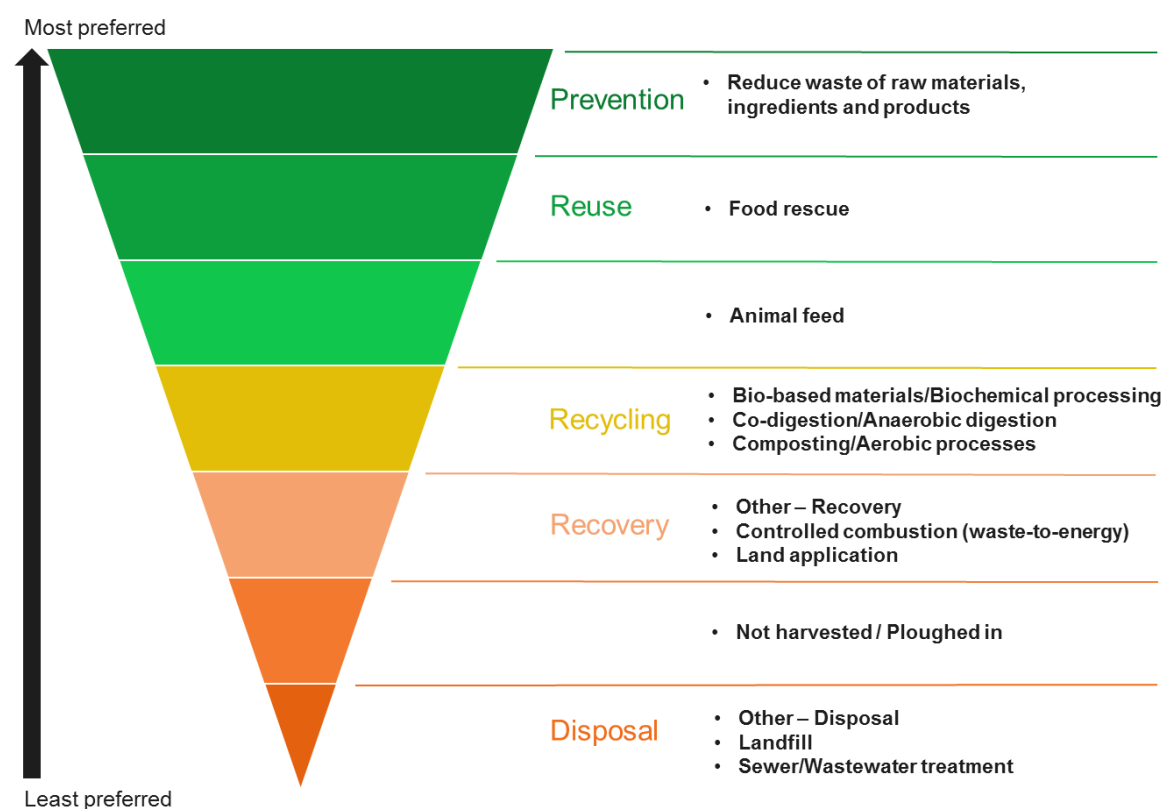


Figure 3: The food waste hierarchy indicating preferred outcomes

The waste hierarchy presented in Figure 3 has modified the model presented in the National Food Waste Strategy to reflect further consultation on the management and recovery value in the Australian context and the refined FLW Standard destinations.

Figure 3 identifies the disposal destinations as other disposal, landfill and sewer. The destination of not harvest / ploughed in is, on balance, considered a recovery destination offering some level of soil improvement. It is recognised that not all crop types offer soil improvement and ploughing them in is little more than on-farm disposal, however there is benefit in many cases, and this may even be a specific factor in crop selection. Due to the limited research globally on the beneficial aspects of different crops, fruit and vegetables when ploughed in, international practice is to designate all produce going to this destination as offering low level resource recovery. Additional research is required to refine the assumption in future assessments.

Similarly, land application is likely to provide some soil improvement benefits in using it as a destination (disposal method), any enhancement to soil quality is less than fully processed organic materials such as compost.

Controlled combustion as a destination may or may not include energy recovery. However, combustion in the Australian context is largely used for energy recovery, such as to provide on-site power at food manufacturing facilities, and is therefore considered resource recovery.

## 1.2. Defining the food waste reduction target

The United Nations does not define food waste nor the specific terms, but defines the SDG Target 12.3 as halving per capita global food waste at the retail and consumer levels and reducing food losses along the production and supply chain, including post-harvest, by 2030. National governments are left to determine their own approaches in reaching the target allowing them to take into consideration local context.

The National Food Waste Strategy's definition of food waste is critical in defining the reduction objective. The adopted definition of food waste – being any solid or liquid food material, including inedible parts, that does not reach the consumer or is thrown away once it reaches the consumer – means all food waste destinations other than food consumed by humans are considered waste.

Animal feed is considered to remain within the human food system as the majority of the animals or animal products are destined for human consumption. It is noted that some animal feed will go to other uses, with material quantities destined for pet food. However, it is not possible to isolate the proportion of pet food sourced from human-intended food to allow more refined assumptions around animal feed. It is further discussed in Section 4.2.

The definition of food waste represents a shift from the primary view of waste as being materials that are disposed to non-value outcomes, including landfill and sewer, illegal dumping, incineration, burning, stockpiling, burying and onsite legal disposal. While each jurisdiction has specific definitions of waste, data collection typically focuses the disposal-based conception of waste. This is sensible when considering losses to the economy as a whole, but is not fit-for-purpose where the policy goal is to reduce losses to a single sector of the economy, being the food supply and consumption chain.

This definition of food waste and the associated 2030 reduction objectives recognise that the environmental and social impacts of the food system are two-fold; they come from the loss of resource-intensive food commodities to non-food outcomes, and the disposal of food materials to landfill and sewer. Many benefits can be derived from reducing food waste. These include:<sup>12</sup>

- Increased economic opportunities through the creation and development of new products services and markets
- Reduced costs for businesses in saved resource inputs, reduced waste management and disposal fees, and increased profits through efficiency gains
- Reduced costs for households by lowering food bills
- Reduced environmental impacts and improved food security through effective redistribution of surplus food.

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*The adopted definition of food waste – being any solid or liquid food material, including inedible parts, that does not reach the consumer or is thrown away once it reaches the consumer – means all food waste destinations other than food consumed by humans are*

Progress towards the 2030 food waste reduction goal will be achieved by working together across the priorities within the food waste hierarchy, with the prevention of food waste the highest priority.

The National Waste Report series will continue to monitor and evaluate state / territory disposal and recovery of general solid and liquid waste, including food waste, under a consistent data approach (Section 2). The National Food Waste Baseline data framework has been designed with the flexibility to report against the National Waste Report.

The National Food Waste Baseline draws on the considerable amount of international work undertaken to define food, food waste and the options for framing food waste reduction under SDG Target 12.3. While differences remain between national approaches, there is an emerging best practice consensus across the major aspects of defining and measuring food waste (Section 2).

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<sup>12</sup> National Food Waste Strategy 2017

### 1.3. State of food waste data

Food waste data globally is typically limited in quantity and quality, even among the countries that have undertaken the most work on definition and measurement. This is a significant challenge in Australia.

Studies to date have confirmed there are no formal data capture systems to collect comprehensive food waste generation information in any part of the Australian supply chain. Other than food rescue and moderate data in some jurisdictions on household waste behaviours, there is negligible publicly available data on food waste quantities, composition and destinations. These gaps occur in all sectors of the food supply and consumption chain.

Existing public datasets include:

- Standard loss estimates across some primary industry commodity types, from research and industry groups including CSIRO and Horticulture Australia
- The National Waste Report
- State government reports on food waste volumes (some jurisdictions only)
- Broad Commercial & Industrial sector waste audits, such as the New South Wales BinTrim program
- A limited number of compositional audits of household residual waste to estimate the food fraction in red top bins (e.g. Love Food Hate Waste programs in New South Wales and Victoria)
- Targeted research by universities, CSIRO, industry associations and other groups
- International literature as guidance, although no data from other countries has been used in the baseline assessment.

Information and data sourced from the UK waste agency Waste and Resources Action Programme (WRAP) indicates the UK Government was in a similar position around five years ago, with significant data gaps and no consistency in data collection. Since then it has addressed many of the major weaknesses and evolved its data framework to progressively improve the dataset, including recasting the original data with refined assumptions from several years of studies.

As part of developing the National Food Waste Baseline, extensive consultation has been undertaken to supplement the existing public datasets. More than 300 organisations were approached to provide data. Of these, 91 provided information, including raw data on waste volumes, indicator data such as composition or loss factors, destination data for waste flows and ancillary information including waste costs and drivers.

This data capture exercise has aligned with the definitional framework for food waste and broadened the base of Australian food waste data, providing a reasonable modelling platform to establish the National Food Waste Baseline and repeatable methodology for future assessments.

### 1.4. Australian waste context

Food waste in Australia is managed at various scales. The earlier segments in the supply and consumption chain with more dispersed locations experience more informal and on-site solutions; segments later in the chain, where operations are often larger and centralised, are served by more formal, industrial scale collection, processing and disposal, covering both solid and liquid waste.

There are a wide range of resource recovery and recycling processes. For recovery of primary production wastes, the main pathways are on-site management, which could include land application and recycling into new bio-based products. For non-agricultural wastes, the main recycling pathways are anaerobic (enclosed) and aerobic (windrow) composting, bio-digestion and alternative waste treatment for the residual waste stream containing food.

The composting and bio-digestion industries are reliant on separated food organics streams from primary production and manufacturing, as well as kerbside collection of household food organics (with or without garden organics).

Alternative waste treatment (AWT) facilities process residual waste from municipal and commercial sectors. There are various classes of AWT, which broadly involve removal of recyclables and hazardous wastes before processing to extract value from the remaining organic fraction, which in terms of food waste can be 30-40% (by weight) in a household residual waste bin. Outputs can include generation of electricity or bio-gas and soil conditioning products for applications including mine rehabilitation, forestry and the turf industry, although this has been defined as land application rather than compost due to uncertainties around the soil benefits<sup>13</sup>.

Solid food waste is also managed through disposal to putrescible landfills, which may include an element of recovery through the capture of the landfill gas generated by decomposing organic waste, to generate energy. Liquid food waste is managed through on-site or third-party liquid waste treatment facilities, with disposal to sewer. The hazardous components associated with food production and hospitality are managed through appropriately licensed hazardous waste treatment facilities, with disposal either to sewer or landfill.

On a non-industrial scale, some food waste is managed through household or community composting or worm farming. These practices are often supported and / or subsidised by local governments.

The destination of food waste is highly influenced by government policy, management costs and end markets. All state governments aim to increase diversion of waste from landfill through policy measures such as explicit resource recovery targets, a landfill levy and financial support for resource recovery infrastructure.

Organic waste has been a particular policy focus for the last decade due to its high environmental impact through generation of greenhouse gases and landfill leachate, and also high potential recoverability. One notable change has been the rise of combined food organics and garden organics collection (FOGO) for households, with the greatest absolute uptake in New South Wales (16 councils) and South Australia, but examples exist in most states. FOGO services have typically been implemented in rural and regional councils due to the proximity to end markets for compost. However, a number of metropolitan councils have also implemented, piloted or considered FOGO services.

Development of waste-to-energy or combustion facilities to process residual waste is an increasing focus of the waste industry, although there are significant regulatory and planning hurdles. The first two large-scale waste-to-energy facilities to receive planning approvals are located in Perth, with the Kwinana waste-to-energy facility announcing in October 2018 that it had secured financial backing to proceed to development.

A basic flow diagram is shown in Figure 4, focusing on the destinations managed by the formal waste management industry, which typically does not service primary production and packing operations.

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<sup>13</sup> The NSW EPA in October 2018 banned application of AWT-derived compost to agriculture and suspended application to mine site rehabilitation and forestry, pending new controls. It stated that a confidential study found limited agricultural benefits.

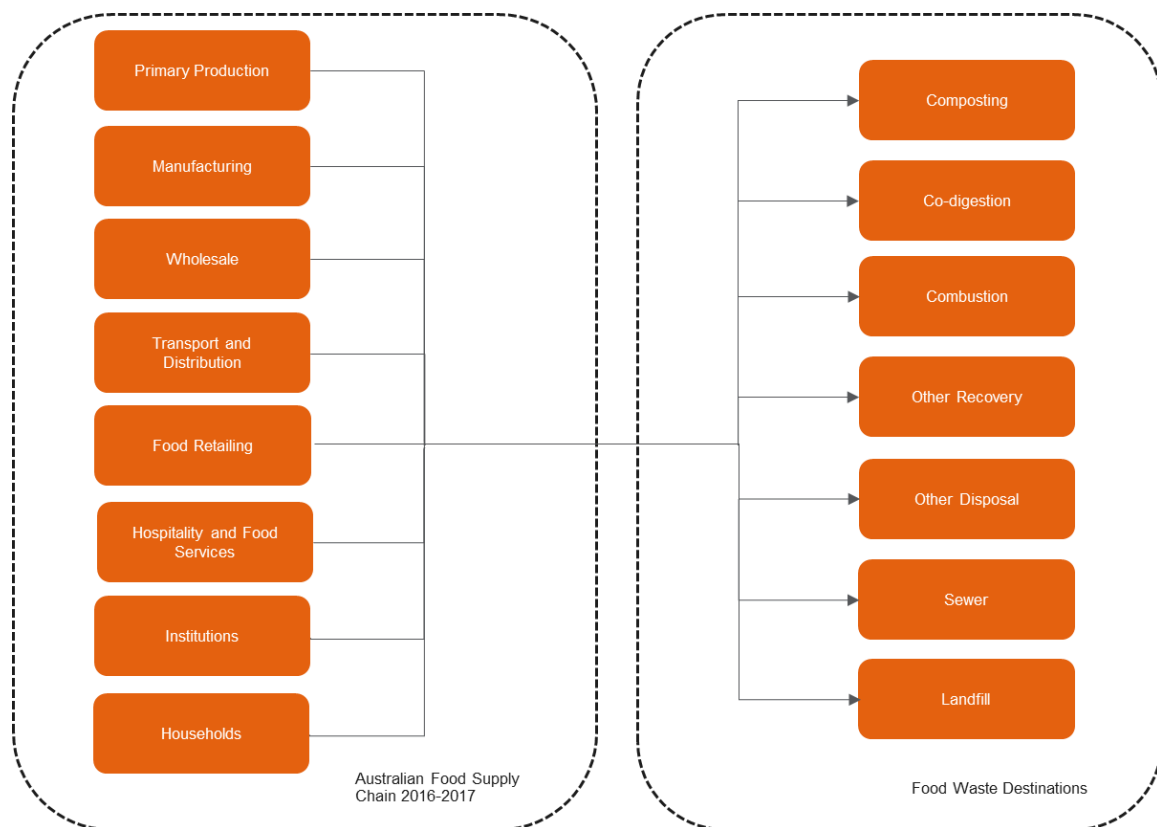


Figure 4: The boundaries and relationship of the food system to the waste management system

## 2. BASELINE METHODOLOGY

### 2.1. Definition, parameters and boundary conditions

The definition of food waste in the National Food Waste Baseline report is based on the flexible framework under the international Food Loss and Waste Accounting and Reporting Standard (FLW Standard), Version 1, 2016<sup>14</sup>.

The standard, which can be used by any entity, provides parameters to consider when defining food waste. This includes the types of material that constitute food, but goes on to categorise food waste via a set of 11 conceptual destinations for the food surplus and waste and its associated inedible parts. Entities then determine which destinations are considered food waste according to their specific context and policy objectives, and which are considered to remain within the food system via activities such as redistribution and repurposing.

The National Food Waste Baseline project has made three modifications to the suite of destinations to suit the Australian context: divided the Other category into two destinations (Disposal and Recovery); deleted Refuse / Discards / Litter due to the lack of datasets; and added Food Rescue. The key parameters and 12 designated food waste and food system destinations in Australia, as adapted from the FLW Standard, are captured in Figure 5, including base year (2016/17), material types, the destinations defined as waste for inclusion in the Baseline calculations, and the system boundary.

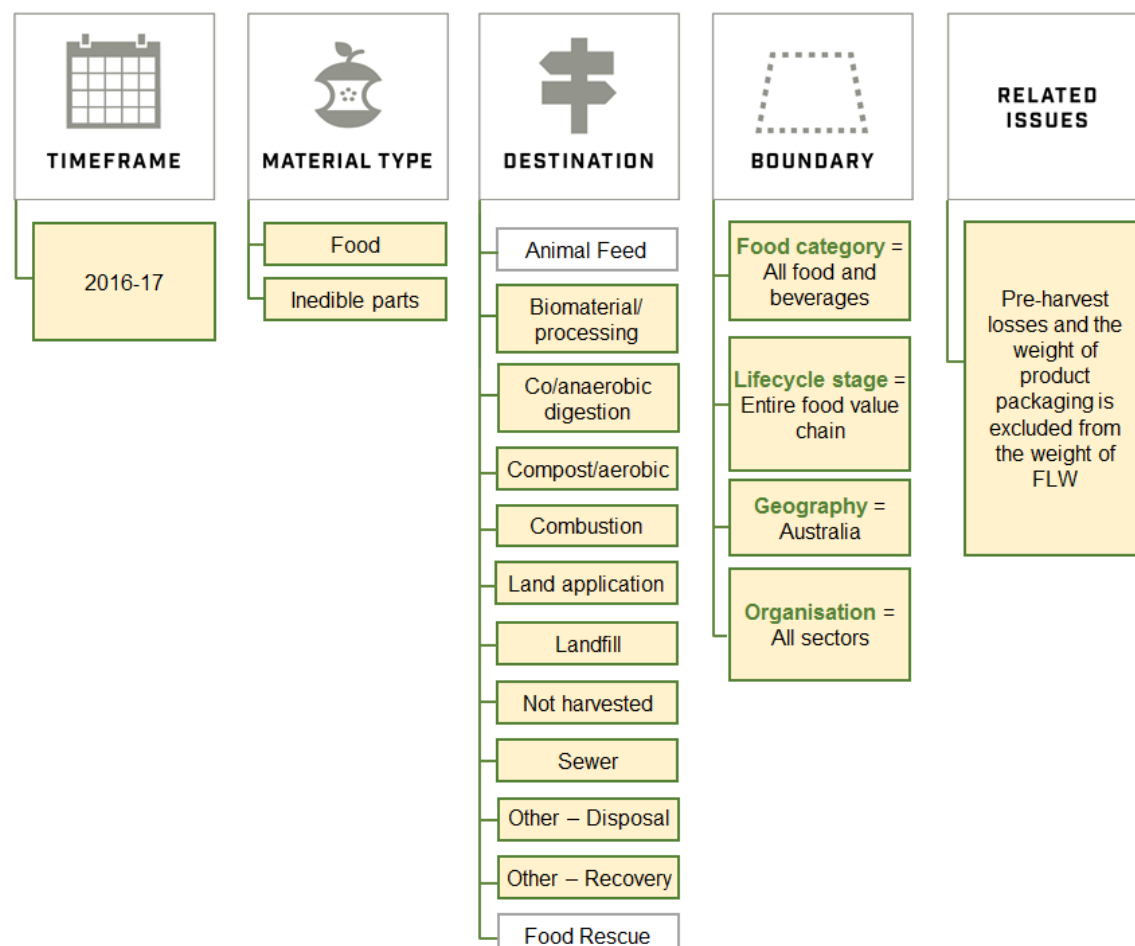


Figure 5: Key National Food Waste Baseline parameters, noting destinations as either food waste (highlighted) or remaining within the food system based on Australian Government policy

<sup>14</sup> Developed by the multi-stakeholder Food Loss & Waste Protocol partnership, <http://flwprotocol.org>



The inedible parts associated with food have been included in the definition of food waste. The implications are significant as inedible parts are a large proportion of food waste. They are also a major challenge to reduce, recover or redistribute, given many types have no nutritional or other value (see Section 2.2 for a definition of inedible parts).

The practical reason is that data on the inedible portion of food waste cannot at this time be extracted from the overall dataset. The edibility of food waste is not of particular concern to food companies, which, as a result, do not typically capture data on the edible and inedible fractions of their food waste stream. As a result, the National Food Waste Baseline is not able to isolate the inedible parts associated with food in order to focus the assessment solely on the edible portion of food waste.

The FLW Standard recommends the inclusion of inedible parts in the baseline assessment, for both definitional and practical reasons. While Australia adopts the FLW Standard approach on the inclusion of inedibility, the suite of potential food waste destinations has been modified to reflect the Australian food context. The approach has divided the 'Other category' into 'Disposal' and 'Recovery', particularly to address scenarios such as recovery or treatment / disposal of hazardous food wastes, with liquid waste in some jurisdictions classified as hazardous, including bio-solids, grease trap sludge and wastes from abattoirs and tanneries.

The inclusion of the 'Food Rescue' category recognises redistribution as an area of particular commercial interest. It is not designated as a waste destination because donations remain within the food system, avoiding food waste.

The other destination not considered food waste is surplus food sent to animal feed. This allocation aligns with the definition adopted in the UK, Canada and New Zealand and developed by Champions 12.3, a group of companies, countries, research agencies and civil society groups established to accelerate progress on the United Nations SDG Target 12.3. It recognises the majority of animals being fed are ultimately destined for human consumption, a recovery loop considered in practical terms to remain within the human food system.

In total, the National Food Waste Baseline defines a set of 12 destinations for food, with food waste being any destinations defined in the Australian context as being outside the human food supply chain. The 12 destinations are further outlined in Table 2.

*Table 2: Description of potential destinations for food, other than direct human consumption*

Destination	Definition*	Status
Bio-based materials / biochemical processing	Converting material into industrial inputs / products. Examples include creating fibres for packaging material; creating bioplastics (e.g., polylactic acid); making "traditional" materials such as leather or feathers (e.g. for pillows); and rendering fat, oil or grease into a raw material to make products such as soaps, biodiesel or cosmetics. Biochemical processing does not include energy generation through anaerobic digestion or production of bioethanol through fermentation.	Food Waste
Co-digestion / anaerobic digestion	Breaking down material via bacteria in the absence of oxygen to generate energy (typically in the form of biogas) and nutrient-rich matter. Co-digestion refers to the simultaneous anaerobic digestion of food waste and other organic material in one digester. This destination includes fermentation, converting carbohydrates – such as glucose, fructose and sucrose – via microbes into alcohols in the absence of oxygen to create products such as biofuels.	
Composting / aerobic processes	Breaking down material via bacteria in oxygen-rich environments to produce organic material (via aerobic processes) that can be used as a beneficial soil additive.	
Controlled combustion	Sending material to a facility that is specifically designed for combustion in a controlled manner, which may include some form of energy recovery (this may also be referred to as energy from waste).	

Land application	Spreading, spraying, injecting or incorporating organic material onto or below the surface of the land to enhance soil quality.	
Not harvested / ploughed in	Leaving crops that were ready for harvest in the field or tilling them into the soil. It applies only to the food portion of the crop, with the exception of the bagasse portion of harvestable sugarcane left in field.	
Other – Recovery	Sending material to a destination that is different from the specific destinations listed above (the FLW Standard destinations), for recovery. This may include recovery of hazardous food waste.	
Other – Disposal	Sending material to a destination that is different from the specific destinations listed above (the FLW Standard destinations), for disposal. This may include treatment and disposal of hazardous food waste at a hazardous waste treatment facility.	
Sewer / wastewater treatment	Sending material to the sewer (with or without prior treatment), including that which may go to a facility designed to treat wastewater.	
Landfill	Sending material to an area of land or an excavated site that is specifically designed and built to receive wastes.	
Food rescue	The process of diverting food from landfill to charities and other organisations who redistribute food in the form of groceries or meals to Australians in need. Rescued food is considered part of the food supply chain, although the distribution pathway is different from that originally intended.	Not a Food Waste
Animal feed	Diverting material grown for human consumption from the food supply chain (directly or after processing) to animals. Material sent to animal feed is not considered food waste.	

\* Based on the FLW Standard, with the exception of Other–Recovery, Other–Disposal and Food Rescue.

## 2.2. Inclusions and exclusions

In addition to the headline parameters in Figure 5, the following key features of the Australian food waste definition are noted.

Table 3: Key inclusions and exclusions in the scope of assessment

Included in Baseline assessment	Excluded from the assessment
<b>The food supply and consumption chain</b> begins at the stage when on-farm primary produce (crops and livestock) is ready for harvest or slaughter, and ends at the end consumer (household, business or institution).	<b>Wastes that are not food</b> or a part / component derived from the food. Examples are the non-food parts of plants (e.g. wheat stubble or left over sugarcane trash), the spent layer hen, soil attached to the crop and packaging such as agricultural film.
<b>The inedible parts of food</b> are either unable to be processed / consumed (e.g. seeds, bones, coffee grounds, skins, or peels) or are considered undesirable under current cultural, social and economic conditions (e.g. chicken feet or offal may be consumed in some countries).	<b>Refuse / Discards</b> are excluded from the baseline calculations due to the lack of data on food material abandoned on land (e.g. litter, open dumps, the portion of harvested crops eaten by pests) or disposed in the sea (e.g. fish catch thrown away or 'slipped' from the net before being taken on board).
<b>The water content</b> of food waste is included where inherent to the material.	<b>Water used in food production</b> that does not become part of the product is not captured.
<b>The food component of sewage</b> from industry and household is included, where possible. Industry estimates are based on researched standard losses	<b>The transport and storage sector</b> has been quantified to facilitate policy focus, but the estimate has not been integrated into the baseline quantification as a discrete sector. This aligns with

Included in Baseline assessment	Excluded from the assessment
for relevant sectors. There is no available data on household food waste disposal to sewer, but the quantity is not considered to be material to the overall assessment.	international practice. Data from the sector is limited and uncertain, with no capacity to isolate logistics-related waste from generation in the receiving sectors, whether the original supplier, the intended receiver, food rescue or landfill (Section 3.15).
<b>Imported foods</b> are considered food waste from the point of use.	<b>Exported foods</b> leave the Australian food system. Only food waste before export is included.
	<b>Non-consumption crops</b> intentionally grown for bioenergy, animal feed, seed or industrial use
	<b>Sugarcane bagasse</b> left over from the sugar milling process and the bagasse proportion from harvest losses left in-field has been excluded. While defined as food waste, this large, single waste stream has been excluded due to its significant skewing of the national food waste estimate, as well as the performance of specific food sectors and states / territories.

## 2.3. Food industry sectors

The scope of the baseline covers the full extent of the Australian food supply and consumption chain and encompasses the key food sectors classified by the Australian Bureau of Statistics (ABS) and Australian and New Zealand Standard Industrial Classification (ANZSIC) (Table 4).

Where possible, major food types within each sector have been reported individually, such as by crop or commodity for processing. However, waste that occurs later in the supply chain (such as in the retail or hospitality sectors and in households) is not able to be practically disaggregated to support discrete reporting by food product. Food waste in these parts of the chain is reported as a single consolidated category.

Table 4: Sectors within the Australian food supply and consumption chain

Sector	Sub-sector	
Primary Production	<ul style="list-style-type: none"> <li>• Fruit &amp; Vegetables</li> <li>• Nuts</li> <li>• Wine Grapes</li> <li>• Crops</li> </ul>	<ul style="list-style-type: none"> <li>• Fisheries</li> <li>• Eggs</li> <li>• Livestock</li> <li>• Milk</li> </ul>
Manufacturing	<ul style="list-style-type: none"> <li>• Fruit and vegetable processing</li> <li>• Oil and fat manufacturing</li> <li>• Grain mill &amp; cereal manufacturing</li> <li>• Bakery product manufacturing</li> </ul>	<ul style="list-style-type: none"> <li>• Sugar &amp; confectionery manufacturing</li> <li>• Other food product manufacturing</li> <li>• Seafood processing</li> <li>• Meat &amp; meat product manufacturing</li> <li>• Dairy product manufacturing</li> </ul>
Transport & Storage	<ul style="list-style-type: none"> <li>• Cold Chain <ul style="list-style-type: none"> <li>– Cold stores</li> <li>– Refrigerated transport</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Ambient <ul style="list-style-type: none"> <li>– Storage</li> <li>– Transport</li> </ul> </li> </ul>

Wholesale & Distribution	<u>Wholesale</u> <ul style="list-style-type: none"><li>• Fruit &amp; vegetable wholesaling</li><li>• Liquor wholesaling</li><li>• General line grocery</li><li>• Other grocery wholesaling</li><li>• Fish &amp; seafood wholesaling</li><li>• Meat, poultry &amp; smallgoods wholesaling</li><li>• Dairy produce wholesaling</li></ul>	<u>Distributors</u> <ul style="list-style-type: none"><li>• Fresh produce distributors</li><li>• Small good distributors</li><li>• Dry grocery distributors</li><li>• Bread distributors</li><li>• Wholesale egg distributors</li><li>• Dairy distributors</li></ul>
Food Retailing	<u>Grocery</u> <ul style="list-style-type: none"><li>• Full service supermarkets</li><li>• Independent supermarkets</li></ul> <u>Convenience</u> <ul style="list-style-type: none"><li>• Independent stores</li><li>• Convenience stores</li></ul>	<u>Specialised</u> <ul style="list-style-type: none"><li>• Fruit &amp; vegetables</li><li>• Delicatessen</li><li>• Bakery, cake &amp; pastry</li><li>• Butcher, poultry &amp; seafood</li></ul>
Hospitality and Food Services	<ul style="list-style-type: none"><li>• Accommodation (the food and beverage outlets within hotels and in-room services)</li></ul>	<ul style="list-style-type: none"><li>• Cafes, restaurants &amp; takeaway food services</li><li>• Pubs, taverns &amp; bars</li><li>• Clubs</li></ul>
Institutions	<ul style="list-style-type: none"><li>• Residential aged care</li><li>• Education and training</li><li>• Child care</li></ul>	<ul style="list-style-type: none"><li>• Health care &amp; social assistance</li><li>• Correctional &amp; detention services</li><li>• Defence</li></ul>
Household	No disaggregated categorisation	
Food Rescue	No disaggregated categorisation	
Waste Management	Outside the food system boundary, providing recovery and disposal services	

## 2.4. The baseline assessment methodology

Quantifying national food waste generation by building up the national baseline from multiple industry sectors across the supply and consumption chain is a complex modelling task, particularly given the large number of sub-sectors in some industries.

In order to scale up collated data for each major primary commodity type and industry sub-sector to produce a national estimate, a best-fit approach has been used for each sector, based on the available data on industry production and waste generation.

It is noted that data on food waste is a challenge on many levels. Many organisations have no reporting frameworks to collect food waste data. What data is collected can be highly variable, with uncertain protocols on data management, food waste definition and transparency on end destinations.

The approach to data collection and modelling was designed to address these issues to the fullest extent possible, including verifying the approach with experienced food waste practitioners in Australia and the UK, assessment of best practice internationally and direct consultation with local stakeholders to gather data and validate assumptions.

The modelling approach, data sources and limitations are detailed in the follow sections, starting with a summary of the overall approach.

**Step 1: Confirm sectors for coverage** – The sector coverage by the baseline is in line with international practice, notably the Food and Agriculture Organisation (FAO), and each sector is individually defined by the ANZSIC and reported on by the ABS, which is important for industry profiling.

**Step 2: Profile and map each sector** – To understand the relevant industry dynamics and waste flows in each sector, a high-level profile was developed for each one that covered: industry scale (revenue, employees or businesses), breakdown of business sizes, the concentration of competition, waste drivers and any indication on waste generation rate. The system boundary and waste flows were mapped for each sector (Section 2.5) to ensure there were no data gaps or double counting.

**Step 3: Develop the data framework** – The data framework and associated data collection template (Appendix C), which were reviewed externally, provide a concise and logical data template, in line with the definition of food waste and end destinations. The framework captures overall company data for 2016/17, along with food waste generation by type and jurisdiction, a breakdown of waste destinations and contextual information about waste issues and cost. Multiple options for quantification units were permitted to minimise barriers to data submission, with all entries later converted to tonnes.

**Step 4: Stakeholder engagement plan** – A structured approach was taken to engaging stakeholders for data acquisition. For companies, this was primarily based on companies with the largest market share as they are the most representative of sector operating practices and waste dynamics, and more likely to collect and report waste data. Small to medium enterprises (SMEs) were also targeted in order to estimate their food waste contribution and illustrate differences in drivers and opportunities. The other key stakeholders approached were:

- Industry groups, which in most cases had limited data on industry-wide generation or typical loss factors, but were useful in setting context and helping engage their sector
- Research organisations, including CSIRO, Rural Research and Development Corporations (RDCs), Cooperative Research Centres (CRCs) and universities
- State government agencies and departments, including environment, waste, agriculture and industry, and public sector operating entities such as health, aged care, education and corrections
- Australian government departments, including environment, defence and agriculture.

**Step 5: Data collation and analysis** – All food waste data collected from stakeholders (including data that was provided in confidence) and sourced from food waste literature was collated into an Excel-based model. The data for each sector was analysed to determine the level of coverage, the types of data, the size of data gaps and any double counting. In all sectors, modelling has been required to scale up the available data to an industry estimate. The resulting reliance on indicative waste factors and assumptions varied by sector, but in some cases was relatively high (Section 5), reflecting the status of food waste data ahead of the first National Food Waste Baseline. Data coverage, currency and accuracy is expected to improve over time.

**Step 6: National Food Waste Baseline** – The sector analysis was consolidated to estimate food waste generation in Australia, and to highlight the major generators of food waste by industry and by state / territory.

The modelling methodology and the principal data sources for each sector have been summarised in Table 5, and detailed further in Appendix B.

Table 5: The modelling approach for each food sector (detailed further in Appendix B)

Food Supply Chain Sector	Modelling Approach	Data and Investigation Limitations	Confidence around material waste estimates
Primary Production	Using loss rates provided by primary producers and industry groups, Arcadis modelled waste based on national production statistics (ABS Agricultural Commodities 2016/17)	<ul style="list-style-type: none"> <li>Limited number of primary producers participated.</li> <li>Stakeholders reported concerns with the derivation and quality of ABS national production statistics, and very few industry groups were able to provide alternatives.</li> </ul>	<p>The key estimates that have a material impact on the national baseline assessment are listed in this section. They are discussed in terms of certainty, confidence and the means by which they were derived.</p> <p><b>Broadacre Crops</b> (approx. 2.27 million tonnes)</p> <ul style="list-style-type: none"> <li>Broadacre Crops are a significant Australian commodity, so minor loss rates are amplified by scale. Sugarcane and 'other pulses' were the two largest sources. Sugarcane harvest losses of 5-15% were determined by Sugar Research Australia through a large and current research project. Losses from pulses are based on FAO food loss estimates for Oceania.</li> </ul> <p><b>Vegetable Production</b> (approx. 816,000 tonnes)</p> <ul style="list-style-type: none"> <li>Farmers who participated in the consultation reported significant on-farm loss rates, with particular reference to high quality standards specified by their buyers. High loss rates are supported by other research, including Rogers 2013 and FAO food loss estimates for Oceania. The overall estimate was developed by comparing national production statistics to the estimated percentage losses reported by baseline project respondents. These figures were compared against local research findings and FAO food loss estimates. The accuracy of these estimates is limited by the accuracy of the reported proportional loss estimates, and the Australian Agricultural Production Statistics.</li> </ul>
Manufacturing	<ul style="list-style-type: none"> <li>Packing, grain processing and abattoir data estimated as losses to national production statistics (ABS Agricultural Commodities 2016/17)</li> </ul>	<ul style="list-style-type: none"> <li>The food manufacturing sector is highly complex and diverse, with 22 manufacturing categories captured by the ABS, being: <ul style="list-style-type: none"> <li>Meat Processing, Poultry Processing, Cured Meat and Smallgoods Manufacturing, Seafood Processing</li> </ul> </li> </ul>	<p><b>Grain Manufacturing</b> (approx. 882,000 tonnes)</p> <ul style="list-style-type: none"> <li>The grain manufacturing loss estimates are from the Feed Grain Supply and Demand Report 2016, as well as calculated estimates based on production statistics and the percentage loss estimates of project respondents. There is confidence in the referenced material, as well as calculated</li> </ul>



Food Supply Chain Sector	Modelling Approach	Data and Investigation Limitations	Confidence around material waste estimates
	<ul style="list-style-type: none"> <li>Animal feed statistics from the Feed Grain Supply and Demand Report 2016 were used to understand mill mix, malt combing and other waste streams. A very significant volume of grain goes to animal feed (~8MT pa), however the intended use is both as human and animal food (depending on quality) and the animal component has not been defined as a waste from the human food system.</li> <li>Where waste generation figures were provided for some organisations along with employment or turnover, this was converted to an industry waste generation estimate using the organisation's market share.</li> <li>For manufacturing groups where no data was available, generalised food manufacturing rates were applied to an indicative average number of staff within each of small, medium and large enterprises (ABS Counts of Australian Businesses,</li> </ul>	<ul style="list-style-type: none"> <li>Milk and Cream Processing, Ice Cream Manufacturing, Cheese and Other Dairy Product Manufacturing,</li> <li>Fruit and Vegetable Processing,</li> <li>Oil and Fat Manufacturing</li> <li>Grain Mill Product Manufacturing, Cereal, Pasta and Baking Mix Manufacturing, Bread Manufacturing (Factory based), Cake and Pastry Manufacturing (Factory based), Biscuit Manufacturing (Factory based), Bakery Product Manufacturing (Non-factory based)</li> <li>Sugar Manufacturing, Confectionery Manufacturing, Potato, Corn and Other Crisp Manufacturing,</li> <li>Other Food Product Manufacturing n.e.c. (not otherwise classified)</li> <li>Soft Drink, Cordial and Syrup Manufacturing, Beer Manufacturing, Spirit Manufacturing, Wine and Other Alcoholic Beverage Manufacturing.</li> <li>It is not possible within the scope of the project to access raw data and information for every manufacturing category. The challenges were further limited by the low response rate and the dated nature of Australian food waste manufacturing studies. As such, many categories were modelled using a standard food manufacturing loss rates derived from the NSW EPA C&amp;I Waste Generator Pilot Audit.</li> </ul>	<p>estimates, as it is based on industry intelligence. However, consultation indicated that the majority of grain waste goes to animal feed uses, which is not classed as food waste.</p> <p><b>Poultry Processing</b> (approx. 823,000 tonnes)</p> <ul style="list-style-type: none"> <li>A major chicken producer provided information that the average weight of a chicken is 2.7kg, with approximately 33% of the chicken being wasted. The estimated loss rate was applied to chicken numbers reported under the Australian Agricultural Production Statistics. However, consultation indicated that the majority of poultry waste goes to animal feed uses, which is not classed as food waste.</li> </ul> <p><b>Fruit and Vegetable Pack House</b> (approx. 422,000 tonnes)</p> <ul style="list-style-type: none"> <li>Project respondents reported significant losses at the pack house when fruit and vegetables do not meet the standards of the buyers. Generalised pack house loss estimates provided by the respondents were applied to all fruit and vegetables, from the Australian Agricultural Production Statistics. As generalised loss estimates were applied across all the fruit and vegetable types, there is opportunity to improve the accuracy of the estimates over time. Participation by the primary producers was limited and loss estimates are therefore based on the observations of few producers. The reported loss estimates are significantly larger than the FAO post-harvest loss estimates for Oceania. A significant proportion of this stream goes to animal feed which is not included in the figure above.</li> </ul> <p><b>Dairy Processing</b> (approx. 630,000 tonnes)</p> <ul style="list-style-type: none"> <li>Whey production is predominantly generated from cheese manufacturing, with smaller quantities through yoghurt production. According to Dairy Australia, approximately</li> </ul>

Food Supply Chain Sector	Modelling Approach	Data and Investigation Limitations	Confidence around material waste estimates
	including Entries and Exits).		337,000 tonnes of cheese was manufactured in 2016/17 <sup>15</sup> . A waste generation rate of 8.12 L per 1kg cheese was applied, based on consultation. This estimate is consistent with the whey production reporting of project participants and the literature <sup>16</sup> . Also from consultation, it is estimated that 77% of whey is dried to recover whey solids by the larger operators that dominate the market. Dairy Australia reports 50,000 tonnes of whey products were recovered in 2016/17 for ingredients in human and animal foods, and is therefore not food waste <sup>17</sup> . One major operator is thought to apply whey to land without recovery whilst it is generally not viable for smaller operators to recover whey, so it becomes a food waste in those cases.
Wholesale	Wholesale figures are estimated based on waste generation rates / FTE and employment statistics (ABS Counts of Australian Businesses, including Entries and Exits). This compared against other estimates based on waste/business.	Wholesale waste generation / FTE rates are based on a limited number of surveys from wholesalers/distributors and markets.	Confidence level in this sector is low as waste rates were derived from small samples. The overall impact is not considered material given the estimated scale of food waste produced.
Retail	Food waste from retail has been estimated by waste tonnes / '000 revenues (\$), multiplied by aggregated industry turnover (ABS Retail Trade).	Food retailing waste estimates were based on publicly available waste estimates for major supermarkets and datasets of large shopping centre organisations.	The data that was available represented the major operators in this sector so there is a moderate level of confidence that the estimates are representative of the broader sector.

<sup>15</sup> *Australian Dairy Industry In Focus 2017*, Dairy Australia

<sup>16</sup> Hauser 2017, Pintado et al. 2001

<sup>17</sup> *ibid*



Food Supply Chain Sector	Modelling Approach	Data and Investigation Limitations	Confidence around material waste estimates
Hospitality and Food Services	Industry figures are estimated based on waste generation rates / FTE and employment statistics (ABS Counts of Australian Businesses, including Entries and Exits).	Hospitality and Food Service waste generation/FTE rates are based on a limited number of surveys and published figures.	Confidence level in this sector is moderate as waste rates were derived from published audit reports. The overall impact is not considered material given the estimated scale of food waste produced.
Institutions	<p>Higher Education, High Schools and Primary School food waste is modelled according to the number of enrolled students in Australia.</p> <p>Prison waste was extrapolated by the number of inmates.</p> <p>Health sector waste was modelled according to the number of patients / residents.</p> <p>Aged care sector waste was modelled per bed / per day.</p> <p>Child care sector waste was modelled on food waste per employee.</p>	<p>Large data sample for food waste in schools to be analysed further and estimates to be further refined. However, the results were considered too high so waste loss rate / student from an international publication was used (WRAP Food Waste in Schools).</p> <p>Several university food waste estimates provided across several states.</p> <p>Large data sample for prisons, with opportunity for further analysis and refinement of estimates.</p> <p>Hospital waste based on audit results from a large state government investigation.</p> <p>Aged care waste was based on South Australian Government data on waste generation in 23 aged care facilities, with the food waste percentage estimated from one best practice facility.</p> <p>Child care waste was derived from NSW EPA data on waste per employee, and Productivity Commission information on sector employment.</p> <p>Department of Defence food waste data was provided only as financial costs of waste management, but this could not be converted to weight for integration into the baseline assessment.</p>	Confidence level in this sector is low as waste rates were derived from small samples. The overall impact is not considered material given the estimated scale of food waste produced.

Food Supply Chain Sector	Modelling Approach	Data and Investigation Limitations	Confidence around material waste estimates
Household	Household waste generation estimated by modelling forward previous aggregated state government estimates for the National Waste Report 2016.	<p>Few states were able to provide more recent estimates. Queensland and Victoria were the only states to provide new estimates.</p> <p>Major changes in food waste collection in NSW (via a combined food and garden organics collection, FOGO) were incorporated using NSW EPA analysis of collection performance in councils with FOGO services.</p> <p>Food waste estimates from the National Waste Report (and a consistent composition estimate) were used for the other states.</p>	<p><b>Household Waste</b> (approx. 2.5 million tonnes)</p> <p>This estimate is based on figures provided by state and territory governments, as well as estimates from the National Waste Report 2016. These figures can be used with reasonable confidence as they are developed with a consistent estimation methodology, and based on real data.</p>
Transport & Storage	Food waste was based on Australian Government estimates of percentage losses for nine food types across the food chain, sourced from the Project on Food Losses and Waste System (FLOWS) project by the Asia-Pacific Economic Forum (APEC) <sup>18</sup> . Scale factors are based on national production statistics.	<p>Very limited current data was available on food waste in the logistics sector. The APEC FLOWS data is high level and based on 2011 data. The derivation is not known. The assumption is that loss rates have not significantly changed, but the loss rates were correlated with current production data (2016/17).</p> <p>The food waste from transport has not been integrated into the baseline quantification as a discrete industry sector as there is insufficient confidence in the data to isolate transport-related food waste from that reported in other sectors.</p> <p>It has been separately quantified to provide indicative estimates to inform policy decisions and establish a baseline for subsequent iterations of the national food waste assessment.</p>	Confidence level in this sector is low as waste rates were derived from generic loss rates which could not be verified by stakeholder data. The overall impact is not considered material given this sector is not additional to the total food waste estimate.

<sup>18</sup> APEC-Project on Food Losses and Waste System (2016), Asia-Pacific Economic Forum (2016).

## 2.5. Data quality assessment

To provide greater clarity on the quality of data underpinning the estimates, the above data source and constraints have been consolidated into a qualitative data quality rating for each sector and some of the major sub-sectors (Table 6).

Table 6: Qualitative rating of data quality

Food sector / sub-type	Industry production data source	Data quality - Production*	Waste generation / loss rate estimate source	Estimate quality - Waste
<b>Primary Production</b>				
Broadacre crops	ABS Agricultural Commodities data 2016/17	High	Industry consultation and broad literature values	Low
Fruit, nuts, grapes		High	Limited stakeholder input and FAO loss rates, applied to all crops	Low
Vegetables		High	Industry estimates or literature values for most crops	Medium
Livestock (eggs only)		High	Industry / literature estimates	Medium
<b>Manufacturing</b>	Mix of production volumes from ABS, literature data and ABS employee numbers in each enterprise category	Medium	Mix of stakeholder and literature estimates (some quite dated), supplemented by FAI loss rates.	Low-Medium (varies)
<b>Transport</b>	ABS Agricultural Commodities data 2016/17	High	FAO generic loss rates	Low
<b>Wholesale</b>	ABS industry employee numbers	High	Limited stakeholder estimates	Low
<b>Retail</b>	ABS industry turnover	High	Stakeholder estimates and reported data for major operators	Medium
<b>Hospitality</b>	ABS industry employee numbers	High	Industry waste audits	Medium
<b>Institutions</b>				
Childcare, schools, higher education	ABS Student numbers	High	Generic literature values	Low

Prisons	ABS prisoner numbers	High	Stakeholder estimates	Medium
Aged care, hospitals	Bed / patient numbers from industry data	High	Generic literature values and SA EPA data on aged care facility waste	Medium
Child care	Employment (FTE) from Productivity Commission	High	NSW EPA, Bin Trim	Medium
<b>Households</b>	Waste tonnages to landfill / composting, from National Waste Report 2016 (2014/15 data), supplement with new published data from some states	Medium	National Waste Report, food content in residual MSW from audits	Medium
<b>Food Rescue</b>	NA	-	Tonnages and source estimates from major operators	High

\* Production data quality is rated as High where from a reliable public source (such as ABS), based on actual data (not estimates) and 2016/17 estimates.

## 2.6. Data sources and coverage

A structured data collection strategy ran from March to May 2018, collating publicly available sources and new data through direct engagement with industry associations, research groups, federal, state and local government agencies and individual companies. Stakeholders were selected from across the supply and consumption chain and in alignment with the conceptual definition of the Australian food system in Table 4.

Different types of data have been collected, both by intention and according to the information and metrics that were available from stakeholders. The main data types are:

- Industry level data – data on waste generation, destinations and practices across an industry or association membership
- Company level data – specific waste and company profile data to support the sector's information base and inform modelling
- Inventory data – generic loss factors and waste ratios for specific activities, such as the industry standard for on-farm crop losses or waste per food service employee
- Sector profile data – information on each sector to support modelling to scale up the results across an industry.

More than 300 companies and other organisations were invited to provide data, with 91 submitting some level of data and others providing discussion, anecdotal information and informal estimates to help validate the results. The primary focus was on companies with the largest market share as they were considered most representative of their sector's operating practices and waste dynamics and make the largest contribution to waste generation. Wherever possible, small and medium sized enterprises have also been engaged to provide a perspective on waste generation and destinations within smaller operations, which for multiple reasons may differ from larger companies.

Effort was distributed according to the complexity of the sector and its anticipated scale of food waste generation. Greater focus was given to sectors such as primary production and manufacturing that feature multiple food types and food-related companies.

Table 7 provides a breakdown of the number of stakeholders engaged in each major sector as well as the data response rate. Where data was not available, organisations were often willing to provide broader, qualitative context around business operations and waste dynamics, and informal waste generation or composition estimates that supported subsequent review of quantitative data.

*Table 7: Stakeholder data submissions, by sector*

Sector	Invited	Provided some data	Assessment of coverage*
Primary Production	49	19	Low
Manufacturing	57	17	Low
Transport & Storage	12	6	Low
Wholesale	15	1	Low
Retail	24	9	Medium
Hospitality and Food Services	71	12	Low
Institutions (organisations)	61	14	Medium
Household (state, territory and local governments)	9	6	High
Food Rescue	7	5	High
Other (government agencies, research)	4	2	-
<b>Total</b>	<b>309</b>	<b>91</b>	<b>-</b>

\* An amalgamated assessment based on the number of respondents, a high level estimate of collective market share (Low: 1-30%, Medium: 31-70%, High: >70%) and the type of information provided.

### 3. FOOD SECTOR PROFILES

In order to define the Australian food system, the boundaries, features and linkages of the principal food sectors and activities have been mapped at a high level. This system mapping ensures comprehensive coverage of food waste activities and flows, and minimises the likelihood of gaps and double counting that would skew the data.

This section provides a definition of the major food sectors as identified by the ABS and ANZSIC (discussed in Section 2.3). The structure and dynamics of each sector are described, along with the type(s) of food material / product, key food material flows and an overview of waste drivers and types. It combines information from the public domain with findings from the consultation with industry and other stakeholders.

The first eight sections are primary production commodity types (Sections 3.1 to 3.8), with the subsequent six sections addressing sectors along the supply and consumption chain (Sections 3.9 to 3.14).

#### 3.1. Primary Production: Fruit & Vegetables

##### 3.1.1. Sector Definition

The fruit and vegetable segment is one of the primary agricultural industries within the food supply and consumption chain. It features a highly diverse mix of produce types, with the structure and dynamics of the supply chains and associated waste varying for each type.

Food waste across the fruit and vegetable supply and consumption chain is among the highest of all primary production segments<sup>19</sup>. The rate and location of loss will vary between types of produce, with 10% applied across all fruit types and a range of losses for vegetable types, commonly 30-35% but with some outliers (e.g. 10% and 70%).

The segments of the fruit and vegetable sector include: indoor hydroponic farming, outdoor industrial farming, undercover farming, organic farming and vegetable wholesale and processing.

There are an estimated 85,681<sup>20</sup> farms in Australia. Of fruit and vegetable farms, more than 15,000 are classed as small to medium size, with over 60% classified as non-employing enterprises<sup>21</sup> that are either family run or owner operated. The hydroponic / undercover farming sub-sector is far more industrialised.

The majority of fruit and vegetables grown in Australia are for the domestic market, with only 7% being exported in 2013/14, though fruit exports are expected to rise over the coming years as demand in Asia intensifies<sup>22</sup>. Australia imported 8% of fresh and processed fruit and vegetables in 2016/17<sup>23</sup>.

Figure 6 maps the boundary and food / waste flows within the sector for system definitional purposes. The flow diagrams include fruit and vegetables as ingredients within manufactured products, and their associated waste outcomes.

##### KEY SECTOR FEATURES

- **Industry profile:** High diversity of crop types, growers and market dynamics. Mainly small owner-operated or family-run businesses; over 60% are non-employing enterprises
- **Revenue (2016/17)\*:** \$9.9 billion
- **Businesses:** 85,000
- **Waste profile:** High diversity by crop type and even between similar farms; more waste among perishable crops
- **Other issues:** Seasonal / climate variability; harvest rate impacted by commercial factors.
- **Data quality:** Very limited waste data, ABS industry data primarily economic

<sup>19</sup> APEC-Project on Food Losses and Waste System (2016), Asia-Pacific Economic Forum (2016).

<sup>20</sup> Food, Fibre & Forestry Facts (2017), National Farmers Federation

<sup>21</sup> Fruit and Vegetable Processing in Australia 2017, IBIS World, 2017

<sup>22</sup> Agricultural commodities: March quarter 2018, ABARES, 2018

<sup>23</sup> Australian Horticulture Statistics Handbook 2016/17

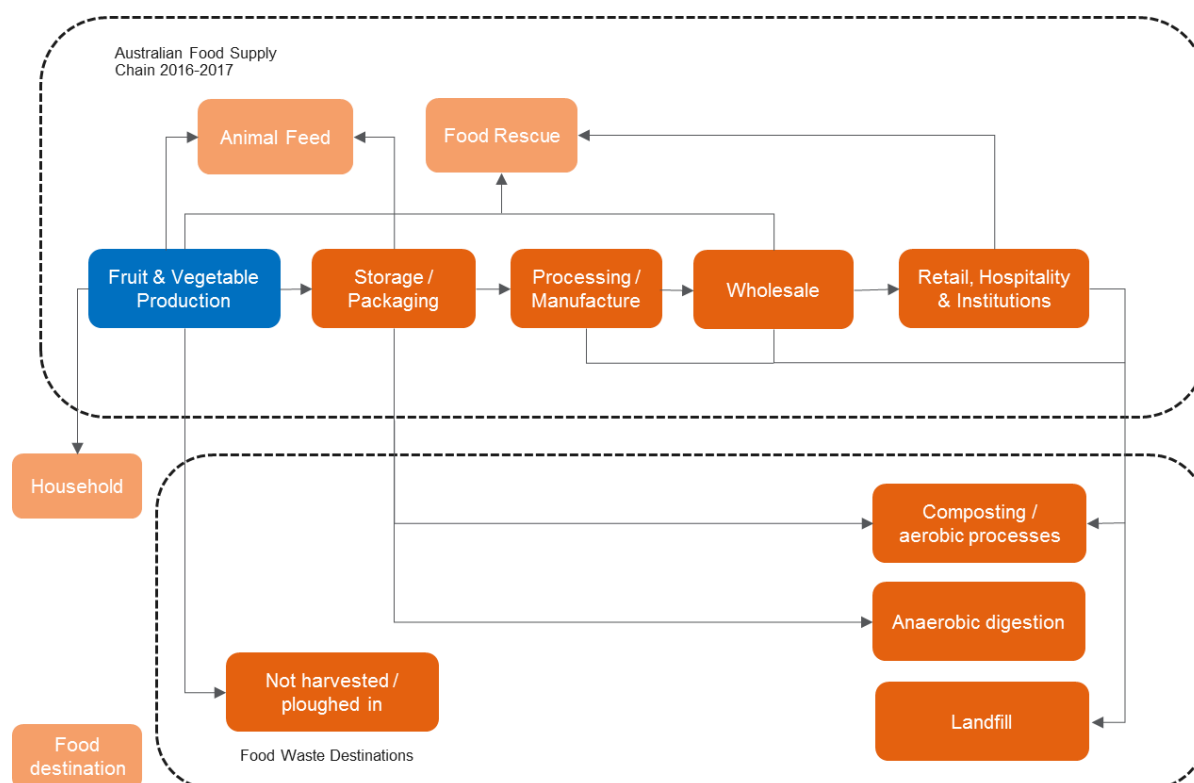


Figure 6: The fruit and vegetable sector's system boundary and destinations

### 3.1.2. Waste Generation

Fruit and vegetables as a category has large loss rates before produce reaches the farm gate<sup>24</sup>, and depending on product type will experience further significant waste in storage and packing. Food waste addresses the harvestable part of the fruit or vegetable, such as the apple or tomato, and any associated inedible parts of that food produce, but does not include the parent plant that remains on-farm.

The drivers of food losses within the sector are numerous, categorised broadly as on-farm damage, market forces, cosmetic standards, perishability and processing and transport losses. Among the market factors are price variation, which may make it uneconomic to harvest, and challenges securing seasonal employees for picking.

Product deterioration is a particular challenge due to the long distances between farm and table. The fruit or vegetable must be harvested and stored appropriate to its shelf-life so it can be delivered to market effectively. For perishable produce, this can involve a complex cold chain of refrigerated transport and facilities, with one stakeholder citing a strawberry chain with 17 stages.

Food loss rates were provided by primary producers, industry groups and research organisations (Section 2.4).

The National Food Waste Baseline estimates the fruit and vegetable production sectors respectively generated 174,000 tonnes and 816,500 tonnes of on-farm food waste that was not harvested and / or ploughed in, with another 336,500 tonnes of vegetables diverted to animal feed and is not food waste. Further details on primary production are provided in Section 5.2.

It is noted that approximately 422,000 tonnes of fruit and vegetables went to waste at pack houses (accounted for in manufacturing, Section 3.9), and was mostly sent for composting. Estimated losses of approximately 840,000 tonnes were associated with fruit and vegetable processing, such as canning and frozen goods, but this stream was primarily redistributed to animal feed outlets. Smaller

<sup>24</sup> APEC-Project on Food Losses and Waste System (2016), Asia-Pacific Economic Forum (2016).

quantities fruit and vegetables were also donated to food rescue from primary production and pack houses, but are not counted as food waste.

## 3.2. Primary Production: Nuts

### 3.2.1. Sector definition

Nut production is defined as a horticultural activity, which broadly includes fruits, vegetables and flowers. The nut sector contains eight food commodities, comprising seven types of tree nuts and one legume (peanuts), and had a gross value of over \$830 million in 2016/17.

Production has been growing strongly at around 5-6% per annum in recent years, making Australia the largest producer of macadamias and second largest producer of almonds in the world.

The seven tree nuts are almonds, chestnuts, hazelnuts, macadamias, pecans, pistachios and walnuts. Almonds have by far the largest market share, accounting for more than half of Australian nut production, followed by macadamias at around a third of production, and peanuts (13%). The remaining five tree nuts are not discussed further in this report as they represent much smaller quantities and there is no individual ABS or ABARES data.

At the farm level, there are approximately 2,000 businesses dedicated to almonds, macadamias and peanuts, primarily in New South Wales, Queensland and Victoria. Farm size and ownership structure is diverse, ranging from family-owned orchards to commercial farms at medium and large scales.

Nut processing/manufacturing is undertaken in a relatively few, centralised facilities, typically involving the top tier growers either within an industry co-operative or as an owner or part-owner. At this stage, nuts are generally dried (to maximise shelf life and quality of the end product), cracked (removed from their shell, if required), graded (by size and quality) and packaged.

Not all nuts are removed from their shell as some customers/markets prefer in-shell nuts, for example, in-shell macadamias are very popular with the Chinese export market. At this stage, nuts may also be further processed into nut products such as nut meal or oil.

Australian nuts are heavily consumed by the local market, with shortfalls in supply met by imports. Processed nuts and nut products are sold via the wholesale market to retail, which is dominated by the major supermarkets, and food manufacturing as inputs into goods such as health food snacks, confectionary and patisserie/bakery. It is also a natural additive to some beauty products, in which case it is considered a loss to the food system.

Exports are increasing as production volumes have grown and global demand rises, with nuts accounting for 45% of all horticultural exports.

The food / waste flows and system boundary for nut production are illustrated in Figure 7.

#### KEY SECTOR FEATURES

- **Industry profile:** A rapidly growing sector, dominated by almonds, macadamias and peanuts.
- **Revenue (2016/17):** \$838 million
- **Number of businesses:** 1,100
- **Waste profile:** Mostly shells and husks from cracking in the manufacturing stage.
- **Other issues:** Nut exports are expanding, with much of the waste occurring domestically.
- **Data quality:** Low response rate, data provided was at relatively high level.



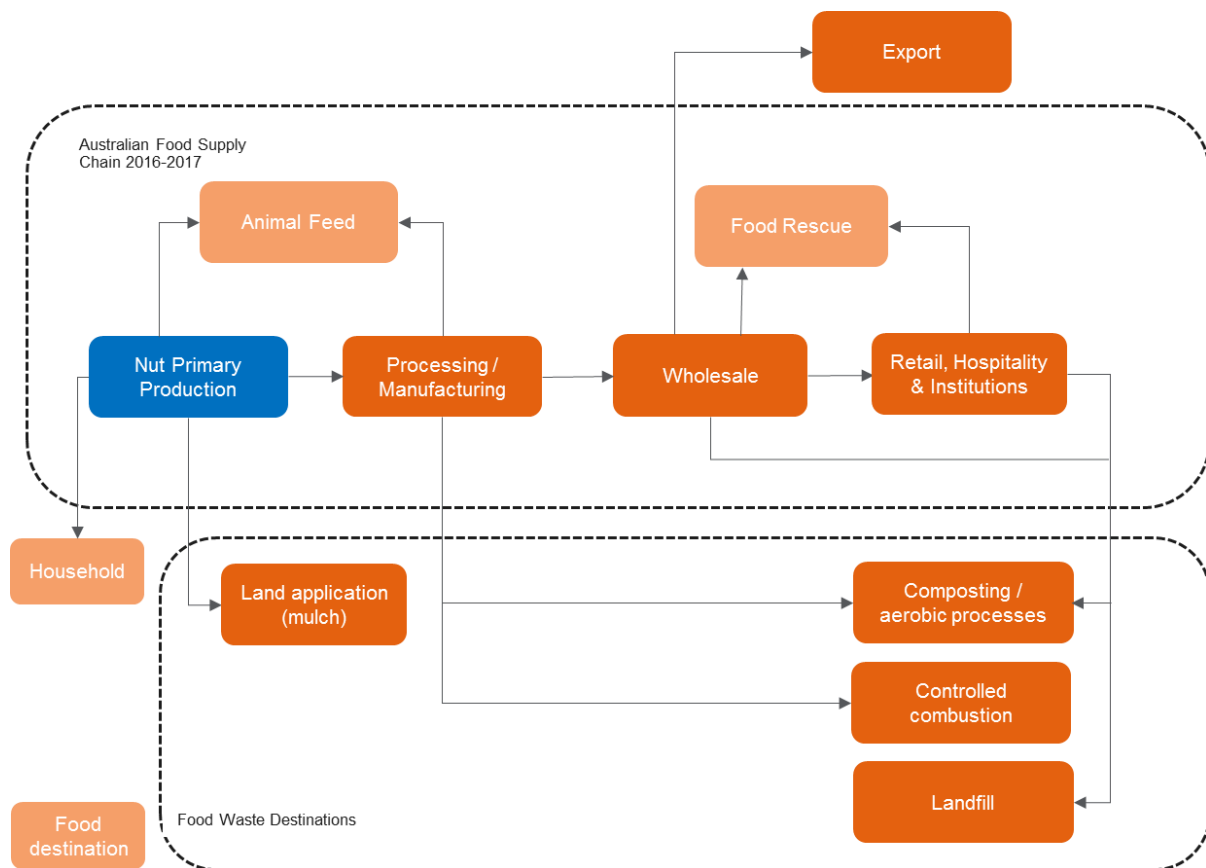


Figure 7: The nut growing sector's system boundary and destinations

### 3.2.2. Waste generation

On-farm nut waste is minimal, with the main being damage through storm / weather events. However, a significant amount of food waste occurs at the processing / manufacturing stage, estimated at 34% of inputs overall across the sector. This waste is mostly inedible by-products of cracking, being shells and husks for nut types where these are removed during manufacturing, although some nuts are sold in-shell and generate very minimal waste.

Shells / husks are a woody waste stream that is classified as an inedible component of food but defined as food waste under the National Food Waste Strategy definition. The hull and shell account for around 55% of the weight of an almond and up to 70% for macadamias. A large proportion of this is recovered for off-site applications such as mulch (land application) or animal feed (a food destination), and more recently as feedstock for on-site controlled combustion to power the shelling / husking process.

Other waste drivers include quality rejects in the processing stage and spoilage / damaged packaging at the wholesale and retail stage. However, waste in these areas is minimal as companies can generally downgrade the nuts into meal or paste for milk, which keep them in the human food chain.

The National Food Waste Baseline has not estimated nut waste on-farm due to very low quantities of food waste. Nut waste in manufacturing accounted for 82,500 tonnes in 2016/17, based on the derived loss rates for the different nut types, with 90% sent to compost and the rest to combustion. Further details are provided in Section 5.2.

### 3.3. Primary Production: Wine Grapes

#### 3.3.1. Sector definition

Unlike many food types, wine grapes can be easily traced throughout the entire supply and consumption chain due to a retail structure that only sells alcohol through licensed stores. The key aspects of the supply and consumption chain are wine grape growing, wine manufacturing, and distribution of wine to retail and hospitality outlets, typically via wholesale.

Wine grapes dominate the grape growing industry, representing approximately 90% of the total grape crop volume, with the remainder being table grapes grown for direct consumption (both fresh and dried). Different grape varieties contribute to production of red, white and sparkling wine.

The majority of grape producers are small-scale independent growers who sell their grapes to Australian wine producers under contract. Of total wine grape crush, it is estimated that the majority of wine grapes are purchased from grape growers rather than grown by the winery.

The Australian wine industry is the sixth largest wine producer in the world. It is highly competitive, with the four largest wine producers collectively accounting for only 37.1% of the domestic market share. The largest companies own multiple brands and sites and are active across key segments of the supply and consumption chain, including grape growing, wine manufacturing, and distribution of their wine both locally and internationally. The remaining wine market share largely consists of smaller players, particularly family-owned businesses, and a number of mid-sized companies.

Liquor retailing is dominated by large and mid-sized chains. It has become increasingly concentrated as supermarket brands have expanded into the sector by combining economies of scale and a growing network of outlets. The supermarket operators have also increasingly bypassed the wholesale sector, which is mainly focused on wine and spirits.

A diagram of the wine grape supply chain is provided in Figure 8, including tracking grapes as an ingredient in wine-making, and its associated waste outcomes.

#### KEY SECTOR FEATURES

- **Industry profile:** Low concentration with the grape growing market dominated by small family-owned businesses
- **Revenue (2016/17):** \$6 billion
- **Number of businesses:** 6,251 grape growers and 2,468 wineries
- **Waste profile:** Grape marc and lees are the largest waste components, commonly reused on-site as compost and mulch or recovered off-site.
- **Other issues:** Grape quality influenced by seasonal factors; waste reuse / recovery options influenced by the size of the vineyard or winery.
- **Data quality:** Moderate. National Vintage Reports published annually with total crush data, and the loss factors are relatively well estimated.

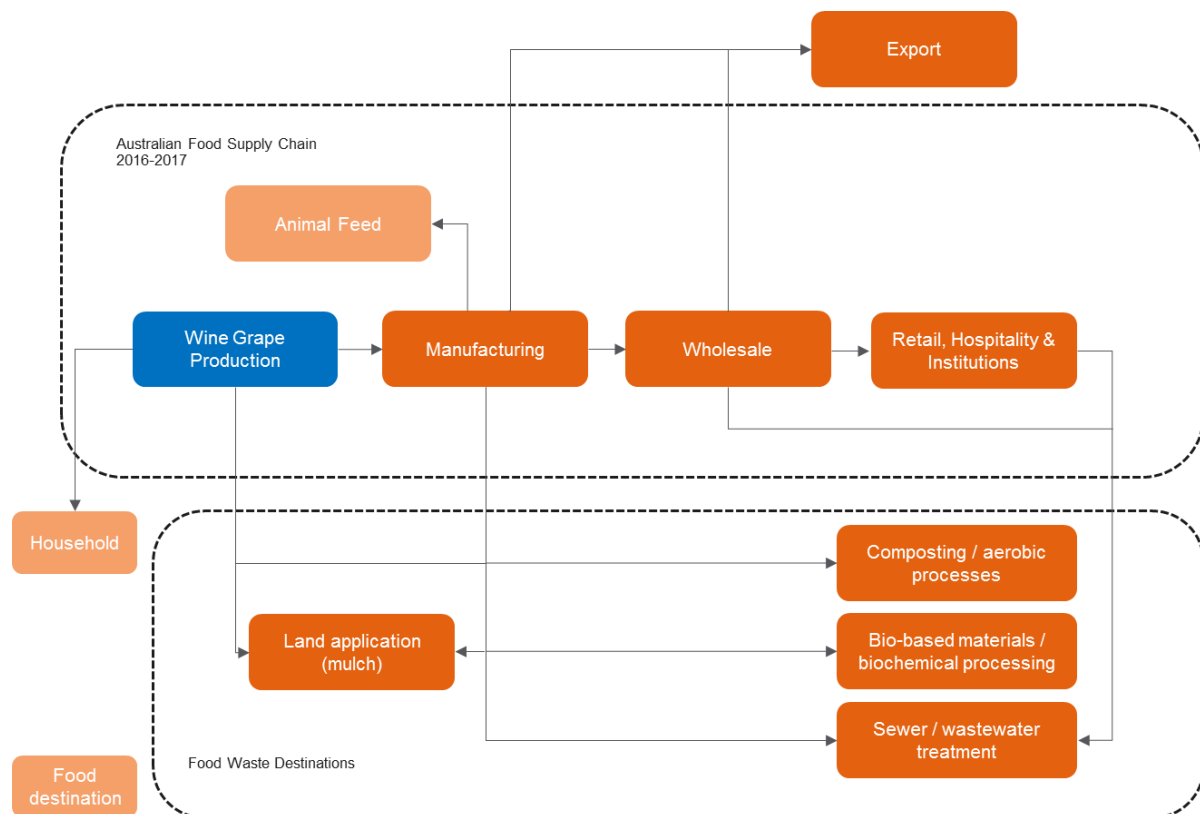


Figure 8: The wine grape growing sector's system boundary and destinations

### 3.3.2. Waste Generation

Wine grape waste tends to be measured as a percentage of the total wine grape crush. The bulk of this waste occurs during wine manufacturing (which includes crushing, pressing, fermentation, filtration and blending), but minor quantities are also generated during grape harvesting and collection, handling and transport.

The largest food waste from production is grape marc, which is the stalks, seeds and skin that remains after crushing. The location and size of a winery heavily influences its ability to reuse, recover and dispose of grape marc. The highest value destination is animal feed. However, the two principal grape marc processors only operate in close proximity to the main national crush areas, meaning other wineries have to rely on on-site land application or composting, or off-site disposal. Small wineries have limited space to store grape marc for composting and therefore rely more heavily on immediate land application or off-site disposal.

The other main food waste stream is lees, which is the residue yeast deposits following fermentation. These wastes are typically sent to compost or mulched prior to land application, with minor quantities disposed to landfill.

Broader, systemic drivers of wine grape waste include seasonal factors (such as excess rain or frost damage) and challenges forecasting demand for wine grapes due to the extended period between planting, harvesting and wine production.

On-farm losses from the wine grape sector were too small and uncertain to quantify, with the National Food Waste Baseline estimating the sector in 2016/17 generated 224,000 tonnes of grape marc and lee by-products at the processing stage (accounted for in manufacturing). Further details are provided in Section 5.2.

It is noted that a further 125,000 tonnes went to animal feed and is not included within the baseline quantification.

## 3.4. Primary Production: Crops

### 3.4.1. Sector definition

Broadacre crops is a large and diverse sector that is inclusive of grains, oilseeds and pulses intended for human consumption.

It relates to two ANZSIC industry types, 'Sheep, Beef Cattle and Grain Farming' and 'Other Crop Growing' and a wide variety of crop types from wheat and sugar to minor crops of seeds and spices (Table 8).

Due to the broad scope of the National Food Waste Baseline investigation, the focus is on the major crop categories grown for human consumption (excluding crops grown for animal feed or industrial uses).

The Australian Bureau of Agriculture and Water Resource Economics and Sciences (ABARES) categorises these crops as coarse grains (barley, oats, grain sorghum, corn (maize), oil seeds, triticale), pulses, rice, sugar and wheat.

Table 8: Industry categories covering crop varieties (ANZSIC)

ANZSIC Industry Type	Definition
Sheep, Beef Cattle and Grain Farming	
Rice Growing	Rice only. No further categorisation.
Other Grain Growing	Grains are the key crop types by volume and value. The major edible grain crops are barley, canola, grain sorghum, oats and wheat. Minor crop types include cereal grain, coarse grain, field pea or field bean, grain seed, lupin, corn (maize), millet, oilseed n.e.c., safflower, sorghum, soybean and sunflower.
Other Crop Growing	
Sugar Cane Growing	Sugar cane only. No further categorisation.
Other Categories not elsewhere classified (n.e.c.)	The edible Other crops are smaller by volume and value and include arrowroot, bamboo, flax seed, forage sorghum, ginger, hops, mustard seeds, peanuts, seed growing n.e.c. and spices. (Peanuts have been included under Nuts)

#### KEY SECTOR FEATURES

- **Industry profile:** A broad suite of mostly global commodities, with industry high fragmentation due to small business sizes (with small-medium in sugarcane).
- **Revenue (2016/17):** \$32.8 billion
- **Number of businesses:** 19,000
- **Waste profile:** On-farm losses are low, with the exception of sugarcane, which loses up to 10%. Greater losses occur in crop processing.
- **Data quality:** Low. Limited data on specific loss factors for each crop type.

Crop production is undertaken by small businesses, with none of the companies holding more than a 2% market share. The sugar industry is dominated by small to medium size enterprises each producing on average 7,200 tonnes of sugar cane.

A system diagram of the sector is provided in Figure 9, which includes crops as ingredients within manufactured products, and their associated waste outcomes.

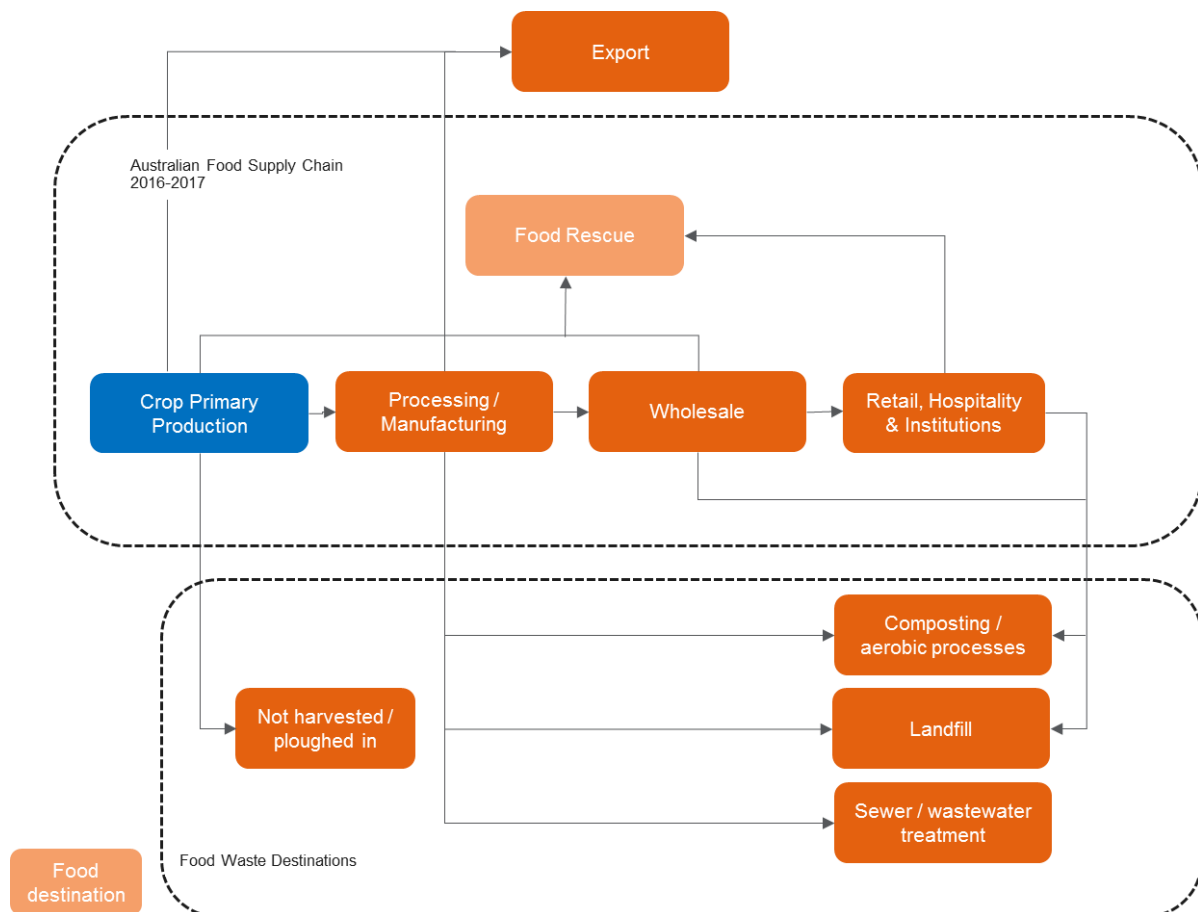


Figure 9: The cropping sector's system boundary and destinations

### 3.4.2. Waste generation

Crop loss on-farm is heavily dependent on crop type, but in the main is significantly less as a proportion than in horticulture given the more perishable nature of fruit and vegetables compared to grains, sugarcane, rice and other crops. Food waste addresses the harvestable part of the crop, such as the corn cob or ear of wheat, but does not include non-food parts such as the parent plant or stubble after harvesting.

Consultation and data sources including FAO estimates for the Oceania region were used to estimate losses ranging from 1% for many crops up to 10% for sugarcane (excluding cane trash left in fields).

Based on percentage loss estimates for each crop type, the National Food Waste Baseline estimates the consolidated broadacre crops sector generated 1.3 MT of on-farm food waste in 2016/17, of which sugarcane, 'other pulses' and wheat were the largest sources. All this food waste was not harvested and / or ploughed in. Further details are provided in Section 5.2.

## 3.5. Primary Production: Seafood

### 3.5.1. Sector definition

Seafood is defined as fish and other aquatic plants and animals intended for human consumption. Food, in general, includes the edible and non-edible components associated with food, which is a particular challenge in the seafood sector in terms of the different edible yield and gutting requirements of each species and the consumer habits in Australia.

The key segments of the seafood supply chain include the agricultural divisions of fishing and aquaculture, the manufacturing division of seafood processing, and the wholesale division of fish and seafood wholesaling within the ANZSIC.

Fishing includes rock lobster and crab potting; prawn fishing; line fishing; fish trawling, seining and netting; and other fishing. Aquaculture comprises offshore longline and rack aquaculture; offshore caged aquaculture; and onshore aquaculture.

The processing stage includes skinning or shelling, grading, filleting, boning, crumbing, battering and freezing of seafood. A wide range of products are manufactured, including processed crustaceans, processed mollusc, processed oysters, fish fillets, preserved scallops, paste, pate, canned fish, dried or smoked fish, canned seafood, preserved seafood and whole frozen fish.

The primary wholesaling activities cover fish, crustaceans and molluscs (including processed, excluding canned) and fresh and frozen seafood.

There are a number of data challenges in this sector. One is the significant diversity of seafood types, each of which has a specific gutting requirement that impacts waste generation. Another is the point at which raw materials enter the human food system, with the incidental capture of non-target species (by-catch) not defined as food because it is not intended for consumption due to the factors such as limited markets, protected species listing, size or age.

The fishing industry is characterised by small businesses, with no single entity having a larger market share than 2%. This is also broadly the case in aquaculture, although there are three major companies with a combined 35% market share. Seafood processing is dominated by three large companies, which account for 62% of the segment's revenue. Wholesaling is also dominated by small to medium size business, typically employing fewer than 20 staff.

Unlike many other countries, seafood supply exceeds local demand. However, high global prices see premium products exported, with imports dominated by lower value products such as frozen fillets and prawns and canned fish, predominantly from Thailand, New Zealand, Vietnam and China.

It is exposed to regulatory influences such as licensing requirements and environmental policy relating to sustainable harvesting and biodiversity. The industry system is illustrated in Figure 10, excluding by-catch shipped at sea, which has not been quantified as a destination.

#### KEY SECTOR FEATURES

- **Industry profile:** Business sizes vary from small fishing firms to medium sized aquaculture and processing companies.
- **Revenue (2016/17):** \$5.8 billion
- **Number of businesses:** 7,942, across the seafood chain
- **Waste profile:** Waste has been defined as occurring on-shore, principally during processing and wholesale activities.
- **Data quality:** Low

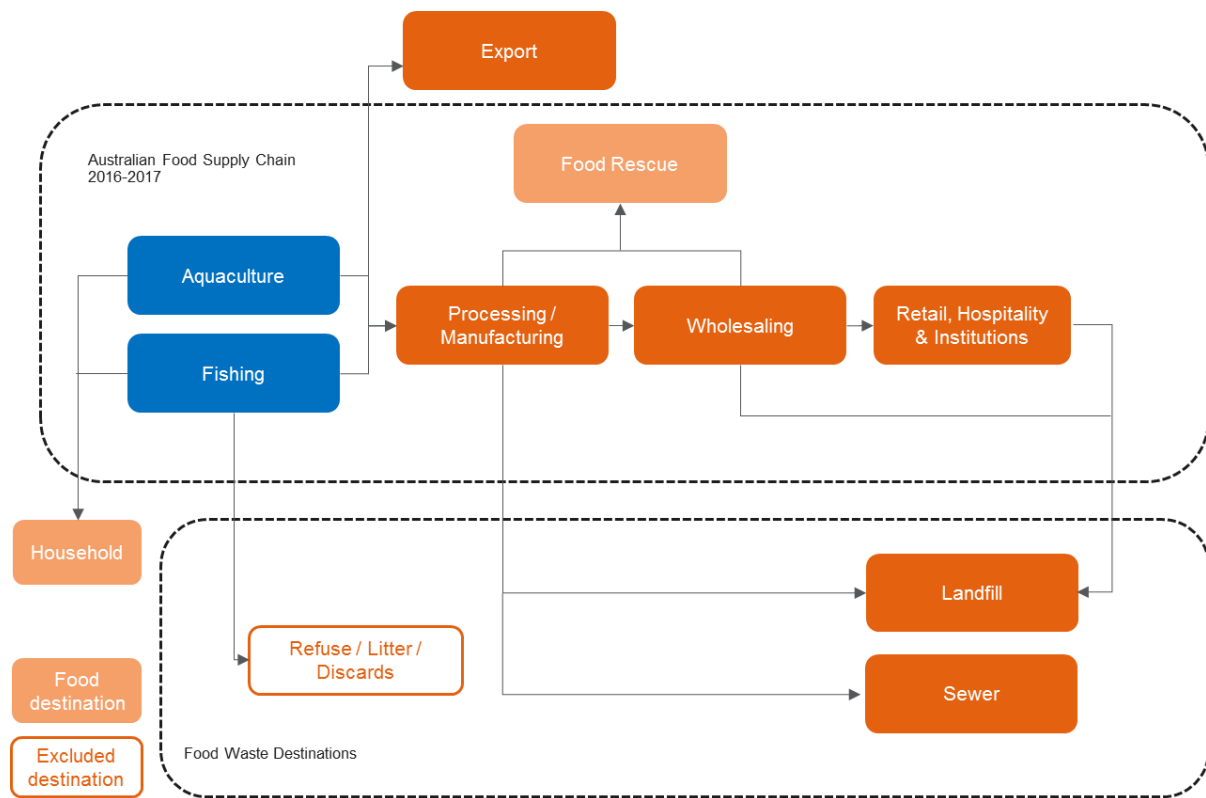


Figure 10: The seafood sector's system boundary and destinations

### 3.5.2. Waste generation

Waste occurs at every stage of the seafood supply and consumption chain. The Australian fishing industry undertakes little processing of fish at sea, but some offshore processing occurs for most catches. For practical reasons, the category of 'Refuse / Discards' has not been adopted as a waste destination for the purposes of this study.

The bulk of waste generation in the supply chain occurs within on-shore processing to prepare the fish for consumption, including trimming of inedible components and canning. Further wastage occurs at wholesale and retail levels when food perishes or cannot be sold for other reasons.

Some waste from fish processing can be processed into bio-based products, but the majority is either disposed to landfill or processed into animal feed, with limited volumes to sewer. Small quantities of frozen and canned seafood are also donated from processing and wholesale to food rescue.

The National Food Waste Baseline has not estimated seafood waste in the primary production stage. Without strong industry participation in this study, academic references are the primary reference for estimated food waste during seafood processing. The Centre of Excellence for Science, Seafood and Health estimated approximately 50,080 tonnes of seafood waste is generated through trimming of inedible components (accounted for in manufacturing), of which half is assumed to be disposed to landfill and half to animal feed (with non-material quantities going to sewer and food rescue). Further details are provided in Section 5.2.

## 3.6. Primary Production: Eggs

### 3.6.1. Sector definition

Chicken eggs are categorised as either caged, barn laid or free range, according to the production system, with the majority sold as fresh shell eggs and a smaller proportion processed to make products such as pulp (liquid eggs) or powder.

Cage systems represent about 80% of egg production in Australia, due to significant production efficiencies and the price sensitivity of the majority of egg consumers. However, there is a growing market share for free range and barn eggs, which represent 15% and 6% of production, respectively.

Eggs are typically washed, graded and packed by either the primary producer or a dedicated food processing company. They are then distributed through wholesalers or direct channels to general grocery, specialist retail and the hospitality sector, with smaller quantities to manufacturers of fresh and shelf-stable food products. Eggs that are damaged, fail aesthetic standards or otherwise not fit for sale are separated during grading and often supplied to food manufacturers, where they are washed, sanitized and then broken, with the yolks and whites separated and/or combined in mixtures.

The domestic market accounts for 80-85% of egg sales, with the remaining eggs processed and sold domestically or exported. While local demand fluctuates, making forecasting difficult and leading to incidences of over- or under-supply, overall demand has been growing over the years due to the perceived health benefits of eggs.

Other egg-producing avian species such as ducks, quails, pigeon and guinea fowl form a minor part of the egg market and are not separately assessed here. There is no specific data on the egg sector available from the ABS or ABARES.

An overview of egg sector materials flows is provided in Figure 11, which includes eggs as ingredients within manufactured products, and their associated waste outcomes.

#### KEY SECTOR FEATURES

- **Industry profile:** Many small companies, with larger producers typically also processing their own eggs.
- **Revenue (2016/17):** \$819.6 million
- **Number of businesses:** 459
- **Waste profile:** Very little occurs on-farm, with most waste occurring during transport, grading and manufacturing with egg inputs.
- **Data quality:** Low



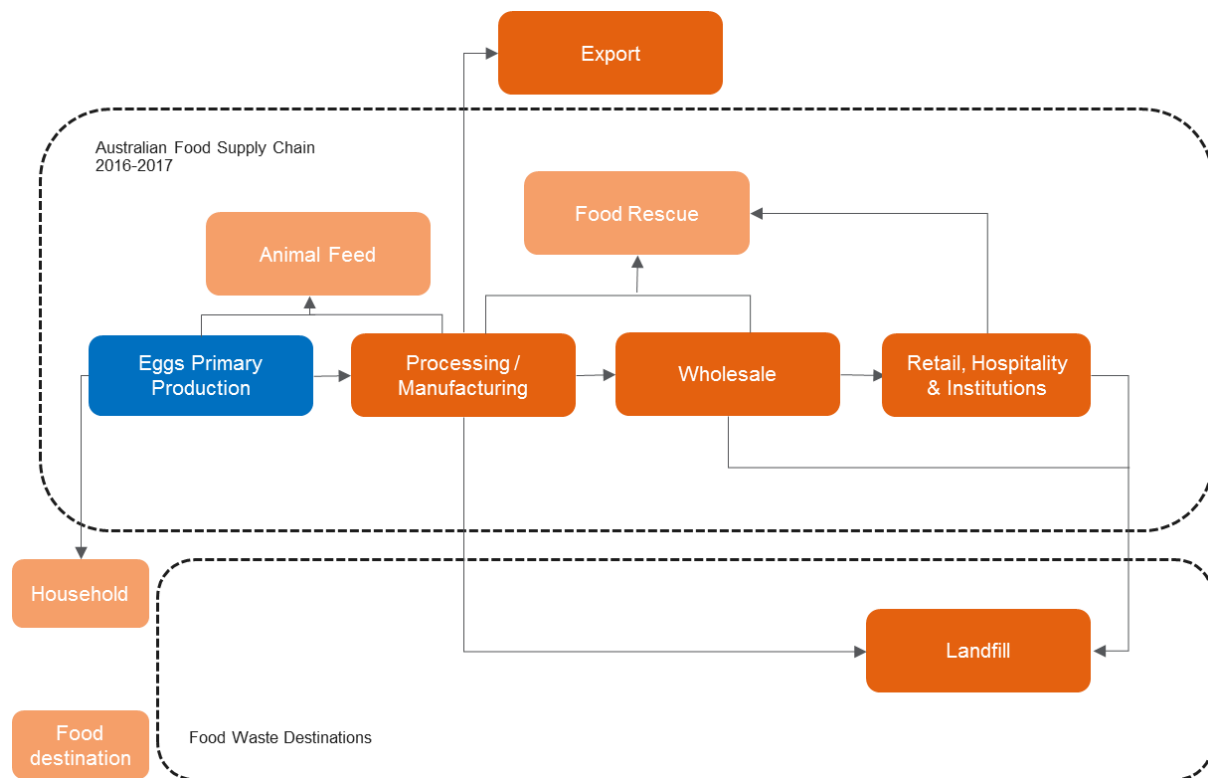


Figure 11: The egg sector's system boundary and destinations

### 3.6.2. Waste generation

Food wastes from the egg industry are egg losses through factors such as size limits (too small/large), aesthetics (wrong shape), incorrect laying location (floor / ground eggs), cracking and contamination, as well as processing wastes from egg product manufacturing. Consultation for this project derived loss rates of 2%.

It should be noted that food waste from the egg sector does not include the laying hens, because the Australian egg industry does not supply spent hens (or male chicks) to human food production, in part due to biosecurity risks. Practically, therefore, they are never within the human food system.

The National Food Waste Baseline estimates the egg sector generated 5,000 tonnes of food waste on-farm in 2016/17. This food waste is accounted within the livestock sub-sector and is generally sent to animal feed (and is not a food waste). Section 5.2 provides further details.

## 3.7. Primary Production: Livestock

### 3.7.1. Sector definition

The total number of livestock animals farmed for food and other purposes nationally is approximately 179 million. The four main types in order of animal population are meat chickens (46%), sheep (40%, with half estimated to be for meat), meat cattle (13%) and pigs (1.4%). Other poultry, such as ducks and turkey, and 'other' livestock, including kangaroos and deer, in total account for nearly 0.03%.

For this assessment, the livestock sector has been defined as the raising and processing of farm animals for food. In total, it is estimated that 134 million livestock are farmed for domestic and export meat, with approximately 2.675 million accounting for live exports (sheep and lambs accounting for 65% and remainder cattle). The largest proportion of livestock is in New South Wales (36%), followed by Victoria (21%), Queensland (16%) and South Australia (15%).

It should be noted that the total number of livestock farmed in any year is not necessarily equal to the total number slaughtered and therefore used to produce meat products, due to the variety in the maturity ages of animals to be ready for slaughter. Table 9 highlights the difference, in particular for meat chickens, which are grown to maturity between 35 to 55 days, or 8 weeks. Hence over a year, the number of chickens slaughtered can be up to 7 times higher than the number on farm at any one time. According to ABS data for 2016/17, approximately 33% of Australia's meat product is for export.

Table 9: Key livestock sector summary statistics<sup>25</sup>

Livestock	Total farmed for meat production (no.)	Total Slaughtered (no.)	Total meat product (tonnes)	Total meat product exported (tonnes) <sup>26</sup>
Meat Cattle	22,745,770	10,603,336	2,068,617	991,265
Sheep and Lambs	14,554,416	28,896,909	669,604	390,000
Pigs	2,485,699	5,159,828	397,140	30,700
Meat Chickens	95,011,549	652,679,978	1,229,505	35,400
<b>Total</b>	<b>134,797,434</b>	<b>697,340,051</b>	<b>4,364,866</b>	<b>1,447,365</b>

The overall supply chain for each animal is broadly similar. Initial farming and growth of the animal can be either pasture-based, where the animals roam freely, or intensive, where the animals are contained in feedlots or sheds.

Pigs, chickens and other livestock are typically transported direct to a meat processing facility, where they are slaughtered and produced into meat products for sale. Meat cattle and sheep/lamb typically have an intermediary stage where they are sold at saleyards, either to an abattoir for processing or for live export. Some are also sold direct from farm to an abattoir or for live export.

#### KEY SECTOR FEATURES

- **Industry profile:** A large and diverse sector with vertically integrated firms, supplying domestic and global markets.
- **Revenue (2016/17):** \$19.7 billion (slaughtering and other disposal)
- **Number of businesses:** There are around 1,000 meat, chicken and pig farms nationally. Meat cattle farms outnumber all other livestock.
- **Waste profile:** There is a high level of industrial symbiosis, with by-products such as blood, bone, fat, heads and offal rendered into meat meal and tallow.
- **Data quality:** High. ABS and ABARES publish annual production data and the losses are relatively well known.

<sup>25</sup> ABS Livestock Product 2014-15

<sup>26</sup> ABARES Rural Commodities 2014-15

There are approximately 1,000 meat processing companies nationally, with the majority (65%) focused on red meat processing. Processed products may be packaged or sold fresh, either to a wholesale agent or direct to market, at which point it enters the retail segment. In general, like with many other agricultural industries, the supply chain of livestock is highly fragmented, with an extensive number of operators. At the farm level, the majority of businesses are family run. The processing stage is largely characterised by major companies, which increasingly are vertically integrated to deal direct with supermarkets and exporters. Some companies such as Inghams are completely vertically integrated, from farming through to wholesale (excluding transportation), including managing processing of residues or non edible parts of the animals through company owned rendering facilities. Meat wholesaling encompasses a range of models, including agent, broker and independent distributor, sometimes including packaging and product value-adding.

ABARES trend data on domestic meat consumption indicates strong growth in chicken meat consumption over the past four decades, while exports in the last five years show a strong increasing trend for beef and veal. Lamb and mutton exports are mostly stable, while pig meat and poultry have fluctuated but generally show a decline. However, the demand from exports for red meat has not offset the reduction in local demand, which highlights a correlation between declining consumption and the national head count of meat cattle and sheep / lamb.

Figure 12 illustrates the supply chain for the livestock sector.

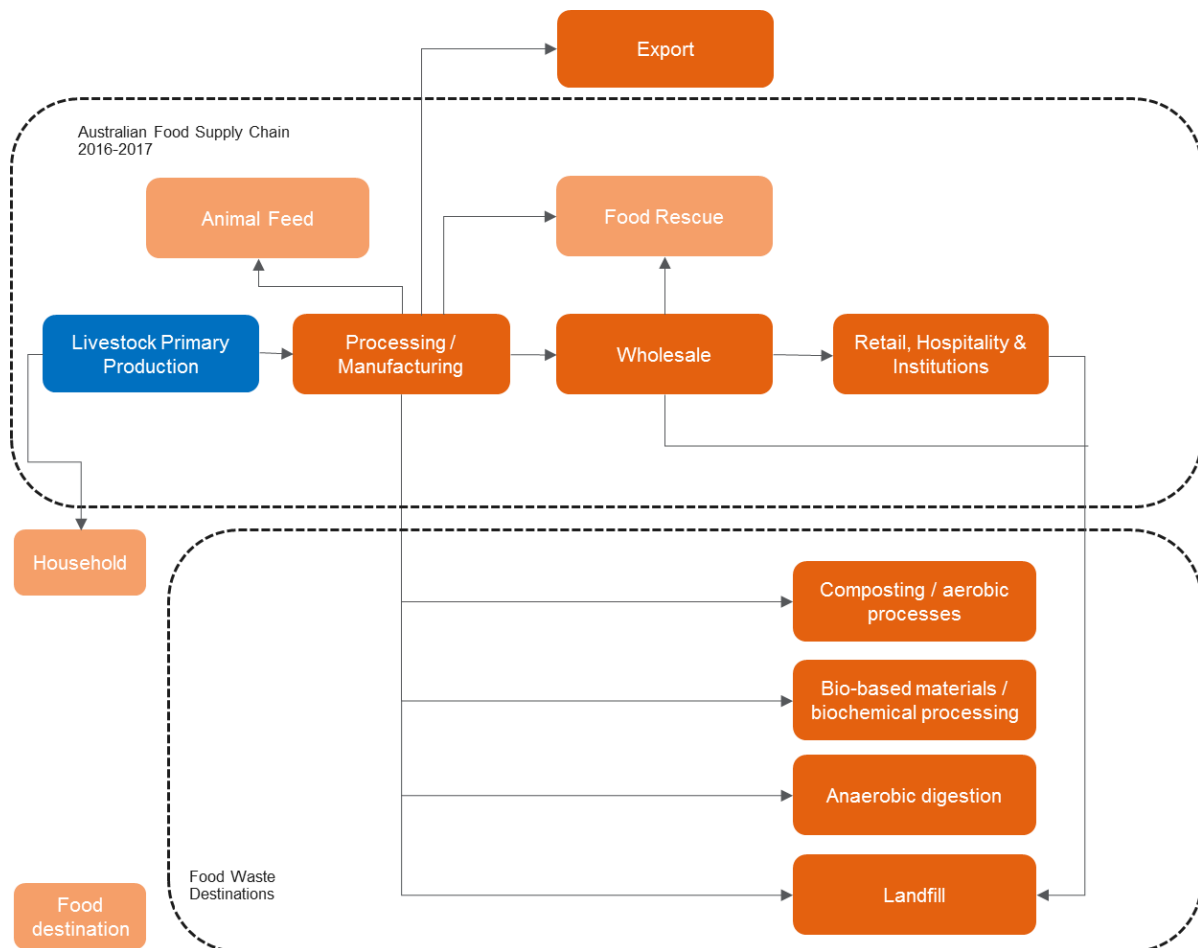


Figure 12: The livestock sector's system boundary and destinations

### 3.7.2. Waste generation

The majority of food waste in the livestock sector is produced at the meat processing stage, at the point where the animal is taken for slaughter to an abattoir. Abattoirs typically have a kill floor and boning room, and most sites have their own rendering plant and a dedicated wastewater treatment system to treat effluent.

It should be noted there is a high level of industry symbiosis, with a number of wastes at this stage converted into useful products, including rendering into Meat and Bone Meal (MBM) for animal feed or sent to low-value composting. Consultation with targetted players in this sector indicated that companies generally consider all parts of the animal as a resource (edible and inedible), with food waste including the associated parts used in pet / stockfeed manufacturing or rendering processes. These are relatively high-value offtake markets, with their own demand and market dynamics.

As per the FLW Standard, the food system boundary starts at harvest and slaughter, and as such any primary production livestock losses are excluded because market-ready livestock (i.e. meeting the definition of food) is rarely slaughtered on-farm. At the abattoir (accounted in manufacturing), the National Food Waste Baseline estimates 123,000 tonnes of food waste was generated across the beef, lamb, pork and chicken industries in 2016/17, and sent to compost or bio-based products. Another 1.3 MT went to animal feed and is not food waste. Further details are provided in Section 5.2.

## 3.8. Primary Production: Dairy

### 3.8.1. Sector definition

The dairy industry, incorporating farms and dairy product production, is Australia's third largest agricultural industry after wheat and beef, with a gross value of more than \$4.7 billion in 2014/15.

The industry comprises more than 6,000 farms and around 120 factories. The majority of farms are in Victoria (65%). Farm size and ownership structure is diverse, ranging from family-owned farms to commercial farms at large scales. Farm consolidation since deregulation of the industry in July 2000 has seen the number of farms decrease as these businesses shift from small to predominately medium and large scale.

Dairy farmers sell raw milk to milk processors and dairy product manufacturers, either directly or through a dairy cooperative. Milk processing / manufacturing is highly concentrated, with a relatively small number of centralised facilities that are in most cases owned and operated by the top five processing companies, which control 78% of the market share.

At the processing / manufacturing stage, raw milk is pasteurised (partial sterilisation for extended shelf life) and further processed (e.g. ultra-filtration or centrifuging for standardised fat and protein content, and homogenisation to evenly disperse the fat globules) for sale as drinking milk (skim and full fat, as well as flavoured milk). Supermarkets have increased in dominance and now control over 50% of the fresh milk market.

Pasteurised milk is also used in the manufacture of dairy products. Depending on the size of the processing facility, dairy products may be manufactured at the same facility as drinking milk, or the pasteurised milk may be transported to a specialised factory for manufacture into dairy products such as butter, cream and cheese. Whey, a residual product after milk is processed, can be used locally in the manufacture of ice cream, confectionary, protein drinks and animal feed, or exported to markets in Asia. While whey is a challenging and expensive waste stream to dispose for smaller dairy product manufacturers (e.g. boutique cheeseries), the small volumes constrain the business case for drying the whey for on-sale. Instead, disposal to sewer or transport to piggeries is a common option.

The industry has faced a range of challenges over the past five years, including demand fluctuations, global market shifts and fluctuating farmgate prices. Supply chain influence is concentrated in the large processors, with prices heavily influenced by global markets as well as domestic retail, with supermarkets including fresh milk in their low pricing strategies.

#### KEY SECTOR FEATURES

- **Industry profile:** Mostly small farms, with supply chain influence by the large dairy processors and supermarkets.
- **Revenue (2016/17):** \$4.7 billion
- **Number of businesses:** Approx. 6,000 farms and 120 factories
- **Waste profile:** Few losses on-farm and low loss rates in processing, although industry scale is sufficient to generate large waste volumes.
- **Data quality:** Moderate, based on industry and research data.

Approximately 34% of Australia's milk production was exported in 2014/15, which equates to 6% of world dairy trade. A large proportion of exports are value-added products such as cheese, butter, ultra-heat treated milk and milk powders.

Victoria, New South Wales, Tasmania and South Australia are large raw milk producers and supply both local drinking milk and the manufacturing markets, which are largely located in those states due to proximity to milk supply and ports for export. By comparison, Queensland and Western Australia have small herds and mostly supply drinking milk for local markets.

An overview of the dairy supply chain is provided in Figure 13.

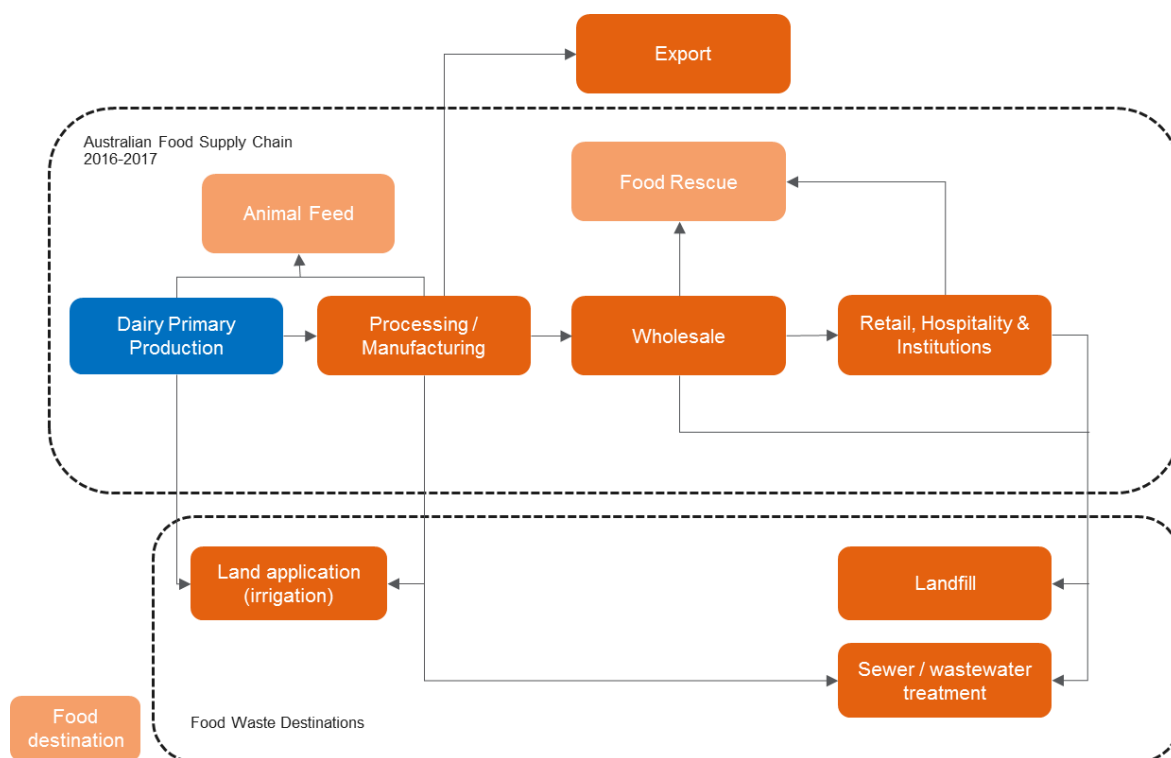


Figure 13: The dairy sector's system boundary and destinations

### 3.8.2. Waste generation

The industry is relatively automated and waste milk is tightly controlled. Consultation determined around 4% of total on-farm production is wasted, due to factors including milking cows that are too fresh (too young), milk that is abnormal in composition, or milk from cows that have been treated with a drug that has a minimum withdrawal time. This waste is often recovered for reuse such as diluted irrigation sprays onto pastures (land application) or off-site applications such as animal feed for piggeries and the like (not included in the baseline).

At the processing / manufacturing stage, an estimated 5% of raw milk input is considered waste, largely due to system failures and quality control rejects. A large proportion of this is recovered for off-site applications such as composting, with the rest disposed to sewer.

The biggest quantities of food waste in the sector are from sludges in wastewater generated through site operations and the whey left over from product manufacture, in particular cheese. While whey is 95% water and much of it is evaporated, significant tonnes are still disposed to sewer and some land spraying.

Based on the processing loss rates, the National Food Waste Baseline estimates the dairy sector in 2016/17 generated 630,000 tonnes of food waste at the manufacturing stage. Further details are provided in Section 5.3.

## 3.9. Manufacturing

### 3.9.1. Sector definition

Primary products are converted into food through a broad range of packing, processing and manufacturing activities, all of which are classed as manufacturing.

For crops, those processes include milling, cooking, canning and packaging, with waste arising largely consisting of crop residues such as husks, brans, shells and skins. For livestock, the process includes slaughter, processing and packaging (unless sold fresh).

To provide a rounded perspective on food waste from primary products, the processing activities and food waste quantities for each commodity have been outlined in the primary production profiles above. However, the waste from these activities is accounted for in the manufacturing sector.

Manufacturing ranges from refining of single primary products to production of complex food products consisting of multiple primary commodities and other additives. As a result of this complexity, primary products cannot be traced all the way through the supply chain, but are aggregated within the estimate of waste from manufacturing.

This part of the food manufacturing industry is dominated by major players, including large national companies and global brand name companies. The ABS lists 22 food manufacturing sectors (Section 2.4) under the following headline categories:

- Fruit and vegetable processing
- Oil and fat manufacturing
- Grain mill & cereal manufacturing
- Bakery product manufacturing
- Other food product manufacturing
- Seafood processing
- Meat & meat product manufacturing
- Dairy product manufacturing
- Sugar & confectionery manufacturing.

Given this diversity, the food waste drivers, opportunities and challenges are typically specific to the individual sector. Food processors early in the supply and consumption chain typically have higher levels of food waste due to the presence of inedible and unavoidable food wastes, such as peels, bones, pits and nut shells. These streams also tend to be relatively homogenous and uncontaminated, which supports high levels of resource recovery.

Manufacturers later in the supply and consumption chain may have lower rates of inedible waste as their inputs tend to be refined. Their outputs may also be directly consumable and less perishable, supporting higher levels of food donation.

The manufacturing sector has been conceptualised in Figure 14.

#### KEY SECTOR FEATURES

- **Industry profile:** A wide range of processes, products and scales, from niche processors to global brands.
- **Revenue (2016/17):** \$105 million\*
- **Number of businesses:** 13,300
- **Waste profile:** Varies widely across sub-sectors, including between businesses early and late in the value chain.
- **Other issues:** Food waste from refining of sugarcane has been excluded as it skews Australia's food waste generation and the Manufacturing sector's food waste profile.
- **Data quality:** Variable. Global and some local companies have excellent data, but limited data on specific sub-sectors.

\* Includes (limited) tobacco manufacturing

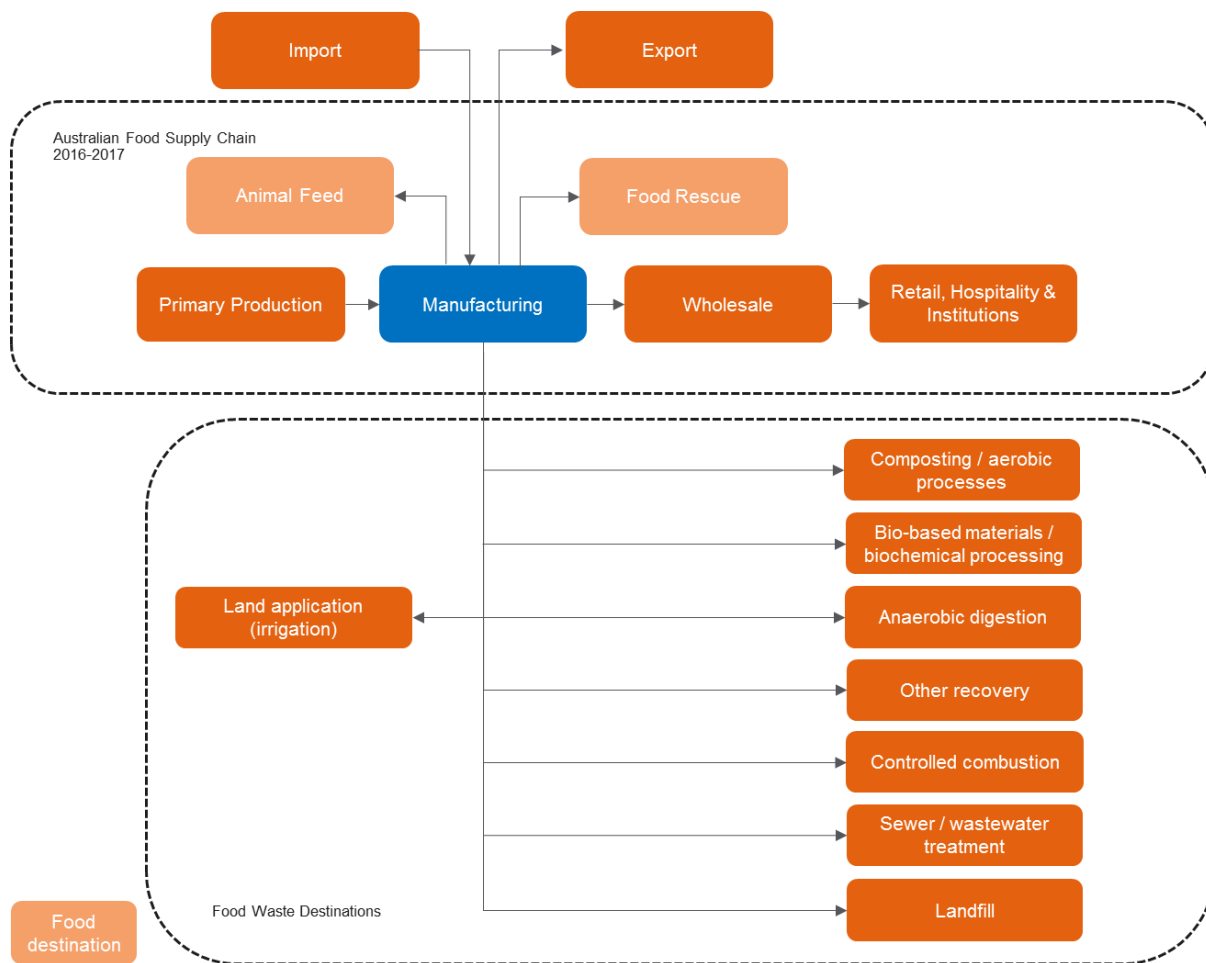


Figure 14: The manufacturing sector's system boundary and destinations

### 3.9.2. Waste generation

Waste in the manufacturing sector is in most cases a relatively small part of a company's cost base, but it may receive attention as it is a controllable variable cost and represents a broader set of inefficiencies including non-productive use of energy, water and labour.

The opportunities to reduce food waste and disposal depends on the sector and its type of waste. Edible wastes, which have the potential to be retained within the food system, are generated through process by-products and where food material is not marketable due to factors including cosmetic damage and weak local demand, such as for chicken feet. Inedible wastes include by-products from processing, spillage and damaged and spoiled products due to pests, contamination and the like.

There is a strong industry focus on opportunities to transport waste off-site at low or no-cost, with the primary outcomes being animal feed (not a food waste) and composting. Anaerobic digestion for energy recovery is a small but growing option in Australia, with two treatment facilities fully operational in 2016/17 (Earthpower, NSW and Richgro, WA) and another opening in June 2017 (Yarra Valley Water, Victoria). Additional facilities are at various stages of development or consideration. While capable of processing relatively homogenous food wastes from diverse commercial sources, manufacturing has been the primary feedstock sector.

A broad range of specific industry data and food loss rates was required to estimate waste in such as diverse sector (Section 2.4).

The National Food Waste Baseline estimates the manufacturing sector generated 1.76 MT of food waste in 2016/17, noting the one-off exclusion of 10 MT of useable sugarcane bagasse to avoid skewing the national and sectoral results with a single stream. The sector's food waste profile was significantly impacted by dairy manufacturing, which accounts for 36% of manufacturing food waste



generated. Dairy waste has very high water content and a significant proportion is evaporated off at the generation site. Of the remainder, 80% is recovered through land application and 20% disposed to sewer / wastewater treatment. There were also sizeable quantities from fruit and vegetable packing (24%) and wine making (12%), which were largely sent to compost. The remainder of generation was dispersed across the other food manufacturing industries. Further details are provided in Section 5.3.

## 3.10. Wholesaling

### 3.10.1. Sector definition

Wholesaling occurs in many food chains in order to achieve scale, increase distribution efficiency or leverage different business models between manufacturing and downstream sectors. In some cases, wholesalers act as exporter and importer.

Some wholesalers target specific geographies, client sectors or products, such as meat, seafood and small goods. However, the trend over the last decade has been consolidation, with customers pursuing economies of scale and convenience by turning to larger companies with a broader range of products. One key wholesaler to the hospitality sector stocks more than 55,000 items across its network.

Hospitality has become the largest client sector for most of the major wholesale companies, as a growing proportion of meals are consumed away from home and large retailers take more of their inventory management in-house. For general grocery wholesale, the food service sector accounts for more than half of revenue, followed by supermarkets and convenience stores.

The business model for wholesalers varies according to the supply line. Sales agents for major buyers are common in sectors such as meat, either operating on consignment or as a pure broker, in which case they do not physically handle any product. The other major model is the independent distributor, which aggregates and distributes food, and may provide quality control, fumigation, packing and additional product value-add.

Another model for both seafood and fruit and vegetables is central wholesale markets, which aggregate a large number of small businesses into a central facility. Few of these market wholesalers operate in more than one state, resulting in no individual wholesaler capturing a significant share of wholesale markets nationally.

In some food chains, such as meat, wholesaling is under pressure from vertical integration by manufacturers and large retailers, who are both adopting wholesale bypass strategies to strip costs out of the system. The National Food Waste Baseline has identified waste generated within the different supply and consumption chain segments of these integrated companies, for example between waste generated at a supermarket-owned distribution centres compared to the supermarket itself.

Figure 15 indicates the system boundary and material flows for the wholesale sector.

#### KEY SECTOR FEATURES

- **Industry profile:** Wholesaling may involve multiple players and stages
- **Revenue (2016/17):** \$86 million\*
- **Number of businesses:** 12,200\*
- **Waste profile:** The largest losses are of perishable products, which are distributed through the cold chain.
- **Other issues:** Temperature controls in the cold chain significantly impact food quality, and so downstream waste.
- **Data quality:** Low. There is little data on waste in wholesale and through the

\* Covers grocery, liquor and tobacco wholesaling



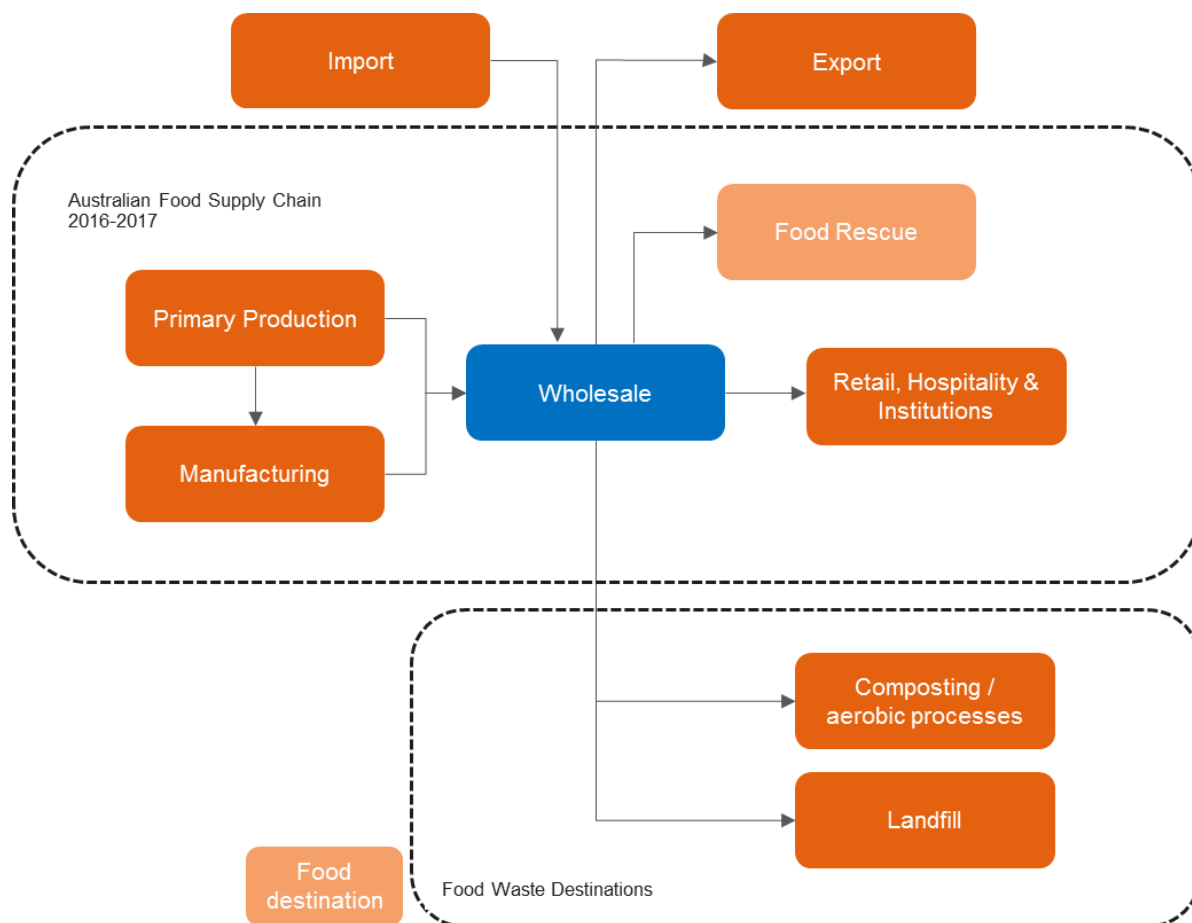


Figure 15: The wholesale sector's system boundary and destinations

### 3.10.2. Waste Generation

Waste generation within independent wholesalers is primarily a function of commercial dynamics within customer sector, such as lean inventory management, demand forecasting, minimum order sizes and quality control. Wholesalers are efficient at moving stock to minimise waste before the used by date and responding to oversupply. Depending on the food type (e.g. fresh, frozen or dry), wholesalers may experience some spoilage and damage where they value add by packaging, as well as storing and transporting products.

The National Food Waste Baseline estimates the wholesale sector generated 26,300 tonnes of food waste in 2016/17. Nearly 53% was fruit and vegetables, entirely sent to compost, and 41% was seafood that was fully disposed to landfill. Wholesale also redistributed a significant proportion of surplus food to food rescue, which is not food waste. Further details are provided in Section 5.4.

## 3.11. Retail

### 3.11.1. Sector definition

The retail segment is among the most diverse sectors of the food supply and consumption chain in terms of industry structure and the mix of food types, and one of the most powerful influences across the system.

The segment spans single stores selling specialist produce through to convenience stores, farmers' markets and national brands operating full service supermarkets.

This is reflected in the wide range of food products within the segment, with the key food types including meat and poultry, bakery, fruit and vegetables, dry grocery goods, ready-to-go meals and confectionery.

The diversity presents challenges in terms of defining the segment's commercial drivers, supply and consumption chain dynamics and causes of food waste. Supermarket brands are the largest operators and account for an increasing share of retail food sales as they open new stores and expand their service offerings.

The supermarket and grocery segment is one of the most highly concentrated industries in Australia, with the top four brands accounting for more than 90% of sales<sup>27</sup>. It is also highly competitive, with earnings margins under pressure from existing and new competitors, resulting in a highly cost-sensitive operating environment.

The niche food retail industries are characterised by much smaller operations, although in each case there are a small number of chains, typically operating franchise models and with varying levels of market share. For example, specialty bread retailers make up about 25% of total bread sales, with nearly 7% of the market comprising other stores such as delicatessens and convenience stores<sup>28</sup>.

A significant proportion of food retailing in Australia occurs through shopping centres, with approximately 37% of total retail space nationally found within shopping centres (around 18.7 million square metres of gross lettable area (GLA)). This is a higher proportion than most developed countries apart from the US and Canada<sup>29</sup>. There are more than 1,753 shopping centres in Australia, with the top five owners being national in scale.

With the exception of the four main supermarkets, which manage their own waste and recovery, waste management within shopping centres tends to be a centralised responsibility of the shopping centre owner. This has obvious implications for food waste management and as such, shopping centre owners are becoming increasingly prominent in driving systems to recover food waste through both on-site and off-site organics processing, and also in encouraging waste avoidance initiatives such as food rescue.

Food includes beverages, but the food retail sector does not include liquor retailing, which is separately categorised by the ABS. A diagram of the retail sector is illustrated in Figure 16.

#### KEY SECTOR FEATURES

- **Industry profile:** Highly diverse by company type and scale, with extremely high concentration in supermarkets.
- **Revenue (2016/17):** \$115.8 billion
- **Number of businesses:** 25,000
- **Waste profile:** Largely consists of perishable fresh food items. Some fresh products remain the responsibility of the supplier to manage on the shelf.
- **Other issues:** A key setter of quality standards and commercial dynamics across the chain.
- **Data quality:** Moderate. Supermarket brands have good internal data, but small retail does not track performance.

<sup>27</sup> <http://www.roymorgan.com/findings/7234-woolworths-coles-aldi-iga-supermarket-market-shares-australia-march-2017-201705171406>

<sup>28</sup> <http://www.roymorgan.com/findings/7198-slicing-up-australias-bread-market-201703281034>

<sup>29</sup> <http://www.scca.org.au/industry-information/key-facts/>

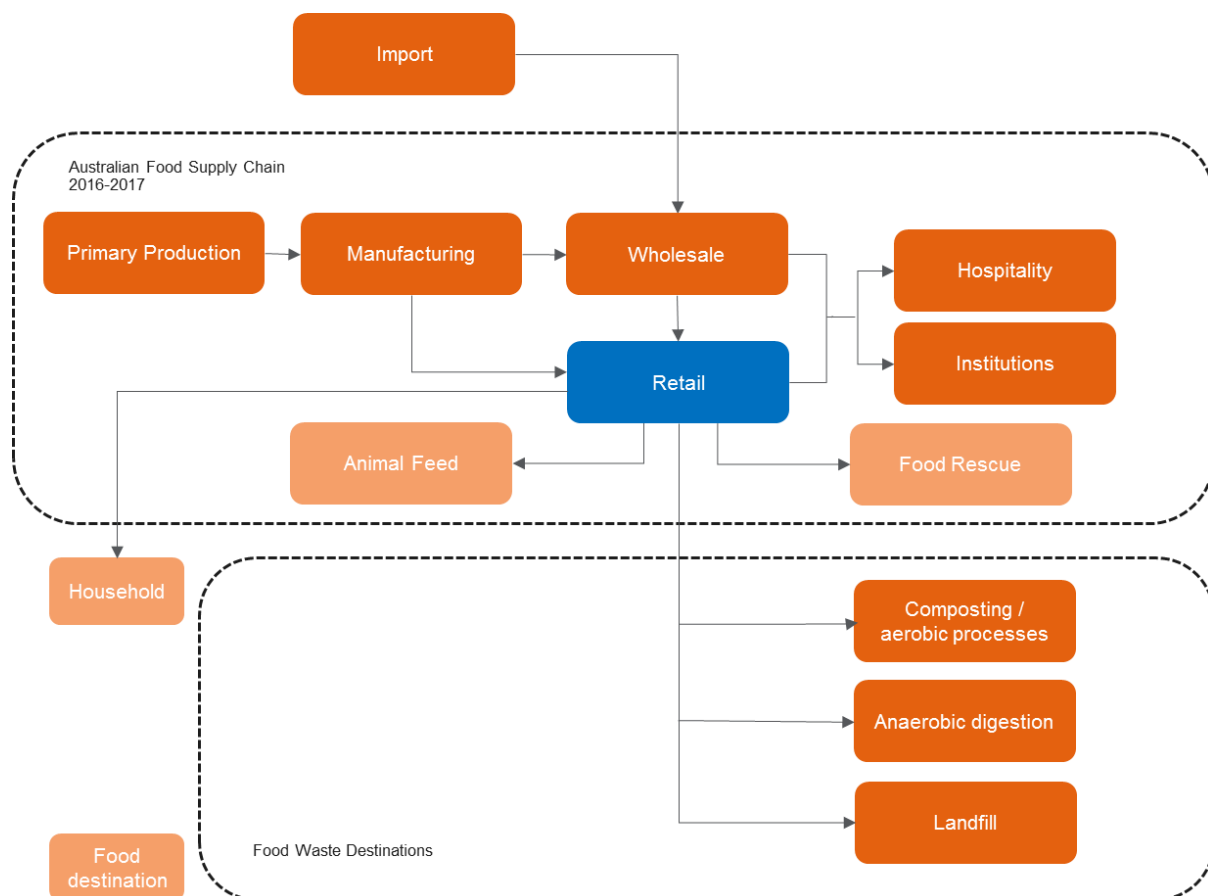


Figure 16: The retail sector's system boundary and destinations

### 3.11.2. Waste Generation

The retail (and hospitality) sector commonly defines food waste as an aspect of shrinkage, which refers to the loss of inventory through all reduction factors, including deterioration, damage, theft and waste. The drivers of food waste are numerous, with a key division being between food types with high and low levels of perishability and microbiological risk.

Store-level drivers of food waste are product rejection for reasons including failing to meet product quality specifications and damage (more detail on transport losses in Section 3.15), and shop-floor issues including spoilage, damage, limited shelf-life, surplus product (e.g. bakery) and unavoidable fresh produce waste (e.g. trimmings)<sup>30</sup>.

The supermarket brands, in particular, are the most influential stakeholders across the entire food supply and consumption chain due to large scale and more recent extension across other retail types and along the supply chain into manufacturing, wholesaling and logistics. The level of influence varies according to food type, but factors such as quality standards and 'best before' dates, demand forecasting, minimum orders and stocking practices and packaging design are critical to both the commercial dynamics and food waste generation within the supply chain.

At the household level, retail has a high level of influence on consumption patterns. Key influences range from price reductions and bulk purchase discounts to move stock with short shelf life, through to deeper structural changes such as the growth in ready-to-go meals and online shopping. The sector is also a key donor to food rescue.

The volumes and drivers of food waste vary in each of the major types of food retail operation, and according to the scale of the business. Note that while some retailers will also have logistics and

<sup>30</sup> Lewis et al (2017)

wholesale operations, the retail segment has been defined at the store-level, with food waste in these other operating sectors attributed within them. This requires some disaggregation of data between aspects of the large, integrated supermarket brands.

Food waste estimates per retail employee were derived based on publicly available waste estimates for major supermarkets and datasets of large shopping centre organisations consulted for this exercise (Section 2.4).

The National Food Waste Baseline estimates the retail sector generated 232,000 tonnes of food waste in 2016/17. Further details are provided in Section 5.5.

## 3.12. Hospitality & Food Services

### 3.12.1. Sector definition

Food service and hospitality is a fast-growing sector in Australia as an increasing number of meals are consumed away from the home. The industry includes restaurants and cafes, hotels, catering, food courts and take-away food from quick service outlets.

The ANZSIC-defined Accommodation and Food Services sector is estimated to contain approximately 87,500 businesses (ABS, 2017) and this is continuing to grow. These businesses operate at varying scales, including national brands and franchises with centralised procurement systems, shopping centre food courts and individual stores.

Where major retailers are in many cases pursuing wholesale bypass strategies to shorten their supply and consumption chains, food service businesses rely more heavily on wholesalers due to their smaller scale and intensity of procurement.

The type and scale of food service businesses correlates to their level of influence over waste generation factors. For example, take-away businesses have almost no capability to control post-consumer food waste, while the influence of food court operators is limited as diners are encouraged to clear their tables by taking waste to nearby waste bins.

Figure 17 illustrates the supply and consumption chain for the hospitality sector.

#### KEY SECTOR FEATURES

- **Industry profile:** A relatively complex sector. Many businesses ranging in sizes and employees.
- **Revenue (2016/17):** \$83 million
- **Number of businesses:** 80,000
- **Waste profile:** Complex and variable, depending on the nature of the business and food sold / manufactured for consumption.
- **Other issues:** Head chefs are key stakeholders as waste costs are typically included in their KPIs.
- **Data quality:** Little oversight into operational aspects makes data capture weak, limiting waste data.

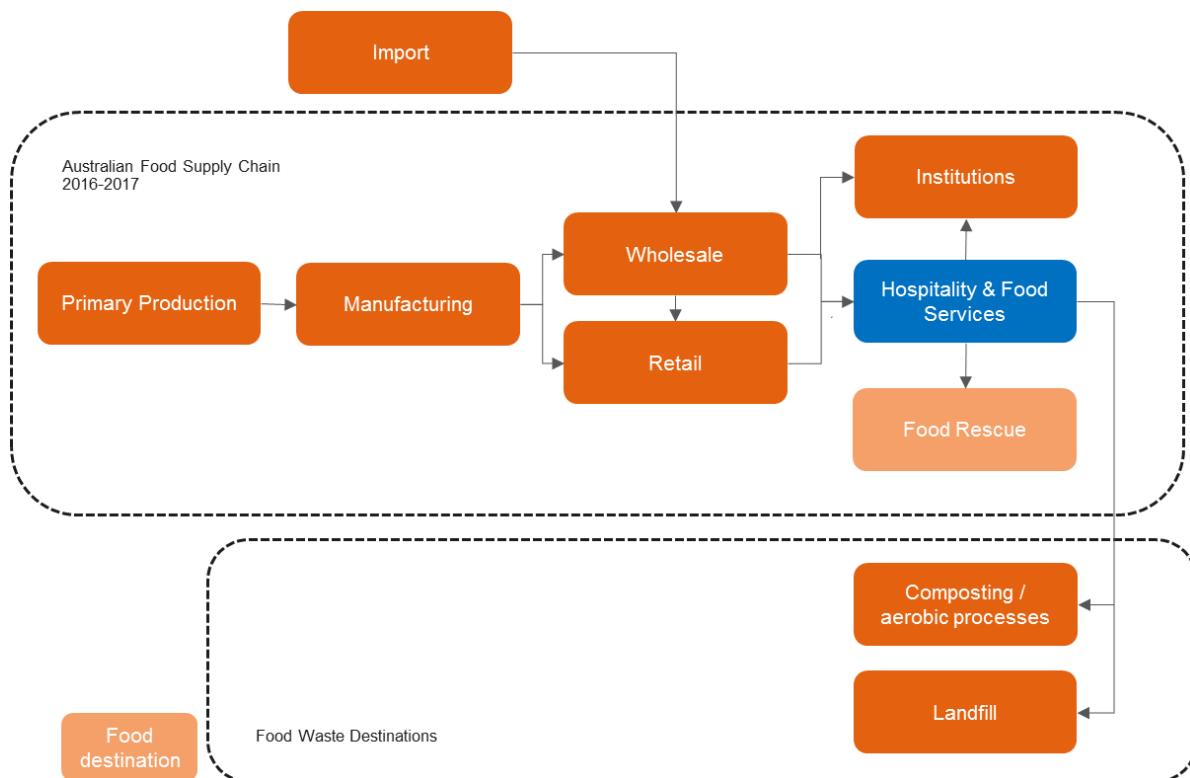


Figure 17: The hospitality sector's system boundary and destinations

### 3.12.2. Waste generation

The diversity in the business model leads to a wide range of waste types, including:

- Damaged or spoiled food due to improper food transportation or storage
- Neglected / unprepared food and ingredients past their use-by date
- Food preparation offcuts and by-products
- Uneaten foods suitable for charitable or discounted redistribution
- Food purchased in excess of patrons' requirements.

The food service sector is also a significant generator of liquid waste, notably grease trap waste. There is no comprehensive, publicly available data on grease trap waste, although it may be captured in some jurisdictional regulated (hazardous) waste tracking systems, and therefore captured in the baseline as hazardous liquid waste within the manufacturing sector.

Food waste estimates per hospitality sector employee were derived based on a limited number of survey responses and published figures (Section 2.4).

The National Food Waste Baseline estimates the hospitality sector generated 324,000 tonnes of food waste in 2016/17. Details are provided in Section 5.6.

## 3.13. Institutions

### 3.13.1. Sector definition

Institutions are a broad category generally considered as spaces or structures established to govern and regulate a group of individuals.

The ANZSIC system does not define ‘institutions’ as a stand-alone classification, so an aggregate of different ANZSIC subdivisions and classes has been assessed in order to attain a well-rounded understanding of the sector’s presence within the food supply and consumption chain. These institutions are:

- Defence establishments
- Correctional and detention establishments
- Preschools, primary schools, secondary schools and tertiary education
- Child care
- Hospitals
- Aged care facilities.

It is estimated there were more than 30,000 such institutions across Australia in 2015. The supply and consumption chain dynamics for the varying types of establishments do not appear to differ significantly, with food-related functions in all institutions primarily receiving food from wholesalers, before preparing and distributing meals to occupants and disposing of food waste via contracted collectors to landfill. Figure 18 provides an overview of the institutions segment.

#### KEY SECTOR FEATURES

- **Industry profile:** Diverse in type, yet consistent food dynamics, including lack of flexibility in service and recovery.
- **Revenue (2016/17):** N/A
- **Number of businesses:** 15,600
- **Waste profile:** Leftover food post-occupant consumption is the bulk of food waste, which is directed to landfill.
- **Other issues:** Emerging models across to provide more tailored food choices to increase service and reduce waste.
- **Data quality:** Low. No national data sets capturing total food waste generation from any of the institution sub-sectors.

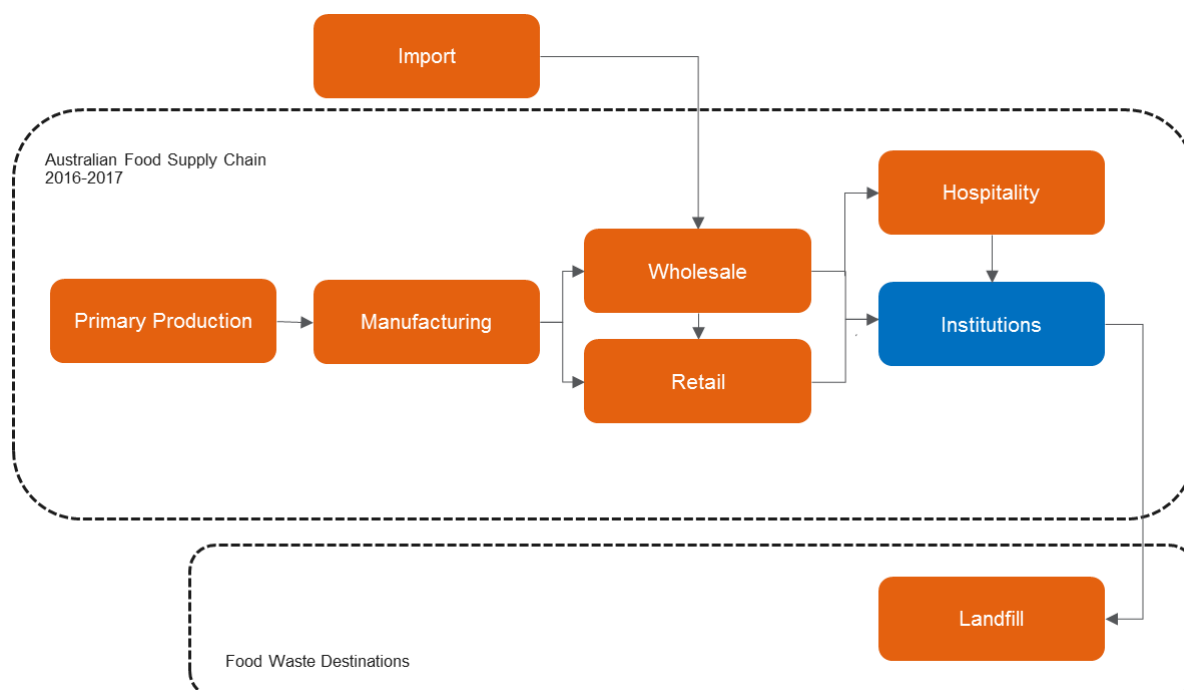


Figure 18: The institutions sector’s system boundary and destinations

### 3.13.2. Waste generation

Food waste generation is typically a function of the size and characteristics of the institution. As there is limited data available for waste generation within this sector, estimates are typically a combination

of per occupant rates (such as per full time prisoner or per student), floor area and industry knowledge concerning the typical waste breakdown.

Food loss typically occurs during the preparation of meals for occupants at on-site kitchens and as a result of occupant consumption. Post-consumption waste is relatively high in this sector as there are relatively rigid food requirements that do not take into account individual variabilities. Such requirements include:

- Standardised serving sizes
- Food purchased in excess of occupants' needs
- Set number and timing of meal services per day
- Limited menu choice
- Strict health and safety regulations, which restrict food reuse and rescue.

Food waste data was collected from the various institutional types to derive targeted food waste generation per population member in each sub-sector, with a focus on overnight stays. The exception is childcare which relies on publicly available information (Section 2.4).

The National Food Waste Baseline estimates the institutions sector generated 209,000 tonnes of food waste in 2016/17. Details are provided in Section 5.7.

## 3.14. Households

### 3.14.1. Sector definition

The household sector consists of single-unit dwellings (SUDs) and multi-unit dwellings (MUDs), which impacts consumption and waste behaviours, bin configurations and collection dynamics.

While it is a generalisation, MUD residents typically consume more pre-prepared meals, experience higher contamination rates in recycling bins and have less opportunity for home composting or worm farms. However, there is no specific information on the difference in food waste attitudes and behaviours between SUDs and MUDs residents.

Food waste in the home principally consists of unconsumed food that has perished and the edible and inedible scraps from food preparation and consumption. The content of food waste within the residual waste stream differs between communities, but the more reliable compositional audits estimate food waste to represent 30-40% of the household residual waste stream<sup>31</sup>.

Research by WRAP published in its *Household Food Waste in the UK* report found some correlation between household food waste, food prices and wages, but it was not able to estimate the magnitude of influence (WRAP, 2015). The report also found household food waste generation was influenced by the proportion of food eaten at home compared to away from home. Arcadis is not aware of any local investigations that relate economic conditions to quantitative household food waste data.

Programs to address food waste include *Love Food Hate Waste*, which was developed by WRAP and delivered by a number of state governments through a licensing agreement directly with WRAP, to raise awareness about food waste avoidance and management. Some states also actively support the uptake of combined food organics and garden organics (FOGO) services.

An overview of the flows into household segment of the food supply chain is provided in Figure 19.

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<sup>31</sup> National Food Waste Assessment (UTS, 2011)

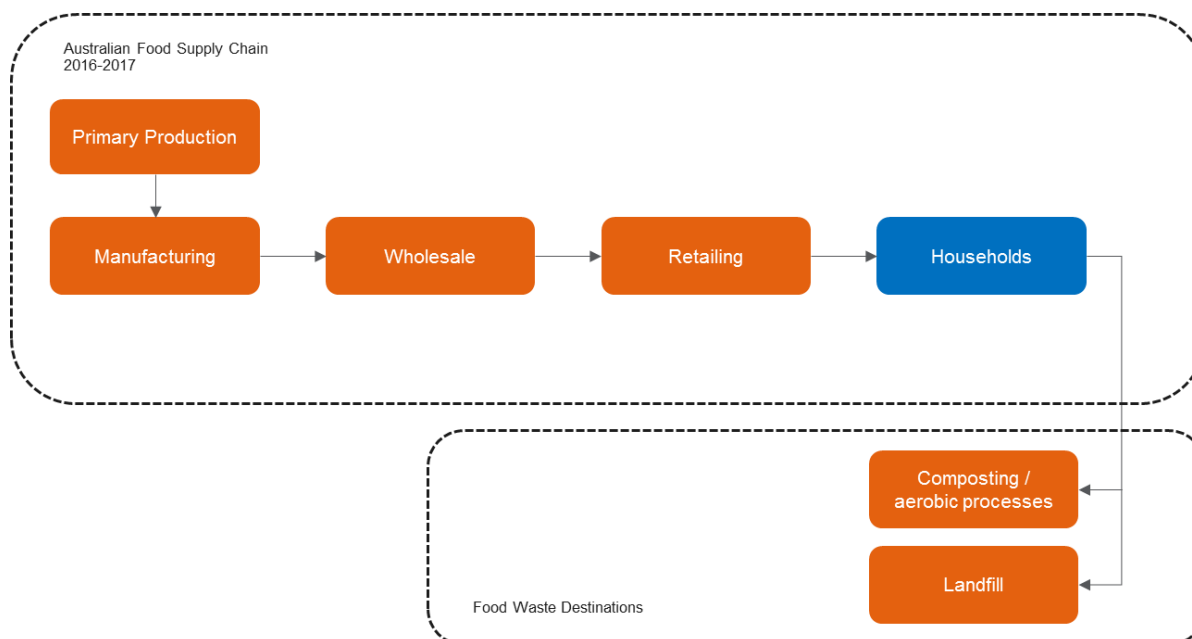


Figure 19: The household sector's system boundary and destinations

### 3.14.2. Waste generation

Conventional food waste disposal can be via the residual waste service, a dedicated food waste service or a combined FOGO service. Some residents also have worm farms or undertake home- or community-scale composting, but their prevalence and scale are not easily quantifiable as the waste does not enter the formal waste management system.

Finally, some households use kitchen appliances such as an InSinkErator to dispose of food via the sewerage system, although this is less common and often discouraged by many municipal water authorities as it significantly increases the load on the sewerage system and wastewater treatment plants.

Household waste generation was estimated through state government data or by modelling previous aggregated state government estimates for the National Waste Report 2016 (Section 2.4).

The National Food Waste Baseline estimates the household sector generated 2.5 MT of food waste in 2016/17, of which 92% went to landfill and the rest to compost. Details are provided in Section 5.8.

## 3.15. Transport & Storage

### 3.15.1. Sector definition

Transport connects all sectors of the food supply and consumption chain with the exception of households, which are stocked by householders themselves (with some minor volume of groceries home delivered). The function and complexity of distribution varies by food type and, to a lesser extent, customer base. Products can be frozen, chilled, fresh or dry, with the critical distinction being the perishability of the product.

Perishable products are primarily transported via the cold food chain of refrigerated facilities and vehicles. For many such fresh products, including most fruits and a large proportion of vegetable crops, the cold chain starts inside the farm gate, with refrigeration commencing as soon as possible after picking. Dry products are transported through ambient (non-refrigerated) networks.

Road freight dominated transport of all food types, regardless of ambient or cold chain. Distribution centres provide strategic points to aggregate volume to improve the efficiency of the overall distribution system.



Australian food transport is typified by high temperatures and long distances, resulting in significant food losses in this sector, particularly among more perishable streams such as soft fruit, dairy and leafy vegetables. Anecdotal evidence highlighted high loss examples, such as a herb grower losing up to 90% of produce in transport, and a strawberry chain with 17 links between grower and store.

The cold chain for perishable foods consists of several distinct segments, including:

- Cool rooms alongside the packing sheds in egg, meat, fruit and vegetable production
- Dairy refrigeration including milk vats, jacketed tanks and processing systems
- Blast freezers and chillers in the fishing fleet and dockside in fishing ports
- Cold stores at manufacturing facilities
- Large cold storage facilities at distribution centres, including at port facilities and rail heads
- Refrigerated transport involving vehicle engine driven refrigeration systems on trucks and vans of many sizes plus refrigerated shipping containers and some refrigerated rail cars.

It is estimated there is 15 million m<sup>3</sup> of industrial refrigeration in cold storage and distribution centres nationally, along with a refrigerated fleet of nearly 10,000 articulated trucks and trailers or containers, 7,000 rigid trucks and 20,000 small trucks and vans. The number of refrigerated shipping containers used to export / import food is unknown, but estimated to be in the tens of thousands<sup>32</sup>.

Some larger retailers and manufacturers operate their own distribution networks, but third party logistics firms are responsible for the majority of produce distributed around Australia. Some may take responsibility for managing surplus produce, including salvaging it by repositioning in the market (e.g. lower price) or disposing of it<sup>33</sup>.

Figure 20 indicates the system boundary and flows for the transport and storage sector, highlighted in dark orange.

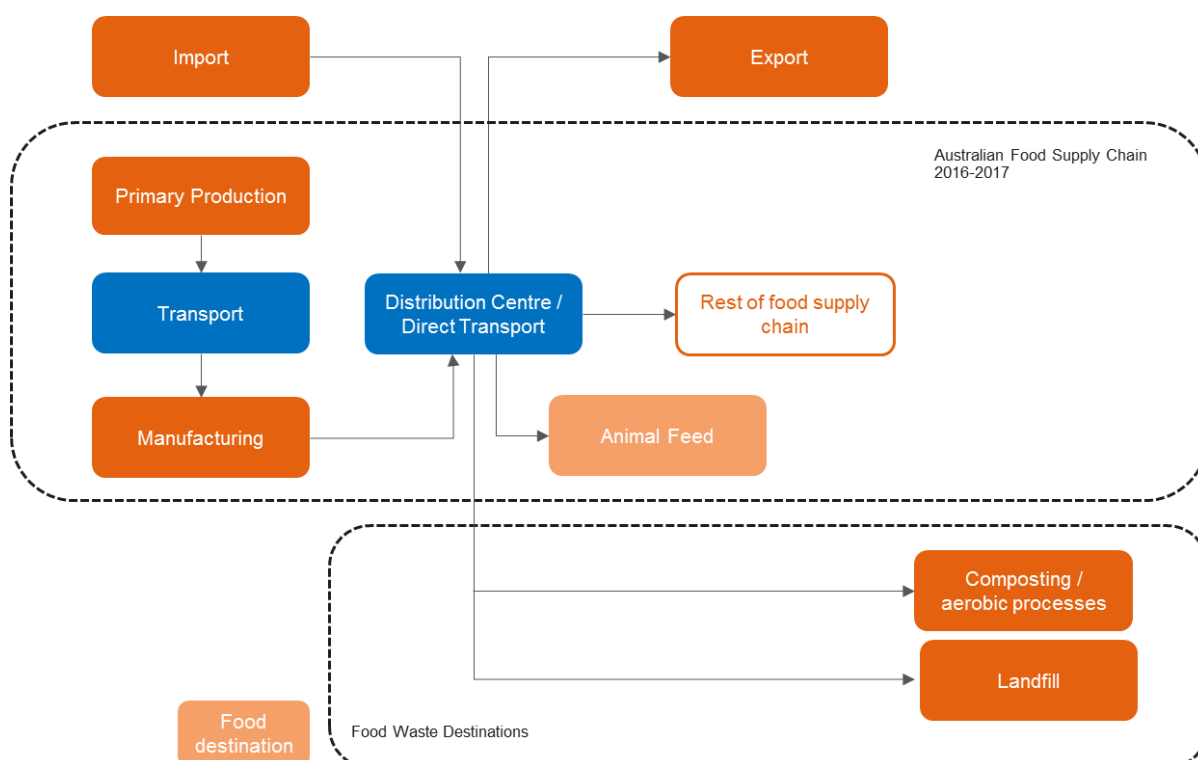


Figure 20: The transport sector's system boundary and destinations

<sup>32</sup> Cold Hard Facts 3 (2018), [www.environment.gov.au/protection/ozone/publications/cold-hard-facts](http://www.environment.gov.au/protection/ozone/publications/cold-hard-facts)

<sup>33</sup> 2017 Third-Party Logistics Study, [www.sipotra.it/wp-content/uploads/2017/06/2017-Third-Party-Logistics-Study.-The-State-of-Logistics-Outsourcing.pdf](http://www.sipotra.it/wp-content/uploads/2017/06/2017-Third-Party-Logistics-Study.-The-State-of-Logistics-Outsourcing.pdf)

### 3.15.2. Waste Generation

The transport and storage sector generates food waste both directly and indirectly. Food waste is generated directly when destination facilities reject a load for not meeting specifications or a non-conformance in the supply chain, such as an anomaly in the temperature record. The load may be returning to sender, accepted on-site or directed straight to landfill, given the potential markets for the rejected product are likely to be limited.

Waste is also indirectly generated where a load makes it to market but the produce has been impacted in transit, which reduces its shelf life or spoils in-home before it can be consumed.

A 2017 Natroads survey of refrigerated transporters (unpublished) indicates the key driver of rejections is products that do not meet receiver specifications, followed by missed time slots, product damage and product that is spoiled / overripe. Fresh produce is by far the most problematic food type from a waste perspective, with dairy, pre-packaged meals and meat products also a challenge.

Distribution centres will generate some waste through breakage or other damage on pallets, but the bulk of food waste is generated during transport, particularly in the cold chain. The critical control points in the cold food chain that drive waste include:

- Poor storage on- and near-farm
- Loading / unloading in unrefrigerated loading docks
- Inadequate insulation and temperature control in refrigerated vehicles
- Monitoring of air temperature rather than product temperature, which could see produce take too long to cool if it had not been cold-soaked before collection.

Accessible food waste data in the sector is very limited and uncertain. The only identified industry-wide food waste information was Australian Government estimates of percentage losses for nine food types across the food chain, sourced from the Project on Food Losses and Waste System (FLOWS) project by the Asia-Pacific Economic Forum (APEC)<sup>34</sup>.

While a range of stakeholders provided general information on transport industry operations and the dynamics around food waste, none shared more specific or recent data on typical loss rates.

This data gap creates a risk of double counting or undermining the accuracy of other sectors by deducting an indicative quantity of transport-related food waste. Therefore, while the transport sector has been individually quantified to facilitate policy focus and future iterations of the Baseline, the tonnes do not contribute to the Baseline as they have been assumed to be generated in the receiving sectors.

This approach mirrors countries such as the United Kingdom, which do not separately quantify the transport sector on the basis that all loads are either delivered to the destination, returned to source or diverted to landfill. This broadly aligns with commercial practice, in that transport contracts assign responsibility for rejections to the supplier, who may accept the load back or send it to landfill.

Indicative transport loss factors have been applied to key food types to estimate food waste in the transport sector (Section 2.4), however no data was identified to allow the food waste arising in transport to be isolated from the waste estimates in the sectors that ultimately receive the waste, whether the original supplier, the intended receiver or landfill. No assessment of destinations can be derived from the available data.

The National Food Waste Baseline estimates 227,000 tonnes of food waste was generated through the transport and storage network in 2016/17, with fruit accounting for 51% and vegetables 41%. Details are provided in Section 5.9.

The sector's food waste performance has been specifically estimated to highlight its significant potential to reduce food waste, but the estimated tonnes do not contribute to the baseline assessment as they have been assumed to be generated in the receiving sectors. This sector should be a research focus for future iterations of the assessment.

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<sup>34</sup> APEC-Project on Food Losses and Waste System (2016), Asia-Pacific Economic Forum (2016).

## 4. FOOD DESTINATIONS

### 4.1. Food rescue

Food rescue is the process of capturing and diverting food from landfill to charities and other organisations, who redistribute food in the form of groceries or meals to Australians in need.

Although the distribution pathway is different to the commercial sale originally intended, rescued food is considered part of the food supply chain as it is ultimately consumed by humans<sup>35</sup>. The practice helps combat food waste and food insecurity.

Food rescue has been profiled here as a key initiative to avoid food waste that is of particular interest to policy makers and commercial actors in the food supply chain. It has been quantified as a destination within the food system.

Food rescue organisations operate across the supply chain from 'paddock to the plate'. They typically work through established partnerships with food donor businesses to capture surplus, blemished, expiring and unsaleable food, including from farmers, manufacturers, hospitality (i.e. cafes and caterers), wholesalers and retailers. In order of magnitude, the largest food donating sectors are retail, wholesale and manufacturing.

The market, defined by the volume of donated food materials, is highly concentrated, with three major players accounting for 98% of the tonnes. Foodbank Australia focuses on bulk and packaged food from earlier in the supplier chain, including manufacturing, primary production and retailer distribution centres, while SecondBite and OzHarvest primarily target short-shelf life foods from retail stores and hospitality. The remaining 2% consists of small to medium players such as Fare Share, Food Rescue, Produce to the People, the Big Umbrella and Communities@Work.

Geographically, food rescue organisations operate around Australia within both urban and regional areas, with a number of different organisations operating within New South Wales and Victoria, and a limited number in the Northern Territory and Western Australia.

Fruit, vegetables, meat, dairy and bread comprise the majority of the food donated to rescue organisations, followed by canned food, drinks, cooked meals, dessert, pastries and sandwiches. Dry food types comprise 56% of donated food, reflecting their lower risk nature, followed by fresh food (33%) and then chilled and frozen.

Although rescue organisations are diverting substantial volumes of food waste that would otherwise be disposed, there is still a minor waste component. This includes:

- Inedible parts associated with food, such as peels, seeds and scraps
- Food waste from the processing of donations into meals
- Inability to manage large volumes of rescuable food received
- Downstream waste from households or community groups that receive food in the form of groceries or meals.

Currently there are no national data sets that capture food donations to rescue organisations, nor any data recording the downstream waste from rescue organisations. Individual organisations are the sole data source, providing summaries and estimates.

#### KEY INDUSTRY FEATURES

- **Industry profile:** Dominated by four organisations, with operations extending from donors to receiving communities
- **Revenue (2016/17):** N/A
- **Number of businesses:** Undefined
- **Waste profile:** Rescue organisations closely control donations accepted, with waste estimated at 5% of donations.
- **Other issues:** Lack of education on food waste handling by donors can result in donations not being accepted
- **Data quality:** High. There are no national data sets, but food rescue organisations and donors capture strong donation data.

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<sup>35</sup> FUSIONS Definitional Framework for Food Waste

From the information available it has been estimated that approximately 48,000 tonnes of food was donated to food rescue organisations in 2016/17 (Figure 21), which represents around 96 million meals<sup>36</sup>. Waste generation from the industry is thought to be negligible (estimated at 5% of incoming donations) and is mostly composted or reused in animal feed.

This is surplus food that did not become waste, and has been quantified for policy and business interest but not added to the food waste baseline. These figures are mostly based on actual data provided by the major food rescue organisations who participated in this study.

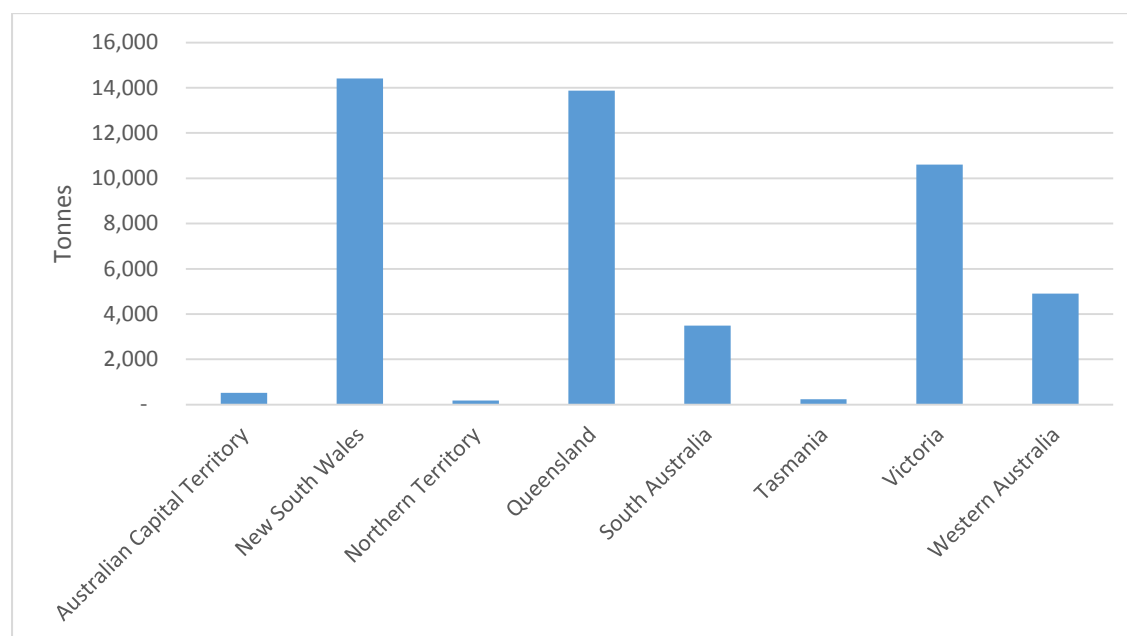


Figure 21: The distribution of food rescue in 2016/17, by state/territory

Table 10: Estimated food rescue tonnes by state/territory

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
Rescue	524	14,385	175	13,865	3,491	246	10,484	4,932	48,102

Note: All modelled figures have been rounded as appropriate

## 4.2. Animal Feed

Together with food rescue, animal feed is the other destination that has been designated in the Australian context as within the food system rather than a waste. This draws on the influential FUSIONS definitional framework recommended to the European Commission and already adopted by UK, recognising the animal fed with this food is likely to enter back into the human food chain.

For clarity, crops grown with the intention to feed animals are not included in the baseline assessment as they do not meet the definition of human food.

It is also noted that some animal feed diverted from the human food system will go to non-livestock animals, such as family pets, chickens and wild birds. For consistency with the definitional framework, food fed to these animals is also excluded from the definition of food waste and shall not be included as in food waste quantification.

<sup>36</sup> Based on a 500g meal size.

In the case of pet food, this is likely to be a significant quantity. The Australian pet food sector had a total market size of 862,000 tonnes in 2018<sup>37</sup>, however it is not possible to isolate the proportion sourced from human-intended food to allow more refined assumptions around animal feed. Further research is recommended to quantify human-intended food destined for pet food.

Animal feed represents a substantial diversion of food waste and surplus in Australia, and is a high potential pathway for further waste avoidance<sup>38</sup>. The National Food Waste Baseline estimates 3.9MT was diverted from food waste to animal feed in 2016/17, with 87% sourced from the manufacturing sector. The quantity was not added to the baseline assessment.

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<sup>37</sup> <https://www.statista.com/outlook/40130000/107/pet-food/australia>, accessed 5/11/2018

<sup>38</sup> Quantification of food surplus, waste and related materials in the grocery supply chain, 2016, WRAP.

## 5. FOOD WASTE QUANTIFICATION

### 5.1. National Food Waste Baseline

In 2016/17, Australia produced an estimated 7.3 MT of food waste, representing the overall quantity of Australian food material intended for human consumption that was sent to outcomes other than human food.

Of that, 1.2 MT was recycled and 2.9 MT was subject to some form of value recovery. A total of 3.2 MT was sent to disposal outcomes where no value is recovered, primarily coming from households but with significant quantities from the hospitality sector and institution including hospitals, aged care, correctional facilities, schools and universities. That equates to 132 kg of food waste disposed per person in Australia.

The baseline project quantifies the tonnes of surplus or unwanted food sent to the waste outcomes designated by the Australian Government, as adapted from the international FLW Standard to suite the local food supply and consumer context and the objectives of the National Food Waste Strategy. Of the 12 potential destinations, animal feed and food rescue keep food within the human food system and do not count towards food waste.

Sugarcane bagasse has also been excluded from the primary production and manufacturing sectors on the basis that the single stream of 11 MT in 2016/17 is an outlier that skews the national baseline. Removing bagasse from the dataset, being all bagasse generated in sugar mills and the proportion from sugarcane not harvested / ploughed in, allows a more refined analysis and comparison across the economy, better reflecting the scale of food waste generation in the rest of the primary production and manufacturing sectors. Bagasse is reported below for transparency, but not included in the National Food Waste Baseline.

Finally, food waste in the transport and storage sector has been recognised as a food waste destination but not independently quantified due to data limitations at present (Section 3.15.2).

Figure 22 provides the headline results for the National Food Waste Baseline, by state / territory and by the sectors across the supply and consumption chain.



Figure 22: Total estimated food waste generation (excluding food rescue, excluding bagasse), by sector

## 5.2. Sector: Primary Production

Altogether, the primary sector produced 2.27 MT of food waste on farms in 2016/17 (Figure 23), with around 56% of generation accounted for by broadacre crops, with harvestable sugar (from cane left in-field) and other pulses the largest contributors (Figure 31). The data has been provided below in three primary sub-sectors that align to ABS categorisation:

- Broadacre Crops
- Fruit, Nuts and Wine Grapes
- Vegetables.

Note that livestock-related food waste is included in primary production data. Premature mortalities on-farm are not included as the animal was not ready for market and so not defined as a food, with the sector's waste occurring at slaughter (manufacturing). The only livestock waste captured at primary production is egg losses on-farm.

Seafood waste is not included in this sector as the waste occurs when processed onshore, with by-catch slipped at sea excluded from this investigation. Food waste associated with dairy production occurs within the manufacturing sector and is not included here. The bagasse proportion of harvestable sugarcane left in-field (separate to cane trash) is not included, in line with the exclusion for all bagasse.

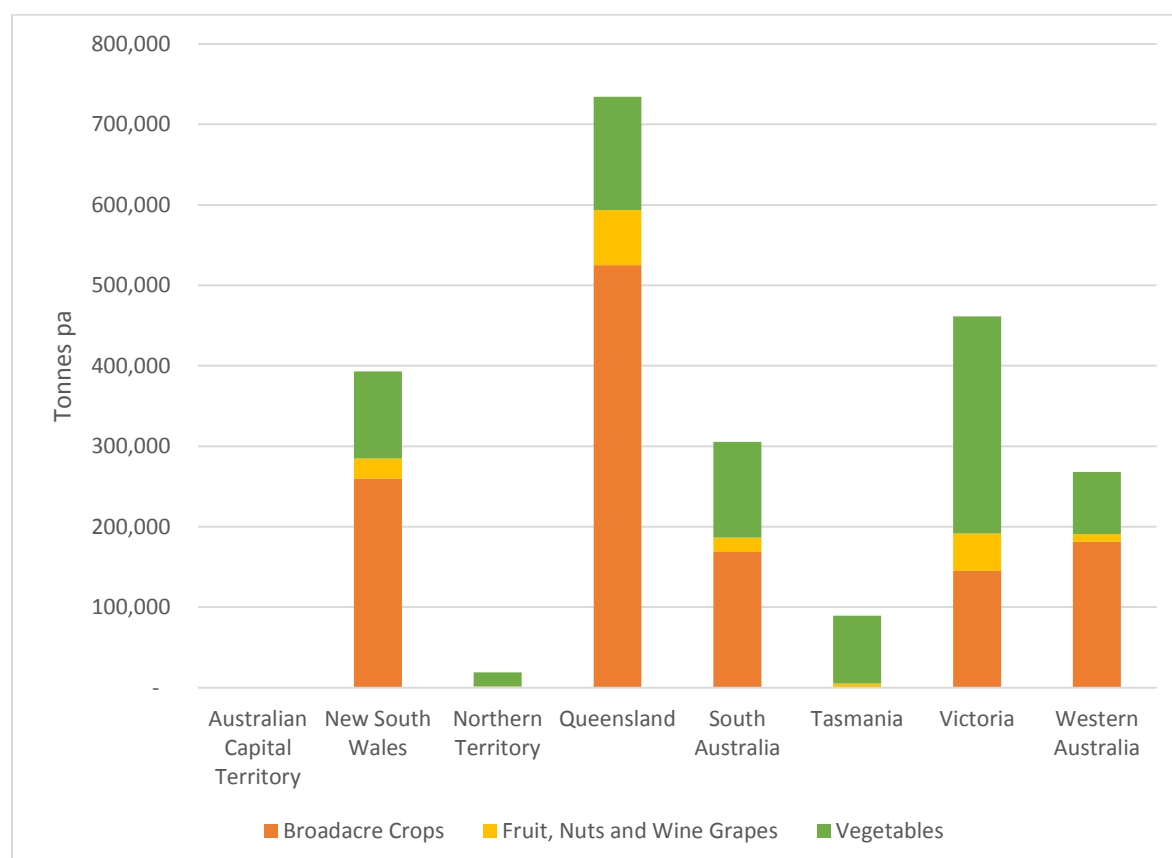


Figure 23: Estimated primary sector food waste generation by state/territory (tonnes)

Table 11: Estimated primary sector food waste generation by state / territory (tonnes)

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
Broadacre Crops	0	260,000	20	525,000	169,000	720	145,000	181,000	1,280,740
Fruit, Nuts and Wine Grapes	0	24,900	1,500	68,600	17,700	4,200	46,900	9,900	173,700
Vegetables	0	108,000	17,400	141,000	119,000	84,300	270,000	76,800	816,500
<b>TOTAL Food Waste</b>	<b>0</b>	<b>392,900</b>	<b>18,920</b>	<b>734,600</b>	<b>305,700</b>	<b>89,220</b>	<b>461,900</b>	<b>267,700</b>	<b>2,270,940</b>
Food Rescue	120	3,300	40	3,200	800	60	2,400	1,100	11,020
Animal Feed	0	33,800	0	20,100	89,500	95,900	74,600	22,600	336,500

Note: All modelled figures have been rounded as appropriate

There is a wide range of typical loss factors within the fruit, vegetables and crops sub-sectors, depending on the type of produce. Losses range from 1% to as high as 10% for sugar cane (excluding cane trash left in fields). Figure 24 to Figure 26 provide additional insight into the key food types responsible for food waste generation within the fruit, nut and wine grape sub-sector, followed by the other sub-sectors.



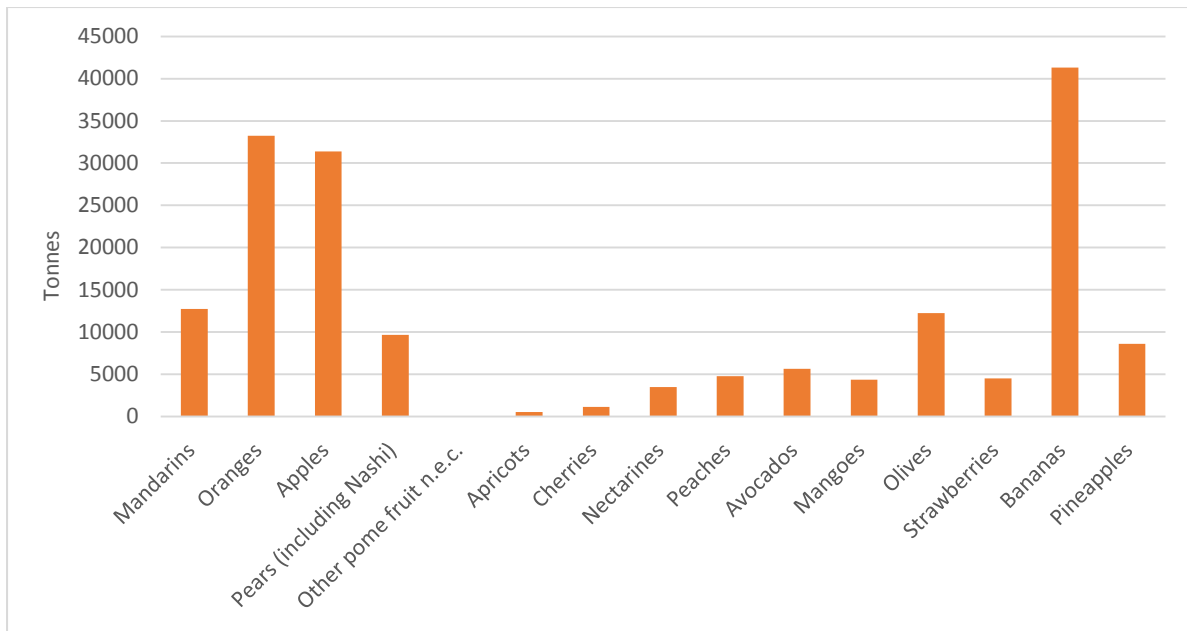


Figure 24: Estimated national on-farm losses from fruit production, 2016/17 (wine grape losses were too small to quantify)

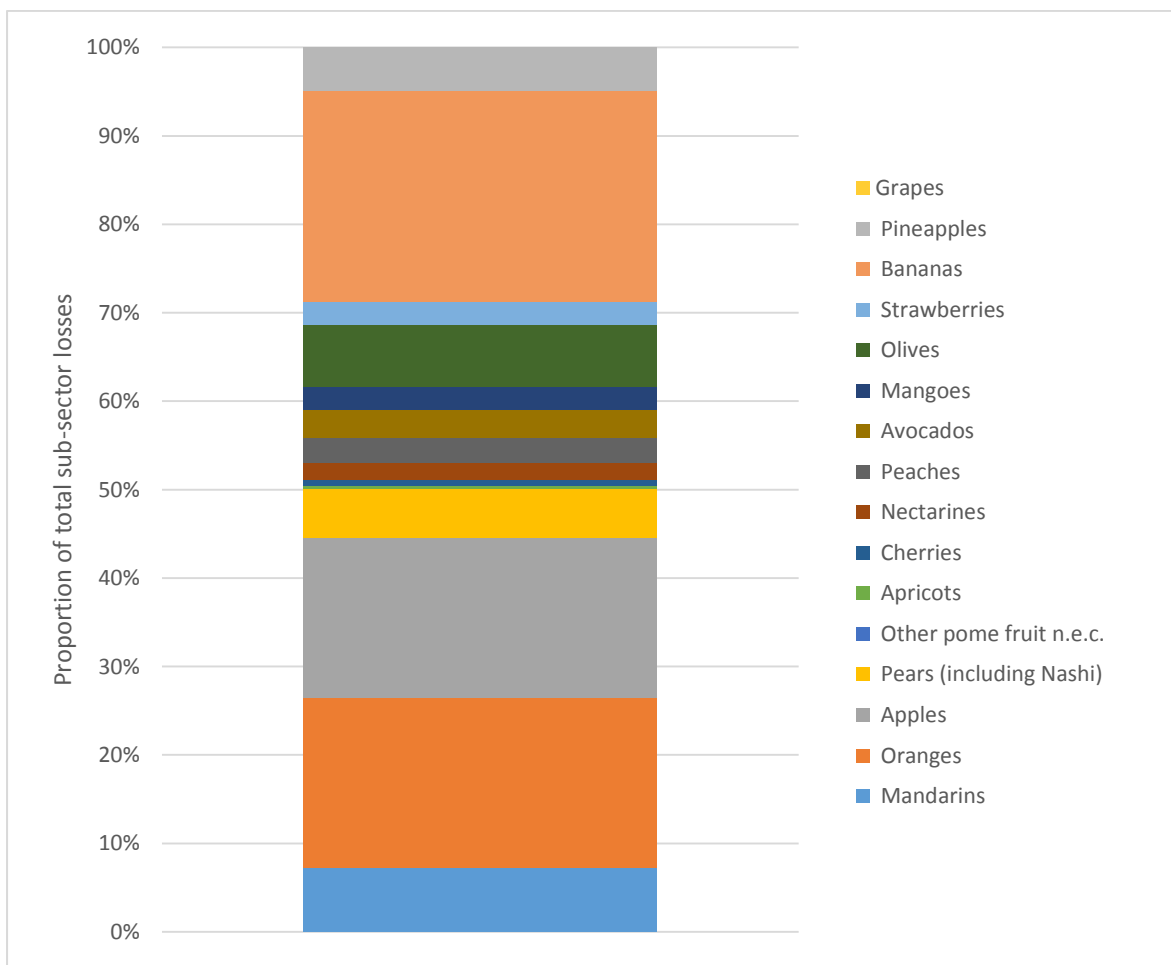


Figure 25: National breakdown of on-farm losses from fruit, nut and wine grape production, 2016/17

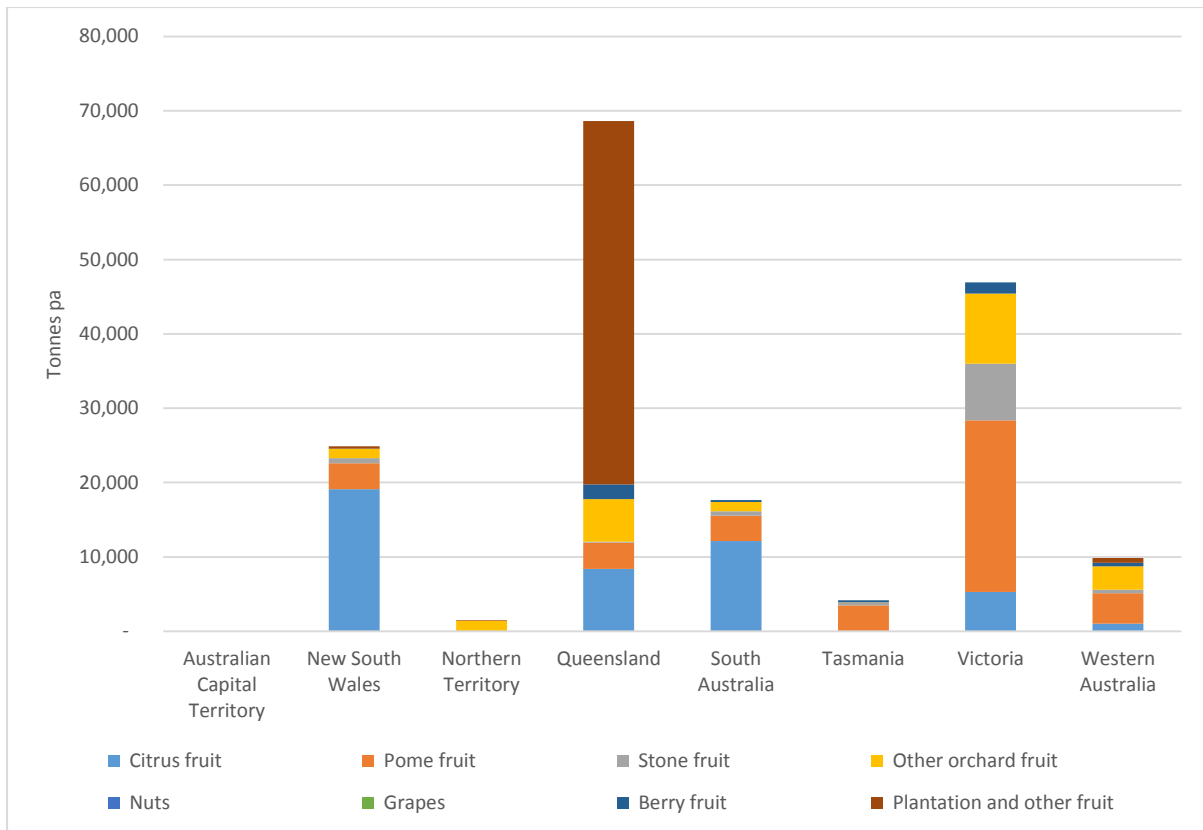


Figure 26: Breakdown of on-farm losses from fruit, nuts and wine grape production by jurisdiction, 2016/17

Figure 27 to Figure 29 provide additional detail on food waste in the vegetable sub-sector by crop type, including a state and territory breakdown.

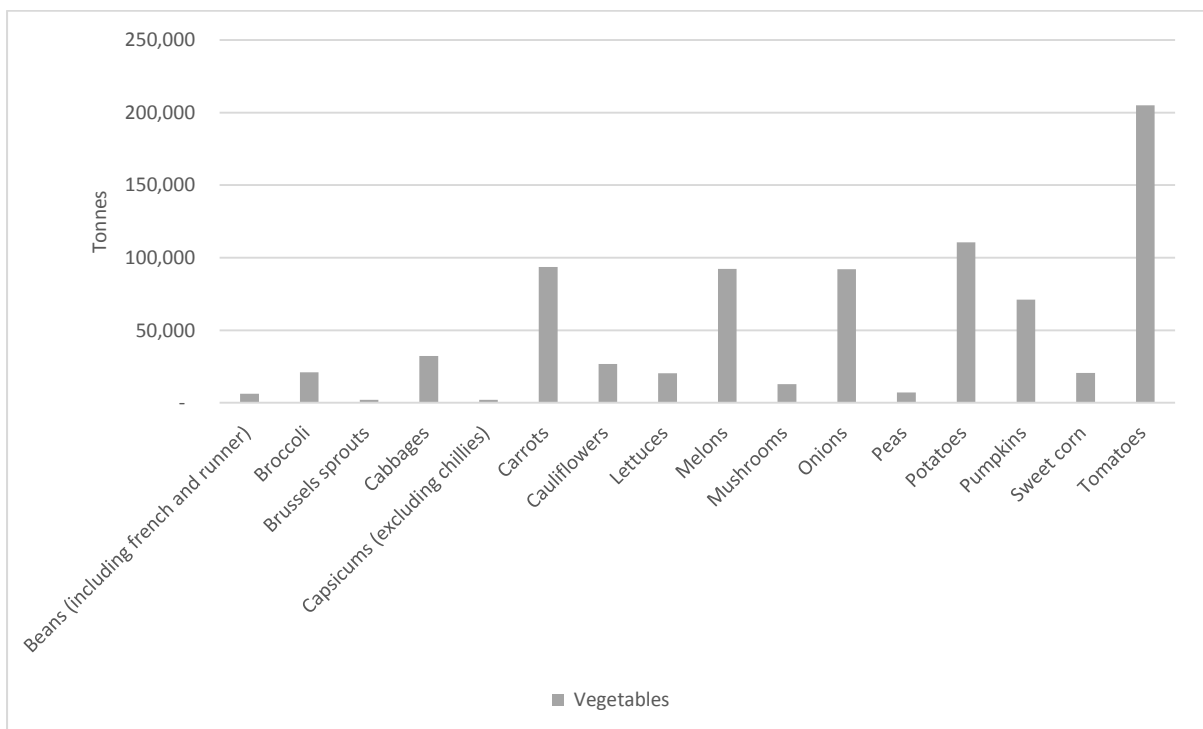


Figure 27: Estimated national on-farm losses from vegetable production, 2016/17

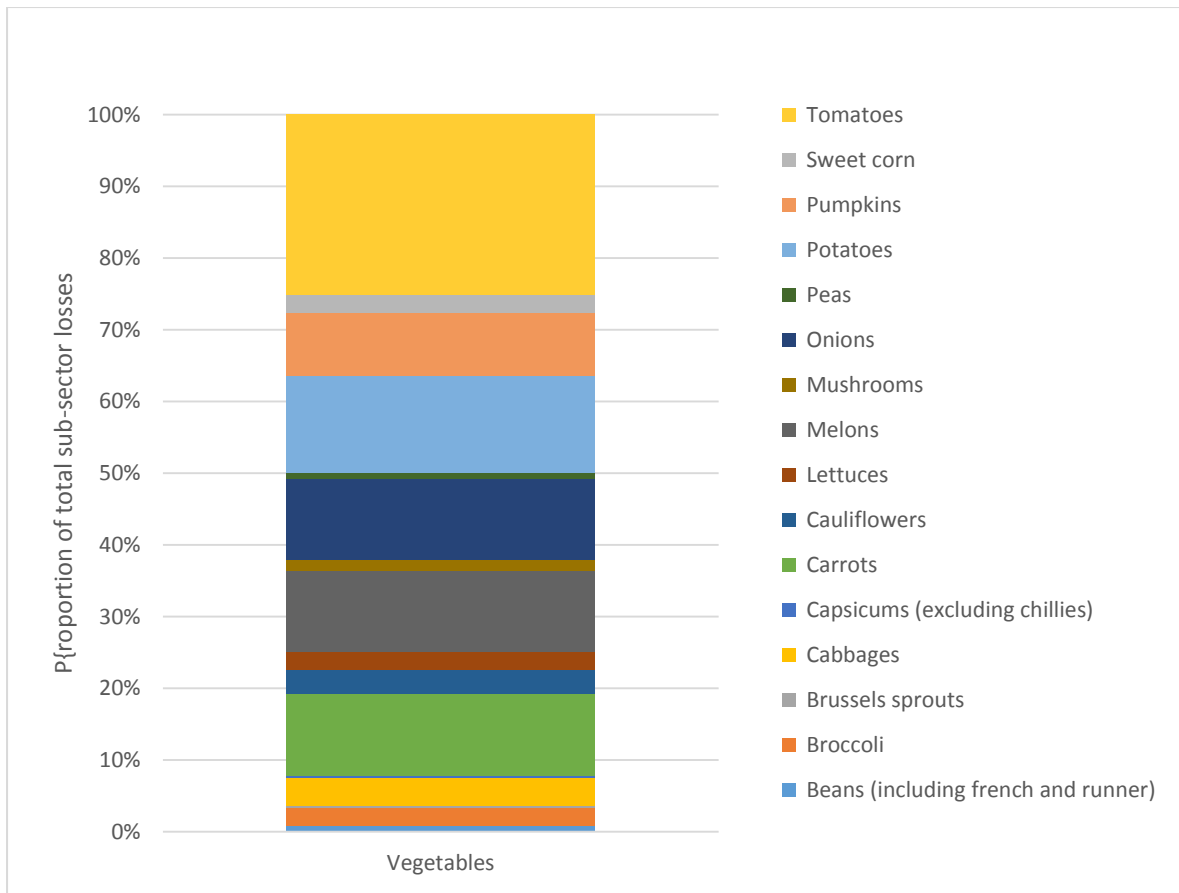


Figure 28: National breakdown of on-farm losses from vegetable production, 2016/17

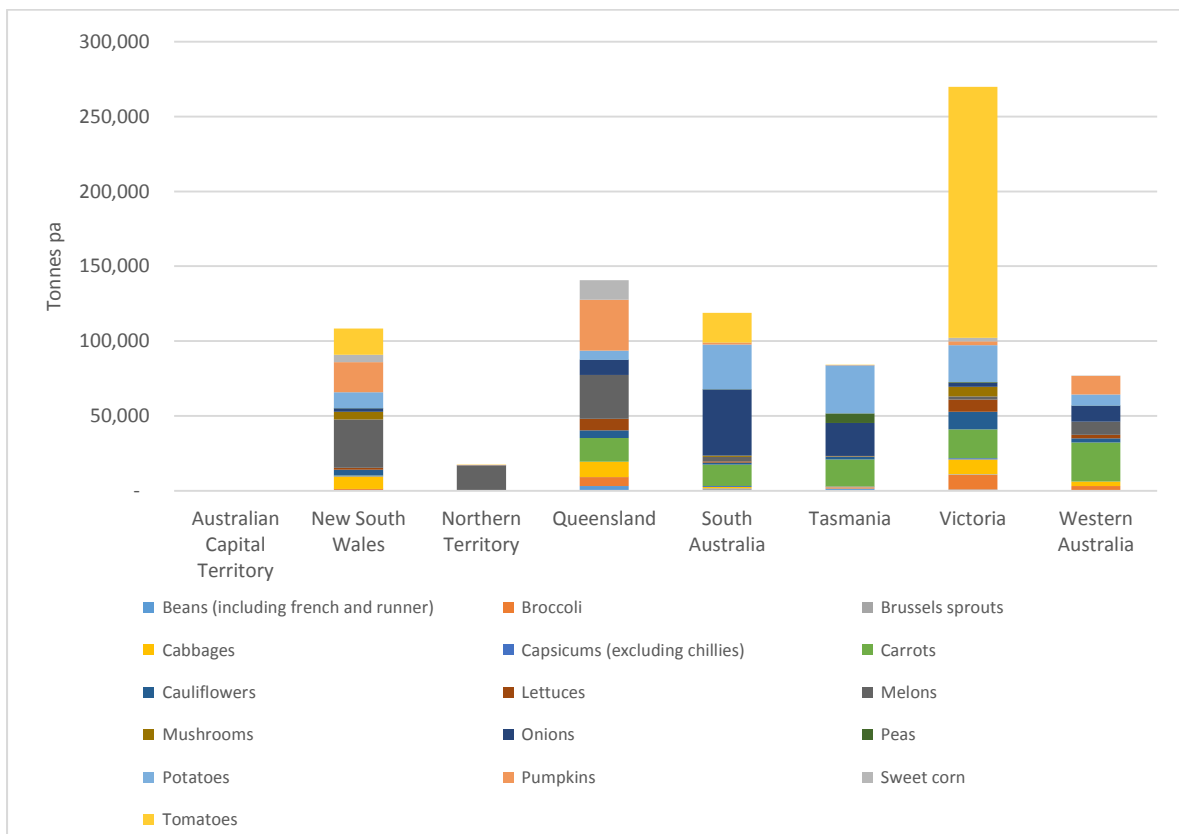


Figure 29: Breakdown of on-farm losses from vegetable production by jurisdiction, 2016/17

Figure 30 to Figure 32 provide additional detail on broadacre cropping sub-sector by crop type, including a state and territory breakdown.

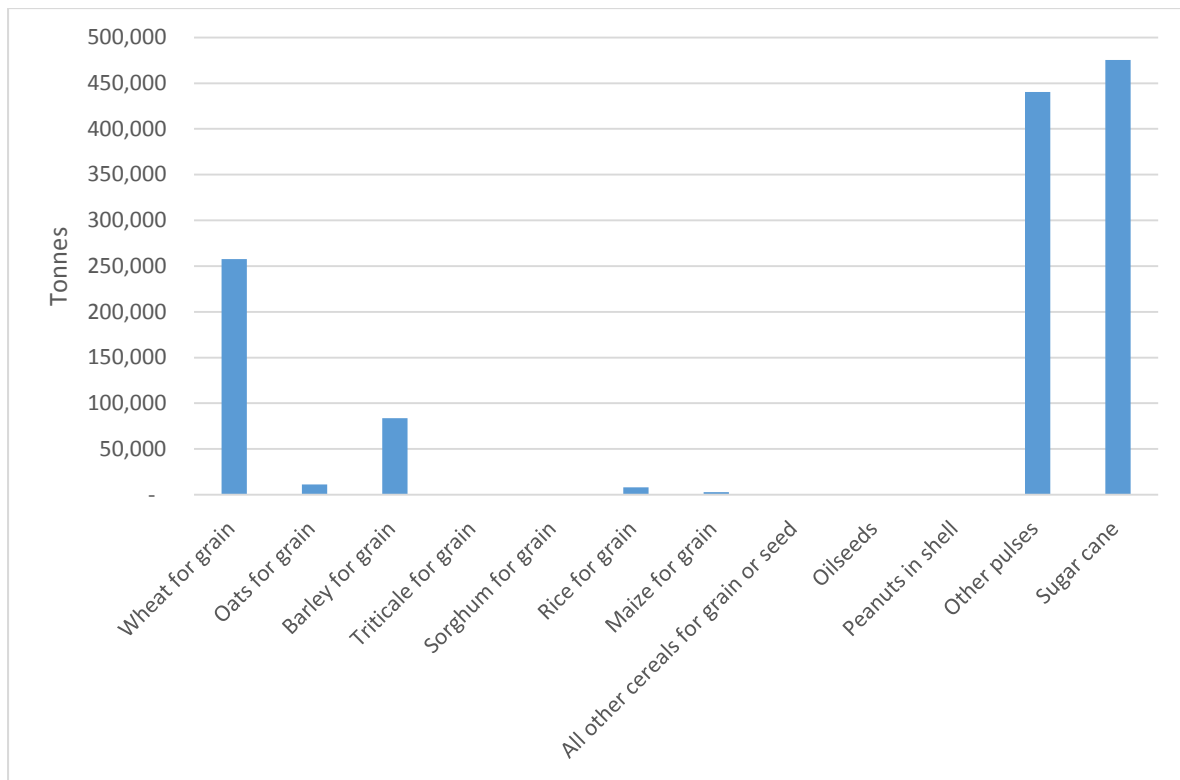


Figure 30: Estimated national on-farm losses from broadacre crop production in 2016/17

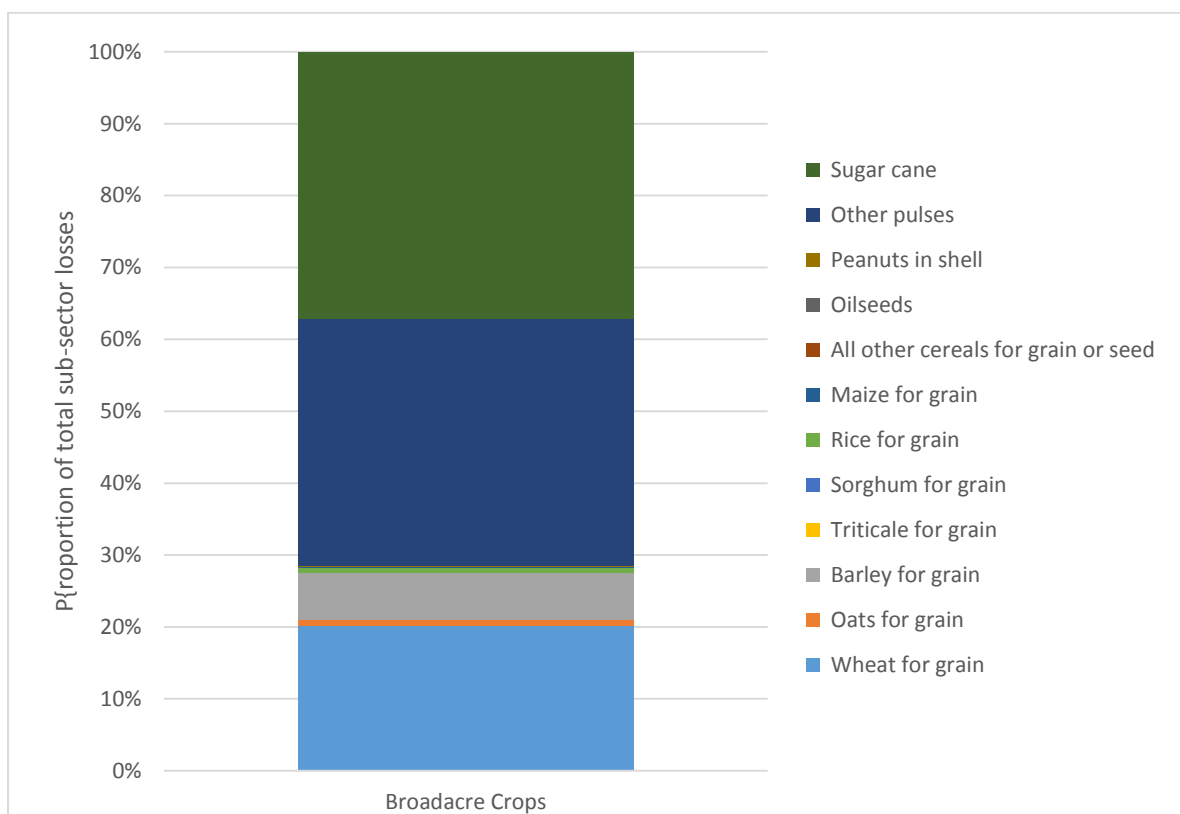


Figure 31: National breakdown of on-farm losses from broadacre crop production, 2016/17

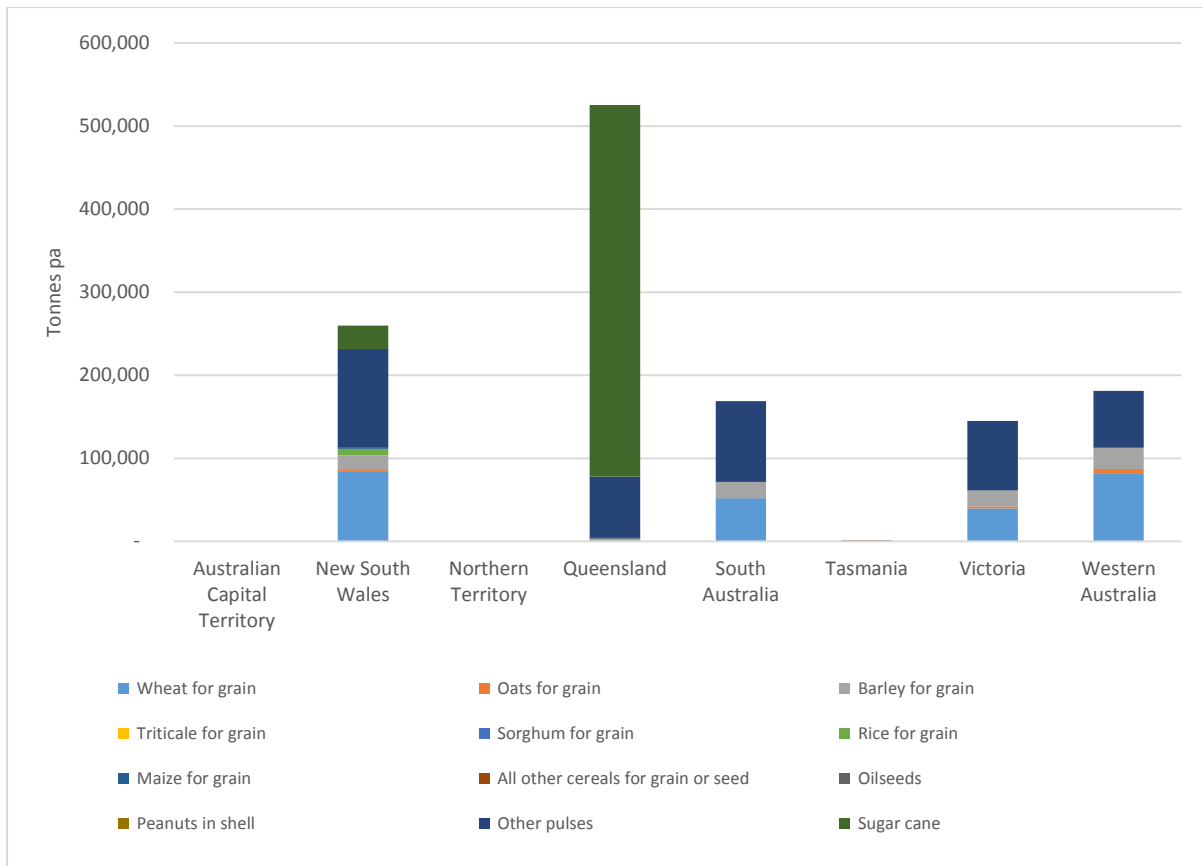


Figure 32: Breakdown of on-farm losses from broadacre crops by jurisdiction, 2016/17

The primary destination for food waste from crops and vegetable production and to a lesser extent, fruit and nuts, is ploughing back in on-farm, or not harvesting in the first place (see Figure 33 below). Food waste from egg farms and some fruit and nut farms is primarily sent to animal feed and is therefore not considered a food waste to be quantified in the national baseline figure.

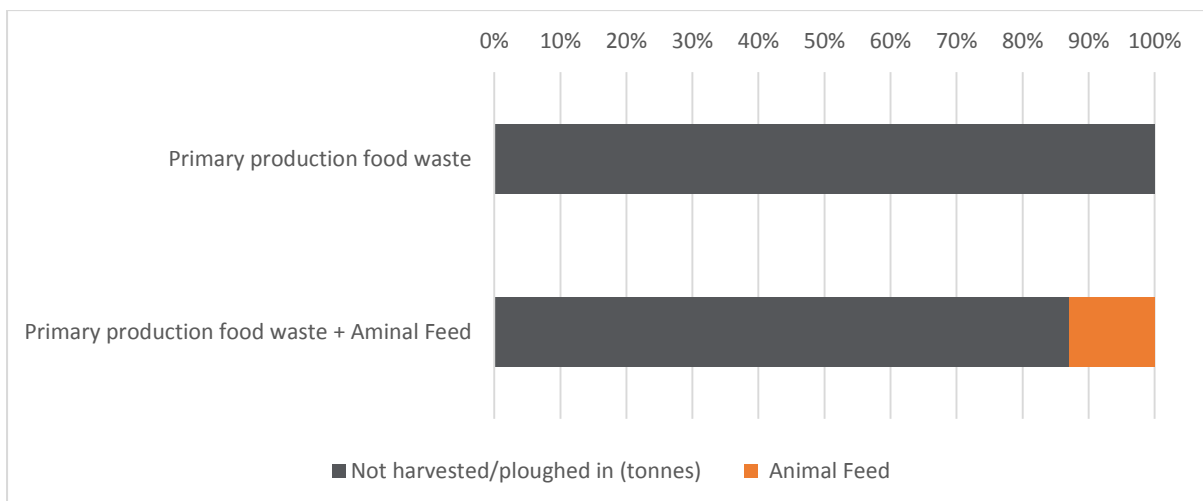


Figure 33: Destination of food waste from primary production sector, excluding animal feed (top) and including animal feed (bottom)

### 5.3. Sector: Manufacturing

The food manufacturing sector is highly complex to model due to the variety of types of manufacturing, scale and automation. From a food waste management perspective, the

manufacturing sector can be broadly divided between food processors early in the supply and consumption chain and later stage manufacturers of complex food products.

The largest quantities of food waste are generated in food packing and processing, with the key generators being dairy, livestock, grain, poultry and fruit and vegetables. Baked product, pasta, confectionary, beer and other product manufacturing accounts for relatively small quantities.

Data has been presented without sugar mill waste to account for the exclusion of bagasse (Figure 34), which is over six times the scale of total food waste in the rest of the manufacturing sector. Food waste in the sector is estimated to be 1.76 MT in 2016/17 (Table 12).

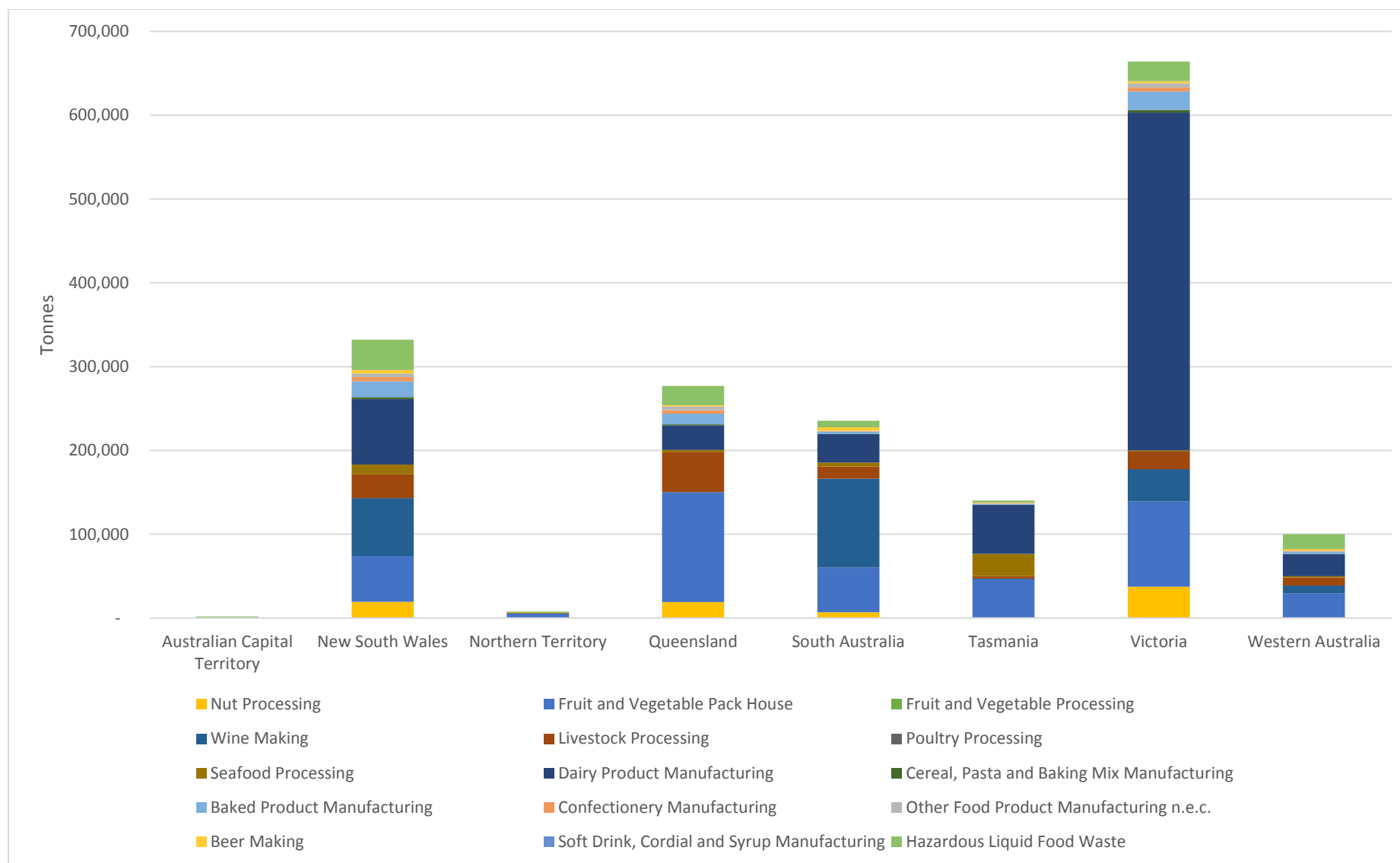


Figure 34: Estimated food waste in manufacturing (excluding sugarcane waste) in 2016/17

The data underpinning the estimate of manufacturing sector food waste, minus sugarcane bagasse, is provided in Table 12.

Table 12: Estimated manufacturing sector food waste generation by state, excluding bagasse (tonnes)

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
Nut Processing	0	19,300	0	19,000	6,800	0	37,300	120	82,520
Fruit and Vegetable Pack House	0	55,000	5,400	131,000	53,400	46,200	102,000	29,300	422,300
Wine Making	10	68,800	0	210	106,000	1,100	38,400	9,400	223,920
Livestock	0	28,400	0	47,300	14,400	2,800	20,700	9,400	123,000
Seafood	0	11,600	880	3,200	4,600	26,500	1,700	1,600	50,080
Dairy Product Manufacturing	0	78,200	0	29,200	34,000	58,300	403,000	26,500	629,200
Cereal, Pasta & Baking Mix	0	2,200	0	1,100	440	150	3,200	220	7,310
Baked Product	90	19,000	160	12,700	2,500	1,200	22,200	2,600	60,450
Confectionery	0	4,800	110	4,100	580	560	4,400	740	15,290
Other Food Product	20	4,300	0	4,700	690	370	5,300	710	16,090
Beer Making	40	4,400	20	1,400	3,900	610	2,400	1,800	14,570
Soft Drink, Cordial & Syrup	0	190	0	90	20	10	140	20	470
Hazardous Liquid Food Waste	1,900	35,800	1,200	23,100	8,000	2,400	23,200	17,700	113,300
<b>TOTAL Food Waste</b>	<b>2,060</b>	<b>331,990</b>	<b>7,770</b>	<b>277,100</b>	<b>235,330</b>	<b>140,200</b>	<b>663,940</b>	<b>100,110</b>	<b>1,758,500</b>
Food rescue	210	5,800	70	5,500	1,400	100	4,200	2,000	19,280
Animal feed	3,400	1,130,000	1,200	677,000	349,000	125,000	790,000	367,000	3,442,600

Note: All modelled figures have been rounded as appropriate

The destinations of food waste from the sector are illustrated in Figure 35. Manufacturing uses the most diverse range of resource recovery pathways of any sector, with sub-sectors pursuing options based on the nature of their food waste streams. For example, drink manufacturing generates a small tonnage (470 tonnes) and is assumed to be solid waste (e.g. fruit peel / pressings and residues from fruit drinks, which are less than 100% pure juice). Spoiled or expired drinks are often disposed to sewer but that would mostly be in the wholesale chain.



## NATIONAL FOOD WASTE BASELINE

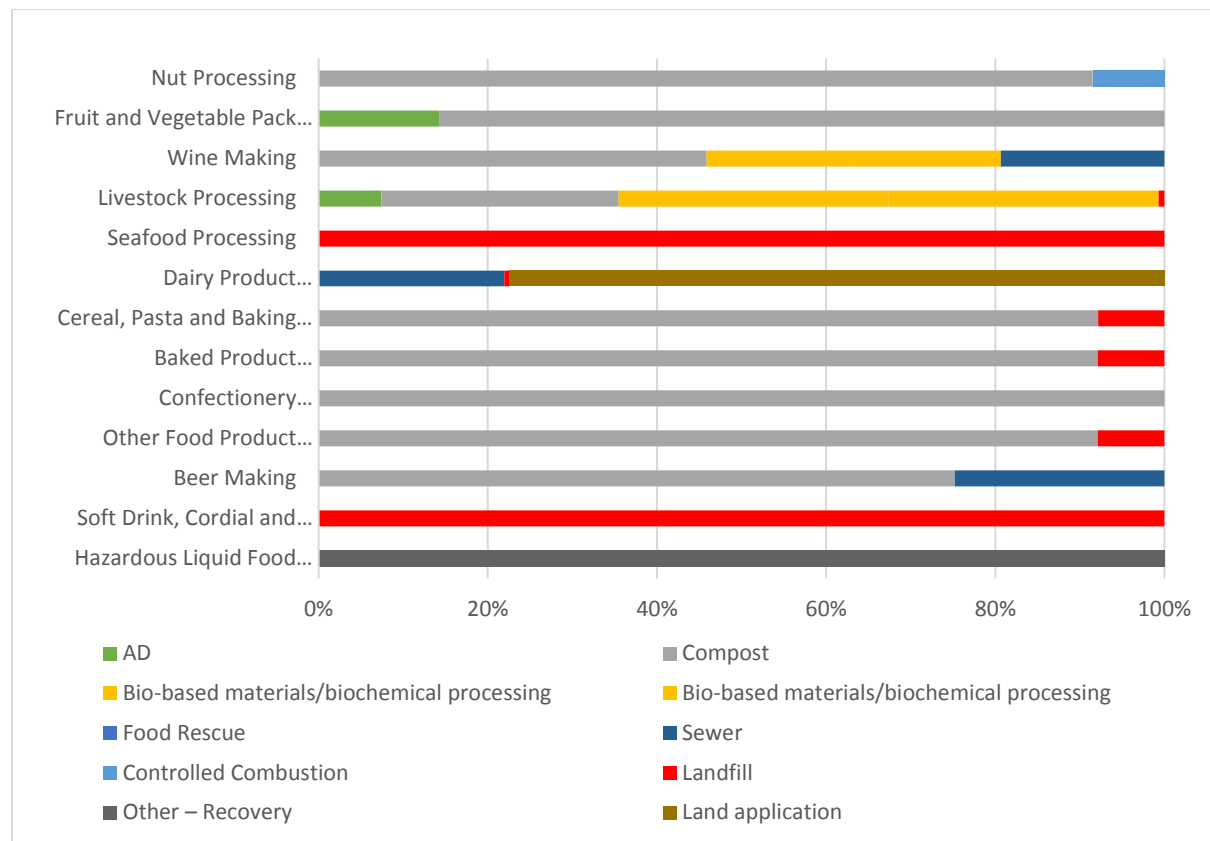


Figure 35: Destination of food waste and redistribution to food rescue, by manufacturing sub-sector

## 5.4. Sector: Wholesale

The wholesale sector generated an estimated 26,300 tonnes of food waste in 2016/17 based on the data provided by stakeholders, the majority coming from general line grocery wholesaling, which supplies a wide range of food products to the hospitality and retail sectors (Figure 36). Generation volumes broadly mirror the distribution of the population across the states and territories.

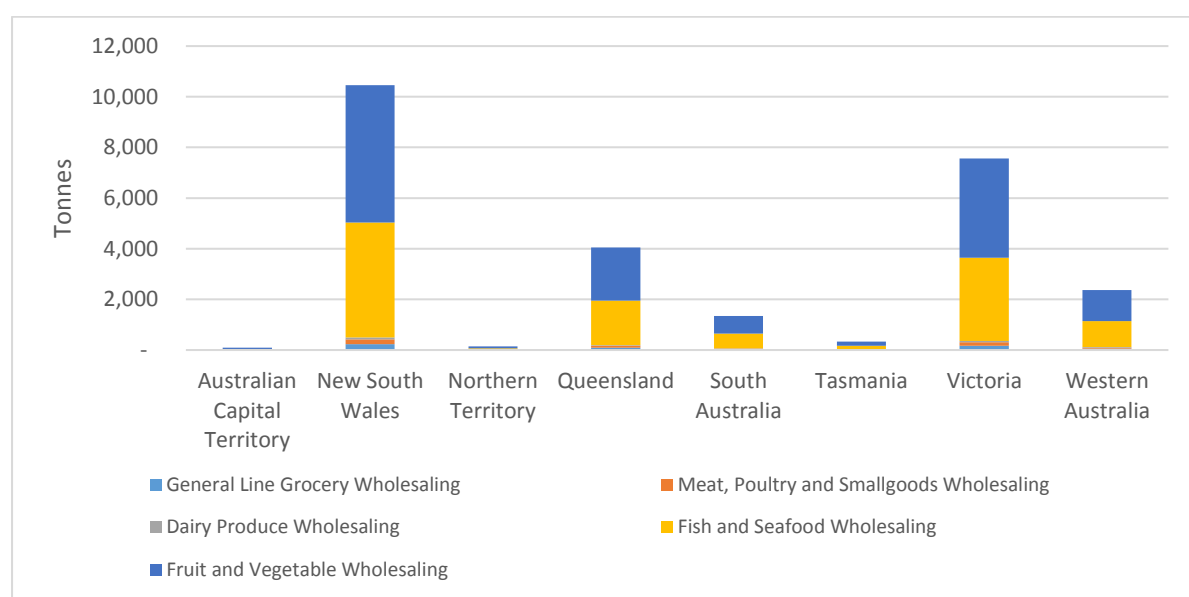


Figure 36: Estimated food waste in wholesale in 2016/17, by state/territory

Table 13: Estimated wholesale sector food waste generation by state (tonnes)

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
General Line Grocery	2	240	3	90	30	8	170	50	593
Meat, Poultry, Smallgoods	2	190	3	70	20	6	140	40	471
Dairy Produce	1	70	1	30	10	2	50	20	184
Fish and Seafood	40	4,500	60	1,800	590	150	3,300	1,000	11,440
Fruit and Vegetable	50	5,400	70	2,100	700	170	3,900	1,200	13,590
<b>TOTAL Food Waste</b>	<b>95</b>	<b>10,400</b>	<b>137</b>	<b>4,090</b>	<b>1,350</b>	<b>336</b>	<b>7,560</b>	<b>2,310</b>	<b>26,278</b>
Food rescue	10	240	0	230	60	0	180	80	800
Animal feed	90	10,100	140	3,900	1,300	330	7,300	2,300	25,460

Note: All modelled figures have been rounded as appropriate

A large proportion of surplus food from wholesaling goes to food rescue (Figure 37) which is not counted in the waste tonnage above. The industry closely manages the 'use by' dates of its inventory by pushing products nearing expiry, but it is also donating food when the shelf life is too short for sale.

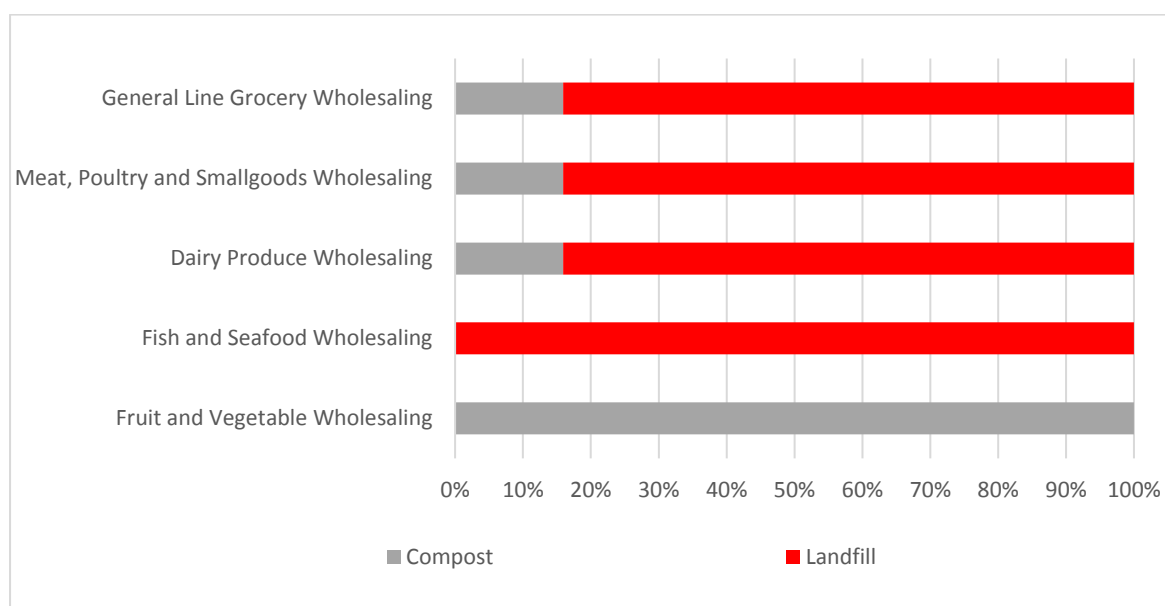


Figure 37: Destination of food waste (excluding food rescue and animal feed) from the wholesale sector

## 5.5. Sector: Retail

Despite the size and throughput of the retail sector, it is not among the largest generators of food waste, at 232,000 tonnes in 2016/17 (Figure 38). Little food is wasted in-store, the primary stream being perishable fresh food.

## NATIONAL FOOD WASTE BASELINE

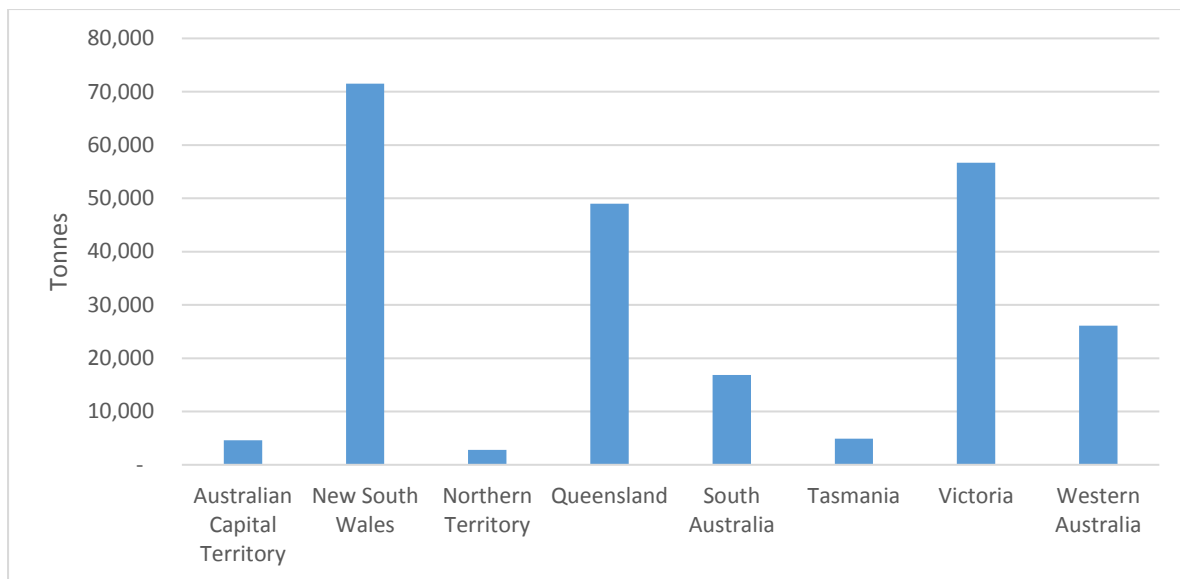


Figure 38: Estimated food waste in food retailing, by state/territory

Table 14: Estimated food retail sector waste generation by state, tonnes

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
<b>TOTAL Food Waste</b>	<b>4,600</b>	<b>71,500</b>	<b>2,800</b>	<b>49,000</b>	<b>16,800</b>	<b>4,900</b>	<b>56,700</b>	<b>26,100</b>	<b>232,400</b>
Food Rescue	180	4,900	60	4,800	1,200	80	3,600	1,700	16,520
Animal Feed	2,700	41,500	1,600	28,400	9,800	2,800	32,900	15,200	134,900

Note: All modelled figures have been rounded as appropriate

Animal feed is the second largest outlet for retail sector food waste after landfill, while the major supermarket brands are all major donors to food rescue organisations. The significant proportion sent to landfill is generated where food waste is presented in general waste bins (Figure 39).

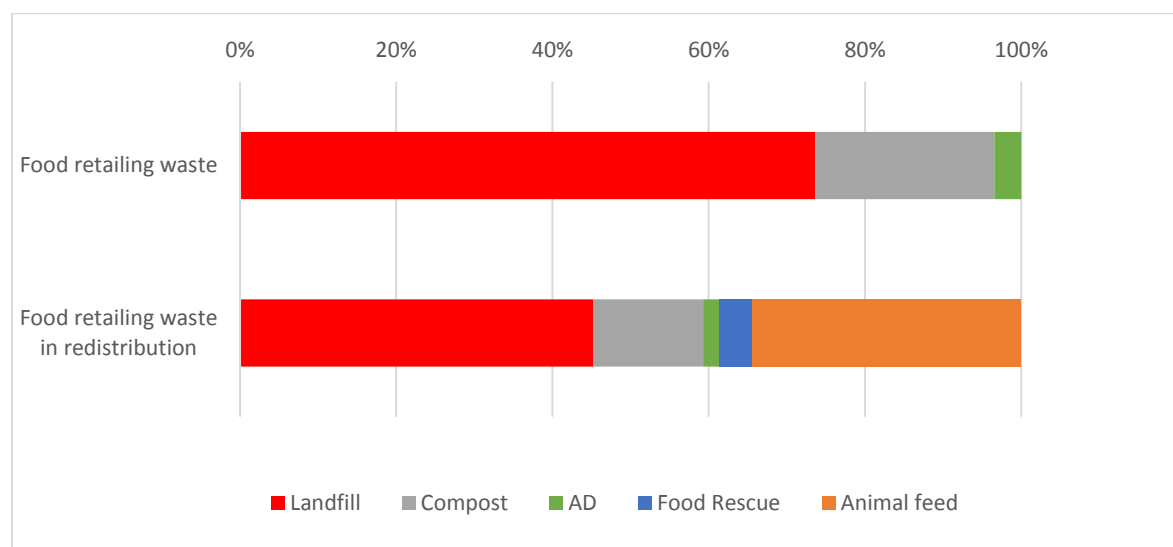


Figure 39: Destinations of food waste from retail sector, excluding (top) and including (bottom) redistribution to food rescue and diversion to animal feed

## 5.6. Sector: Hospitality & Food Services

The hospitality sector generated an estimated 324,000 tonnes of food waste in 2016/17 (Figure 40), with the greatest quantity coming from takeaway outlets where there is no control over post-consumer waste.

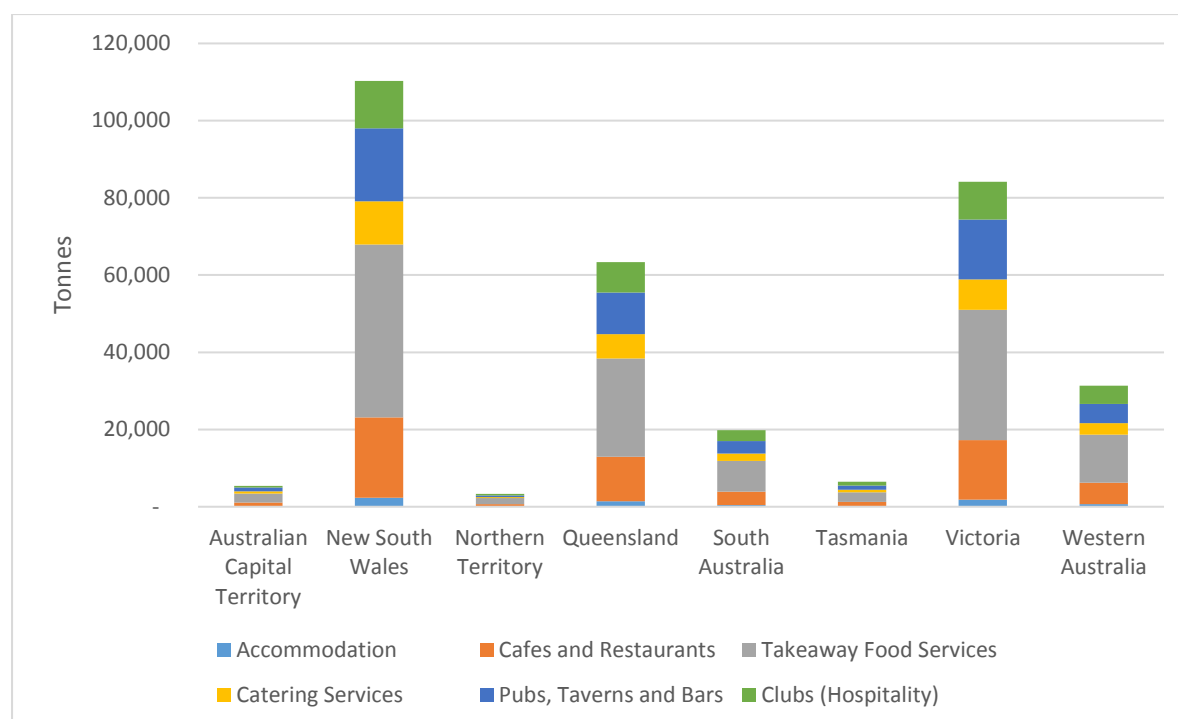


Figure 40: Estimated food waste in hospitality in 2016/17, by state/territory

Table 15: Estimated hospitality sector food waste generation by state, tonnes

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
Accommodation	90	2,400	70	1,400	400	130	1,800	640	6,930
Cafes & Restaurants	1,000	20,800	650	11,600	3,500	1,100	15,400	5,600	59,650
Takeaway Food	2,300	44,700	1,600	25,400	7,900	2,500	33,700	12,500	130,600
Catering Services	580	11,200	260	6,300	1,900	640	7,900	3,000	31,780
Pubs, Taverns & Bars	1,000	18,900	400	10,800	3,200	1,100	15,500	5,000	55,900
Clubs	440	12,300	400	7,900	2,800	990	9,800	4,800	39,430
<b>TOTAL Food Waste</b>	<b>5,410</b>	<b>110,300</b>	<b>3,380</b>	<b>63,400</b>	<b>19,700</b>	<b>6,460</b>	<b>84,100</b>	<b>31,540</b>	<b>324,290</b>
Food rescue	5	140	2	130	30	2	100	50	459

Note: All modelled figures have been rounded as appropriate

There is limited data across the sub-sectors of hospitality, with recovery and disposal practices assumed to be broadly consistent across the sector (Figure 41).

## NATIONAL FOOD WASTE BASELINE

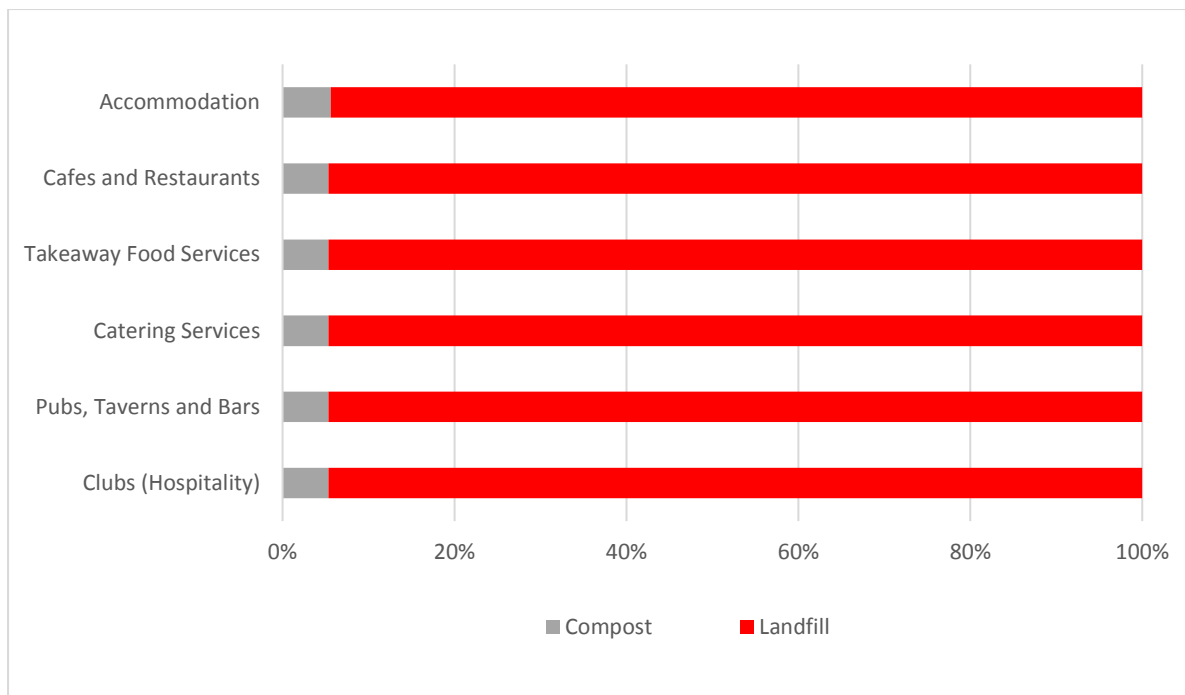


Figure 41: Destinations of food waste from hospitality and food services sector<sup>39</sup>

### 5.7. Sector: Institutions

Industrial catering kitchens and high levels of unconsumed food saw institutions generate an estimated 209,000 tonnes of food waste in 2016/17 (Figure 42). Many institutions serve food to fixed meal plans, which is a key driver of uneaten food due to misalignment with occupant preferences. Aged care and primary schools were the principle sources of food waste.

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<sup>39</sup> Data challenges within the hospitality sector prevent meaningful disaggregation of food waste performance by sub-sector.

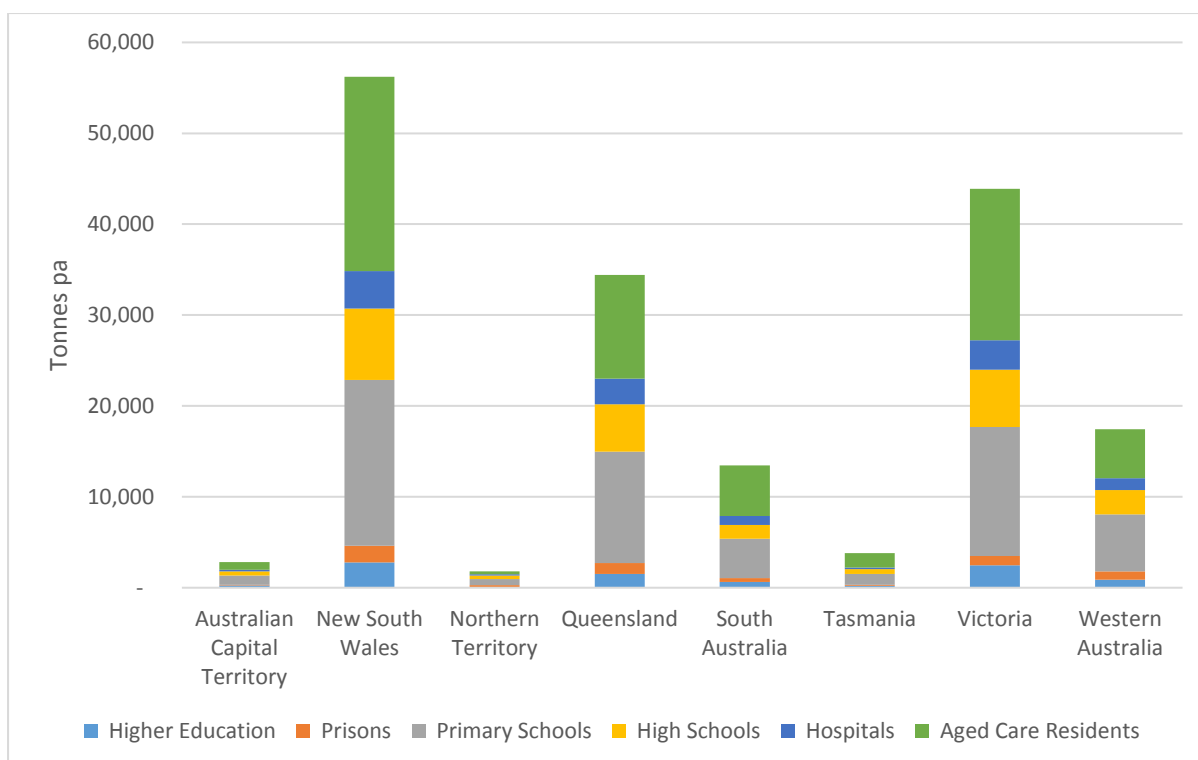


Figure 42: Estimated food waste within institutions in 2016/17, by state/territory

Table 16: Estimated institutions sector food waste generation by state, tonnes

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
Higher Education	250	2,800	70	1,500	620	230	2,500	870	8,840
Prisons	60	1,800	220	1,200	420	80	1,000	940	5,720
Child Care / Preschools	370	9,800	710	11,200	2,400	450	7,800	2,200	34,930
Primary Schools	1,000	18,200	660	12,300	4,300	1,200	14,200	6,200	58,060
High Schools	470	7,900	370	5,200	1,500	530	6,300	2,700	24,970
Hospitals	160	4,100	140	2,800	970	180	3,300	1,300	12,950
Aged Care Residents	850	21,400	320	11,400	5,600	1,600	16,600	5,400	63,170
<b>TOTAL Food Waste</b>	<b>3,160</b>	<b>66,000</b>	<b>2,490</b>	<b>45,600</b>	<b>15,810</b>	<b>4,270</b>	<b>51,700</b>	<b>19,610</b>	<b>208,640</b>
Food rescue	0	5	0	5	1	0	4	2	17

Note: All modelled figures have been rounded as appropriate

Institutions typically have restrictions on the redistribution of surplus food or recovery of unconsumed food due to concerns about contamination. The vast majority of food waste (assumed 100%) is estimated to go to landfill, the highest proportion of any sector in the food chain (see Figure 43 below).

## NATIONAL FOOD WASTE BASELINE

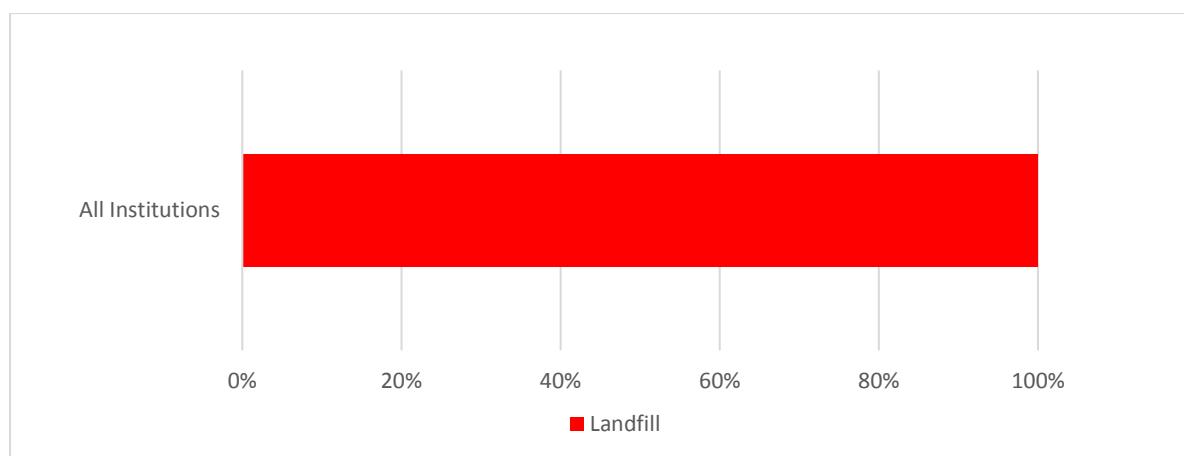


Figure 43: Destination of food waste from institutions sector

## 5.8. Sector: Households

Households in 2016/17 generated an estimated 2.5 MT of food waste (Figure 44), as reported by state and territory governments in the National Waste Report 2016. It is a key sector in which to address food waste reduction given the scope to improve consumer behaviours regarding food.

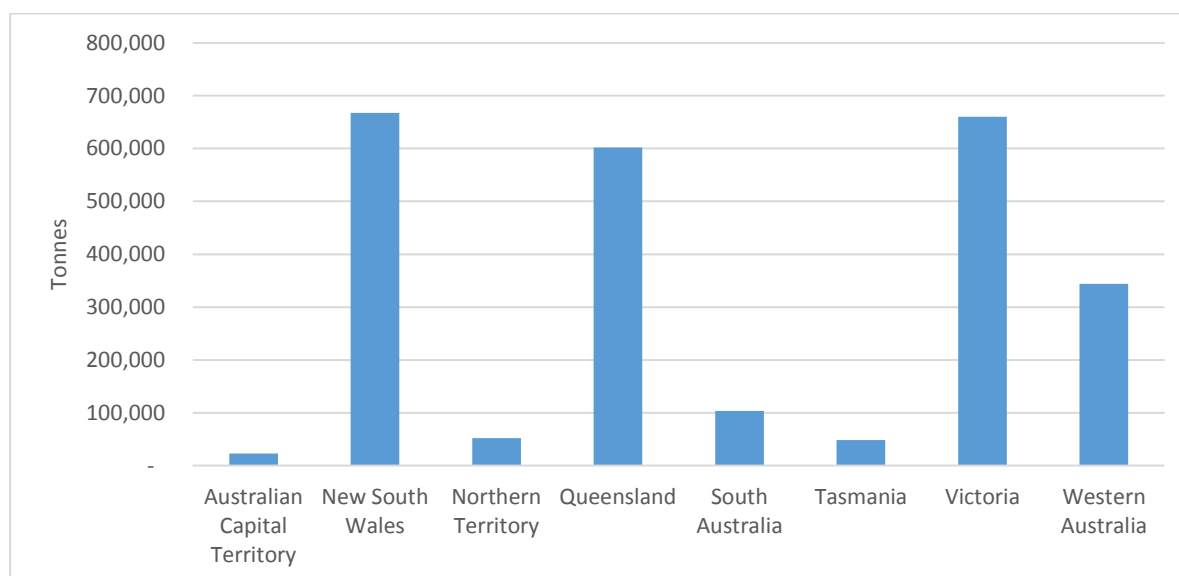


Figure 44: Estimated household food waste generation, by state/territory

Table 17: Estimated household sector food waste generation, tonnes

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
<b>TOTAL Food Waste</b>	<b>23,000</b>	<b>668,000</b>	<b>52,100</b>	<b>602,000</b>	<b>103,000</b>	<b>48,100</b>	<b>660,000</b>	<b>344,000</b>	<b>2,500,200</b>

Note: All modelled figures have been rounded as appropriate

Landfill is the primary destination for household food waste although industrial and domestic scale composting is a significant destination (Figure 45). Compost is inclusive of mixed waste compost derived from alternative waste technology (AWT) facilities. This may need to be reviewed in future

iterations following the October 2018 regulatory amendment by NSW EPA banning application to agriculture and suspending application to the major end markets of forestry and mining pending new controls.

A small quantity goes to sewer, in wash down water or via InSinkErator type devices, but there is no data to quantify this stream. Negligible quantities go to alternate pathways such as energy recovery, which sits below compost on the food waste hierarchy.

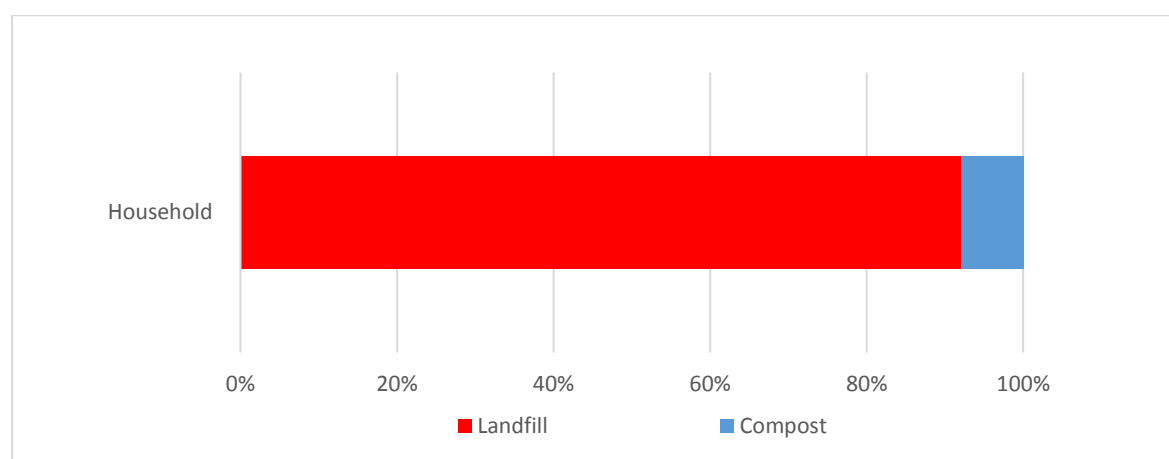


Figure 45: Destinations of food waste from the household sector

## 5.9. Sector: Transport & Storage

The transport and storage sector generated 227,000 tonnes of food waste in 2016/17, with the bulk of that being fruit and vegetables (Section 3.1).

However, this waste stream is reported here as a discrete estimate alongside the national baseline rather than a component of the overall estimate, due to limitations in the available data. Neither the logistics sector nor its key adjoining sectors (originators, receivers and disposal) have been able to isolate food waste that has specifically been generated by and within the transport stage.

As a result, it cannot be meaningfully isolated from the other sectors and reported as a discrete part of the food chain. Nevertheless, an estimate has been provided due to the strategic importance of the sector within the food chain and anecdotal evidence of high loss rates. Confidence in the data is low.



## NATIONAL FOOD WASTE BASELINE

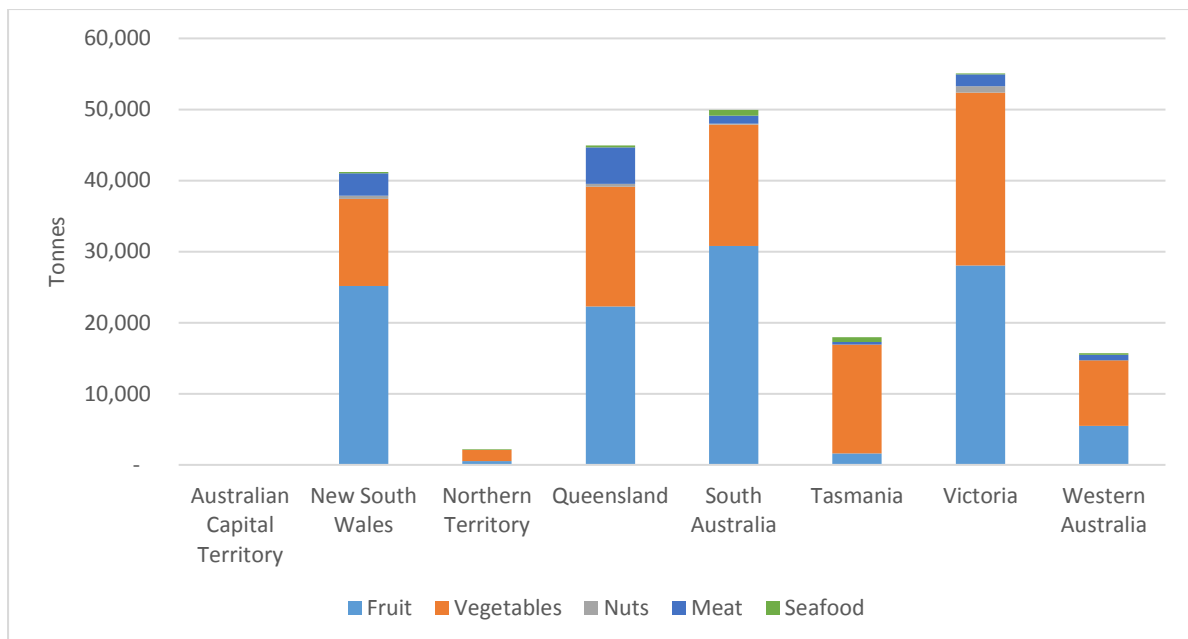


Figure 46: A breakdown of transport losses for the major food types.

Table 18: Estimated transport sector food waste generation, tonnes

Sub-Sector	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	AUS
Fruit	3	25,200	540	22,300	30,800	1,600	28,100	5,500	114,043
Vegetables	0	12,200	1,600	16,800	17,000	15,300	24,300	9,200	96,400
Nuts	0	450	0	430	160	0	900	3	1,943
Meat	0	3,200	0	5,100	1,100	350	1,700	780	12,230
Seafood	0	160	80	270	800	680	120	220	2,330
<b>TOTAL Food Waste</b>	<b>3</b>	<b>41,210</b>	<b>2,220</b>	<b>44,900</b>	<b>49,860</b>	<b>17,930</b>	<b>55,120</b>	<b>15,703</b>	<b>226,946</b>
Animal Feed	0	255,000	550	55,400	171,000	5,700	150,000	241,000	878,650

Note: All modelled figures have been rounded as appropriate

## 6. FOOD WASTE REDUCTION AND RECOVERY OPPORTUNITIES

The scale, cost and impact of food waste has become a growing community concern over at least the last decade in Australia. It has also been a key focus within the food supply and consumption chain, driven by factors including the issue's profile in the community, improved cost management, broader sustainability programs and the development of a technologies that improve supply chain transparency and inventory management.

Large scale research into primary production sector is underway through universities, the CSIRO, Rural Research and Development Corporations (RDCs) and some industry groups to increase yield, reduce losses or recover more value from food commodities on- and near-farm. CSIRO's proposed Food Loss Bank is an online platform that will allow the networked supply chain quickly identify, classify and repurpose underutilised edible biomass. Others are exploring options to turn potatoes that are unfit for sale on cosmetic grounds into either potato puree or potato salad.

These are typically large, discrete research and industry development projects. Most of the business-level opportunities identified in the literature review and by stakeholders were in the downstream sections of the supply and consumption chain. The major and cross-cutting opportunities are outlined in Table 19.

Table 19: Key food waste reduction opportunities

Supply chain segment	Opportunity
Manufacturing	Whey from the manufacture of dairy products, in particular cheese, is a key opportunity. While the larger companies dry the whey to recover whey powder and concentrate, the large number of small and medium sized (artisanal) cheese manufacturers are in many cases unable to justify either the investment in drying equipment or transporting the high-volume, low value waste to piggeries. This may present an opportunity to develop regional solutions to provide sufficient scale.
Wholesale	<p>Yüme is a new business model that serves as an online wholesale marketplace and matching service for primary and manufactured products that are at risk of not being sold like: products with short remaining shelf life, imperfect, excess stock and ingredients no longer needed in particular supplying the large industrial caterers in the institutions sector to move bulk quantities, but also hospitality.</p> <p>Yüme prevents consumable food from going to waste, it sells the product on behalf of the supplier at a discounted price (for a commission) and usually leaves it to the supplier to arrange the logistics through their own established channels.</p> <p>The model is particularly powerful where there is a major over-supply. Yüme's unique technology allows buyers and suppliers to connect in a secure and quick way to ensure suppliers receive a return on food that might have otherwise gone to waste and allows buyers to save on their food costs.</p>
Retail	<p>The National Australian Built Environment Rating System (NABERS) environmental rating program for buildings is expected to soon roll out a new waste rating tool for shopping centres that will benchmark them nationally according to their waste performance.</p> <p>Given that shopping centre assets are key components of many investment company portfolios, there is significant public scrutiny over their environmental performance. The new NABERS waste rating system is likely to drive increased adoption of innovative waste solutions across the shopping centre sector nationally, particularly addressing food organics.</p>
Retail	The four major supermarket brands and the shopping centre owners are responsible for managing the vast majority of food waste generated from the retail sector. They are already making significant strides in reducing and recovering food waste, including surplus food donations or partnerships with local farmers for

## NATIONAL FOOD WASTE BASELINE

Supply chain segment	Opportunity
	<p>animal feed, discounting fresh product ranges that don't meet normal aesthetic standards of size and shape, food organics collections and consumer education campaigns to assist householders in maximising the longevity of purchased food.</p> <p>The wide geographic distribution of food retail outlets nationally presents a barrier to reducing food waste sent to landfill, particularly outside of metropolitan areas.</p> <p>Retailers and shopping centre owners are good targets for the planned voluntary commitment to reduce food waste and report to the National Food Waste Baseline.</p>
Manufacturing	<p>Increasing product quality to meet retail specification would provide gains, but there may be more benefit in converting the off-specification produce into a new product, depending on the crop. For example, reject potatoes could be processed into potato puree or potato salad.</p>
Hospitality	<p>Melbourne's Crown Entertainment Complex, which has approximately 70 businesses and 7000 staff, has increased food organics collection almost 10-fold over three years to 220 tonnes per month, through a dedicated focus on reducing contamination. Management conduct five audits a month per business at random times and undertake spot checks of bins; contamination compliance is a key performance indicator (KPI); all staff undertake online induction and waste management training, and simple kitchen design efficiencies help improve diversion, such as the capacity to wipe down benches into a food waste compartment, rather than having to walk to the bin.</p>
Hospitality	<p>In general, there is limited data in the hospitality sector on food waste quantities and composition, including the percentage of avoidable and unavoidable food waste. Some companies are actively collecting and analysing food waste data from their kitchens to better understand the options to reduce avoidable food waste costs.</p> <p>This can be achieved through site specific audits and implementing commercially available solutions at preparation and disposal points to weigh and identify food waste by type. This can inform the goals and KPIs for head chefs and kitchen staff and drive options including food rescue, amending menus, using surplus food for staff meals and investigating on-site organics treatment technologies such as digestion.</p>
Manufacturing, retail and hospitality	<p>A major problem faced by the food rescue industry is the lack of training in donor organisations on the correct handling and storage of food donations. Sectors such as wholesale and retail (both small and large enterprises) could substantially increase the quantities accepted by food rescue organisations through improvements in staff awareness on how to manage donations awaiting collection.</p> <p>For example, staff may overlook the different storage methods required for packaged meats versus fruit and vegetables, leading to rejections at the time of collection. Food rescue organisations recommend a schedule be set for collection days and times to establish a consistent routine, and that all staff with the potential to handle donations be educated on the approved procedures.</p>
Institutions	<p>New food service models are being trialled and introduced across many institution types to improve food standards and reduce food waste quantities. The set menu model and rigid 'per occupant' requirements around food quantity and timing have long resulted in the over ordering and over catering of food.</p> <p>With limitations on food donations due to the potential 'contamination factor' from some institutions, the focus has been on the front-end arrangements such as foods ordering and exploring the potential to alter current models to account for individual variability. Increasing occupant responsibility for food orders (such as frequency and serving size), and changing service types (such as from cold plating to hot plating) should influence ordering requirements and significantly reduce uneaten food.</p>

Supply chain segment	Opportunity
Food rescue	<p>The existing capacity of the food rescue network isn't sufficient for the quantities of surplus food available for donation nationally. For example, one supermarket brand reported it requires collection at least three times per week. Coverage outside the main metropolitan areas is also limited, being either non-existing, too infrequent or travelling such long distances that the surplus food that has limited shelf life.</p> <p>A hub-and-spoke network model of local food rescue organisations covering major population areas would help donor companies develop more systematic approaches to donations of edible food, particularly major food retailers that are distributed nationally.</p>
Food rescue	<p>One of Foodbank's most innovative initiatives is the School Breakfast Program (SBP), which for registered schools supplies free breakfast to disadvantaged students who may otherwise attend school hungry.</p> <p>SBP supplies non-perishable products such as canned fruit, wheat biscuits and UHT milk, and fresh produce where available, including bread, yoghurt and fresh fruit and vegetables. Most state and territory governments are understood to have supported the SBP.</p>

## APPENDIX A ABBREVIATIONS

Abbreviation	Full term
ABS	Australian Bureau of Statistics
ANZSIC	Australian and New Zealand Standard Industrial Classification
APEC FLOWS	Asia-Pacific Economic Cooperation – Multi-Year Project on Food Losses and Waste System
AWT	Alternative waste treatment
CO <sub>2</sub> e	Carbon dioxide equivalent
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organisation
FLW Standard	Food Loss and Waste (FLW) Standard
FOGO	Food organics and garden organics collection
FTE	Full time equivalent
FUSIONS	Food Use for Social Innovation by Optimising waste prevention Strategies
MBM	Meat and Bone Meal
MT	Million tonnes
NABERS	National Australian Built Environment Rating System
n.e.c.	Not elsewhere classified
n.o.c	Not otherwise classified
NSW EPA	New South Wales Environment Protection Authority
RDC	Rural Research and Development Corporation
SDG	Sustainable Development Goal
SME	Small to medium enterprises
UK WRAP	Waste and Resources Action Programme
WtE	Waste to Energy



## APPENDIX B DETAILED METHODOLOGY

This section provides a detailed description of the methodology developed to collect available data and model food waste across the food chain. The key data sources and assumptions are detailed in Section 2.4.

### Definition and System Boundaries

The first step was to define food waste, which has been characterised subject to the following destinations adapted from the international Food Loss and Waste (FLW) Standard to suite the Australian context and policy objectives:

- Bio-based materials / biochemical processing
- Co-digestion / anaerobic digestion
- Composting / aerobic processes
- Controlled combustion
- Land application
- Not harvested / ploughed in
- Other - Recovery (including discards and hazardous materials)
- Other - Disposal (including discards and hazardous materials)
- Landfill
- Sewer / wastewater treatment.

Food that is redistributed to food rescue or diverted to animal feed is not considered a food waste but has been quantified or estimated where data was available.

The boundary conditions are in accordance with the Food Loss and Waste Standard, which seeks to quantify food waste from the point of harvest or slaughter through to final disposal or resource recovery.

### Data Collection

In the absence of any existing comprehensive food waste data sets, a survey was developed to capture new food waste data from stakeholders across the supply and consumption chain. The survey required reporting on:

- Known staff numbers
- Production statistics
- Waste quantities by type and destination
- End-destinations for waste generated
- Circumstances leading to waste arising
- Current practices to avoid waste generation.

More than 300 stakeholders were contacted across government, primary production, transport, manufacturing, wholesale, retail, hospitality, institutions and food rescue. The response rate, which is defined to be provision of a survey, alternate data or information that can be used within the model or report, was low, with the exception of food rescue, government and institutional organisations. A number of other stakeholders provided useful contextual or background information, but not quantitative data that could support the modelling. The lowest response rate was within the wholesalers and hospitality sectors, although the least primary data was provided by stakeholders in the transport and storage sector.

# Food Waste Modelling

This step involved consolidation of the completed surveys, alternative data or reference information provided by stakeholders. Where no data was available, or there were data quality concerns, alternate reference information was identified and used. Sources included consultants' reports into relevant subject matters, international investigations or academic papers.

Key to this process was capacity to extend data nationally, which therefore required correlation with national industry data for each sector covering production statistics, turnover, employment and number of entities. Other relevant market data such as market share was also utilised.

## Primary Production

Using loss rates provided by primary producers and industry groups, Arcadis modelled waste based on national production statistics (ABS Agricultural Commodities 2016/17) and the volumetric loss estimates from the limited number of participating stakeholders. Reported volumetric loss estimates were compared against FAO 2011 'Global food losses and food waste – extent, causes and prevention' food loss estimates for Oceania and local academic references where available.

### Relevant Assumptions

#### Broadacre Crops

- Estimates for losses are based on the reported losses of grain produces on-farm and through transportation, which sum to 1% for grains, and 12% for pulses.
- According to Sugar Research Australia, approximately 5-15% of millable cane is lost on farm through green cane harvesting, which is practiced by over 75% of the industry. Of this, the Australian Sugar Milling Association estimates approximately 28% (by weight) would have become bagasse (excluded from the baseline), 13% would have become refined sugar, 2.8% would have become molasses intended for animal feed (not a food waste for the baseline) and the remainder (56%) moisture loss<sup>40</sup>.
- There is opportunity for debate regarding loss assumptions for this model, as some crops are deliberately left on-farm for nitrogen fixing purposes. This is common for pulses.
- Based on research, commodities of triticale and sorghum have been entirely excluded as these crops are predominantly grown for animal feed. Proportions of wheat, oat, barley and maize crops grown for animal feed were excluded.
- Oilseeds were entirely excluded as they are predominantly used for cooking rather than direct consumption.

#### Fruit, Nuts and Wine Grapes

- A blanket assumption of 10% on-farm losses was applied based on the reported losses of participating stakeholders.

#### Vegetables

- On-farm loss estimates were derived from stakeholder estimates, 'Identifying new products, uses and markets for Australian vegetables - a desktop study' by Horticulture Australia, 'Primary Production Food Losses' by the South Australian Research and Development Institute PIRSA and 'Tomato waste at rotten levels' by the University of the Sunshine Coast.

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<sup>40</sup> <https://asmc.com.au/industry-overview>



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### Livestock

- For the purposes of modelling, it has been assumed that no on-farm losses occur with livestock. According to the FAO standard, the boundary conditions for food waste are at harvest and slaughter.
- On-farm egg losses are included, and assumed to be 2% as per estimates of participating stakeholders.

### Seafood

- Environmental regulations prevent disposal at sea. 'By-catch' is a waste but not included within the boundaries of this investigation as 'by-catch' is not intended for human consumption. Seafood waste is quantified within the manufacturing sector (seafood processing).

### Limitations

- There is potential for error in the data as it is based on self-reporting for the Rural Environment and Agricultural Commodities Survey 2016/17.
- Stakeholders reported concerns with the derivation and quality of ABS national production statistics, but very few industry groups were able to provide alternatives.
- The loss rate has been applied to total production. The quantity that may have been produced for seed purposes was not apparent from the ABS Production data.
- Limited number of primary producers participated.

## Manufacturing

The following approaches were taken for estimating waste across the multifaceted manufacturing sector:

- Packing, grain processing and abattoir data estimated as losses to national production statistics (ABS Agricultural Commodities 2016/17)
- Animal feed statistics from the Feed Grain Supply and Demand Report 2016 were used to understand mill mix, malt combining and other waste streams. A very significant volume of grain goes to animal feed (~8MT per annum), however the intended use is both as human and animal food (depending on quality) and the animal component has not been defined as a waste from the human food system.
- Where waste generation figures were provided for some organisations along with employment or turnover, this was converted to an industry waste generation estimate using the organisation's market share.
- For manufacturing groups where no data was available, generalised food manufacturing rates were applied to an indicative average number of staff within each enterprise (ABS Counts of Australian Businesses, including Entries and Exits).
- Sugarcane bagasse has been excluded as the stream is a significant outlier within the national food waste dataset and skews performance across states and between sectors.

### Relevant Assumptions

- Of all the segments, this is the most challenging to model as many of the commodity groups were analysed and quantified based on the raw data of a few organisations. Market shape and geographic distribution data were used to extrapolate across the entire industry and on a national scale.
- Detailed modelling assumptions cannot be listed due to the data confidentiality of participating stakeholders. They are detailed within the model supplied to the Australian Government.

## Limitations

- Production statistics are a more reliable modelling metric than employment. Manufacturing is a diverse industry with differing levels of automation, therefore employment is not necessarily an indicator for the scale of food waste generation.
- The food manufacturing sector is highly complex and diverse, with 22 manufacturing categories captured by the ABS, being:
  - Meat Processing, Poultry Processing, Cured Meat and Smallgoods Manufacturing, Seafood Processing
  - Milk and Cream Processing, Ice Cream Manufacturing, Cheese and Other Dairy Product Manufacturing,
  - Fruit and Vegetable Processing,
  - Oil and Fat Manufacturing
  - Grain Mill Product Manufacturing, Cereal, Pasta and Baking Mix Manufacturing, Bread Manufacturing (factory based), Cake and Pastry Manufacturing (factory based), Biscuit Manufacturing (factory based), Bakery Product Manufacturing (non-factory based)
  - Sugar Manufacturing, Confectionery Manufacturing, Potato, Corn and Other Crisp Manufacturing,
  - Other Food Product Manufacturing n.e.c. (not otherwise classified)
  - Soft Drink, Cordial and Syrup Manufacturing, Beer Manufacturing, Spirit Manufacturing, Wine and Other Alcoholic Beverage Manufacturing.
- It is not possible within the scope of the project to access raw data and information for every manufacturing category. The challenges were further limited by the low response rate and the dated nature of food waste studies in the Australian manufacturing sector. As such, many categories were modelled using standard food manufacturing loss rates derived from the NSW EPA C&I Waste Generator Pilot Audit.

## Transport and Storage

Indicative Australian loss ratios for handling and storage of nine mainstream food types were sourced from Australian Government data provided to the Asia-Pacific Economic Forum (APEC) as part of the APEC-Project on Food Losses and Waste System (FLOWS). 'Handling & Storage' loss factors are defined as losses due to storage and transportation between farm and distribution, and spillage and degradation during handling.

The loss factors were applied to national production statistics of the relevant food type to derive an estimate of food waste in the sector.

As noted, feedback from stakeholders is that food losses occurring in the transport sector are commonly attributed to and captured by data for the source or origin sectors (i.e., primary production, manufacturing, wholesale / retail). Therefore, transport sector losses have been considered differently to other sectors in that it is not standalone, additional losses, but overlaps with those other sectors. The extent of overlap is not possible to quantify with existing data, hence this sector is considered separately.

## Relevant Assumptions

- Destinations were allocated between compost and landfill (or animal feed) based on a common sense assumption for each food type.

## Limitations

- The loss factor assumptions are based on dated data (2011) and their derivation is uncertain.

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- The allocation of destinations is indicative, at best.
- It is not possible under this high level modelling approach to delineate transport-impacted food waste from food waste generated in related supplier and destination sectors. As a result, Transport and Storage cannot currently be quantified as a discrete sector within the National Food Waste Account.

## Wholesale

Wholesale figures are estimated based on food waste generation rates per full-time equivalent employee (FTE) based on industry employment statistics (ABS Counts of Australian Businesses, including Entries and Exits). This compared well against other estimates based on food waste generated per business.

### Relevant Assumptions

- It was assumed the limited data available from food wholesaling facilities and markets was sufficient for estimating waste arising nationally from the wholesale sector.

### Limitations

- With the amount of information available transport and storage losses cannot be disaggregated from these figures. Based on intelligence provided by stakeholders, these losses are often captured at the generator or receiver end.
- There are overlaps between wholesale and retail sectors, particularly with the major retailers. With the limited amount of information provided this cannot be disaggregated.
- Wholesale waste generation / FTE rates are based on a limited number of surveys from wholesalers / distributors and markets.

## Retail

Food waste from retail has been estimated by waste generation per \$'000 of revenue, multiplied by aggregated industry turnover (ABS Retail Trade).

### Relevant Assumptions

- It is assumed that turnover is the best modelling metric for extrapolating food waste data across the retail sector on a national scale. Similar to manufacturing, employment is not considered the best metric due to differences in productivity between retail businesses.

### Limitations

- While there are many sub-sectors for retail, it is not within the scope of this project to investigate waste generation on a more disaggregated level.
- Given the limited participation by the major food retailers, estimates were based on publicly available waste estimates for major supermarkets and datasets of large shopping centre organisations. There was significant discrepancy between some of the major supermarkets in waste disposal per \$'000 of revenue, which is surprising given comparable operations.

# Hospitality and Food Service

Industry figures are estimated based on waste generation per full time equivalent (FTE) and employment statistics (ABS Counts of Australian Businesses, including Entries and Exits).

## Relevant Assumptions

- Hospitality and Food Service waste generation / FTE rates are based on a limited number of surveys and published figures.

## Limitations

- Given the limited participation by the hospitality sector, estimates were based on few completed surveys, alternate data and publicly available waste estimates from food industry consultants' reports.
- There was insufficient data to model by revenue, although some major fast food retailers were starting to do this for their franchises. This was in the form of litres / \$'000 of revenue.

# Institutions

Food waste in this sector is based on the number of people served. Across the education sub-sector (higher education, high schools and primary schools) the modelling accords with the number of enrolled students in Australia. In correctional facilities, food waste is extrapolated by the number of inmates. The health and aged care sectors are modelled according to the number of patients making overnight stays (i.e., per bed, per night). Child care is estimated differently, based on waste per employee in the sector.

A large amount of information was provided for the correctional and health systems through surveys of state and territory government services. Similarly, a broad dataset was submitted by primary and high schools, but it yielded unrealistic quantities when extrapolated on a national scale. As such alternate references were used.

## Relevant Assumptions

- As the primary and high school figures yielded unrealistic results, proxy data from a comprehensive international study was used (WRAP Food Waste in Schools).
- For hospitals, only overnight patients were included in the model, with an average stay of 5 days, 3 meals a day. It was assumed day surgery patients did not receive meals.

## Limitations

- While a large data sample of food waste in schools was provided, the results were considered too high, so a waste loss rate per student was derived from a detailed study in the United Kingdom (WRAP Food Waste in Schools).
- Several university food waste estimates were provided across several states.
- Large data sample for prisons was provided, with opportunity for further analysis and refinement of the estimates in future iterations of the National Food Waste Account.

# Households

State and territory governments provided estimates for household food waste generation within the jurisdiction, where available. In the absence of state government figures, the National Waste Report

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was used for food waste to landfill, which is the predominant destination for most household food waste generated in Australia. No modelling was required.

## Food Rescue

The high participation rate of the food rescue sector meant modelling was not required. Rather, the raw data provided by food rescue organisations was consolidated for national estimates. It is noted that all data is self-reported and often difficult for donor or rescue organisations to estimate, creating some potential for uncertainty in these figures.

## **APPENDIX C DATA COLLECTION TEMPLATE**

Data collection was undertaken via a structured Excel spreadsheet that included explanations and examples, defined the destinations, provided drop down menus to provide consistency and ease of entry. Variations were developed for industry, government and food rescue organisations. The main data collection sheet within the industry data collection template is provide below.

2. Food Waste Quantities									
Year: We would appreciate if you could provide this for 2014-2015, 2015-2016 and 2016-2017. However, if this is not possible an estimated annual waste figure would be greatly appreciated, with the associated reporting period (provided in the notes section)	State	Enter each type of solid and liquid food waste that occurs as a result of your industry's operations (excludes waste that occurs elsewhere in the supply chain). For example, bakery waste, bagasse or mixed food waste. If your organisation is involved with multiple segments within the supply chain please note the origin (for example mixed food waste from supermarkets or apple harvesting losses that occur at primary production)	Food type classification (could the food waste have been consumed by humans before it was wasted or spoiled? Or was it inedible - bones, feathers or husks for instance?)	Method for estimating waste quantity	Quantity generated	Units	Fate Category	Cost of management (\$) (external costs for waste collection / disposal / recovery and internal direct costs where managed onsite)	Notes
Example: 2014-2015	Vic		Combination of edible and inedible components of food	Compositional estimates		Tonnes	Animal Feed		
Select from drop down	Select from drop down		Select from drop down	Select from drop down		Select from drop down	Select from drop down		
Select from drop down	Select from drop down		Select from drop down	Select from drop down		Select from drop down	Select from drop down		
Select from drop down	Select from drop down		Select from drop down	Select from drop down		Select from drop down	Select from drop down		

## APPENDIX D FUTURE ITERATIONS AND IMPROVEMENTS

As discussed throughout this document, the response rate to data request was low, in large part due to the following reasons:

- Data is not collected internally
- There is limited knowledge in the food industry about this issue
- Inability to respond within the timeframes of the investigation
- A lack of incentive or requirement to participate in the study
- Concern that participation would lead to a regulatory response.

Of the participating stakeholders, data quality varied and there was some confusion regarding definitions and boundary conditions, which required clarification. Some industries were more forthcoming than others, while capacity to provide actual data varied. Volumetric estimates as a proportion of production was a common means of estimation for the sectors earlier in the supply chain.

Overall data available at the time of the investigation was limited, and of varied quality. Given the baseline is entirely dependent on the data provided by stakeholders, as well as published data sets, the quantitative estimates are only as accurate as the available data. Where data was limited, reported information was compared to other local and international investigations.

Confidence in the estimates of the National Food Waste Baseline is moderate, with lower confidence in some of the food manufacturing sub-sectors. The data available for transport, wholesale, retail and hospitality was limited and there may be opportunity for further refinement in future investigations.

This is not surprising given food waste has not been a particular focus for data collection in Australia. Some state governments have in recent years started tracking food waste practices and performance at the household level, but the data remains limited in scope and certainty.

Food Innovation Australia Ltd (FIAL) is endorsed to implement the National Food Waste Strategy and is responsible for delivering a monitoring and evaluation framework to track Australia's progress to reduce food waste by half by 2030. It is intended that the National Food Waste Baseline will be revised in a future point in time.

### Industry engagement

Food waste data in Australian business is weak. This primarily reflects the general lack of detailed recording of waste by businesses, while the additional layer to specifically report food waste represents a further barrier. It also reflects sensitivities among some organisations that transparency on food waste could lead to mandatory reporting or other interventions.

The only food waste type with a regulatory requirement to report is hazardous waste, such as animal and vegetable oils and derivatives (K200) which are classified as hazardous in some states due to their liquid nature.

The main business motivator for food waste monitoring is cost tracking. For industries where this was a priority, data was often available, or at least an estimate of losses. Where food waste was not a financial or sustainability priority, there was no real incentive to quantify or track this loss. A good example was a major confectionary producer that was unable to increase sale prices so had to investigate all costs, and found food waste reduction was an area they could address to improve their margins.

For some sectors, such as primary production, it's not currently realistic to expect robust data collection on food waste. According to a grain peak body, there are major challenges in providing production statistics, let alone detailed measurements of loss. On-farm losses are a major cost to farmers, and many certainly had a sense of the proportion of losses, but they were unable to provide measured quantities. The key way to improve the quantification of loss for different agricultural commodities is through comprehensive field surveys.



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Unlike manufacturing and primary production, where producers often face pressure on margins due to price constraints or fixed price contracts with buyers, hospitality has a greater opportunity to pass waste costs on to retail customers – and therefore a lesser incentive to reduce these cost.

However, there is a growing body of literature that is increasing transparency around the overall costs to business of food waste, which supports the business case for addressing it. An active program of engagement with the food industry should focus on both broad education around the issue and opportunities, and targeted initiatives to increase data collection and reporting. This should be designed to increase the coverage of the National Food Waste Account over time, reducing the reliance on modelling to scale up to a national estimate.

FIAL's planned voluntary commitment program for the food industry under the National Food Waste Strategy, similar to the Courtauld Commitment in the UK, would provide an overarching framework for engagement. It is recommended that other initiatives be tailored to the major food waste generating sectors, taking into account the industry context and its food waste types, drivers and opportunities.

The Fight Food Waste CRC is also likely to improve the literacy of businesses regarding food waste and data capture. With 57 participants from around Australia and overseas, who collectively raised \$91 million in addition to the \$30 million from the Australian Government CRC Program, it has identified food waste data as a key enabler of its mission to reduce food waste throughout the value chain, up-cycle unavoidable waste and promote behavioural change.

## Research into sectors and issue

Targeted research into food waste and the opportunities and barriers to food waste reduction would improve the baseline and drive reduction in food waste generation. This was certainly the experience of the United Kingdom, a leader in food waste quantification, which has been quantifying food waste for a decade and found that targeted studies into particular sectors of the food supply chain improves data quality.

While many important findings have been made through this investigation, the breadth of this study has meant in-depth analysis into each sub-sector of the food supply chain was not achievable. Manufacturing, wholesale and retail are areas where further investigation could improve data quality, while SMEs were a general challenge given their data systems are often less mature than in larger companies.

The rates of food waste and loss vary according to each sector, and even within sectors and food types. The data is sensitive to assumptions around loss rates, with margins for error magnified by the significant size of some food sectors. The CSIRO's Food Loss program and research by groups such as the Rural Research and Development Corporations (RDCs) are critical to improving understanding of the percentage of losses and refining the dataset.

Unlocking food waste reduction opportunities requires research and investment at the sector level, but also into specific issues that may cut across sectors, such as limited space for bins in SME establishments or opportunities to redistribute or recover specific food waste streams that arise in multiple parts of the supply and consumption chain.

Case studies on food waste in individual sectors would also be of high value, highlighting the food waste drivers, challenges and opportunities. Examples include lifecycle studies by food type or an assessment of the cost of transporting food along a supply and consumption chain.

Other metrics could also be considered, such as the carbon dioxide equivalent (CO<sub>2</sub>e) emissions from food waste, and the associated food waste reduction initiatives.

## Liquid food waste streams

There is little industry data around food waste to sewer. Water authorities do not typically monitor trade waste in the sewerage system for factors that correlate to food waste, and company reporting on disposal to sewer and on-site wastewater treatment plants is limited.

Liquid food waste is tracked in some jurisdictions as it is automatically classified as hazardous, with the data captured under the K200 hazardous waste code. But in other states and territories there is no available data on liquid waste.

Any program to engage food businesses should include techniques and tools to monitor liquid waste for parameters that correlate to food in the stream, such as biological oxygen demand (BOD).

### Data quality and frequency

Continuous improvement to the baseline data is required to address data gaps and improve the accuracy and rigour of existing data.

Perhaps the key decision regarding the level of investment in improving data quality is deciding on the objectives of the monitoring and evaluation regime and its relative importance in the overall food waste reduction agenda.

The level of accuracy expected for this task is subject to investigation of priorities. Broad estimates are useful in that they provide an understanding of scale, and the contribution across sectors to food waste generation in Australia. They provide a basis for comparison over several years. For greater accuracy, more investigations would be required into each of the sectors, with larger time periods and sample sizes.

Key questions are:

- Frequency of reporting (e.g. annual, every 3 years, every 5 years)
- The desired level and scope of direct measurement of food waste through bottom-up analysis
- The acceptable level of dependence on indicative loss factors modelled against industry data that is already monitored, such as production or revenue
- How often loss factors should be updated, for example via field studies, waste audits and direct measurement tools like diaries, consumers panel
- How often should direct measurement be updated?

These questions need to be considered in light of the costs and benefits of a bottom-up data approach to populating the National Food Waste Account, including the opportunity cost of the monitoring and evaluation program compared to direct investment in food waste reduction measures.

### Assess the economic value of food waste

Estimating the economic value of food waste across the supply and consumption chain should be undertaken in future iterations to guide investment in food waste reduction. A rigorous assessment is a complex exercise that was beyond the scope of this initial baseline report as it requires a dedicated framework to assess economic value and loss through the food supply and consumption chain.

Among the challenges:

- The economic value of a tonne of food waste is very different according to both food type and the point in the supply and consumption chain. Losses in economic value are simplest to assess in primary production, where waste from individual food commodities has been estimated. A similar level of granular data is required for the other supply chain sectors, for example within the sub-sectors of manufacturing.
- To provide a useful identification of the key areas of economic loss from food waste, a comprehensive economic valuation methodology is required to estimate the loss for each sector and sub-sector of the supply chain.
- Primary data is difficult to access. Food companies were consulted about the economic value of their food waste as part of the baseline report, but they do not typically assess their food waste as a loss of economic value. Most consider waste as a financial cost in terms of waste management,

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but even this was challenging to collect due to commercial sensitivities and the difficulty many companies had in isolating food waste from general waste costs.

## APPENDIX E REFERENCES

- ABARES. (2017). Agricultural commodities: 2017. *Rural commodities - meat - general*. Australian Bureau of Agricultural and Resource Economics.
- ABS. (2017a, November). Agricultural Commodities 2016/17. 7121.0. Australian Bureau of Statistics (ABS).
- ABS. (2017b). Counts of Australian Businesses, Including Entries and Exits (CABEE), June 2013 to June 2017. Australian Bureau of Statistics (ABS).
- ABS. (2017c, June). 7215.0 - Livestock Products, Australia, Jun 2017. Australian Bureau of Statistics.
- ABS. (2017d). 7503.0 - Value of Agricultural Commodities Produced, Australia, 2016/17. Australian Bureau of Statistics (ABS).
- Asia-Pacific Economic Forum. (2016). *APEC-Project on Food Losses and Waste System (FLOWS)*. Department of Agricultural Economics, National Taiwan University.
- Australian Government. (2009). National Waste Policy 2009. Department of the Environment and Energy.
- Australian Government. (2017). National Waste Report 2016. Department of the Environment and Energy.
- Australian Government. (2017). National Food Waste Strategy, 2017. Department of the Environment and Energy.
- Australian Sugar Milling Association. (2017). Accessed online 05/03/19: <https://asmc.com.au/industry-overview>
- Blue Environment. (2017). *Analysis of Australian Food Waste Data 2017*. Department of the Environment and Energy.
- Champions 12.3. (2017). *Guidance in Interpreting Sustainable Development Goal Target 12.3*.
- Dairy Australia. (2017). *Australian Dairy Industry In Focus 2017*.
- Dalgleish, R., & Agar. (2017). *Sheepmeat market structures and systems investigation*. North Sydney: Meat and Livestock Australia (MLA).
- Expert Group. (2018). *Cold Hard Facts 3*. Department of the Environment and Energy.
- Food Loss and Waste Protocol (2016). *Food Loss and Waste Protocol Accounting and Reporting Standard, Version 1*.
- FUSIONS (2014). *Definitional Framework for Food Waste*. FUSIONS (Food Use for Social Innovation by Optimising waste prevention Strategies).
- GHD. (2003). *A review of waste solids processing with energy capture technologies*. Meat and Livestock Australia (MLA).
- Green Industries SA. (2018). *Waste and Recycling in Aged Care Facilities - Better Practice Guide*. Green Industries SA and Aged and Community Services Australia.
- Gunders, D. (2012) *How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill*. Natural Resources Defense Council
- Hauser, J. (2017). *Analysis of South Australia whey processing options*. Dairy Australia project.
- Horticulture Australia (2017). *Australian Horticulture Statistics Handbook 2016/17*.
- IBIS World. (2017). *Fruit and Vegetable Processing in Australia 2017*.
- Lewis, H., Downes, J. Verghese, K., & Young, G. (2017). *Food waste opportunities within the food wholesale and retail sectors*. Prepared for the NSW EPA by the Institute for Sustainable Futures at the University of Technology Sydney.
- Malher, X., Coudurier, B., & Redlingshofer, B. (2014). *Food losses and waste in the poultry production chain: from farm to retail*.

## NATIONAL FOOD WASTE BASELINE

- National Farmers Federation (2017). *Food, Fibre & Forestry Facts – 2017 Edition*.
- Natroads. (2017). *Survey for Refrigerated Transporters: Food Product Rejection Rates*. (Unpublished)
- NSW Environment Protection Authority. (2015). *Pilot generator site-based audit – Commercial and industrial waste stream in the metropolitan levy areas of New South Wales*.
- NSW Environment Protection Authority. (2016). *Final Report and Attachments: Industry Specific Data Analysis of Bin Trim Round 1*.
- Pintado et al. (2001). *Review: Technology, chemistry and microbiology of whey cheeses*. Food Science and Technology International.
- Productivity Commission. (2017). *Volume B: Childcare, education and training*
- ReFED. (2016). *Roadmap to Reduce U.S. Food Waste by 20 per cent*.
- Rentfrow, G. (2010). *How Much Meat to Expect From a Carcass*. Lexington: University of Kentucky.
- Rogers, G. (2013). *Identifying new products, uses and markets for Australian vegetables: A desktop study*. Horticulture Australia.
- Spencer, S. & Kneebone, M. (2012). *FOODmap - An analysis of the Australian food supply chain*. Department of Agriculture, Fisheries and Forestry.
- Statista. (2018). *Pet Food Market – Australia*.
- Sugar Research Australia (2017). *Reduce harvester losses: Dollars in your pocket not in the paddock*.
- United Nations (1992). *United Nations Framework Convention on Climate Change*
- Woolworths. (2018). *Tomorrow Together Sustainability Report*.
- WRAP UK. (2016). *Quantification of food surplus, waste and related materials in the grocery supply chain*. Waste and Resources Action Programme UK.
- WRAP UK. (2018). *Food Surplus and Waste Measurement and Reporting, A Reference Document for Suppliers*. Waste and Resources Action Programme UK.

