Understanding and managing the impacts of climate change on Australian onion production – VN23001

Created by thinkstep-anz on behalf of Hort Innovation

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Executive summary

Why Hort Innovation commissioned this report

Hort Innovation is a grower-owned, not-for-profit research and development corporation for Australia's horticulture industry. Through research, marketing and trade, it works with growers, industry and partners to support innovation, grow demand and open new markets for Australia's horticulture sector.

Hort Innovation commissioned this Life Cycle Assessment (LCA) to help the Australian onion industry understand the environmental impacts of growing onions. The study creates an industry-level baseline for several environmental impact indicators including greenhouse gas emissions (also referred to as carbon footprint). It identifies the hotspots, where the biggest impacts occur across the supply chain. This information will help the onion industry to:

- understand its current environmental performance
- focus on the areas where it can reduce emissions and other impacts
- track progress over time, especially as Australia works towards net zero emissions by 2050.

The results are designed to help industry make decisions. They are not suitable to support public claims that compare Australian onions with other products.

What we did

We worked with onion growers to assess the environmental impacts of Australian farmed onions:

- This study follows ISO 14040 and ISO 14044, the international standards for LCA.
- The assessed environmental indicators come from European standard EN 15804+A2.
- The declared unit is 1 kilogram (kg) of onions, plus packaging.
- As presented in Executive Summary Figure 1, the study covers cradle-to-gate impacts. This means it covers the steps from raw materials through to packed onions leaving the farm or packing facility. This includes:
  - **Upstream:** producing raw materials used in onion growing.
  - **Core:** transporting raw materials to onion producing farms, onion growing, harvesting, curing, grading, storage, packing and waste management.
- Data was collected from production years 2023 and 2024. It was provided by five onion growers across three states who collectively produced 8,461 tonnes of onion.

Executive Summary Figure 1: System boundary of the onions LCA

What we found

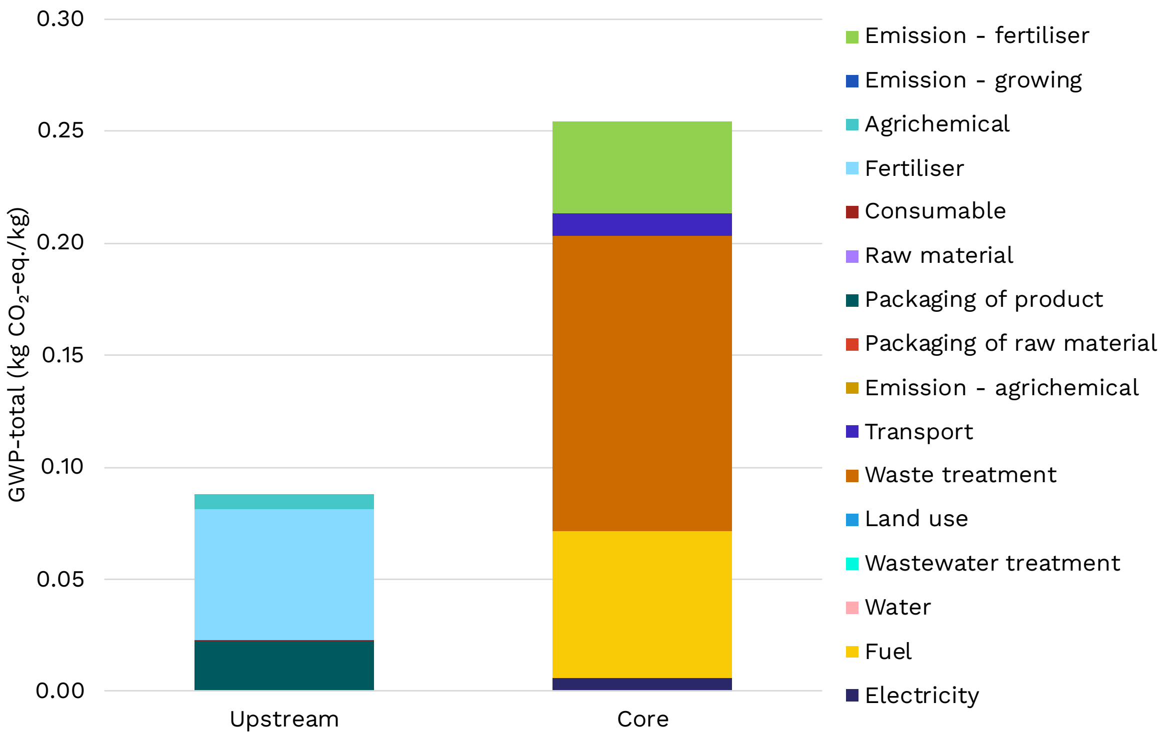
The cradle-to-gate carbon footprint of Australian-grown onions is **0.34 kg CO_2-eq. per kg of packed onions**, as presented in Executive Summary Figure 2. This includes producing raw materials, onion growing, manufacturing typical packaging materials and packing. It is based on data from participating onion producers.

The main contributors of the carbon footprint of onions are:

- **Disposal of rejected onions** on farm.
- **Fuel used on farm** including for tractors, irrigation pumps and other machinery.
- **Production of raw materials**, particularly fertilisers and soil amendments (e.g. lime).
- **Emissions from using fertiliser** and soil amendment.
- **Packaging** of finished onions, particularly plastic net use.

If transport to retail stores is included, the carbon footprint could increase to **0.56 kg CO_2-eq. per kg of packed onions**.

This shows that distribution can make a big difference to the overall impact of onions by the time they reach supermarket shelves.



Executive Summary Figure 2: Cradle-to-gate carbon footprint of Australian onions

Our recommendations

To reduce the environmental impacts of Australian onions, the industry should focus on the biggest impact areas identified in this study.

- **Improve saleable yield** (wherever feasible) supported by good soil, crop nutrition and irrigation management.
- **Avoid leaving rejected onions on farm** where suitable alternatives are available, such as using them for animal feed.
- **Use less fossil fuel** by improving energy efficiency and moving away from diesel, LPG and petrol where practical.
- **Optimise fertiliser use** through practices such as improving soil organic matter, reducing fallow periods and tillage, using cover crops, splitting fertiliser applications, applying fertilisers at the appropriate timing, and considering enhanced efficiency fertiliser products.
- **Take a whole-of-life view** before making changes so improvements in one area do not create bigger impacts somewhere else.

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1. Goal of the study

Hort Innovation commissioned this Life Cycle Assessment (LCA) study to help the Australian onion industry better understand the environmental impacts of growing onions. The report is mainly for Australian onion growers. It provides a baseline for key environmental impacts, including greenhouse gas emissions. This baseline can help growers understand current performance, see where the biggest impacts occur and identify practical opportunities to improve over time.

This LCA study follows ISO 14040 (ISO, 2006a) and ISO 14044 (ISO, 2006b), the international standards for LCA. Note that while these standards provide a framework for LCA, they do not provide product-specific rules or a set of environmental indicators to apply. Given that, this study is conducted based on two other documents:

- The environmental impact calculation rules come from PCR 2020:07 Arable and vegetable crops (version 1.0.3), published by the International EPD System (EPD International, 2025). A point of departure is that end-of-life processes for wasted onions are excluded due to the scope of this study is 'from cradle to gate'. Also, note there is very limited data on onion wastage rates in distribution, supermarkets and consumers' homes.
- The environmental indicators used in this study are from EN 15804:2012+A2:2019 (EN 15804+A2) (CEN, 2019/2021). While EN 15804 is designed for construction products, its indicator set is comprehensive and is now widely used in LCA studies worldwide, including LCA studies for non-construction products.

Note that the results of this study are not intended to support comparative assertions disclosed to the public, meaning that peer review is not mandatory (ISO, 2006b). Hence, no peer review has been undertaken as part of this study.

2. Scope of the study

2.1. Production system

Australian onion production typically starts with preparing the field, sowing the crop and growing the onions. During the growing stage, growers manage crop nutrition, irrigation, pests and disease. Field preparation generally includes cultivation and soil amendments to improve soil structure and fertility. Seeds are then sown and fertiliser is applied. As the crop grows, growers use fertilisers, agrichemicals and irrigation to support healthy growth.

Once the onions are mature, they are lifted so they can dry and cure. They are then harvested, graded, packed and stored. Packaging can include plastic net bags, bulk bins, supermarket crates, wraps and labels.

In FY 2024/25, the Australian onion industry produced 252,883 tonnes of onions with a value of AU$307 million (Hort Innovation, 2026). According to Hort Innovation (2026), 81% of the onions produced in Australia is consumed fresh in the domestic market with 10% being exported and the rest (<9%) is processed. Brown and red onions account for 79% and 19% of total onions produced in Australia, respectively, while the remainder 2% being white onions and shallots (Hort Innovation, 2026).

2.2. Declared unit

This study uses a declared unit rather than a functional unit. The declared unit is 1 kilogram (kg) of onions, plus packaging. Industry classifications are found in Table 2-1.

Table 2-1: Industry classification

Product	Classification	Code	Category
Onions	UN CPC Ver.3	01253	Onions
	ANZSIC 2006	0123	Vegetable Growing (Outdoors)

2.3. Market coverage

As described in Chapter 1, the primary aim of this study is to establish a national baseline for the environmental impacts of Australian onions. The original intent was to survey a wide range of onion growers. However, this was challenging. Growers needed to invest time to gather detailed data, and the direct business value of taking part was not always clear. With strong support from our project delivery partner, RM Consulting Group (RMCG), we adjusted the approach. This allowed us to work more intensively with a smaller pool of growers who wanted to understand their environmental impacts better and opportunities for improvement. This study uses specific data from five onion growers across Australia. In the reference production years, these growers collectively produced 8,461 tonnes of onions[1].

[1] Approximately, 3% of total onion production in Australia during FY2024/25.

2.4. Content declaration

Table 2-2 presents the nutrition and moisture content of onion, whereas Table 2-3 presents its packaging.

Table 2-2: Nutrition information of onions (per 100 g)

Nutrition*	Value and unit
Energy	116 - 136 kJ
Moisture	89.2 – 90.8 g
Protein	0.8 – 1.7 g
-gluten	0 g
Fat, total	0 – 0.1 g
-saturated	0 g
-trans	0 g
Carbohydrate, total	4.7 – 5.8 g
-sugars	4.7 – 5.8 g
Dietary Fibre	1.8 – 2.3 g
Sodium	5 - 8 mg
Vitamins	
Vitamin C	6 - 7 mg
Folate, natural	3 - 21 µg
Minerals	
Calcium	19- 24 mg
Iron	0.17 – 0.26 mg
Phosphorus	32 - 44 mg
Potassium	140 - 180 mg

*Detailed nutrition information of onion can be found in Australian Food Composition Database (www.foodstandards.gov.au/science-data/monitoringnutrients/afcd).

Table 2-3: Composition of onion packaging (per declared unit, 1 kg product)

Packaging materials	Weight, kg	Weight-% (versus the product)	Weight biogenic carbon, kg C/kg declared unit
Wood pallet	0.0361	3.61	0.0166
Cardboard	7.58E-04	0.0758	3.49E-04
Label	4.83E-05	0.00483	2.22E-05
Staple	1.39E-05	0.00139	0
Plastic bin	0.00944	0.944	0
Plastic bag	0.00456	0.456	0
Plastic wrap	3.65E-04	0.0365	0
Total	**0.0513**	**5.13**	**0.0170**

Note that some of the packaging materials (such as wood pallets and plastic bins) are reused multiple times before being discarded. This has been accounted for in the modelling of their upstream environmental impacts.

Hazardous properties for Hazardous Substances and New Organisms (HSNO classifications) and Globally Harmonized System (GHS) classifications are reproduced from vendor SDS or OECD's global portal to information on chemical substances available at: https://www.echemportal.org/echemportal/page.action?pageID=134. No products declared within this LCA contain substances exceeding the limits for registration according to the European Chemicals Agency's "Candidate List of Substances of Very High Concern for authorisation" (European Union, 2024).

2.5. System boundary

The system boundary of the LCA study is 'cradle-to-gate', as presented in Table 2-4. It includes all relevant upstream processes and all core onion growing processes. The upstream processes include producing raw materials and generating electricity. The core processes are the steps linked directly to growing onions. These include transporting raw materials to growers, using fuels on farm and emissions released when fertilisers are applied.

This study does not include what happens to onions that are wasted during distribution or in people's homes. This is because there is too much uncertainty about how onions move through the supply chain and how consumers store, use or dispose of them.

The study also does not include the use stage, such as storage, processing or preparation by consumers. These stages were excluded because there was not enough reliable data to create standard scenarios for how onions are used after they leave the farm or packing facility.

Table 2-4: Modules of the production life cycle included in the study

Module	Upstream processes	Core processes	Downstream processes
Included?	Included	Included	Excluded
Life cycle stages	Production of → Electricity and fuel used in upstream processes → Seeds → Fertilisers → Soil amendments (e.g. lime) → Agrichemicals → Packaging → Refrigerants used in onion storage on farm → Other raw materials	→ Transport of raw materials to grower's facility → Use of electricity and fuels used in core processes → Emissions related to the use of fuel, fertiliser, soil amendments and agricultural chemicals during the growing stage → Emissions related to the use of fuels and electricity during the grading and packing stage	→ Onion distribution → Onion use → Onion end-of-life → Onion waste treatment

The system boundary is illustrated in Figure 2-1. Onion production involves field preparation, sowing, growing, lifting, harvesting and packing. Fertilisers (such as NPK fertilisers) and agrichemicals (such as fungicides, herbicides and insecticides) and irrigation water are applied in the growing processes. Plant growth regulators and adjuvants are also used together with fertilisers and agrichemicals. Mature onions will then be lifted, harvested and packed.

Figure 2-1: High level processes (upstream + core)

The following processes are included within the declared modules:

2.5.1. Upstream processes

- Production of onion seeds.
- Production of fertilisers, agrichemicals, soil amendments, refrigerants, and packaging materials.
- Generation of electricity and fuel from primary energy resources, also including their extraction, refining and transport. This includes energy needed for raw material supply and energy for horticulture in upstream processes.

2.5.2. Core processes

- Inbound transport of raw materials to growers' facility.
- Emissions from energy, fertiliser, and agrichemical usage in onion growing.
- Generation of electricity and fuel from primary energy resources, also including their extraction, refining and transport. This includes energy needed for horticulture in core processes, such as growing and packing.

Table 2-5: System boundaries

Included	Excluded
→ Production of raw materials used in onion production → Production of packaging of onion products and raw materials → Transportation of raw materials and packaging to onion farm site → Generation and supply of electricity and water, and their use on the farm site → Emissions due use of energy, fertiliser, agrichemicals → Solid waste and wastewater management	→ Transport to retail stores → Manufacturing of production equipment buildings, and other capital goods → Business travel of personnel → Travel to and from work by personnel → Research and development activities → Health and safety equipment → Storage in distribution, retail and by the consumer → Onion use/consumption → Onion end-of-life

2.5.3. Time coverage

This study is based on five Australian growers' specific data for producing onion during the 2023 and 2024 production periods. All specific data falls within the mandatory 5-year period required under the PCR (EPD International, 2025).

Data for raw materials, electricity, packaging and transportation are from ecoinvent (Wernet, 2016) and AusLCI databases (ALCAS, 2025). The reference year for the data is 2023 and is within the 10-year limit allowable for generic data under PCR. Details for data used in the background system are presented in section 3.3.

2.5.4. Technology coverage

This study focuses on the production technologies currently used at five onion farms across three states in Australia. Processes at each farm included site preparation, sowing, growing, lifting, harvesting, packing and on-farm storage.

2.5.5. Geographical coverage

The study uses specific data from five onion growers from South Australia (SA), Tasmania (TAS) and Western Australia (WA) in Australia. The results show the weighted average results of onions produced by these five growers.

As presented in section 3.3, most raw materials are sourced globally, such as some seeds are from the Netherlands and New Zealand. Fertilisers and agrichemicals are predominantly imported from overseas, such as China, the Middle East, Russia and the United States. Some raw materials are however sourced locally - for example, packaging materials.

All these materials are delivered to the growers' farms.. Supporting background data specific to the country of origin of the raw materials was used whenever possible. When such background data was not available, global or regional datasets were used as proxy. All electricity and water data were regionalised for Australia. For more details on the use of background data, see section 3.3.

2.5.6. Boundaries to nature

System boundaries to and from nature are jointly described by so-called elementary flows. The inclusion of resource flows from nature to the technosphere corresponds to resource use and explorative impact, and on the output side emissions and resource consumption. In an ideal LCA, all flows studied shall be traceable to a natural source or recipient. As such, processes such as mineral extraction and waste production have been modelled to elementary flow level.

For example, datasets for raw materials such as limestone materials include mineral extraction from the ground; wastes such as emissions from fertiliser application are included as emission to air, outputs to water (from wastewater treatment) are modelled as emissions to water rather than an emission of untreated waste. Waste to landfill is modelled assuming a 100-year time horizon.

2.5.7. Boundaries for manufacturing of equipment and for employees

In this study capital goods and infrastructure have been included in the background datasets as provided by ecoinvent (Wernet, 2016). It is not possible, within reasonable effort, to subtract the data on infrastructure/capital goods from these datasets.

The results of the impact categories abiotic depletion of minerals and metals, land use, human toxicity (cancer), human toxicity, noncancer and ecotoxicity (freshwater) may be highly uncertain in LCAs that include capital goods/infrastructure in generic datasets, in case infrastructure/capital goods contribute greatly to the total results. This is because the LCI data of infrastructure/capital goods used to quantify these indicators in currently available generic datasets sometimes lack temporal, technological and geographical representativeness. Caution should be exercised when using the results of these indicators for decision-making purposes.

Note: The system boundaries on manufacturing of equipment and for employees are *not* regarded as limiting the scope of the inventory or as an incomplete inventory (i.e. a cut-off).

2.5.8. Boundaries to other product life cycles

Allocation of recycled material is reported in the LCI as an input or output flow when such materials leave or enter the specific product system. The boundary between the current and the next product system is defined by the willingness to pay for the recycled material. This implies that from the moment the user of a secondary material pays for the material, this (secondary) product system will also be responsible for its environmental burdens from that point onward. This is referred to as the Polluter Pays Principle within EN 15804.

For outflow of material to recycling, transport to recycling facilities and recycling processes, such as sorting and shredding, are included. The material intended for recycling is then an outflow from the product system. Details on allocation are further described in section 2.6.

2.5.9. Biogenic carbon in product and packaging

Onions and some packaging materials (particularly wood pallet and cardboard) contain biogenic carbon. Biogenic carbon is defined as carbon derived from materials of biological origin, excluding material embedded in geological formations (ISO, 2018). The biogenic content of these materials per declared unit (1 kg) is presented in Annex A.

This report assumes that the biogenic carbon sequestered in the bio-based materials is released as carbon dioxide (CO_2) to the atmosphere when those materials are recycled. In other words, the biogenic carbon leaves the system boundary being assessed and becomes part of another product's (or material's) system boundary. This assumption is in line with ISO 14067:2018 (ISO, 2018).

The results for upstream and core processes include 'balancing-out reporting' for the biogenic CO_2 of onion and its packaging. This means the biogenic CO_2 sequestrated in onion and bio-based packaging materials is artificially released in the core process. This approach was used because they have a short life cycle and there is typically no long-term (i.e. over decades) storage of carbon in them.

2.6. Allocation

2.6.1. Multi-output allocation

Multi-output allocation follows the requirements of ISO 14044, section 4.3.4.2 (ISO, 2006b). When allocation becomes necessary during the data collection phase, the allocation rule most suitable for the respective process step is applied and documented along with the process in Chapter 3.

2.6.2. Allocation of background data

Allocation of background data (energy and materials) taken from the ecoinvent databases is documented online at https://ecoquery.ecoinvent.org/3.10/EN15804/search.

Allocation of background data (energy, water and materials) taken from the AusLCI databases is documented online at https://www.auslci.com.au/.

2.6.3. End-of-life allocation

End-of-life allocation follows the requirements of ISO 14044, section 4.3.4.3 (ISO, 2006b).

Material recycling (cut-off approach): The system boundary at end-of-life is drawn after scrap collection to account for the collection rate, which generates an open scrap output for the product system. The processing and recycling of the scrap is associated with the subsequent product system and is not considered in this study.

Landfilling (cut-off approach): The system boundary includes landfilling processes following the polluter-pays-principle. In cases where materials are sent to landfills, they are linked to an inventory that accounts for waste composition, regional leachate rates, landfill gas capture as well as utilisation rates (flaring vs. power production). No credits for power or heat production are assigned.

2.7. Cut-off criteria

In compliance with PCR 2020:07 (EPD International, 2025), the following cut-off criteria were applied during data collection and analysis:

- Data for elementary flows to and from the product system contributing to a minimum of 99% of the declared environmental impacts shall be included (not including processes that are explicitly outside the system boundary as described in PCR 2020:07 section 4.3).
- The application of these cut-off rules was a combination of expert judgment based on experience of similar product systems and a sensitivity analysis in which it is possible to understand how the un-investigated input or output could affect the final results.

Cut-off was applied to lubricant oil and grease used in agricultural machinery. These materials are used in small amounts and are less relevant to the environmental impact of onion production.

The choice of proxy data is documented in Chapter 3. The influence of these proxy data on the results of the assessment has been carefully analysed and is discussed in Chapter 5.

2.8. Selection of LCIA methodology and impact categories

The environmental indicators selected come from EN 15804:2012+A2:2019 (EN 15804+A2) (CEN, 2019/2021). While EN 15804 is designed for construction products, its indicator set is comprehensive and is now widely used in LCA studies worldwide, including LCA studies for non-construction products.

The results of the impact categories abiotic depletion of minerals and metals, land use, human toxicity (cancer), human toxicity, noncancer and ecotoxicity (freshwater) may be highly uncertain in LCAs that include capital goods/infrastructure in generic datasets, in case infrastructure/capital goods contribute greatly to the total results. This is because the LCI data of infrastructure/capital goods used to quantify these indicators in currently available generic datasets sometimes lack temporal, technological and geographical representativeness. Caution should be exercised when using the results of these indicators for decision-making purposes.

2.8.1. Core environmental indicators from EN15804+A2

EN15804+A2 and PCR 2020:07 v1.0.3 (EPD International, 2025) require the Life Cycle Impact Assessment (LCIA) indicators shown in Table 2-6. The characterisation factors from the ecoinvent EN15804 Cumulative database based on EF 3.1 are used. Long-term emissions (> 100 years) are not taken into consideration in the impact estimate. The footnotes below the table come from EN15804+A2.

Table 2-6: Core environmental impact indicators (based on EF 3.1)

Impact category	Description	Indicator	Unit	Original reference
Climate change - total	A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare	GWP-total	kg CO_2-eq.	(IPCC, 2021)
Climate change - fossil		GWP-fossil	kg CO_2-eq.	(IPCC, 2021)
Climate change - biogenic		GWP-biogenic	kg CO_2-eq.	(IPCC, 2021)
Climate change - land use and land use change		GWP-luluc	kg CO_2-eq.	(IPCC, 2021)
Ozone Depletion	A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants	ODP	kg CFC11-eq.	(WMO, 2014)

Impact category	Description	Indicator	Unit	Original reference
Acidification	A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H^+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building materials.	AP	Mole of H^+ eq.	(Seppälä, 2006; Posch, 2008)
Eutrophication aquatic freshwater	Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.	EP-fw	kg P eq.	(Struijs, 2009)
Eutrophication aquatic marine		EP-m	kg N eq.	(Struijs, 2009)
Eutrophication terrestrial		EP-tr	Mole of N eq.	(Seppälä, 2006; Posch, 2008)
Photochemical ozone formation	A measure of emissions of precursors that contribute to ground level smog formation (mainly ozone O_3), produced by the reaction of VOC and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be injurious to human health and ecosystems and may also damage crops.	POCP	kg NMVOC eq.	(van Zelm, 2008)

Impact category	Description	Indicator	Unit	Original reference
Depletion of abiotic resources - minerals and metals[2] [3]	The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources. Depletion of mineral resources is assessed based on ultimate reserves.	ADP-minerals&metals	kg Sb-eq.	(van Oers, et al., 2002; Guinée, et al., 2002)
Depletion of abiotic resources - fossil fuels[2]	The consumption of non-renewable resources leads to a decrease in the future availability of the functions supplied by these resources.	ADP-fossil	MJ	(van Oers, et al., 2002; Guinée, et al., 2002)
Water use[2]	Water (user) deprivation potential, deprivation-weighted water consumption (WDP).	WDP	m^3 world equiv.	(Boulay, et al., 2018; UNEP, 2016)

[2] The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

[3] The results of the impact categories abiotic depletion of minerals and metals, land use, human toxicity (cancer), human toxicity, noncancer and ecotoxicity (freshwater) may be highly uncertain in LCAs that include capital goods/infrastructure in generic datasets, in case infrastructure/capital goods contribute greatly to the total results. This is because the LCI data of infrastructure/capital goods used to quantify these indicators in currently available generic datasets sometimes lack temporal, technological and geographical representativeness. Caution should be exercised when using the results of these indicators for decision-making purposes.

2.8.2. Additional environmental impact indicators from EN15804+A2

EN15804+A2 also requires the calculation and inclusion of additional indicators in the project report, as shown in Table 2-7.

Table 2-7: Additional environmental impact indicators

Impact category	Description	Indicator	Unit	Reference
GWP-GHG[4]	Total global warning potential, excluding biogenic carbon dioxide	GWP-GHG	kg CO_2-eq.	(EPD International, 2024)
Respiratory inorganics	Damage to human health from outdoor and indoor emissions of primary and secondary PM2.5 in urban and rural areas	PM	Disease incidences	(Fantke, et al., 2016)
Ionizing radiation - human health[5]	Impact of low dose ionizing radiation on human health of the nuclear fuel cycle and ionizing radiation from the soil, radon, and some construction materials. Effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities are not considered.	IRP	kBq U235 eq.	(Frischknecht, et al., 2000)
Eco-toxicity – freshwater[2, 3]	Toxic effect on aquatic freshwater species in the water column	ETP-fw	Comparative toxic units (CTU_e)	(Rosenbaum, et al., 2008)
Human toxicity, cancer[2, 3]	A measure of the impact of chemical emissions on human health	HTPc	Comparative toxic units (CTU_h)	(Rosenbaum, et al., 2008)
Human toxicity, non-cancer[2, 3]	A measure of the impact of chemical emissions on human health	HTPnc	Comparative toxic units (CTU_h)	(Rosenbaum, et al., 2008)

[4] This indicator should be identical to GWP-total except that the CF for biogenic CO_2 is set to zero. It has been included in the EPD following the PCR (EPD International, 2024). In this study it is calculated by subtracting the value of Climate change – biogenic (GWP-biogenic) from the value of Climate change – total (GWP-total) since the ecoinvent Excel LCIA results do not include the indicator.

[5] This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

Impact category	Description	Indicator	Unit	Reference
Land use related impacts / soil quality[2,3]	This index is the result of the SQP aggregation, performed by JRC, of the 4 indicators provided by LANCA model for assessing impacts due to land use		Dimensionless (Pt), aggregated index of: kg biotic production / (m^2 *a) kg soil / (m^2 *a)	(Bos, et al., 2016)

The above impact categories represent impact potentials, i.e., they are approximations of environmental impacts that could occur if the emissions would (a) actually follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. In addition, the inventory only captures that fraction of the total environmental load that corresponds to the declared unit (relative approach). LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

2.8.3. Inventory indicators from EN15804+A2

The following environmental parameters are based on the LCI. They describe the use of renewable and non-renewable material resources, renewable and non-renewable primary energy, and water, as shown in Table 2-8.

Table 2-8: Resource use indicators

Parameter	Indicator	Unit
Renewable primary energy as energy carrier	PERE	MJ, net calorific value
Renewable primary energy resources as material utilization	PERM	MJ, net calorific value
Total use of renewable primary energy resources	PERT	MJ, net calorific value
Non-renewable primary energy as energy carrier	PENRE	MJ, net calorific value
Non-renewable primary energy as material utilization	PENRM	MJ, net calorific value
Total use of non-renewable primary energy resources	PENRT	MJ, net calorific value
Use of secondary material	SM	kg
Use of renewable secondary fuels	RSF	MJ, net calorific value
Use of non-renewable secondary fuels	NRSF	MJ, net calorific value
Net use of fresh water	FW	m^3

EN15804+A2 also requires the declaration of waste materials and output flows, such as components for re-use and recycling, as shown in Table 2-9.

Table 2-9: Waste material and output flow indicators

Parameter	Indicator	Unit
Hazardous waste disposed	HWD	kg
Non-hazardous waste disposed	NHWD	kg
Radioactive waste disposed	RWD	kg
Components for re-use	CRU	kg
Materials for recycling	MFR	kg
Materials for energy recovery	MER	kg
Exported electrical energy	EEE	MJ
Exported thermal energy	EET	MJ

EN15804+A2 requires the declaration of biogenic carbon content of the product and its packaging, as shown in Table 2-10.

Table 2-10: Biogenic carbon content indicators

Parameter	Indicator	Unit
Biogenic carbon content - product	BCC-prod	kg
Biogenic carbon content - packaging	BCC-pack	kg

2.9. Software and database

The LCA was undertaken in Microsoft Excel, and uses life cycle inventory data from ecoinvent, allocation, cut-off, EN15804, ecoinvent database version 3.10 (Wernet, 2016) for several of the raw and process materials obtained from the background system. The electricity residual mix is modelled based on AusLCI version 2.45 (ALCAS, 2025). Note that the ecoinvent datasets have not been adapted to Australian conditions as they are provided in Excel and have not been used in conjunction with an LCA software.

2.10. Interpretation to be used

The results of the LCI (Chapter 3) and LCIA (Chapter 4) address the following topics:

- Identification of significant findings, such as the main process step(s), material(s), and/or emission(s) contributing to the overall results.
- Evaluation of completeness, sensitivity, and consistency to justify the exclusion of data from the system boundaries as well as the use of proxy data.
- Conclusions, limitations and recommendations.

2.11. Data quality requirements

The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the study under given time and budget constraints.

- Measured primary data are considered to be of the highest precision, followed by calculated data, literature data, and estimated data. The goal is to model all relevant foreground processes using measured or calculated primary data.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. The goal is to capture all relevant data in this regard.
- Consistency refers to modelling choices and data sources. The goal is to ensure that differences in results reflect actual differences between product systems and are not due to inconsistencies in modelling choices, data sources, emission factors, or other artefacts.
- Reproducibility expresses the degree to which third parties would be able to reproduce the results of the study based on the information contained in this report. The goal is to provide enough transparency with this report so that third parties are able to approximate the reported results. This ability may be limited by the exclusion of confidential primary data and access to the same background data sources.
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope. The goal is to use the most representative primary data for all foreground processes and the most representative industry-average data for all background processes. Whenever such data were not available (e.g., no industry-average data available for a certain country), best-available proxy data were employed.

An evaluation of the data quality with regard to these requirements is provided in Chapter 5 of this report.

2.12. Type and format of the report

In accordance with the ISO requirements (ISO, 2006b) this document aims to report the results and conclusions of the LCA completely, accurately and without bias to the intended audience. The results, data, methods, assumptions and limitations are presented in a transparent manner and in sufficient detail to convey the complexities, limitations, and trade-offs inherent in the LCA to the reader. This allows the results to be interpreted and used in a manner consistent with the goals of the study.

2.13. Critical review

No critical review was undertaken for this study.

3. Life cycle inventory analysis

3.1. Data collection procedure

3.1.1. Primary data collection

Collecting data was one of the main challenges in this study.. This phase of the LCA required multiple revisions to the approach and timeframe to get enough responses from industry. It took more than 12 months to complete and finalise primary data collection from onion growers.

To increase likelihood of grower engagement, thinkstep-anz subcontracted RM Consulting Group (RMCG), who have existing relationships with onion growers. RMCG and thinkstep-anz attempted to develop a pilot group consisting of onion growers, consultants and members from industry bodies and committees. Despite intensive engagement activities, such as distribution of communication materials and presentations at events, the size of the pilot group was insufficient to provide all the primary data required for the study.

The data collection approach was adjusted to reduce dependence on the pilot group. Instead, RMCG engaged onion growers on a per-region basis, with emphasis on building trusted relationships through on-farm visits. To supplement this small but committed grower group, an invitation for a phone interview to collect data was offered to growers across Australia through the AUSVEG communication channel. Growers were incentivised to participate by offering them a carbon footprint snapshot of their own farm based on the data they provided for the study.

Primary data was collected using customised templates, which were emailed to participating growers and followed up with in-person meetings. Upon receipt, each questionnaire was cross-checked for completeness and plausibility using mass balance, stoichiometry, as well as internal and external benchmarking. If gaps, outliers, or other inconsistencies occurred, thinkstep-anz and RMCG engaged with the grower to resolve any issues.

Wherever feasible, the coefficient of variation was established for the different inputs and outputs, either across different data providers or across the reported time period if a breakdown into smaller increments (e.g., 12 months) was available.

Data was checked for consistency by reviewing the model results against the expected results for the main impact indicators and life cycle inventory data points.

A mass balance was also completed to check the accuracy of key flows. Energy and material inputs and outputs were quantified as precisely as practical.

3.1.2. Calculation of carbon sequestration, density and moisture content

As onions grow, they absorb carbon dioxide from the air and store it as biogenic carbon. When onions break down, this stored carbon is released back into the air... Since onions are grown and consumed quickly[6], all carbon dioxide sequestered in the onions was modelled as being artificially released to the air in the core stage, meaning that carbon dioxide emissions cancel out carbon dioxide removals.

3.1.3. Land use

Land use is split into two components:

- Land transformation
- Occupational land use

Land transformation is modelled in Excel using flows that represent the area of land transformed to and from per unit mass of product, based on the predicted time period of occupation and total production rate for each of growers' sites. The annual production rate for the specified time period for data used in this LCA is assumed to be representative of all years that onion growers will occupy each site. Occupational land use accounts for use of the land year-on-year, opposed to the transformation of land due to occupation of the land. Parameters and flow values for land transformation and land occupation of each site are confidential. The industrial average result is calculated based on the weighted average result of land use impacts of all sites.

This modelling applies conservative assumptions, since throughput is expected to increase in future years, due to the likelihood of increased demand for product.

3.1.4. Calculation of PENRM and PERM

The results for upstream and core processes include 'balancing-out reporting' for the PERM and PENRM of onions and their packaging. This is because use phase and end-of-life processes of onion and packaging are not included in the system boundary for this study.

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[6] Onions grow for around 4-6 months depending on type and seeding time. Onions are commonly stored and marketed over a period of up to 12 months. The entire lifetime of onions is considered "short term", given several decades are considered "long term" in climate science (IPCC, 2021).

3.2. Onion product system

3.2.1. Overview of product system

Figure 2-1 presents a high-level overview of the product system, with more details in section 2.5. Section 3.3 presents the relevant datasets used in modelling.

3.2.2. Product composition

Table 2-2 presents a detailed composition of onions.

3.2.3. Onion production

In Australia, onion production generally starts with field preparation, sowing and crop management (e.g. managing crop nutrition, pests and diseases, and irrigation). Once the onions are mature, they are lifted and harvested, then graded, packed and stored. Since no site or region-specific data was available, emissions due to fertiliser and pesticide use are calculated according to PCR (EPD International, 2025). The inputs and outputs of onion production processes are summarised in **Error! Reference source not found.**. It is worth noting that the energy and water usage at the site level are also included in this table.

Inbound transport distances are different for each raw material and each farm site. Therefore, weighted average transport distances are used. In addition, due to lack of transport data for specific fertiliser or agrichemical manufacturers, average transport distances are used to model the import of these materials from overseas, such as from China, the Middle East, Russia, the EU and the US.

Table 3-1: Unit process data – onion production

Type	Flow	Value	Unit	DQI*
Inputs	Seeds	0.0491	unit	Measured
	Agricultural lime	0.00278	kg	Measured
	Fertilisers	0.0310	kg	Measured
	Agrichemicals	0.00200	kg	Measured
	Electricity – grid	0.0283	kWh	Measured
	Electricity – renewable	1.59E-05	kWh	Measured
	Diesel	0.0121	L	Measured
	Liquefied petroleum gas (LPG)	0.00146	L	Measured
	Surface water	0.0578	m^3	Measured
	Packaging of raw materials – polyethylene (PE) drum/intermediate bulk containers (IBCs)/cardboard/PP bulk bag/PP sack bag	1.49E-04	kg	Calculated
Outputs	Onion	1.00	kg	Calculated
	Onion waste – left onsite	0.113	kg	Measured
	Onion waste - recycled	0.0727	kg	Measured
	Water evaporation	0.0568	m^3	Calculated
	General waste - landfilled	0.0914	kg	Measured
	Packaging waste - landfilled	1.73E-05	kg	Calculated
	Packaging waste - recycled	1.31E-04	kg	Calculated
	NH_3 emission to air	2.51E-04	kg	Calculated
	NO emission to air	1.01E-04	kg	Calculated
	N_2O emission to air	1.44E-04	kg	Calculated
	CO_2 emission to air	0.00202	kg	Calculated
	Nitrates emission to water	0.00157	kg	Calculated
	Phosphorus emission to water	2.61E-05	kg	Calculated

* measured / calculated / estimated / literature

3.2.4. Packaging

The inputs and outputs of onion packing and storage process are summarised in **Error! Reference source not found.**. Energy and water use for these processes were included at the site level. The data also showed that some packaging materials, such as wood pallets and plastic bins, are commonly reused. The number of times these materials are reused was estimated based on grower feedback.

Table 3-2: Unit process data - packaging

Type	Flow	Value	Unit	DQI*
Inputs	Onion	1.00	kg	Calculated
	Packaging of product - wood pallet	0.0361	kg	Calculated
	Packaging of product - cardboard	7.58E-04	kg	Calculated
	Packaging of product - paper label	4.83E-05	kg	Calculated
	Packaging of product - steel staple	1.39E-05	kg	Calculated
	Packaging of product - polypropylene (PP) bin	0.00944	kg	Calculated
	Packaging of product - PP bag	0.00456	kg	Calculated
	Packaging of product - low-density polyethylene (LDPE) wrapping	3.65E-04	kg	Calculated
	Cleaner/Sanitiser	1.83E-05	kg	Calculated
	Refrigerant	1.91E-05	kg	Calculated
Outputs	Onion	1.00	kg	Calculated
	Packaging of product	0.0513	kg	Calculated
	Used refrigerant	1.91E-05	kg	Calculated

* measured / calculated / estimated / literature

3.2.5. Water use

Water sources are modelled with AusLCI datasets and are further regionalised by catchment (Bontinck, et al., 2021), as required by EN15804+A2 (CEN, 2019/2021) to allow calculation of water scarcity footprint. These included the relevant catchments in each of those three states: Tasmania, Western Australia and South Australia.

3.3. Background data

The key life cycle inventory datasets used in the model are listed below. Australian average data was used where it was available. Most background datasets were obtained from the ecoinvent database v3.10, EN15804 model, and related documentation can be found at: https://ecoquery.ecoinvent.org/3.10/EN15804.

Some background datasets were obtained from the AusLCI database v2.45, and related documentation can be found at: https://www.auslci.com.au/.

The proxy column is used to indicate whether a dataset accurately represents the desired material or process; a No* indicates the use of a geographical proxy for a correct dataset where the region of manufacture is expected to have little influence on its environmental profile; and a Yes* indicates the use of a geographical proxy for a correct dataset where the region of manufacture is expected to materially influence its environmental profile.

3.3.1. Fuels and energy

National averages for fuel inputs and electricity grid mixes were obtained from the ecoinvent and AusLCI databases.

Market-based modelling has been used for grid supplied electricity consumed in processes at five onion growers' sites. Location-based grid mix EFs (using the published grid mix) is used in secondary datasets for modelling upstream stage (e.g. for production of raw materials) because the aggregated datasets cannot be modified for electricity supply.

For the five growers, electricity generated from on-site solar panels accounts for 0.06% of total electricity consumption. This electricity consumption is modelled with ecoinvent dataset "AU: electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted".

Electricity from the grid accounts for 99.94% of total electricity consumption. The residual electricity mix on the market is therefore used for modelling electricity from grid. Electricity is modelled using ecoinvent datasets for each generation source in the composition detailed below.

Australia publishes state-specific grid mixes, which vary significantly between states. A national Australian residual mix emission factor (RMF) was published for the first time in 2023 in the Greenhouse Accounts (NGA) Factors Workbook (DCCEEW, 2023). However, the residual supply mix (i.e. generation by sources) was not published by the Australian Government, nor the state-specific residual supply mix (RSM).

To support the PCR requirements for market-based reporting, thinkstep-anz published a whitepaper which provides details of electricity grid RSM and RMF for each state in Australia for FY2023 (thinkstep-anz, 2024). The RSMs are calculated by removing the renewable electricity that is considered 'voluntarily surrendered'. The Australian National Life Cycle Inventory Database (AusLCI) has adopted the methodology to publish RMFs. These are included from v2.45 of the database, supported by the methodology paper Life Cycle Inventory of Australian Electricity (Brown & Grant, 2025).

The composition of the residual electricity grid mix of each state is modelled in LCA FE based on published data of the generation per fuel type, and the national electricity mix trade between states for the financial year 2022-07-01 to 2023-06-30 (Australian Government, 2024). Onsite consumption is calculated based on the same source as the grid mix (Australian Government, 2024). The low voltage (<1kV) grid's transmission and distribution losses are calculated based on data based on data from the Australian Energy Market Operator (AEMO, 2022).

Table 3-3 shows the most relevant electricity datasets and Table 3-4 shows other energy datasets used in modelling the product systems.

Table 3-3: Key electricity datasets used in inventory analysis

Material/process	Location	Dataset	Data Provider	Reference Year	Proxy?
Electricity	SA	AU: electricity, low voltage {AU-SA}| market for residual electricity mix, low voltage | AusLCI, S	AusLCI	2023	No
Electricity	TAS	AU: electricity, low voltage {AU-TAS}| market for residual electricity mix, low voltage | AusLCI, S	AusLCI	2023	No
Electricity	WA	AU: electricity, low voltage {AU-WA}| market for residual electricity mix, low voltage | AusLCI, S	AusLCI	2023	No
Electricity	AU	AU: electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted	ecoinvent	2023	No

Table 3-4: Key energy datasets used in inventory analysis

Energy	Location	Dataset	Data Provider	Reference Year	Proxy?
Diesel	AU	GLO: diesel, burned in building machine	ecoinvent	2023	No
LPG	AU	AU: LPG combustion	ecoinvent/thinkstep-anz	2023	No

3.3.2. Raw materials and processes

Data for upstream and downstream raw materials and unit processes were obtained from the ecoinvent database. Table 3-5 shows the most relevant LCI datasets used in modelling the product systems. Documentation for all ecoinvent datasets can be found at https://ecoquery.ecoinvent.org/3.10/EN15804.

Table 3-5: Key material and process datasets used in inventory analysis

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
Seed	GLO, AU	AU: seedling, for transplant, at nursery	AusLCI	2023	Yes
Agricultural lime	AU	ROW: lime production, milled, loose	ecoinvent	2023	No
Fertilisers	GLO, AU	ROW: ammonium nitrate production	ecoinvent	2023	No
	GLO, AU	ROW: ammonia production, partial oxidation, liquid	ecoinvent	2023	No
	GLO, AU	ROW: diammonium phosphate production	ecoinvent	2023	No
	GLO, AU	ROW: monoammonium phosphate production	ecoinvent	2023	No
	GLO, AU	ROW: ammonium sulphate production	ecoinvent	2023	No
	GLO, AU	ROW: calcium ammonium nitrate production	ecoinvent	2023	No
	GLO, AU	ROW: urea production	ecoinvent	2023	No
	GLO, AU	ROW: sodium nitrate production	ecoinvent	2023	No
	GLO, AU	ROW: treatment of poultry manure, drying, pelleting	ecoinvent	2023	No
	GLO, AU	ROW: tap water production, conventional treatment	ecoinvent	2023	No
	GLO, AU	GLO: sand to generic market for inert filler	ecoinvent	2023	Yes
Agrichemicals	GLO, AU	ROW: pesticide production, unspecified	ecoinvent	2023	Yes
	GLO, AU	GLO: sand to generic market for inert filler	ecoinvent	2023	Yes
	GLO, AU	ROW: tap water production, conventional treatment	ecoinvent	2023	Yes

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
Adjuvant	GLO, AU	ROW: paraffin production	ecoinvent	2023	Yes
Plant growth regulators (PGRs)	GLO, AU	ROW: chemical production, inorganic	ecoinvent	2023	Yes
Refrigerant	AU	ROW: refrigerant R134a production	ecoinvent	2023	No
Surface disinfectant	AU	ROW: chlorine production, liquid	ecoinvent	2023	Yes
Polypropylene	GLO, AU	ROW: polypropylene production, granulate	ecoinvent	2023	No
	GLO, AU	ROW: injection moulding	ecoinvent	2023	No
	GLO, AU	GLO: weaving of synthetic fibre, for industrial use	ecoinvent	2023	No
LDPE	GLO, AU	ROW: polyethylene production, linear low density, granulate	ecoinvent	2023	No
	GLO, AU	ROW: extrusion, plastic film	ecoinvent	2023	No
IBC	GLO	ROW: steel production, low-alloyed, hot rolled	ecoinvent	2023	No
	GLO	ROW: polypropylene production, granulate	ecoinvent	2023	No
Paper	GLO	ROW: kraft paper production	ecoinvent	2023	No
Wood pallet	GLO	ROW: EUR-flat pallet production	ecoinvent	2023	No

3.3.3. Transportation

Average transportation distances and modes of transport are included for the transport of the raw materials, operating materials, and auxiliary materials to onion farms and packing facilities. Table 3-6 shows the ecoinvent datasets used to model transportation.

Table 3-6: Transportation datasets

Mode / fuels	Location	Dataset	Data Provider	Reference Year	Proxy?
Truck	AU, GLO	GLO: transport, freight, lorry, all sizes, EURO5 to generic market for transport, freight, lorry, unspecified	ecoinvent	2023	No
Ship	AU, GLO	GLO: transport, freight, sea, container ship	ecoinvent	2023	No

3.3.4. Packaging

The datasets used for modelling product packaging materials are provided in Table 3-7.

Table 3-7: Key material and process datasets used in packaging

Material/ process	Location	Dataset	Data Provider	Reference Year	Proxy?
Wood pallet	AU	ROW: EUR-flat pallet production	ecoinvent	2023	No
Cardboard, label and paper bag	AU	ROW: kraft paper production	ecoinvent	2023	No
Steel staple	AU	ROW: steel production, low-alloyed, hot rolled	ecoinvent	2023	No
	AU	ROW: metal working, average for steel product manufacturing	ecoinvent	2023	No
Polypropylene bin	AU	ROW: polypropylene production, granulate	ecoinvent	2023	No
	AU	ROW: injection moulding	ecoinvent	2023	No
Polypropylene bag	AU	ROW: polypropylene production, granulate	ecoinvent	2023	No
	AU	GLO: weaving of synthetic fibre, for industrial use	ecoinvent	2023	No
LDPE wrapping	AU	ROW: polyethylene production, low density, granulate	ecoinvent	2023	No
	AU	ROW: extrusion, plastic film	ecoinvent	2023	No

3.3.5. Water processes

The datasets used for modelling water are provided in Table 3-8.

Table 3-8: Water processes

Material	Location	Dataset	Data Provider	Reference Year	Proxy?
Ground water	TAS	AU: Ground water, Tasmania	thinkstep-anz	2023	No
Ground water	SA	AU: Ground water, South Australian Gulf	thinkstep-anz	2023	No
Ground water	WA	AU: Ground water, Moore Hill Rivers	thinkstep-anz	2023	No

3.3.6. Waste and wastewater treatment processes

The datasets used for modelling wastewater treatment are provided in Table 3-9. It is worth noting that ecoinvent dataset is used to model rejected onions left onsite and considered as a conservative approach.

Table 3-9: Waste treatment processes

Treatment/ Process	Location	Dataset	Data Provider	Reference Year	Proxy?
General waste for landfill	AU	ROW: treatment of municipal solid waste, sanitary landfill	ecoinvent	2023	No
Plastic waste for recycling	AU	ROW: treatment of waste polyethylene/polypropylene, recycling	ecoinvent	2023	No
Onion waste – left onsite	AU	ROW: treatment of biowaste, open dump	ecoinvent	2023	No

4. Life cycle impact assessment

This chapter presents the results for the environmental impact categories and other metrics described in section 2.8. These results should be read as potential impacts, not actual measured impacts. They are approximations of environmental impacts that could occur if the emissions would (a) follow the underlying impact pathway and (b) meet certain conditions in the receiving environment while doing so. The results are also linked to the declared unit used in this study. This means they show the share of potential environmental impacts associated with that unit only.

LCIA results are therefore relative expressions only and do not predict actual impacts, the exceeding of thresholds, safety margins, or risks.

4.1. Assessment results

This section provides assessment results for 1 kg of Australian onions, plus packaging.

Table 4-1 and Table 4-2 present EN15804+A2 core and additional environmental indicators, respectively. Table 4-3 to Table 4-5 present the inventory indicators.

The results for upstream and core stages include 'balancing-out reporting' for the biogenic CO_2, PENRM and PERM of packaging. This is because downstream stage is not included in the system boundary for this study.

The results show:

- **Core stage** has the greatest impact on most environmental impact indicators.
- **Upstream stage** also contributes to significant environmental impacts.

Table 4-1: Core environmental indicator results for onion, per 1 kg

Indicator	Unit	Upstream	Core	Total
GWP-total	kg CO_2-eq.	0.0878	0.255	0.343
GWP-fossil	kg CO_2-eq.	0.0876	0.127	0.215
GWP-biogenic	kg CO_2-eq.	1.15E-04	0.127	0.127
GWP-luluc	kg CO_2-eq.	8.36E-05	7.50E-04	8.34E-04
ODP	kg CFC11-eq.	2.80E-08	1.04E-09	2.90E-08
AP	Mole of H+ eq.	4.55E-04	0.00153	0.00199
EP-fw	kg P eq.	0.00193	5.38E-05	0.00198
EP-m	kg N eq.	9.07E-05	0.00208	0.00217
EP-tr	Mole of N eq.	0.00110	0.00642	0.00752
POCP	kg NMVOC eq.	2.51E-04	9.32E-04	0.00118
ADP-minerals&metals[2 3]	kg Sb-eq.	8.88E-07	7.65E-07	1.65E-06
ADP-fossil[2]	MJ	1.21	1.04	2.25
WDP[2]	m^3 world equiv.	0.0558	1.78	1.84

Table 4-2: Additional environmental indicator results for onion, per 1 kg

Indicator	Unit	Upstream	Core	Total
GWP-GHG[4]	kg CO_2-eq.	0.0877	0.128	0.216
PM	Disease incidences	4.35E-09	9.54E-09	1.39E-08
IRP[5]	kBq U235 eq.	0.00217	0.00126	0.00343
ETP-fw[2 3]	CTUe	0.942	12.8	13.7
HTPc[2 3]	CTUh	3.40E-11	2.66E-11	6.06E-11
HTPnc[2 3]	CTUh	7.68E-10	4.54E-09	5.31E-09
SQP[2 3]	Dimensionless	0.993	116	117

Table 4-3: Resource use indicator results for onion, per 1 kg

Indicator	Unit	Upstream	Core	Total
PERE	MJ	0.146	0.188	0.334
PERM	MJ	0	0	0
PERT	MJ	0.146	0.188	0.334
PENRE	MJ	1.21	0.997	2.21
PENRM	MJ	0	0	0
PENRT	MJ	1.21	0.997	2.21
SM	kg	0	0	0
RSF	MJ	0	0	0
NRSF	MJ	0	0	0
FW	m^3	0.00118	0.539	0.540

Table 4-4: Waste material and output flow indicator results for onion, per 1 kg

Indicator	Unit	Upstream	Core	Total
HWD	kg	0.00457	0.00393	0.00850
NHWD	kg	0.142	0.419	0.561
RWD	kg	5.24E-07	2.93E-07	8.17E-07
CRU	kg	0	0	0
MFR	kg	0	0.0729	0.0729
MER	kg	0	0	0
EEE	MJ	0	0	0
EET	MJ	0	0	0

Table 4-5: Biogenic carbon content indicator results for onion, per 1 kg

Indicator	Unit	Total
BCC-prod	Kg	0.106
BCC-pack	Kg	0.0170

4.2. Hotspot analysis

A hotspot analysis has been conducted for the EN 15804+A2 core environmental impact indicators as well as for additional environmental indicators. Hotspot analysis shows how much each process contributes to the total result, as a percentage. These percentages need to be interpreted carefully. A product with a lower overall impact can show a higher percentage contribution from one process, even if the actual impact from that process is not higher. Percentage contributions should therefore be understood within the context of the relative impact per product and not assumed to imply that the impacts from that process are higher for a particular product.

4.2.1. Hotspot analysis – Core environmental impact indicators

GWP-luluc is of less relevance to GWP-total results. Therefore, hotspots of GWP-luluc is not analysed in this report. The hotspots of core environmental indicators are presented in Figure 4-1.

The hotspot analysis shows that:

- **Waste treatment** is a hotspot for GWP-total. It is the only hotspot for GWP-biogenic. It also contributes to EP-m and POCP. This is due to some growers leaving rejected onions on the ground.
- **On farm fuel use** is a hotspot for most indicators, such as GWP-total, GWP-fossil, AP, EP-m, EP-tr, POCP, ADP-minerals&metals and ADP-fossil. It has the highest impact on ADP-fossil. This is due to the high diesel consumption during farm operations, such as tillage, crop management, lifting/harvesting.
- **Production of fertilisers** is a hotspot for GWP-total, GWP-fossil, AP, EP-tr, POCP, ADP-minerals&metals and ADP-fossil.
- **Operational emissions due to fertiliser use** also contribute to significant impact of GWP-total, GWP-fossil, AP, EP-m, EP-tr and POCP. It is the main hotspot of AP, EP-m and EP-tr impacts.
- **Onion packaging** is a hotspot for GWP-total and GWP-fossil. It also contributes to POCP, ADP-minerals&metals, ADP-fossil impacts, AP and EP-tr. This is due to the use of wood pallets. However, reuse of wood pallets is also commonly observed across onion farms, which has reduced the impact of wood pallets.
- **Consumables** is a hotspot for ODP. This is due to the use of refrigerant in storage.
- **Production of raw materials** is the only hotspot for EP-fw impacts. This is mainly driven by the use of limestone (if used in field preparation)[7].
- **Upstream transport** contribute to noticeable impact of GWP-total, GWP-fossil, AP, EP-m, EP-tr, POCP, ADP-minerals&metals and ADP-fossil.
- **Agrichemical production** generates noticeable impacts of ODP and minor impacts of GWP-total, GWP-fossil, ODP, AP, EP-m, EP-tr, POCP, ADP-minerals&metals and ADP-fossil.
- **Electricity consumption** is a hotspot for ADP-minerals&metals, while making minor contribution to GWP-total, GWP-fossil, AP, ADP-fossil and WDP.
- **Water use** during onion production is the only hotspot for WDP impact.

[7] Raw materials include seeds and agricultural lime. Note that limestone is not used each year and not on all farms. Some farms use gypsum or dolomite depending on soil conditions.

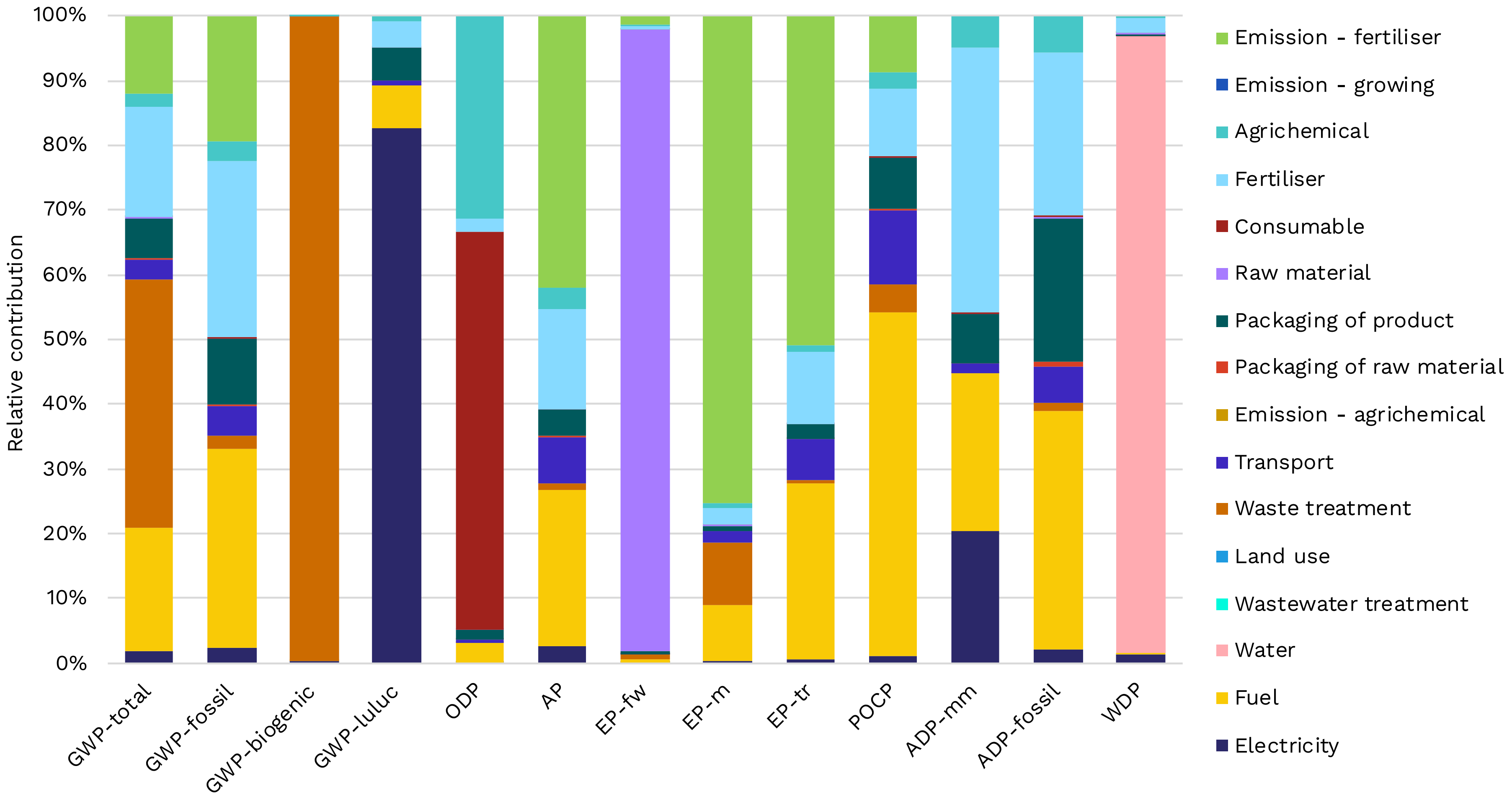

Figure 4-1: Main contributors to core environmental indicators for onions in upstream and core stages (Raw materials include seeds and agricultural lime; Consumable is predominantly refrigerant)

4.2.2. Hotspot analysis – Additional environmental impact indicators

The hotspots of additional environmental indicators are presented in Figure 4-2. According to the figure:

- **Fuel consumption** has notable impacts on GWP-GHG, IRP, HTPc, HTPc and SQP. It is also a hotspot for PM.
- **Production of fertilisers** is another hotspot for GWP-GHG, PM, IRP, HTPc, HTPnc and ETP-fw.
- **Operational emissions due to fertiliser use** also contribute to significant impact of GWP-GHG and PM impacts.
- **Onion packaging** is a hotspot of GWP-GHG, PM, IRP, HTPc and HTPnc.
- **Upstream transport** contributes to GWP-GHG, PM, IRP, HTPc and HTPnc impacts.
- **Agrichemical production** contributes to GWP-GHG, PM, IRP, ETP-fw, HTPc and HTPnc impacts.
- **Operational emissions due to agrichemical use** contribute ETP-fw and HTPnc impacts significantly.
- **Waste treatment** has notable impact on ETP-fw and HTPnc, while having minor impacts on HTPc, GWP-GHG, PM and IRP.
- **Electricity consumption** has impact on HTPc, HTPnc, GWP-GHG, PM and IRP.
- **Site operation** is the predominant hotspot for SQP impact.

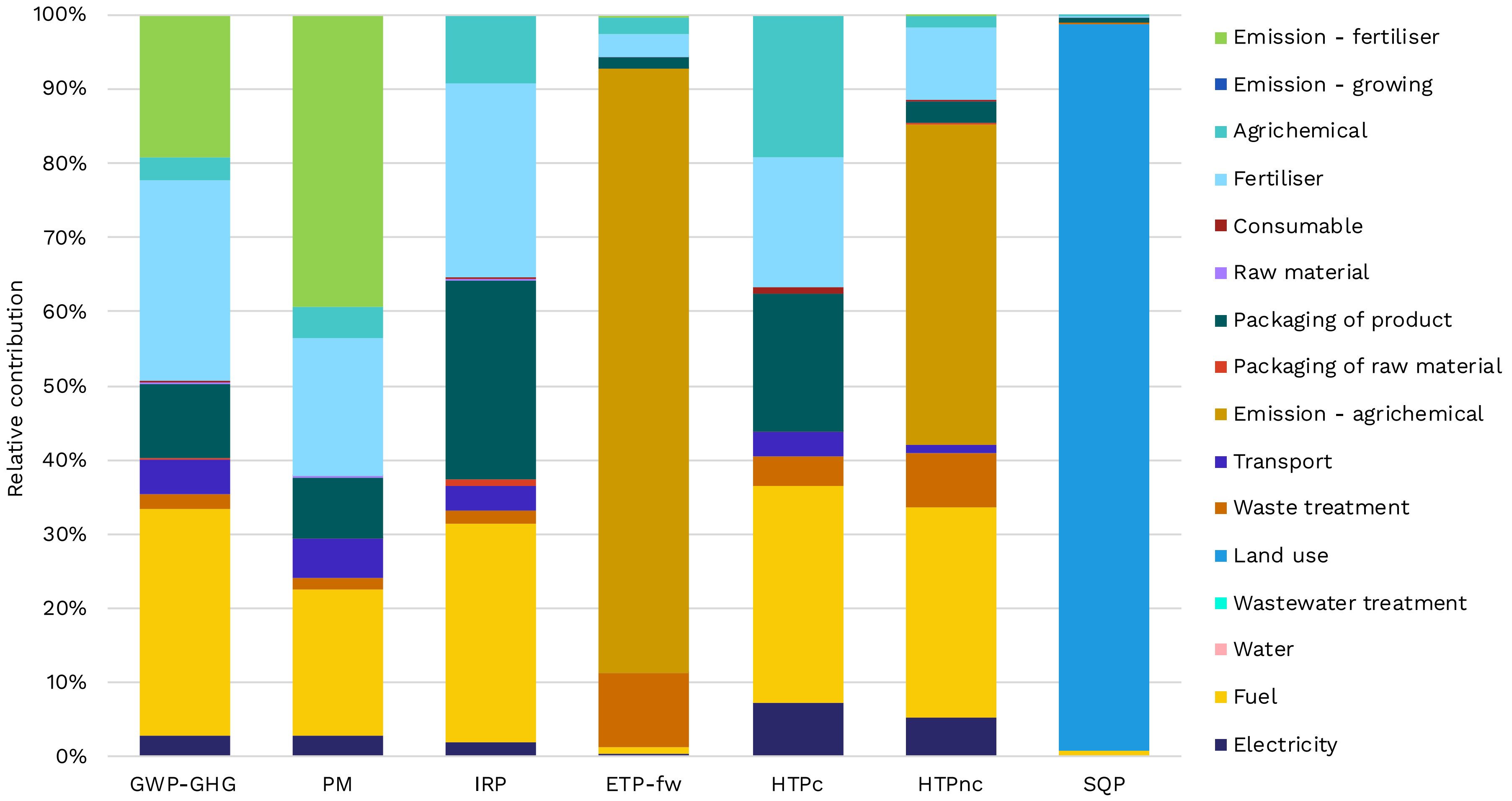

Figure 4-2: Main contributors to additional environmental indicators for onions in upstream and core stages

4.3. Sensitivity analysis

Sensitivity analyses were used to check how much the results change when uncertain assumptions or input values are adjusted.

This helps show whether the findings are robust, or whether they depend strongly on a particular assumption. For example, if changing an uncertain value has little effect on the result, the finding is more reliable. If the result changes a lot, that assumption needs to be treated with more care.

Sensitivity analyses were included for consideration of distribution impact. The environmental impacts were modelled considering two cases:

- **Cradle-to-gate:** representing the current system boundary considered in this study; and
- **Cradle-to-shelf:** representing the inclusion of distribution impact in the system boundary.

Distribution includes transport of product to retailers across Australia. The weighted average distances from five growers to the major cities in Australia were calculated based on the transport distance and city populations due to unavailability of onion distribution data, as presented in Table 4-6. The transport modes are outlined in section 3.3.3.

Table 4-6: Average distribution distance

Type	Distance Truck (km)	Distance Sea (km)
Packaged onion	1,361	587

This is an average scenario that may not be representative for any given customer. Customers should individually establish the transport requirements between distribution centre and their site rather than relying on the average.

The results of the sensitivity analyses show that:

- if onion distribution is accounted for, 0.22 kg CO_2-eq. will be added to the climate change impacts of 1 kg onions (GWP-total), which is a 64% increase.
- Overall, the inclusion of distribution has significant impacts on onion's life cycle environmental impacts – including climate change.

4.4. Case studies

To demonstrate how different farming practises change the environmental impact of onions, two case studies were developed. This was done by adjusting chosen variables in the LCA model and generating LCIA results subsequently. These case studies are purely hypothetical and are not representative of a specific business.

4.4.1. Case study 1: recycling rejected onions

This case study analyses the impact of recycling rejected onions in Australia. It is assumed that all rejected onions are collected and transported to third-party facilities by road for use as animal feed. The impacts of transport are considered under the "waste treatment" category; the road transport distance is assumed as 100 km which is a conservative assumption. The impacts of recycling processes occurring after the rejected onions arrive at the third-party facilities are excluded. Other factors will remain the same as the industry benchmark.

According to Figure 4-3, the 'cradle-to-gate' climate change impacts (GWP-total) of 1 kg onions will reduce to 0.26 kg CO_2-eq., from the industry benchmark of 0.34 kg CO_2-eq. (see section 4.1). This is a 25% reduction in GWP-total impacts. Overall, this highlights the significance of recycling rejected onions.

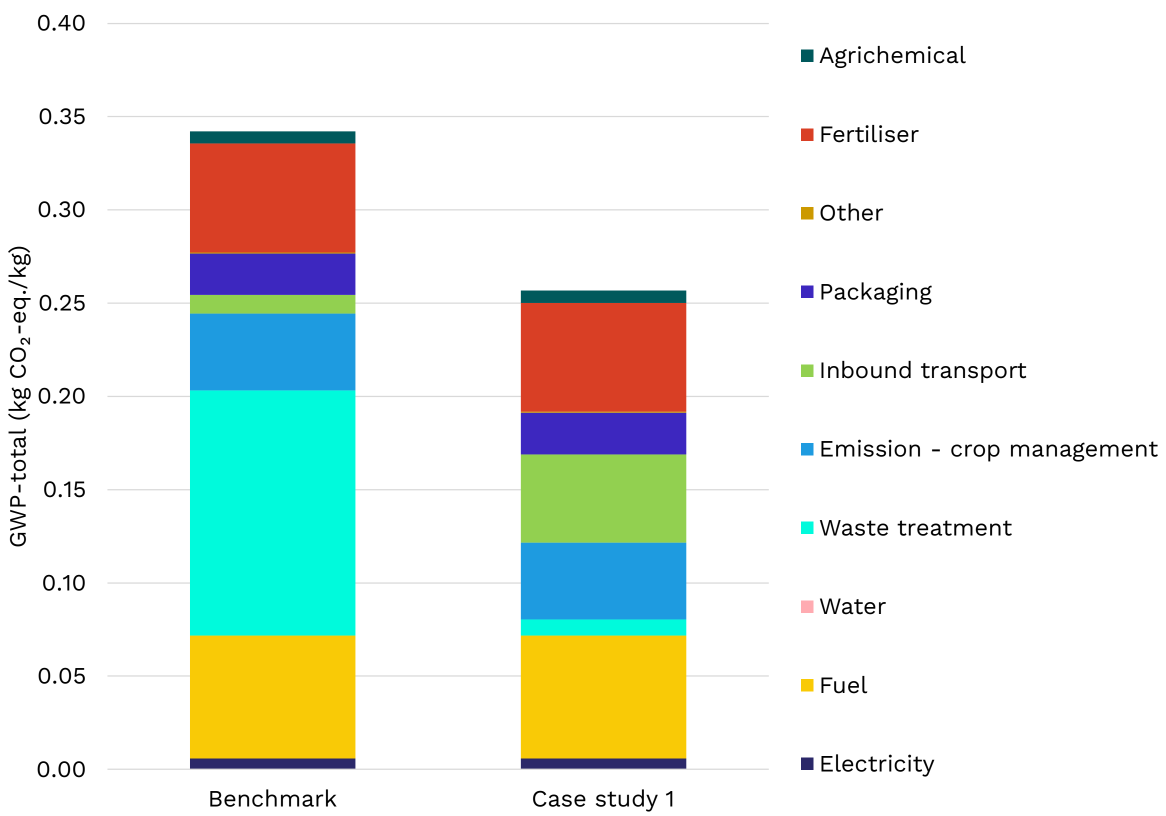

Figure 4-3: GWP-total impacts of Australian onions with recycling of rejected onions

4.4.2. Case study 2: increasing saleable yield

This case study analyses the impact of increasing saleable yield on the climate change impacts (GWP-total) of Australian onions. In this case study, it is assumed that a 20% increase in saleable yield in each farm. While the sold volume increased by 20%, the rejected onions are reduced by the same amount. Other factors will remain the same as the industry benchmark.

According to Figure 4-4, the 'cradle-to-gate' climate change impacts (GWP-total) of 1 kg onions will decrease to 0.21 kg CO_2-eq., from the industry benchmark of 0.34 kg CO_2-eq. (see section 4.1). This is a 40% decrease in GWP-total impacts. Overall, this highlights the significance of increasing saleable yield to reduce the impacts of onion production.

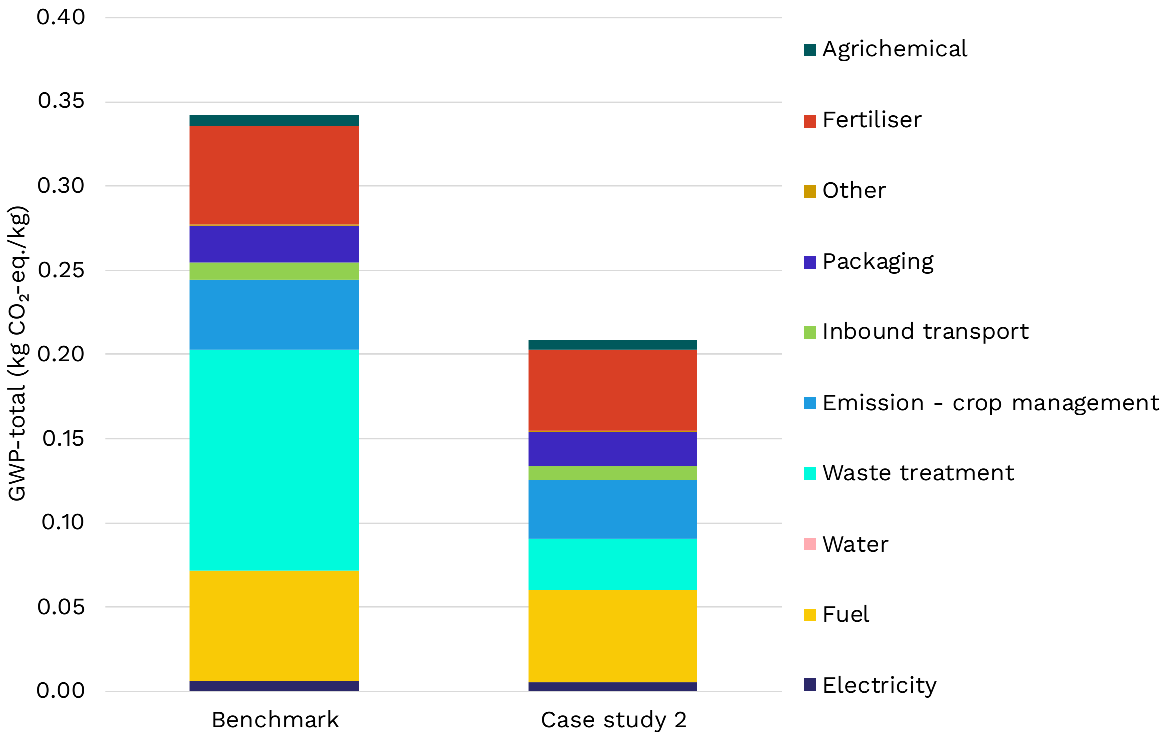

Figure 4-4: GWP-total impacts of Australian onions with higher saleable yield

4.4.3. Case study 3: decreasing in fertiliser use

This case study analyses the impact of reducing fertiliser use on the climate change impacts (GWP-total) of Australian onions. In this case study, it is assumed that a 10% decrease in fertiliser use in each farm. Other factors will remain the same as the industry benchmark.

According to Figure 4-5, the 'cradle-to-gate' climate change impacts (GWP-total) of 1 kg onions will decrease to 0.33 kg CO_2-eq., from the industry benchmark of 0.34 kg CO_2-eq. (see section 4.1). This is a 3% decrease in GWP-total impacts. This shows reducing fertiliser use can potentially lower the impacts of onion production - however, growers should take extreme care when reducing their fertiliser use given that can affect yields.

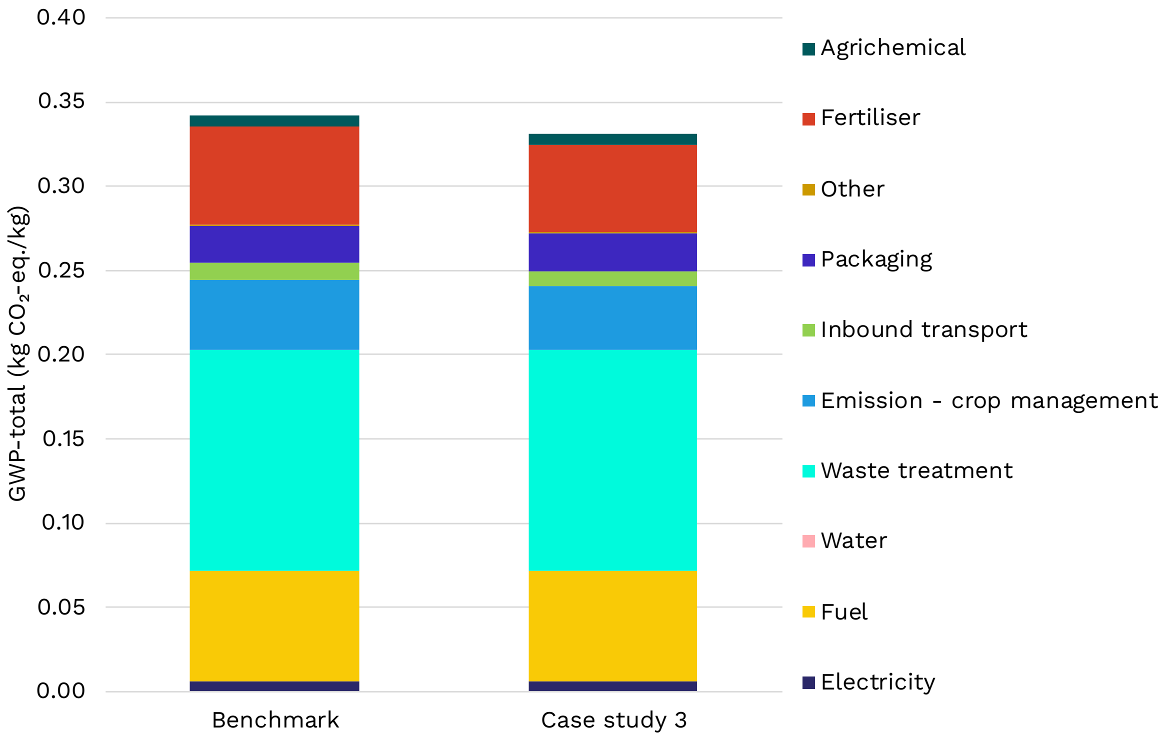

Figure 4-5: GWP-total impacts of Australian onions with less fertiliser use

4.4.4. Case study 4: best practice

This case study analyses the impact of implementing all carbon emission reduction strategies analysed in previous case studies. In this case study, it is assumed that a 10% decrease in fertiliser use, 20% increase in saleable yield and all rejected onions are recycled into animal feed in each farm. Other factors will remain the same as the industry benchmark.

According to Figure 4-5, the ‘cradle-to-gate’ climate change impacts (GWP-total) of 1 kg onions will decrease to 0.18 kg CO_2-eq., from the industry benchmark of 0.34 kg CO_2-eq. (see section 4.1). This is a 48% decrease in GWP-total impacts. This shows the implementation of these carbon emission reduction strategies can significantly reduce the impacts of onion production.

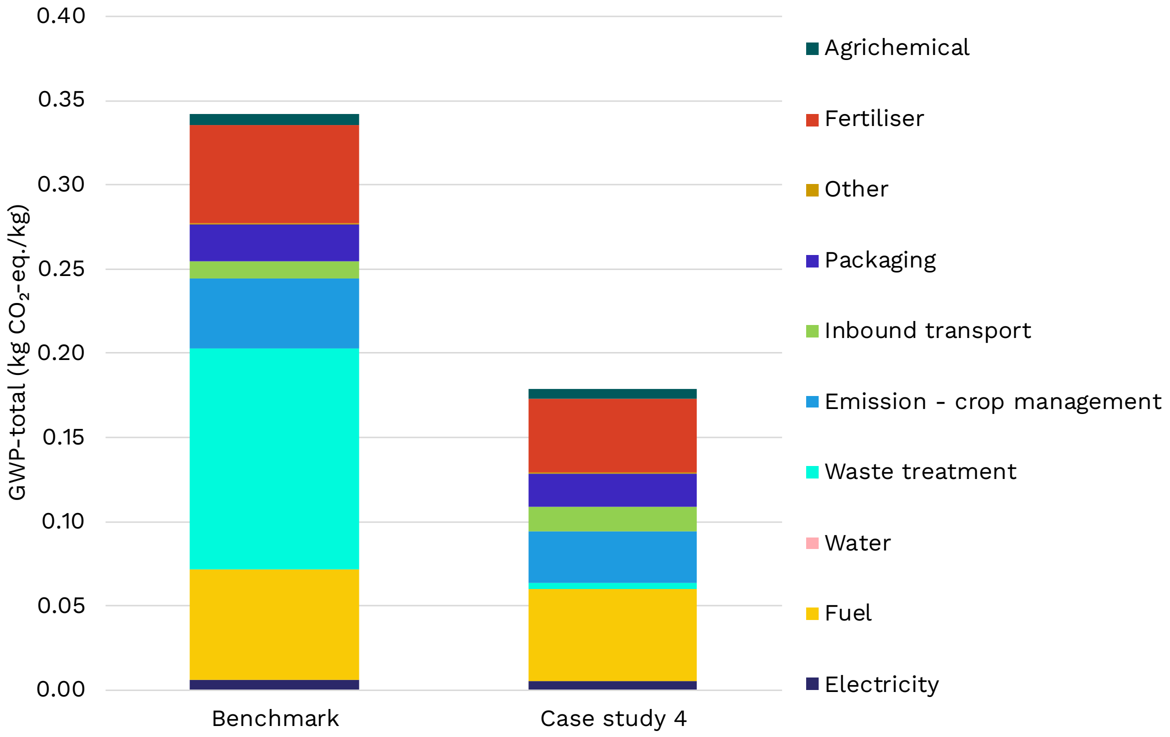

Figure 4-6: GWP-total impacts of Australian onions with best practice

5. Data quality assessment

Inventory data quality is judged by its precision (measured, calculated or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied) and representativeness (geographical, temporal, and technological).

To cover these requirements and to ensure reliable results, first-hand industry data in combination with consistent background LCA information from the ecoinvent database were used. The LCI datasets from the ecoinvent database are widely distributed and used with the MS Excel. The datasets have been used in LCA models worldwide in industrial and scientific applications in internal as well as in many critically reviewed and published studies. In the process of providing these datasets they are cross-checked with other databases and values from industry and science.

5.1. Representativeness

The data quality assessment according to the EN15804 Annex E is provided in Table 5-1 with more details provided below.

- **Temporal:** All primary data were collected for the production years 2023 and 2024. All secondary data come from the ecoinvent and AusLCI databases and are representative of the years 2023. As the study intended to compare the product systems for the production years 2023 and 2024, temporal representativeness is considered to be very good.
- **Geographical:** All primary and secondary data were collected specific to the countries or regions under study. Where country-specific or region-specific data were unavailable, proxy data were used. Geographical representativeness is considered to be good.
- **Technological:** All primary and secondary data were modelled to be specific to the technologies or technology mixes under study. Where technology-specific data were unavailable, proxy data were used. Technological representativeness is considered to be good.

Table 5-1: Data quality assessment

Process	Geographical representativeness	Technical representativeness	Time representativeness
Production of fertilisers	Good	Good	Very Good
Production of agrichemicals	Good	Fair	Very Good
Production of consumables	Good	Good	Very Good
Generation and combustion of fuel used in growing and packaging processes	Good	Very Good	Very Good
Generation of electricity used in growing and packaging processes	Very Good	Very Good	Very Good
Generation of water in growing and packaging processes	Very Good	Very Good	Very Good
Waste and wastewater treatment	Good	Fair	Very Good
Transport of raw materials to growers' sites	Good	Good	Very Good
Production of other raw materials	Good	Good	Very Good

5.2. Precision and completeness

- **Precision:** As the majority of the relevant foreground data are measured data or calculated based on primary information sources of the owner of the technology, precision is considered to be high. Seasonal variations and variations across different manufacturers were balanced out by using yearly averages and weighted averages, respectively. All background data are sourced from ecoinvent and AusLCI databases with the documented precision.
- **Completeness:** Each foreground process was checked for mass balance and completeness of the emission inventory. No data were knowingly omitted. Completeness of foreground unit process data is considered to be high. All background data are sourced from ecoinvent and AusLCI databases with the documented completeness.

5.3. Consistency and reproducibility

- **Consistency:** To ensure data consistency, all primary data were collected with the same level of detail, while all background data were sourced from the ecoinvent and AusLCI databases.
- **Reproducibility:** Reproducibility is supported as much as possible through the disclosure of input-output data, dataset choices, and modelling approaches in this report. Based on this information, any third party should be able to approximate the results of this study using the same data and modelling approaches.

5.4. Model completeness and consistency

5.4.1. Completeness

All relevant process steps for each product system were considered and modelled to represent each specific situation. The process chain is considered sufficiently complete and detailed with regards to the goal and scope of this study.

5.4.2. Consistency

All assumptions, methods and data are consistent with each other and with the study's goal and scope. Differences in background data quality were minimised by exclusively using LCI data from the ecoinvent and AusLCI databases. System boundaries, allocation rules, and impact assessment methods have been applied consistently throughout the study.

6. Interpretation

6.1. Conclusions

This study provides a baseline for understanding the environmental impacts of Australian-grown onions. It is based on data from five onion growers for the 2023 and 2024 production years.

The cradle-to-gate carbon footprint of 1 kg of Australian farmed onions (plus packaging) was 0.34 kg CO_2-eq. during 2023-2024 production period. This result measures climate change impacts, also known as GWP-total. The study also assessed other environmental impacts, including eutrophication, water use and air pollution.

The results show that most impacts occur in the core stage of production. This includes onion growing, storage, packing and waste management. The main contributors to the carbon footprint are:

- rejected onions left on farm
- fuel used by tractors, irrigation pumps and other on-farm machinery
- production and use of fertilisers and soil amendments
- packaging for finished onions.

Other environmental indicators highlight different hotspots. For example, water use is the main driver of water depletion. Refrigerant use in onion storage contributes to ozone depletion. Electricity use is relevant for several impact categories, particularly resource use of metals and minerals. Upstream seed manufacturing and agricultural lime contribute to freshwater eutrophication, while agrichemical production contributes to ozone depletion and fossil resource use.

The sensitivity analysis shows that distribution can make a significant difference when looking beyond the farm gate. If transport to retail stores is included, the carbon footprint increases from 0.34 to 0.56 kg CO_2-eq. per kg of packed onions. This means distribution should be better understood if the industry wants to report cradle-to-shelf results in future.

Overall, the results show that no single activity drives all environmental impacts. The best opportunities are likely to come from a combination of actions: improving saleable yield, finding higher-value uses for rejected onions, reducing fossil fuel use, optimising fertiliser and soil amendment use, improving packaging decisions and considering distribution where relevant.

This baseline can help the Australian onion industry track environmental performance over time and focus improvement efforts where they are likely to have the greatest effect. The results are designed to support industry decision-making and should not be used to make public comparative claims against other products, growers or industries.

6.2. What growers are already doing to improve their environmental performance

Material and energy use varied between onion farms. However, growers shared one common practice that can help improve environmental performance:

- Most packaging of raw materials – such as plastic drums – were collected and recycled by third parties.

6.3. Options available to improve environmental performance

To reduce the environmental impacts of Australian onions, we recommend that the Australian onion industry should:

- **Improve saleable yield** (wherever feasible) supported by good soil, crop nutrition and irrigation management.
- **Avoid leaving rejected onions on farm** where suitable alternatives are available, such as using them for animal feed.
- **Use less fossil fuel** by improving energy efficiency and moving away from diesel, LPG and petrol where practical.
- **Optimise fertiliser use** through practices, such as improving soil organic matter, reducing fallow periods and tillage, using cover crops, splitting fertiliser applications, applying fertilisers at the appropriate timing, and considering enhanced efficiency fertiliser products.
- **Take a whole-of-life view** before making changes so improvements in one area do not create bigger impacts somewhere else.

6.4. Data collection guidance for growers

We recommend that onion growers adopt a suitable process for collecting data for their own operations moving forward. This will make future LCAs easier and help growers respond to future requests for emissions data from customers, industry bodies or the Australian Government.

An LCA typically needs 12 consecutive months of data. This data is often available from central management systems (i.e. accounting). Where this information is not centrally recorded, it typically needs to be compiled from monthly invoices.

While growers record the cost (dollar value) of inputs purchased in their accounting software, the corresponding quantities (e.g. kWh for energy, litres of fuel) are not routinely entered.

- Attaching documents related to financial transactions is also helpful - for example, attaching invoices related to payments
- Growers generally record the amount of chemicals and fertiliser applied to a crop, but do not routinely enter the amount of chemical active ingredient (ai) applied.

Recording these quantities in accounting systems and crop management software would streamline future data collection processes and support more efficient emissions and/or LCA calculations. Keeping the categories consistent year to year helps when making comparisons across years.

The types of data we recommend growers collect includes:

- raw materials (by type and mass/volume e.g. kg of fertiliser)
- energy (kWh of electricity and Litres of fuels)
- water (municipal, surface and ground water collection)
- packaging (by material and mass)
- waste (by type of waste and treatment type).

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Abbreviations and glossary

Term	Definition
ADP	Abiotic Depletion Potential
AP	Acidification Potential, Accumulated Exceedance
CEN	European Committee for Standardization
CML	Centre of Environmental Science at Leiden
DOCf	Degradable Organic Carbon Fraction
EoL	End-of-Life
EP	Eutrophication Potential
ETP	Potential Comparative Toxic Unit for ecosystems
ff	fossil fuels
fw	fresh water
GHG	Greenhouse Gas
GWP	Global Warming Potential (Climate Change)
HTP	Potential Comparative Toxic Unit for humans
ILCD	International Cycle Data System
IRP	Potential Human exposure efficiency relative to U235
ISC	Infrastructure Sustainability Council
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LDPE	Low-density polyethylene
luluc	Land use and land use change
m&m	minerals and metals
NMVOC	Non-Methane Volatile Organic Compound
ODP	Depletion potential of the stratospheric ozone layer
PM	Potential incidence of disease due to PM emissions
POCP	Formation potential of tropospheric ozone
PP	Polypropylene
RSL	Reference service life
VOC	Volatile Organic Compound
WDP	Water (user) deprivation potential, deprivation-weighted water consumption

Glossary

Life cycle

A view of a product system as "consecutive and interlinked stages … from raw material acquisition or generation from natural resources to final disposal" (ISO 14040:2006, section 3.1). This includes all material and energy inputs as well as emissions to air, land and water.

Life Cycle Assessment (LCA)

"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040:2006, section 3.2)

Life Cycle Inventory (LCI)

"Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle" (ISO 14040:2006, section 3.3)

Life Cycle Impact Assessment (LCIA)

"Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product" (ISO 14040:2006, section 3.4)

Life cycle interpretation

"Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations" (ISO 14040:2006, section 3.5)

Environmental Product Declaration (EPD)

"Independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products."

Product Category Rule (PCR)

"Defines the rules and requirements for EPDs of a certain product category."

Functional / Declared unit

"Quantified performance of a product system for use as a reference unit." (ISO 14040:2006, section 3.20)

Functional unit = LCA/EPD covers entire life cycle "cradle to grave".

Declared unit = LCA/EPD is not based on a full "cradle to grave" LCA, common in construction product EPDs.

Allocation

"Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006, section 3.17)

Foreground system

"Those processes of the system that are specific to it … and/or directly affected by decisions analysed in the study." (JRC, 2010, 97) This typically includes first-tier suppliers, the manufacturer itself and any downstream life cycle stages where the manufacturer can exert significant influence. As a general rule, specific (primary) data should be used for the foreground system.

Background system

"Those processes, where due to the averaging effect across the suppliers, a homogenous market with average (or equivalent, generic data) can be assumed to appropriately represent the respective process … and/or those processes that are operated as part of the system but that are not under direct control or decisive influence of the producer of the good…." (JRC, 2010, 97-98) As a general rule, secondary data are appropriate for the background system, particularly where primary data are difficult to collect.

Closed-loop and open-loop allocation of recycled material

"An open-loop allocation procedure applies to open-loop product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties."

"A closed-loop allocation procedure applies to closed-loop product systems. It also applies to open-loop product systems where no changes occur in the inherent properties of the recycled material. In such cases, the need for allocation is avoided since the use of secondary material displaces the use of virgin (primary) materials."

(ISO 14044:2006, section 4.3.4.3.3)

Critical Review

"Process intended to ensure consistency between a life cycle assessment and the principles and requirements of the International Standards on life cycle assessment" (ISO 14044:2006, section 3.45).

Applicability and limitations

Restrictions and intended purpose

This report has been prepared by thinkstep-anz with all reasonable skill and diligence within the agreed scope, time and budget available for the work. thinkstep-anz does not accept responsibility of any kind to any third parties who make use of its contents. Any such party relies on the report at its own risk. Interpretations, analyses, or statements of any kind made by a third party and based on this report are beyond thinkstep-anz's responsibility.

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Legal interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal opinions. Where opinions or judgements are to be relied on, they should be independently verified with appropriate legal advice.

Annex A Biogenic carbon sequestered

The biogenic carbon within the product is shown below.

A.1. Biogenic Carbon in Product

Annex Table A-1: Calculated biogenic carbon content per 1 kg of onions

Product	Biogenic carbon in product (kg/kg)
Onion	0.0289

A.2. Biogenic Carbon in Product

Annex Table A-2: Calculated biogenic carbon content of 1 kg of packaging material

Packaging	Biogenic carbon in packaging (kg/kg)
Paper/cardboard	0.46
Wood pallet	0.46

About thinkstep-anz

We're an independent and award winning sustainability firm with offices in Australia and Aotearoa New Zealand – and a global reach.

Our team works with you to put sustainability at the heart of your business, to set you up to succeed and inspire you to keep achieving more.

We focus on what matters and use data to understand organisations and their impact. We provide practical resources and ideas that move you ahead.

We create value for organisations like yours, bringing our technical expertise and business know-how to help you tell your story. It's what we've been doing since 2006.

Our services cover:

LCA and EPD services

Measure environmental impacts to support informed decision-making.

- Life Cycle Assessment (LCA)
- Environmental Product Declarations (EPD)
- Product carbon footprinting
- Critical review

Carbon footprint services

Calculate your carbon footprint, develop net zero strategies and targets.

- Carbon footprint: Scope 1 & 2
- Scope 3
- Carbon reduction strategy
- Net zero targets

Circular economy services

Identify opportunities to improve resource efficiency and reduce waste.

- Material Circularity Indicator
- Circular economy workshops
- Circular economy strategy
- Circularity declaration

Sustainability strategy

Turn sustainability priorities into practical roadmaps and targets.

- Materiality assessment
- Double materiality
- Sustainability strategy
- ESG policies

ESG and climate reporting

Prepare reports and disclosures supported by robust data and practical implementation.

- Climate related disclosures
- Disclosurekit
- GRI and sustainability reports
- Greenwashing risk review

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We turn complex data into graphics, summary reports and presentations.

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- Summary reports
- Board presentations
- Case studies
- Infographics

Software, data and tools

- LCA calculators
- LCA software
- Material Circularity Indicator
- Spend based emission factors
- Residual grid mix factors
- LCA data
- Carbon reporting software

Upskilling and training

- LCA training
- Carbon workshops
- Supplier workshops
- Training for industry associations
- Taylored in-house workshops
- Greenwash risk training

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