# THE HORTICULTURE SECTOR ACTION PLAN FOR FOOD WASTE REDUCTION 2024

Technical Report

This initiative is supported by the Queensland Government's Recycling and Jobs Fund

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# Abbreviations

| | |
|---|---|
| ABARES | Australian Bureau of Agricultural and Resource Economics and Sciences |
| ARC | Australian Research Council |
| BMP | Best Management Practice |
| CQU | Central Queensland University |
| CRC | Cooperative Research Centre |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| CSR | Corporate Social Responsibility |
| DCCEEW | Department of Climate Change, Energy, Environment, and Water |
| EFWA | End Food Waste Australia |
| FAO | Food and Agriculture Organisation |
| FIAL | Food Innovation Australia Ltd |
| FLW | Food Loss and Waste |
| FLW Standard | The Food Loss and Waste Accounting and Reporting Standard |
| FMA | Fresh Markets Australia |
| GHG | Green House Gases |
| HIA | Horticulture Innovation Australia |
| Hort SAP | Horticulture Sector Action Plan for Food Waste Reduction |
| IAP2 | International Association of Public Participation |
| KPI | Key Performance Indicators |
| MERI | Monitoring Evaluation Reporting Improvement |
| NQ | North Queensland |
| PAG | Project Advisory Group |
| QDES | Queensland Department of Environment and Science |
| RC | Root Cause |
| RDC's | Research Development Corporations |
| SAP | Sector Action Plan |
| SDG | Sustainable Development Goals |
| SFWA | Stop Food Waste Australia |
| WRAP | Waste and Resources Action Program |

# EXECUTIVE SUMMARY

Food waste and loss is currently a critical issue in Australia, and reducing food waste offers economic, social and environmental benefits. The development of a sector action plan (SAP) can provide a system-based approach for reducing food loss and waste, serving as a useful management tool for supply chain partners and collaborators in the horticultural industry in Australia. *The Horticultural Sector Action Plan for food waste reduction* (*Hort SAP*) developed in this document includes background on the horticultural sector and food waste, including definitions of food waste; discussion of the applied methodology and its findings; a detailed action plan and roadmap; and approaches to measuring the outcomes and impact of the *Hort SAP*.

This *Hort SAP* identifies strategic actions to reduce food waste across the horticultural supply chain. Its aims were as follows:

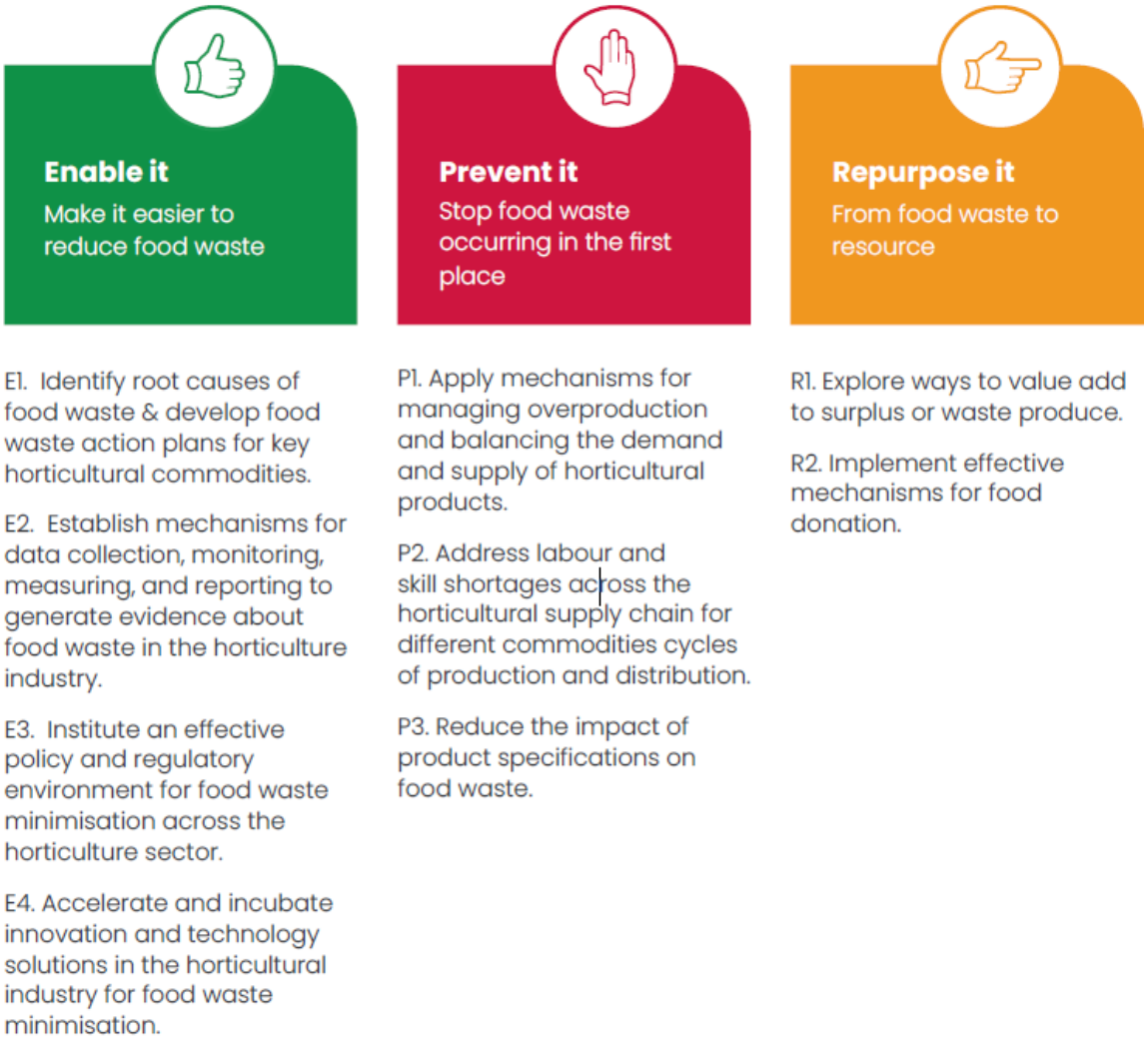
- Identify hotspots of waste in the horticulture sector from primary production to retailing stage (i.e., before consumption). The project does not deal with consumption/household waste.
- Explore root causes of waste.
- Examine and prioritise horticultural waste management strategies using a food recovery hierarchy.
- Prioritise management options (i.e., proposing actions for managing waste).
- Develop a horticultural sector action plan for food waste reduction.

Interventions and actions suggested in the *Hort SAP* aspire to deliver a 50% reduction in horticulture waste by 2030. The study also acknowledges that the horticultural industry is diverse and includes a wide variety of crops and complex supply chains.

Through triangulation of results from a literature review, stakeholder interviews and three stakeholder workshops, nine strategic areas of actions related to hotspots and root causes of food waste and loss were identified.

Actions were prepared through a five stage SAP Review-Plan-Do process. Eleven actions were presented in the final solution workshops, where four criteria were applied (volume, financial feasibility, technical feasibility, and best and highest use principle) for prioritising, and an in-depth discussion was conducted to finalise the actions. The actions also followed Stop Food Waste Australia (SFWA)'s horticulture specific food waste reduction hierarchy and ReFed continuum of prevention, repurpose (i.e., rescue and recycle or value add). Finally, these were consolidated into nine strategic actions, including key objectives, how to achieve the objectives, the desired outcomes, and potential indicators for achievement. The actions suggested are also derived from enablers of change. These include planning, policy and regulatory levers, capacity building and training, sharing information, research and innovation, awareness and behaviour change, collaboration, and evaluation and use of technologies.

This study focused on key game changing actions rather than addressing every issue. Actions were broadly split into 3 strategies: enabling, preventing and repurposing. There are four enabling actions, three prevention actions and two repurposing actions. The actions are as follows:




Each strategic action is presented with how to achieve the action to address the proposed objective of each action. Anticipated short, medium, and long-term outcomes are also specified. Indicators of achievement for each action are also identified. Further, a roadmap for the Hort SAP as a blueprint for identifying, implementing and reviewing the actions is presented.

The Hort SAP establishes a vision for moving forward while recognising the complexity and challenges in the production and distribution stages of the horticultural supply chain. The Hort SAP also sets out a whole-of-sector perspective, identifying opportunities and suggesting targeted interventions towards reducing food waste and bringing about multiple benefits.

# 1. INTRODUCTION

Food waste and loss are a critical issue in many countries all over the world. Reducing food loss and waste and its associated economic, social, and environmental effects brings substantial benefits to people, communities, businesses and society. This section explains context and rationale of the study (i.e., preparing horticulture sector action plan for food waste reduction in Australia). Hereafter, the study refer to "Hort SAP" in an abbreviated term.

Sector action plans (SAPs) provide a systems-based approach to reducing food loss and waste and constitute a useful management tool for supply chain partners and collaborators in the targeted sector. SAPs involve working with different stakeholders, such as producers, policy makers, researchers, community members, or packaging, processing, distribution, and retail companies, to collect evidence and understand causes of and opportunities to reduce food loss and waste. Each SAP is co-designed with key stakeholders—those who are most able to directly control or influence root causes of food waste hotspots and to take actions to reduce or eliminate food waste in the value chain. Initiatives in each SAP are fit-for-purpose, balancing targeted interventions between five different pillars (see Figure 1) and reflecting current knowledge with options for refocusing over time. SAPs are well placed to embody food systems thinking and a circular economy approach in the food sector.

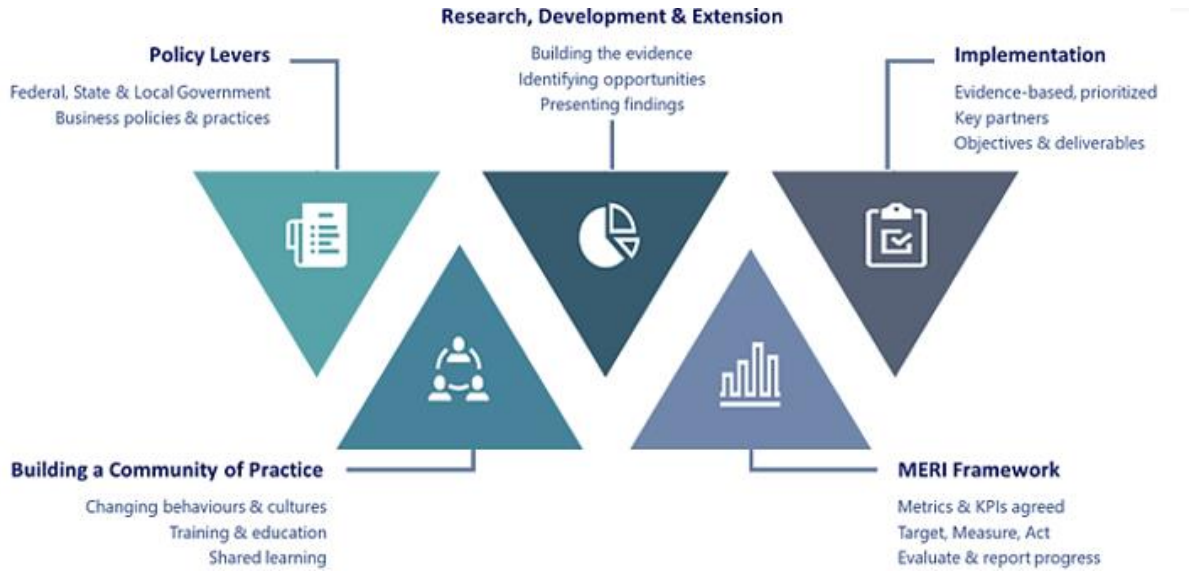



**Figure 1:** The five pillars supporting the delivery of sector action plan

(Source: Supplied by EFWA, 2023)

In the Australian context, the recent *National Food Waste Strategy Feasibility Study* (FIAL, 2021) documents a food waste baseline and identifies hotspots along the supply chain for 18 commodities. Many of these commodities belong to the horticulture sector. Although the horticulture sector is the third highest (17%) in value among agricultural industries (DAFF, 2023), it is accountable for about 50% of the total food waste in Australia (FIAL,2021). At a national level, annually Australia loses about 24% of fruits and vegetables at the production stage, 11% at processing/packing stages, and 11% after processing or packaging until retail (FIAL., 2021). In addition, for some commodities (e.g., banana, melon), waste or loss is much higher than that of these average figures. In addition, one-third of the

production was forcedly discarded from the marketing system. For example, post-harvest loss in the melon industry is high, sometimes going up to 48% (Ambiel et al., 2019). In addition, Australian horticulture supply chain management systems have not been able to significantly prevent food waste and losses (Messner et al., 2022), which are at a very high level compared with supply chains of other agricultural products (McKenzie et al. 2017). Though recent research has highlighted the above issues of horticultural waste and loss (Australian Government, 2017; FIAL, 2019: FIAL, 2021; SFWA, 2023), these studies, however, did not provide clear recommendations to address food loss and waste in the sector. This *Horticulture Sector Action Plan for Food Waste Reduction* (*Hort SAP*) addresses this gap.

This study is a part of the "Horticulture Sector Action Plan Project" and the project also includes Banana and Melon Industry Sector Action Plans for Food Waste Reduction.

# 2. AIM AND EXPECTED OUTCOMES

## 2.1 Aim and Scope

**Aim**

This study aims to develop a sector action plan to reduce food waste across the horticulture sector of Australia. Within its scope, the study focuses on the following issues:

- Hotspots of waste in the horticulture sector from primary production to retailing stage (before consumption). The project does not deal with consumption /household waste.
- For the purposes of this study, the focus is on fruits and vegetables, which are highly perishable.
- Utilisation of currently available data and information on food waste.
- Root causes of waste.
- Reducing horticultural waste by using a food recovery hierarchy.
- Prioritising solutions (i.e., proposing an action plan).
- Proposing a monitoring and evaluation framework to be taken under the action plan.

**Scope**

This study reviewed the volume and value of waste based on the available data and literature. The study did not include:

- Food waste at the consumption or household stage.
- Waste of exported food (food that was produced in Australia but wasted outside Australia).
- Horticultural waste that was never intended for human consumption.
- Quantification of volume and value of food waste through primary data collection or experiments.

## 2.2 Expected Outcomes and Potential Impacts

**Expected outcomes**

Expected outcomes of the study include the following:

- Growers, packaging, processing and distribution companies, wholesalers and retailers across the horticulture supply chain are better informed and empowered to undertake effective food waste reduction measures (i.e., actions).
- Increased awareness about where and why food waste occurs in the horticulture sector.
- Informed interventions across the supply chain through greater understanding of the reasons underlying horticultural waste.
- Cross-industry valorisation and transformation of opportunities, such as utilising waste from one industry (e.g., low-grade bananas) as a raw material for another industry (e.g., banana powder for bakery and bread industries).
- Management of horticultural wastes in line with the food recovery hierarchy.

**Potential impacts**

The main output of this study is the *Hort SAP*, which provides an overall national framework to assist actors across the horticulture supply chain to prevent or reduce waste of fresh produce. Impacts of this project are realised through implementation of the *Hort SAP*. Potential long-term impacts of the present study can be described as follows:

1. Food waste reduced: The National Food Waste Baseline suggests that around 2.27 M tonnes of food never leaves the farm, that accounts for 31% of total food loss (FIAL, 2021; ARCADIS, 2019). About half (i.e., 44%) of this on-farm loss is from fruit and vegetables and rest (56%) of the waste belong to broadacre crops (FIAL, 2021; ARCADIS, 2019). The interventions and actions suggested in this study are aimed at delivering a 50% reduction in horticulture waste by 2030 as this goal was set by Australian Government (Australian Government 2017; FIAL, 2021). This is an aspirational goal for the horticultural sector given the national policy targets and the overall quantum of food waste in the horticultural sector.
2. Industry profitability: A reduction in disposal costs and/or increase in proportion of crop to market will contribute to higher profitability.
3. Food redistribution: More fruit and vegetables will be rescued through redistribution.
4. Greenhouse gas emission savings: There will be reduced greenhouse gas emissions due to reduced use of inputs, such as energy, fertiliser and pesticides, and reduced organics disposed in landfill.
5. Creating a circular economy: Opportunities for converting by-products and secondary streams into new products will be identified and validated, enabling circular economy jobs relating to sorting, processing, stabilisation and transportation and preparation for market.
6. Training industry people: Industry people aware of food waste issues and sharing knowledge on how to address these through their community of practice.

# 3. BACKGROUND OF THE STUDY

## 3.1. The Australian Horticulture Sector

The horticulture industry includes production of a diverse spectrum of fruit, vegetable, ornamental plants (including floriculture), landscaping and turf, olericulture, arboriculture, aromatic and medicinal species, and other novel crops (Lobo & Dorta 2019; Welsh Assembly Government, 2010). The recognition and classification of horticultural crops are often a challenging and time-consuming task due to the great variety of horticultural types, the large amount of intraclass variation, as well as the creation and disappearance of many types each year (Yang & Xu, 2021).

There are different ways to classify horticultural crops based on different features and criteria. For example, they can be categorised according to their commodity type (fruits, vegetables, or ornamentals), taxonomy (order, family, genera), geographical origin (temperate, subtropical, tropical), season of production (summer or winter), reproductive cycle (annual, biannual, perennial), edible part of the plant (root, stem, leaf, fruit), or relative perishability (high/moderate/low perishability), etc. (Midmore, 2015; Yahia, 2019).

This study's focuses on horticultural produce that are highly perishable can be useful, for instance, to the development of effective waste management approaches that are responsive to the product's shelf-life, given that perishability is considered to be critical in making horticultural products vulnerable to waste and loss (McKenzie et al., 2017). Table 1 provides an example of classifying some fresh temperate and tropical horticultural products according to their level of perishability.

**Table 1:** Classification of some horticultural produce according to level of perishability

| Level of perishability | Shelf life (weeks) | Products |
|---|---|---|
| **Very high** | < 2 | Apricot, blackberry, blueberry, cherry, fig, raspberry, asparagus, bean sprouts, broccoli, cauliflower, cantaloupe, green onion, leaf lettuce, mushroom, pea, spinach, sweet corn, tomato (ripe), cut flowers and foliage, fresh-cut fruits and vegetables |
| **High** | 2–4 | Avocado, banana, grape (without $SO_2$ treatment), guava, loquat, mandarin, mango, melon (honeydew, crenshaw), nectarine, papaya, peach, pepino, plum, artichoke, green beans, Brussels sprouts, cabbage, celery, eggplant, head lettuce, okra, pepper, summer squash, tomato (partially ripe) |
| **Moderate** | 4–8 | Apple and pear (some cultivars), grapes ($SO_2$ treated), orange, grapefruit, lime, kiwifruit, persimmon, pomegranate, table beet, carrot, radish, potato (immature) |
| **Low** | 8–16 | Apple and pear (some cultivars), lemon, potato (mature), dry onion, garlic, pumpkin, winter squash, sweet potato, taro, yam, bulbs and other ornamental plants |
| **Very low** | > 16 | Tree nuts and dried fruits/vegetable |

Source: Yahia, 2019

Figure 2 illustrates the land use for horticulture (red colour) in comparison with other agricultural products in Australia. This figure shows horticulture crops are often concentrated in relatively small regions which are best suited to profitable production. This factor may be important in developing and focussing food waste plans.

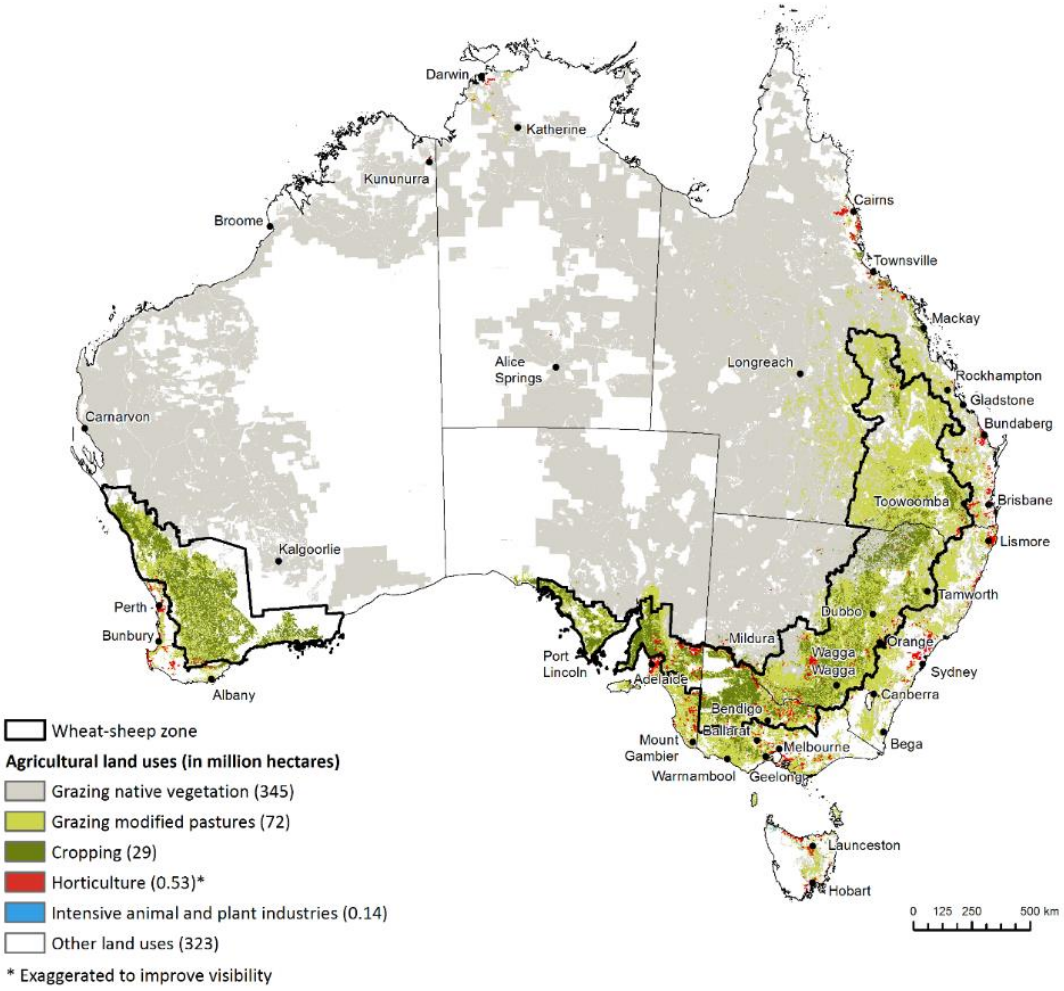



**Figure 2:** Land use for horticulture (in red colour) in comparison with other agricultural products in Australia

Source: DAFF, 2023

In the years 2021/22, although the sector's production volume had decreased by 1.4% due to challenges related to growing, market and seasonal conditions, its value still increased by 4.3%, from $15.2 billion to $15.9 billion (Hort Innovation, 2023). This was because of price increases in most horticulture produce, both in domestic and international markets.

## 3.2. Horticultural Supply Chains in Australia

A typical horticultural supply consists of six stages of product movement from paddock to plate (Figure 4): primary production, post-harvest grading and storage, secondary processing, transportation to wholesale and distribution centres, and transporting to retailers and then consumers (Figure 3). As mentioned earlier, this study only deals with the food waste issues until point of purchase during retail stage.

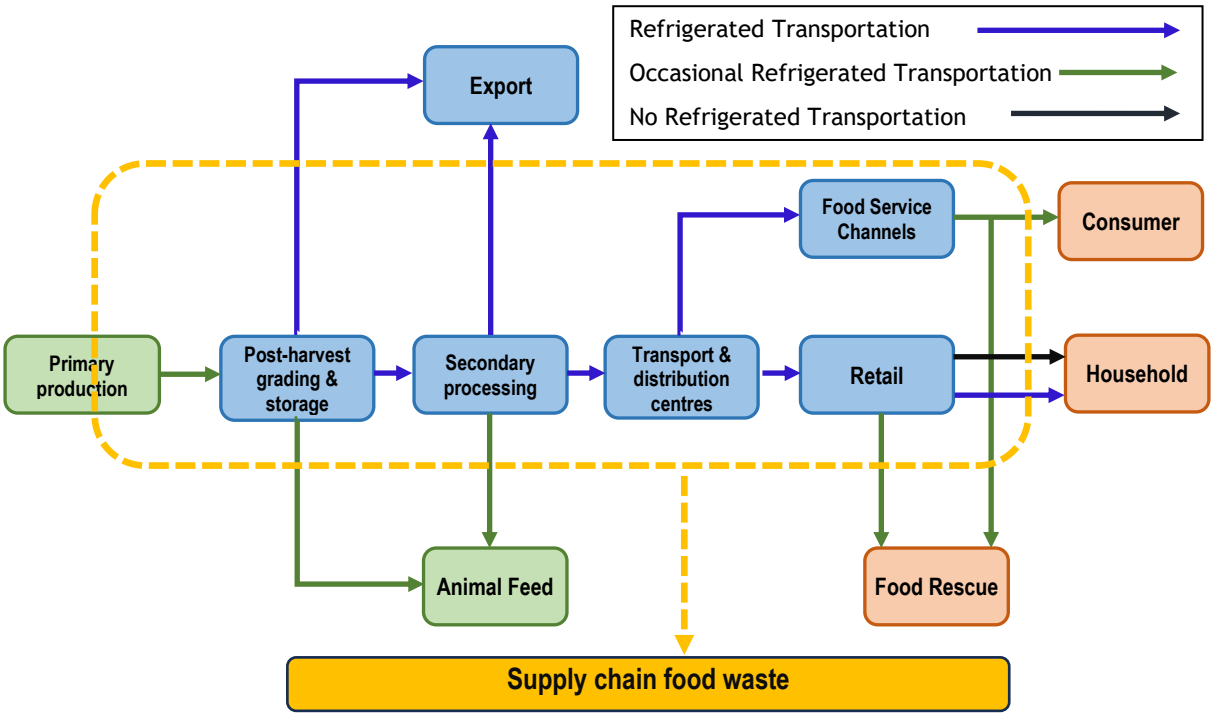



**Figure 3:** Australia's fruit and vegetable supply chain and food waste boundary

Source: Adapted from Brodribb et al., 2020

Among the supply chains of various horticultural commodities, the fruit and vegetable segment are one of the primary food chains in Australia, with a highly diverse mix of produce types and supply chain activities (ARCADIS, 2019). In many instances, the supermarkets have tended to directly buy products from growers and use their market power to determine their own quality requirements, and, thus, have a powerful influence on different conditions and structure of the fruit and vegetable supply chains (Teese, 2020). This influence can potentially create food waste at the beginning of the chain.

## 3.3. Defining Food Waste and Food Loss

The terms *food waste* and *food loss* are not always clearly defined and are often used as interchangeable terms to refer to edible plants and animals, produced for human consumption, but not consumed by people (Beausang et al., 2017; Lipinski et al., 2013). However, researchers suggest there are sometimes subtle differences between food waste and food loss depending upon the context within which they are applied.

**Food loss:** Food loss occurs more often at the production, handling, storage, and processing stages. Here food loss is an unintended result of the way the production and supply chain functions perform (Beausang et al., 2017; Gooch & Felfel, 2020; Yahia et al., 2019). Food loss is, thus, caused by the inefficiency of the functioning of the food production and distribution system and/or its institutional/legal framework across the supply chain (Lipinski et al. 2017).

**Food waste:** Food waste (which can be associated with wasteful behaviour), on the other hand, is generally concentrated at the downstream end of the supply chain, such as distribution, retail, and final consumption stages where food is discarded or thrown away (Beausang et al., 2017; Gooch & Felfel, 2020; Yahia et al., 2019). Food waste, thus, refers to the disposal of food in the supply chain by choice (Lipinski et al. 2017).

For Fusions (2016), food that was intended to be consumed by people but is instead used for animal feed may not be considered as food waste. Gooch and Felfel (2020), in addition, distinguish and illustrate food loss and food waste in relation to supply chain stages as shown in Figure 4. It should be noted here that this distinction is not necessarily applied to all kinds of food supply chains. Ways of processing the food, for instance, can make a difference because the use of conscious or non-automated procedures can minimise food loss. For instance, processing or freezing vegetables can transform this perishable product to a kind of "*shelf stable*" product (FIAL, 2021).

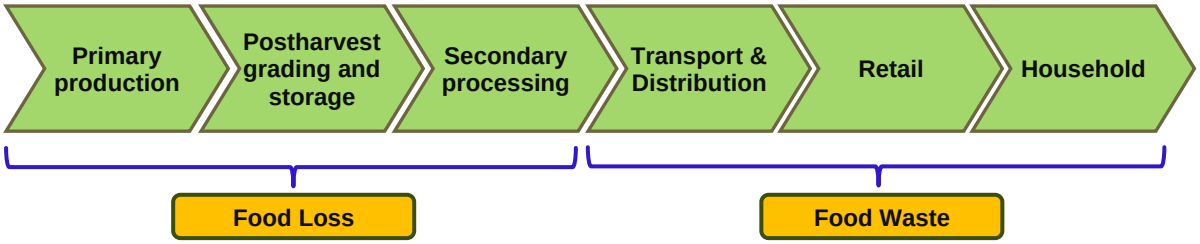



**Figure 4:** Differentiation of food loss and food waste in relation to supply chain stages

Source: Adapted from Gooch & Felfel, 2020

The Australian Government (2017), in the National Food Waste Strategy, however, uses only food waste as a broad term that covers solid or liquid food that is intended for human consumption, but does not reach or is thrown away/disposed of by consumers and others. It adopts a broad and inclusive definition of food waste that covers: (1) solid or liquid food that is intended for human consumption, but (2) does not reach the consumer, or reaches the consumer but is thrown away, including edible and inedible food, which (3) is imported into, and disposed of, in Australia, and (4) produced or manufactured for export but does not leave Australia, but (5) excluding Australia-produced food that is exported and becomes waste in another country (Australian Government, 2017, p. 8). In line with the Australian Government's suggestion, in this study, we apply food waste as a broad term to refer to both food waste and food loss.

## 3.4 Horticulture Food Waste

As mentioned, horticultural products represent a higher level of food loss and waste than most other commodities (McKenzie et al. 2017). Although this varies among commodities, varieties, seasons, geographical areas and logistics systems, Australia's horticulture supply chains in particular often enable food waste (Messner et al., 2022). Figure 5 illustrates an example of annual fruit and vegetable production and loss in Australia. Like other types of food, horticultural loss and waste can occur at different points of the supply chain, from primary production to final consumption.

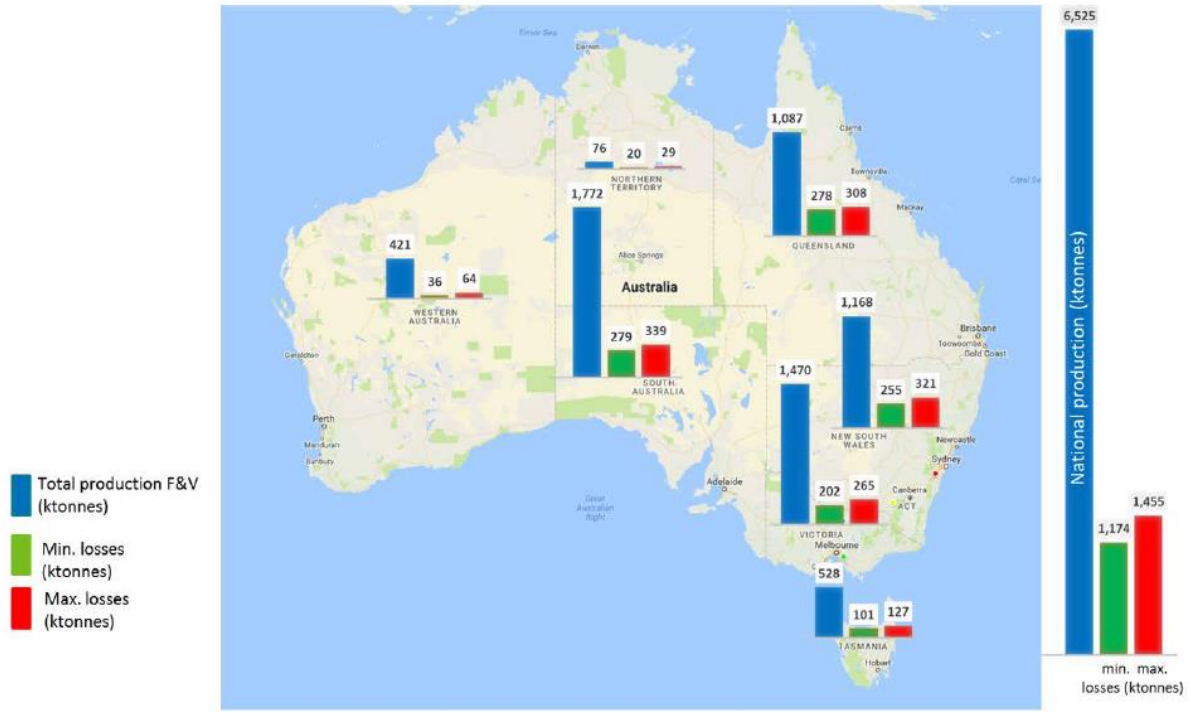



**Figure 5:** Map of production and estimated range of fruit and vegetable (F&V) annual losses in Australia by state

Note: Losses include the total estimates for primary production, packing and processing (Source: Ambiel et al., 2019, p. 22).

The rate of postharvest horticultural waste, for instance, can range from 5%–25% in developed countries (Yahia et al., 2019). It is observed that horticultural waste in developed countries, such as Australia, is partly due to the need to meet high food-quality standards (Yahia et al., 2019).

Inefficiencies in operation at different stages of the horticultural supply chain can lead to food waste and loss. There are multiple factors that may affect a horticultural product's freshness and risk of being wasted across the six stages of the supply chain (see Figure 3). Due to their special characteristics, for example, high perishability or short shelf life, the quality of fresh horticultural produce often changes during and after harvesting. During harvest seasons, the supply chain is labour intensive. Australia's horticultural industry often relies on seasonal foreign workers, with ready access to labour, which is an issue for many horticultural farmers during critical harvest periods (Xia & Nelson, 2018).. Among the post-harvest factors, transport logistics is a critical component of horticultural supply chains because fast and reliable delivery is essential for maintaining the quality of products. Although Australia's transport infrastructure is generally well developed, there have been issues in terms of reliability and cost. This affects the country's national and international market competitiveness in transporting perishable and seasonal horticultural commodities (Xia & Nelson, 2018). As fruits and vegetables are highly perishable, cold chains play a vital role in maintaining quality and reducing waste and losses of the products. Brodribb et al. (2020), in a study on waste in the Australian cold food chain, suggests that the cold chain provides better and precise temperature control during storing, transporting and processing fruits and vegetables, which is essential to maximise their post-harvest life and minimise food waste.

## 3.4. Defining Apparent and Root Cause

*Apparent causes* here refer to any visible symptom as a primary reason of food waste. *Root causes* are the fundamental or structural reasons behind food waste (Møller et al., 2014; Moragues-Faus et al., 2017), and are often location-specific (Van Berkumet al., 2018). The Canadian Commission for Environmental Cooperation (CEC, 2021), however, distinguishes between *apparent causes* (reasons) and root causes (i.e., drivers), suggesting that there are two layers to identifying the root causes of food waste: (1) an immediate/proximate reason why food is wasted or lost, namely "cause" and (2) the underlying factor that plays a role in creating that reason, namely "driver or root causes". For example, if one of the causes of banana food waste is "cosmetic or physical damage", the root causes can be "poor harvesting technique/inadequate equipment' and a range of other contributing factors.

Usually, there are three main reasons (apparent causes) of food waste (Herzberg, Trebbin and Scheider, 2023; CEC, 2021; Feedback & the Rockfeller Foundation, 2017; FAO, 2011):

1. The fruit is cosmetically or physically nonstandard or damaged—i.e., the fruit does not make the criteria for sale or customer expectation; or (b) crop damage—i.e., the crop, fruit and/or plant are rendered unusable, usually in field.
2. Fruit is unviable and does not warrant progressing further in the supply chain, often the result of an oversupply.
3. Fruit is rendered unsaleable at retail due to damage or expiration of shelf life.

Thus, root causes of food waste, which we focus on in the present study, can be understood as fundamental factors contributing to waste.

# 4. METHODOLOGY

The study employs the Review-Plan-Do SAP methodology (FIAL, 2019) to develop the overall *Hort SAP* (Table 1). This method has been endorsed by the Australian National Food Waste Strategy Steering Committee (FIAL, 2019). It first focuses on identifying waste hotspots and investigating root causes of the waste. Using the food recovery hierarchy, it then identifies and prioritises a range of practical solutions through co-designed workshops (Figure 6) to facilitate industry adoption.

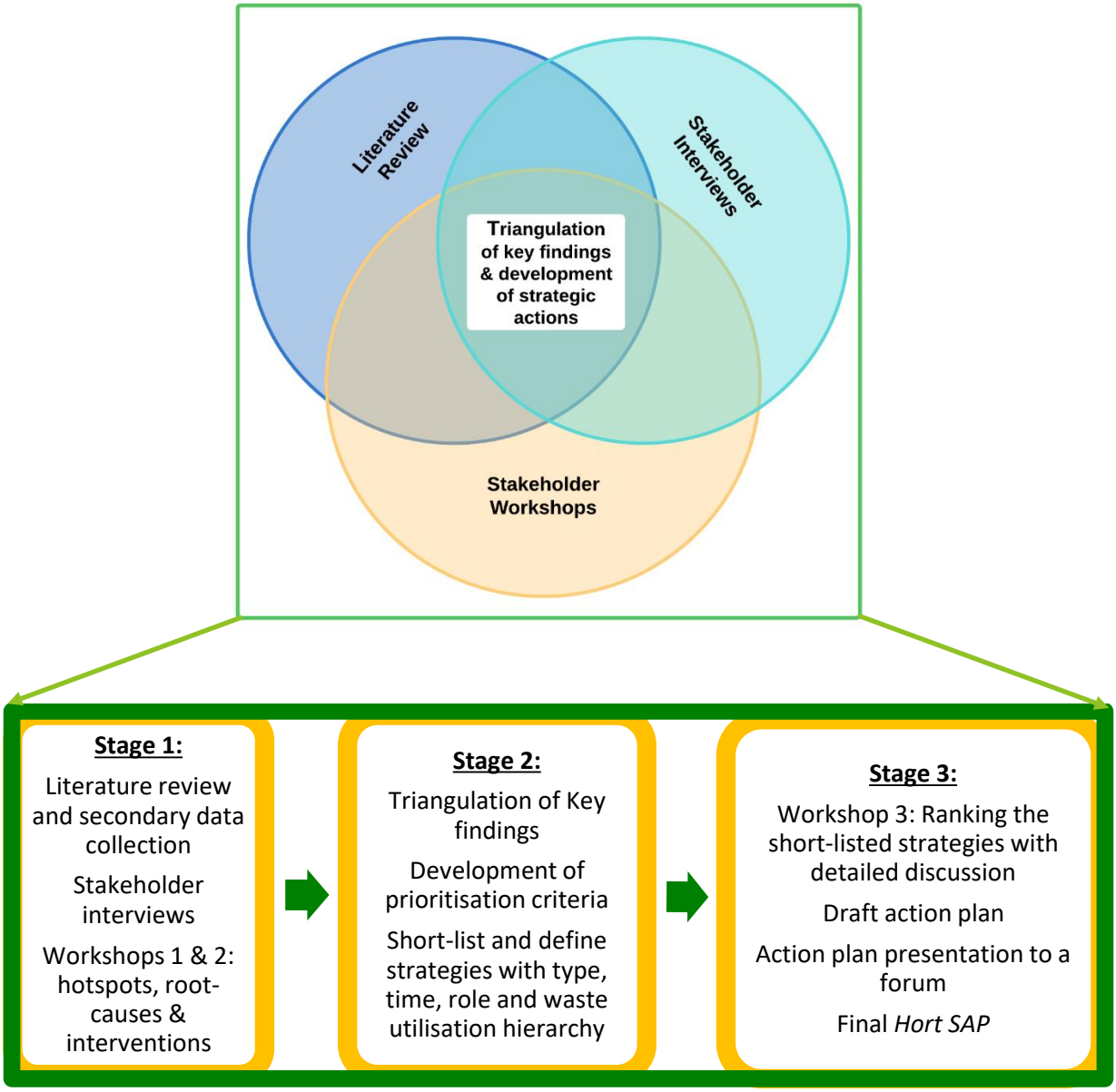



**Figure 6: Research framework and study design for *Hort SAP***

This study used a sequential mixed methodology to conduct the research and to triangulate the key findings. Actions were then prepared based on the key findings.

The study team carried out the following procedure:

1. Conduct the literature review and summarise key findings (Appendix A1)
2. Carry out stakeholder interviews to discuss key findings from the literature review individually with each member of the Hort SAP Advisory Committee and summarise key findings (Appendix A2).
3. Discuss then key findings from the interviews in Workshops 1 and 2 and identify key hotspots, root causes and solutions (Appendix A3).
4. Refine and shortlist the solutions in Workshop 3 (also see Appendix A3).

In step 4 of the procedure, the following four steps for shortlisting the proposed solutions for horticulture sector food waste reduction were applied:

1. A sequential process from literature review to Workshop 3 (see Figure 6) was used, involving the triangulation of findings about root causes, existing interventions, and proposed solutions. A qualitative approach, employing 3 x 5 Whys analysis, was used to identify and validate the root causes.
2. Common areas of strategic actions consistent with the framework for the *National Food Waste Strategy* (2017) adopted by the Australian Government were identified.
3. The feasibility of the interventions was interrogated based on four mutually agreed (between the research team and the Hort SAP Advisory Committee) criteria, including volumes of waste, economics (financial feasibility), technological complexity (technical feasibility) and then best and highest use (based on food waste prevention hierarchy (Figure 7)). A food waste prevention and management hierarchy (Figure 7) and a ReFed continuum of prevention, repurpose (i.e., rescue and recycle or value add) were applied to prioritise all actions proposed in this report. It should be noted that only actions within the green sections, prevention and repurposed, count towards Australia's goal of halving food waste by 2030 (Australian Government, 2017). These actions retain the highest value of the food produced and have the greatest impact in reducing the environmental, social, and financial cost of food waste.
4. These criteria were then used to prioritise short-listed solutions into actions, alongside expert judgement, and industry consultation.

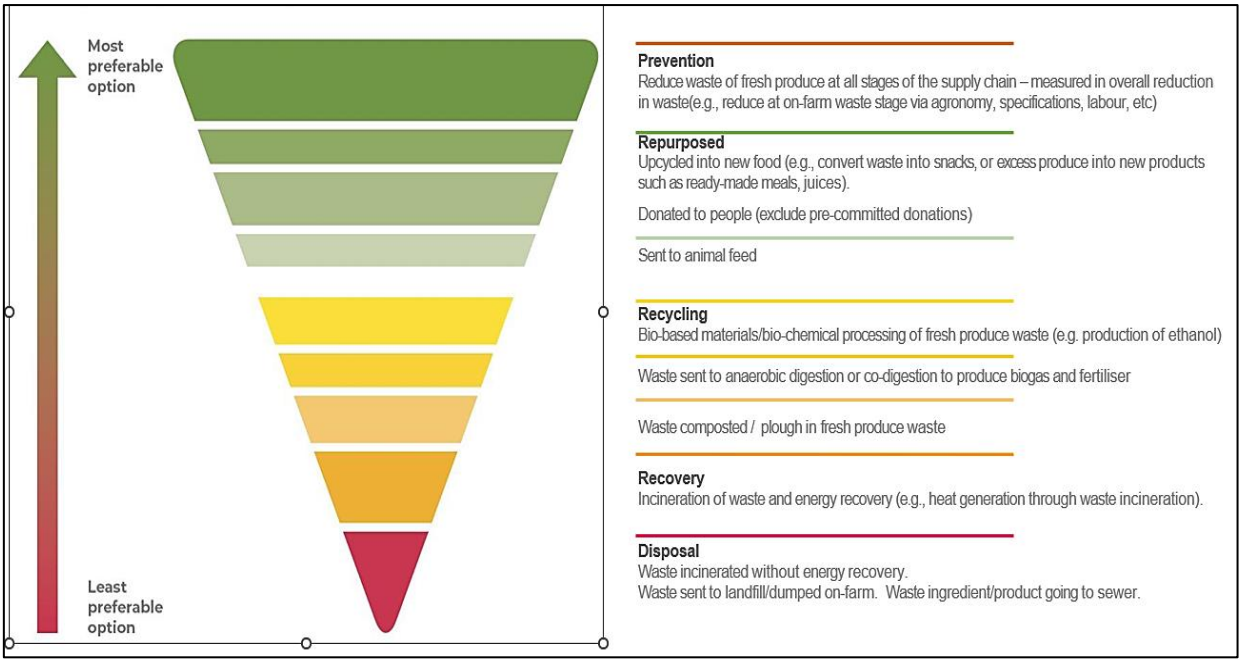



**Figure 7:** Horticulture specific food recovery hierarchy

(Source: SFWA, 2023)

Therefore, the final key actions were undertaken from the triangulated key findings based on the above four-step process but not from any individual findings (such as a unique root cause identified in the literature). A detailed description of the methods and activities for *Hort SAP* are presented in Table 2.

## 4.2. Review-Plan-Do SAP Methodology

Table 2 sets out the details of Review-Plan-Do SAP methodology to develop the overall *Hort SAP*. It outlines key actions, activities and milestones and sets out the framework of how this project was undertaken.

**Table 2:** The *Horticulture Food Waste Sector Action Plan* (*Hort SAP*) methodology

| Sector Action Plan Review-Plan-Do | SAP Component Description | Key activities | Milestones |
|---|---|---|---|
| **Engage champions** | • Identify likely champions and willing participants within the sector to lead the analysis and co-design in their sector, and involve relevant industry bodies, key businesses, and voluntary agreement signatories.<br>• Establish a project advisory group (PAG) (to query identification of sources of data). | **Phase 1:** Form a PAG, and conduct project and engagement scoping:<br>**Project partners**:<br>• SFWA<br>• QLD DES<br>**Horticulture Industry stakeholders**:<br>• Peak Industry Bodies<br>• RDC's<br>• Corporate and Private Growers<br>**Other stakeholders**:<br>• Grading, and packaging shed owners<br>• Transport and logistics: Cold chain<br>• Wholesalers/distributors<br>• Retailers<br>• Develop a stakeholder engagement plan.<br>• Agree on the project scope. | Milestone 1:<br>• Formation of an advisory group and finalization of project scoping.<br>• Stakeholder engagement plan.<br>• Application of ethics for three workshops and stakeholder consultations.<br>• Data management plan. |
| **Understand current systems** | • Agree on waste parameters to track food waste (e.g., volume and value)<br>• Build on the information available for the sector to understand the | **Phase 2a: Conduct a literature review to:**<br>• Define horticulture supply chains.<br>• Determine waste hotspots and how to measure waste across the horticulture supply system. | **Phase 2a Milestones**<br>• A draft report on methodology and literature review. |

| Sector Action Plan Review-Plan-Do | SAP Component Description | Key activities | Milestones |
|---|---|---|---|
| | amount, location and value of current waste generation.<br>• Document existing production and supply chain system(s) to understand where food waste occurs.<br>• Ensure requisite data and information are reviewed and captured.<br>• Undertake a system's (whole supply chain) review (desk-top) to highlight opportunities for improvement.<br>• Review (desk-top) of existing interventions and their effectiveness.<br>• Recognise human dimensions in allowing a culture of waste. | • Document root causes of waste and good practices in reducing waste in Australia and internationally.<br>**Phase 2b:** A mix of desk-top review and interviews with key stakeholders and workshop 1 (Hotspot identification).<br>• Draft a high-level account of horticulture waste along the supply chain.<br>• Undertake limited data gathering across the supply chain via detailed conversations with stakeholders, externally to Workshop 1.<br>• Workshop 1: Hotspot identification—identify likely waste hotspots through stakeholder consultation.<br>• Validate understanding between literature review-based findings and stakeholder's opinions about waste generation and hotspots. | **Phase 2b Milestones**<br>• A draft report on the account of current horticultural-waste-identified hotspots.<br>• A high-level review of selected interventions and their effectiveness. |
| **Develop a fit-for-purpose SAP for the horticulture sector** | Work together through co-design to develop a fit-for-purpose framework for root cause analysis across the horticulture supply chain. | **Phase 3a:** Workshop 2: Root Cause Analysis<br>• Share observations.<br>• Review findings.<br>• Identify root causes. | **Phase 3a Milestone**<br>• Documentation of initial. Workshop 1: interim findings on hotspots and initial causes. |
| **Co-design future Initiatives** | • Selection of initiatives or interventions that can continue and | **Phase 3b** Workshop 3: Final solutions workshop<br>• Expand the idea generation session.<br>• Prioritisation of solutions. | **Phase 3b Milestone**<br>Documentation of solutions<br>Workshop 2—interim findings on |

| Sector Action Plan Review-Plan-Do | SAP Component Description | Key activities | Milestones |
|---|---|---|---|
| | expand to reduce food waste.<br>Compile a draft action plan. | | root causes, current and potential initiatives solutions. |
| **Implement** | • Propose actions with a roadmap to implement the actions<br>• Share learnings and knowledge.<br>• Propose monitoring and evaluation framework with indicators of outcomes and impacts. | **Phase 4: Draft *Hort SAP***<br>• Co-create an action plan involving timing for actions, responsibility and measurement.<br>• Prioritise solutions identified.<br>• Identify KPIs to monitor impacts.<br><br>**Phase 5: Final *Hort SAP***<br>• Send a draft report (which includes actions and roadmap to implement the actions) to the PAG for feedback.<br>• Present the final report to stakeholders. | **Phase 4 Milestones**<br>Documentation of Workshop 3—draft SAP with actions and priorities, and proposed monitoring evaluation framework.<br>**Phase 5a Milestone**<br>Final Report with recommendations and future research/trials, present the report in the annual PAG meeting to share learnings.<br>**Phase 5b**: Progress and financial report. |

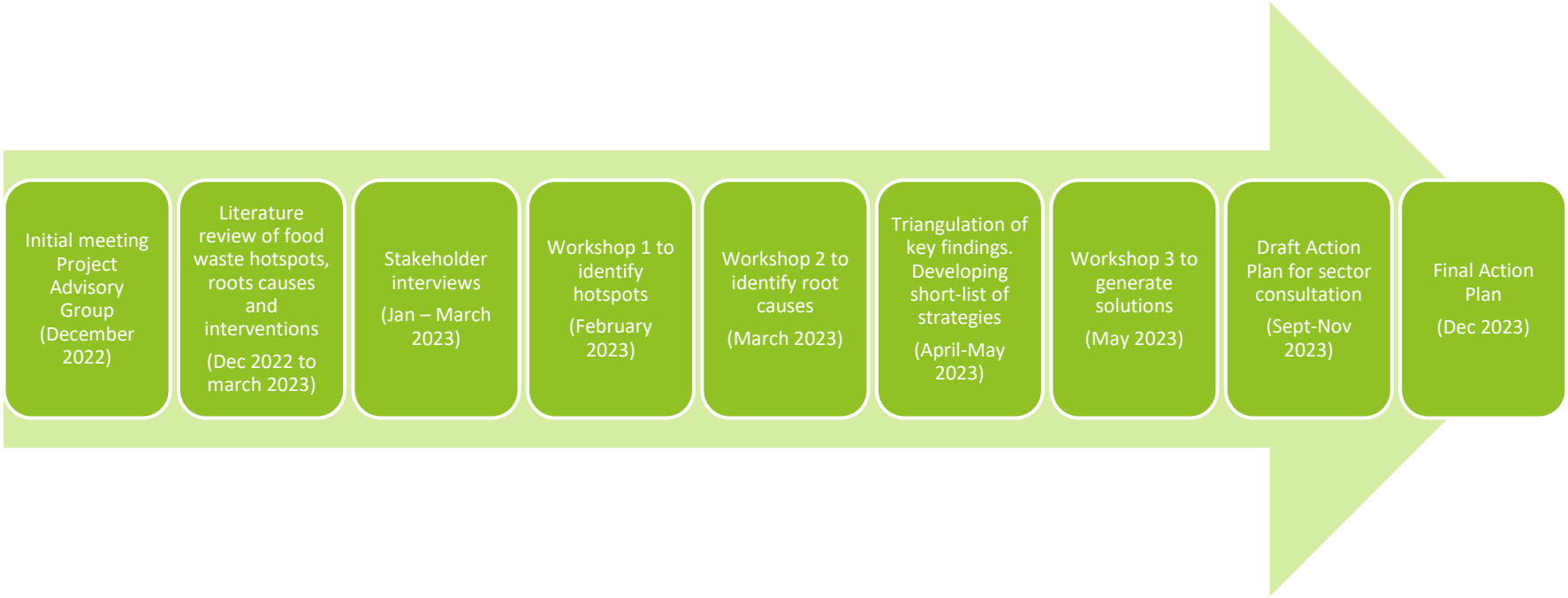



**Figure 8:** Development stages of *the Hort SAP*

The methodology shown in Table 2 has been used to guide all the tasks (see Figure 6 and column 3 in Table 2) required for developing the action plan (Section 6 of the report). This study utilised nine development stages of the *Hort SAP*, as shown in Figure 8.

Over 30 stakeholders and researchers attended the initial project inception and scoping meeting. Subsequently, the study team prepared a stakeholder engagement plan, outlined the research design and scope, and formed a project advisory group (PAG) consisting of members from industry, governments, producer, retailers and distributors.

The study team completed a literature review on horticulture food waste, hotspots, root causes and interventions. Based on the key findings from the literature review, the study team prepared stakeholder interview questions. The interview questions were first piloted before interviews were conducted between January and March 2023 with 19 stakeholders from a wide range of fields, including industry, retail, government, marketing/distribution, transportation and food waste management experts (see details in Appendix 2). Based on the key findings from the stakeholders' interviews, we collectively designed three workshops with End Food Waste Australia (EFWA) experts. The same group of stakeholders attended the three consecutive workshops. The third workshop generated and prioritised the solutions. Subsequently, we consulted with the same stakeholders to further test the validity of the actions and to discuss who could implement which action(s) (see Figure 8).

This interview and workshop processes and tools utilised in this study were approved by the CQU's Human Research Ethics Committee (Application No. 0000023956). We have removed participants name from the dataset and only reported collective and analysed data to ensure the anonymity of the participants.

# 5. FINDINGS AND DISCUSSION

The key findings from the literature review, stakeholder interviews and three workshops are presented below.

## 5.1. Horticultural Food Waste Hotspots in Australia

In Australia, recent data by FIAL (2021) suggests that food waste across the horticulture sector, particularly fruit and vegetable supply and consumption chain is highest among certain food sub-sectors. It is estimated that the fruit and vegetable (root, non-root and brassicas) sub-sectors have generated 908,403 tonnes and 409,744 tonnes of food waste in the primary production and processing stages, respectively, in 2021. The waste varied among fruit, root vegetable, non-root vegetables, and brassicas vegetable, with fruit and non-root vegetable having a higher rate of waste (FIAL, 2021).

FIAL (2021) suggests seven main points of food waste for these sub-sectors across the supply chain, including: primary, processing, distribution, retail, household, hospitality and institutional. As highlighted in Table 3, the three main food waste hotspots of this chain are primary, household and hospitality (household, and hospitality, however, are beyond the scope of the present study). This finding of hotspots aligns with that of similar studies on horticultural food waste in Australia, where primary production has been identified as a major waste point in the supply chain (e.g., SFWA, 2022).

**Table 3:** Estimated food waste of fruit and vegetable in Australia in 2021 across the supply chain

| Supply chain stage | Amount of waste (tonnes) | Percentage of waste in the chain |
|---|---:|---:|
| Primary | 908,403 | 23.7 |
| Processing | 409,744 | 10.7 |
| Distribution | 208,380 | 5.4 |
| Retail | 217,433 | 5.7 |
| Household | 1,271,850 | 33.2 |
| Hospitality | 757,992 | 19.8 |
| Institutional | 57,353 | 1.5 |
| **Total** | 3,831,155 | 100 |

Source: Calculated by the authors based on FIAL (2021)

The horticulture food waste hotspots above have been discussed and verified through stakeholder interviews and in stakeholder Workshop 1 (see Box 1).

**Box 1: Stakeholder's Opinions on Horticulture Food Waste Hotspots and root causes from Workshop 1**

- Food waste hot spots may differ across varieties and products.
- In general, the number one horticulture food waste hotspot is on the farm, either in the paddock or in the grading and packing shed. However, participants also identified that significant initiatives were being undertaken to address agronomical and environmental factors, including areas of soil health, pest and disease, water efficiency and other agronomical activities.

- The triggers for food waste in the grading process depends on product specifications, transport and other related costs.
- Food waste can be impacted by produce and/or retailers' standards as well as gaps between product supply and demand.
- Wholesale markets or distribution centres can often be the next big quality control point in the supply chain, and their standards also affected food waste.
- At the transport/logistics stage, not much waste is evident. However, problems with multiple layers of boxes, a lack of strength of the boxes and box handling mechanisms can cause waste in this stage of the supply chain, and may also appear as waste only later, in consumption stages.
- Where fresh produce is supplied to the food processing centre, the specifications can be more relaxed. This helps to reduce food waste, but there is some waste because of a lack of appropriate or adequate storing facilities for fresh produce.
- At the retail stage, there is often about 5% waste due to damage, shelf-life expiration, oversupply, storage, and stock rotation issues.

## 5.2. Horticultural Food Waste Root Causes in Australia

Fresh horticultural products are living organisms whose quality and shelf life are affected by diverse factors that contribute to food waste (Yahia et al., 2019). Identifying and tracking associated root causes are of critical importance for developingactions for preventing and managing food waste. Various studies have discussed different types of root causes of horticultural waste. Drawing on a review of recent literature on horticultural waste in Australia and international contexts (e.g., ARCADIS, 2019; Australian Government, 2017; Beausang et al., 2017; Brodribb & McCann, 2020; CEC, 2021; McKenzie et al. 2017; Messner et al., 2021, 2022; Yahia et al., 2019), we found nine major types of root causes of horticultural waste, and these have been described below.

1. **Lack of food waste measuring and monitoring systems:** Measuring and monitoring systems are important dimensions in identifying the root causes of food waste: How much food is lost or wasted? Where is food lost or wasted? How much food is lost and where is food lost/wasted along the supply chain? These questions and more are central to the development of effective policies to reduce food loss and waste because if we cannot measure the amount of food waste across the supply chain, then it will difficult to manage this (da Costa et al., 2022; Parmar et al., 2023). Some fresh food companies have started using sensor-based block chain technology to track product's freshness and temperature; however, technology or systems to track, measure and record food waste is not widely used (da Costa et al., 2022). Cost of tracking and measuring food waste is an issue for many organisations/countries (Parmar et. al., 2023), so using or developing a cost-effective method and tool or system, either sector or organisation-specific, is a challenge (Amicarelli and Bux, 2020).
2. **Agronomy and environmental causes:** For horticultural products, pre-harvest and post-harvest agronomic practices greatly contribute to their visual and nutritional quality. Pre-harvest factors include variety selection, availability or effective pest and disease management, and fertilisation (Spang et al, 2019; Kantor et al, 1997). Horticultural loss can be caused by an attack of insects, bacteria, fungicides, animals, pests and diseases, especially when there are wounds or bruises in the products. Even in a better or heathier condition, fresh produce can be damaged during its natural process of development, resulting in loss of quality, nutrition, moisture or

greening/geminating of the product. Sometimes, horticultural produce can have different reactions to the chemicals applied, causing different negative effects, such as oxidation (Yahia et al., 2019; Spang et al 2019). In addition, improper environmental or extreme weather conditions can be a cause of on-farm losses, such as temperature, humidity, water, sunburn, wind or hail (Yahia et al., 2019). Crop development can also be affected by environmental impacts, for example, cold snaps occurring during the flowering period may limit pollination, and that may result in producing low fruit loads or oversized/out of specification fruits (O'Conor et al, 2023). These environmental impacts can also cause a lack of predictability in yield, quality and general aesthetic presentation of produce.

3. **Over production:** These causes are related to issues in the product supply chain operation, such as contract farming, labour force changes, information exchange, knowledge or logistics. Contract farming, for instance, is one of the main reasons why farmers produce greater quantities than needed to ensure they do not undersupply their customers, and thus, an amount of their product may not reach the market (Beausang et al., 2017). Instead of growers, market operators such as retailers and/or wholesalers determine "--how much is grown, what is grown and how it is grown" (Messner et al., 2021, P.4).- In many cases, overproduction (related to demand management) is a significant cause in food waste, resulting in a large amount of surplus staying on the farm and turning to waste (Messner et al., 2021). This significant amount of perishable surplus produce is becoming an unmanageable stock because of the perishable nature, narrow timeframe for redistribution and geographically remote location, thus the stock turns into food waste.

4. **Lack of workforce availability and skills**: Lack of labour in peak harvest seasons is also a cause of products not being picked and stored properly (ARCADIS, 2019). Food waste can be driven by a lack of knowledge and training in areas such as harvesting, handling, or storing the product, or about the market, etc. due to limited education or poor information exchange in the supply chain (Yahia et al., 2019). Some small producers do not have access to an efficient packaging, grading and logistics system, and discard a percentage of edible products on-farm as they cannot be sent to the customers in a timely manner (Yahia et al., 2019). Additionally, the lack of availability of technical skills and knowledge, such as agronomy, food science and business skills, also contributes to food waste. The cost of labour is also a factor, particularly during harvesting. Downham and Litchfield (2022) found that employee payment arrangements vary between regions, types of crops produced and regional labour market conditions, and further, that there was a move towards payment of wages rather than piece rates, resulting in higher costs in some instances. The labour costs can be 23-35% of overall production costs and are higher in horticulture than in other crops (Downham & Litchfield, 2022). Large farms have been increasingly introducing automation to address harvesting and labour shortage issues. There is often a lack of workforce planning across different horticultural commodities, resulting in shortages and skills gaps (Babacan et al., 2019). Around 57% of Australian horticulture farms had difficulty recruiting workers in 2021–22 (Downham & Litchfield, 2022).

5. **Product standards and specification**: Issues of cosmetic standard arise as a cause of food waste (Feedback & the Rockfeller Foundation, 2017). Inadequate or ineffective marketing activities (Yahia et al., 2019), which do not provide enough information about the product to consumers, for example, may lead to a certain amount of the product being unsold. Market uncertainties, such as price variation, can make the product unprofitable to harvest (ARCADIS, 2019; Australian Government, 2017). Cosmetic standards based on visual appearance (size, colour, shape, uniformity and defects) set by retailers are seen as a major cause of food waste because 'non-standard' or 'ugly' produce can be rejected and wasted (Beausang et al., 2017; Yahia et al., 2019;

Messner et al. 2021, 2022). Contract farming and the power of Australian supermarkets in imposing their own standards and specifications on horticultural products have led to food waste across the supply chain (ARCADIS, 2019). For example, Herzberg et al (2023) found from an online survey (for Lidl suppliers in Germany, Italy, and Spain) that 15% of the total production of fruits and vegetables did not comply with retailer's specification and majority of those produce are becoming food waste. This situation is almost similar to Australian context (Messner et al 2021). Consumer behaviour regarding the cosmetic appearance of produce is also a driver of food waste at the retail stage of the supply chain (ARCADIS, 2019; Sprang et al., 2019; Messner et al., 2021).

6. **Lack of redistribution of food surplus**: Redistribution of food surplus plays significant roles in food waste reduction, reducing GHG emission and improving food security with the low and middle incomes families (Sundgren, 2022). Since the inception of food re-distribution programs, such as Foodbank Australia in the early 2000's, there has been a steady increase in the amount of food that is rescued from waste and put back into the food system to be given away to those in need, often through the use of volunteer networks and non-profit organisations (Edwards, 2021). However, there are challenges to food rescue, including logistical and regulatory constraints (SWFA, 2022). Berri and Toma (2023) investigated developing social supermarkets in UK as a food waste retribution model, but wider societal acceptance is questionable because of perceived risks associated with food quality and safety. In addition, redistribution of food waste (i.e., fresh produce) is supply demand, therefore ongoing redistribution is a challenge for a traditional business model (Sundgren, 2022) and this requires alternative or socially accepted and innovative model.

7. **Lack of technological adoption and inadequate infrastructure**: Produce can be lost or wasted due to technological or mechanical reasons. Lack of, inadequate, or poor-quality facilities for watering, harvesting, storing, cooling, processing or transporting can be a determining factor in relation to horticulture waste and loss. An example of this is the case of some mechanised harvesters that cannot discriminate between immature and ripe produce (Beausang et al., 2017). Another example of inadequate facilities is that some farms do not have the capacity to properly cool all products to optimal preservation temperatures for storing (Brodribb & McCann, 2020). Also, in some instances, vehicles and road infrastructure are not good enough to transport perishable and fresh horticultural commodities. In addition, the level of product loss is often higher in peak harvest season, when production can overwhelm a farm's picking or storage capacity, or when some products wait on farm for long periods due to inadequate refrigerated transport (Brodribb & McCann, 2020). Poor handling of produce at the farm or during processing, packaging, transporting and selling can contribute to its waste and losses (Beausang et al., 2017). During transporting, for instance, improper storage management (e.g., related to temperature, humidity, respiration, ethylene, etc.) can negatively affect the product quality (Brodribb & McCann, 2020).

8. **Lack of value adding facilities and collaboration:** Value adding refers to the process of increasing the value of the input through transformation, using manufacturing processes or using differentiated production techniques (CSIRO, 2017). Many challenges exist in value-adding in the horticultural sector, including social habits, institutional practices, added expense, lack of time, lack of knowledge, infrastructure, return on investment and access to markets (McCarthy et al., 2019; Canali et al., 2017; Duarte Alonso & Northcote, 2013). Other specific production problems relate to insufficient infrastructure and difficulty in separating food waste from other waste streams (Kibler et al., 2018). Lack of a collaborative platform between business and business, between producers and producers, and between producers and businesses, is one of the barriers of flourishing value adding facilities for tackling food waste (Surucu-Balci and Tuna, 2022).

9. **Inadequate policy and regulation**: Policy and regulation are critical levers for accelerating the adoption of food waste reduction solutions at individual, business and social levels (Fesenfeld et al., 2022). Additionally, undue regulatory processes or lack of them can also lead to increased waste. Governmental regulations of prices, proper handling procedures, food safety issues, or standard packaging can also have an impact on the market and contribute to waste or loss of a certain amount of the product (Yahia et al., 2019). The food system is complex and interconnected. Food goes through the stages of production, processing, transport, consumption and disposal, with each stage having economic, environmental, health, social and political dimensions. For this reason, policy domains for food waste are complex, inter-departmental and cross jurisdictional. Food waste policies in Australia operate across many areas, such as production, food safety standards, labelling, manufacturing and distribution. Food waste policies have implications for other policy domains, such as sustainable resource management, climate change, energy, biodiversity, habitat protection, agriculture and soil protection (Shen et al., 2023; Garcia-Herrero et al., 2018). The challenge for policy is how to frame food waste given the complexity of viewpoints of diverse stakeholders, timing and process of policy development, and the question of who takes on responsibility (Mesiranta et al., 2022). Furthermore, the three tiers of government make it difficult to align initiatives and harmonise policies and regulation, secure collaboration across jurisdictions and limit fragmentation (Rimmer et al., 2019). The summary of the literature review on root causes is presented in the Table 4. All root causes are summarised under nine categories with tick signs ("√") indicating the locations of root causes across the horticulture supply chain (Table 4).

**Table 4:** Summary of root causes of horticultural waste at different stages of the supply chain based on literature review

| Category of root causes | Root causes | Supply chain stage where food loss/waste often occurs | | | | | |
|---|---|---|---|---|---|---|---|
| | | Primary production | Post-harvest grading and packaging | Processing & manufacturing | Transportation & wholesale/ distribution | Retail | Consumption |
| **Lack of waste measuring and monitoring system** | Lack of food waste measuring and monitoring (i.e., tracking) tools, techniques and systems. | √ | √ | √ | √ | √ | √ |
| | Lack of cost-effective technologies to measure and monitor food waste across the supply chain. | √ | √ | | √ | √ | √ |
| **Agronomy and environmental causes** | Attack of insects, pests or animals. | √ | √ | | | | √ |
| | Attack of diseases, microorganisms, bacteria or fungicides. | √ | √ | | √ | √ | √ |
| | Poor pest/disease management and fertilisation. | √ | | | | | |
| | Loss of product quality (due to greening, growth, germination, colour/flavour changing, fibre development, physiological disorders, etc.). | √ | √ | √ | √ | √ | √ |
| | Negative reactions to/effects by chemicals applied. | √ | √ | √ | √ | √ | |
| | Inappropriate environmental conditions (e.g., related to natural temperature, humidity, water, sunburn, air, wind, hail or weather in general). | √ | √ | √ | √ | √ | √ |
| **Over production** | Inappropriate choice of crops. | √ | | | | | |
| | Poor/rough harvest scheduling. | √ | | | | | |
| | Surplus production. | √ | | | | | |
| | Contract farming. | √ | √ | √ | √ | | |
| | Malfunction and poor maintenance of facilities. | √ | √ | √ | √ | √ | |
| | Poor inventory (e.g., not putting oldest out first). | | √ | √ | √ | √ | |
| | Large quantities/varieties of the product at retailers (too many options for consumers). | | | | | √ | |
| | Improperly handling of the supply chain price variation. | √ | √ | √ | √ | √ | |

| Category of root causes | Root causes | Supply chain stage where food loss/waste often occurs | | | | | |
|---|---|---|---|---|---|---|---|
| | | Primary production | Post-harvest grading and packaging | Processing & manufacturing | Transportation & wholesale/ distribution | Retail | Consumption |
| **Lack of workforce availability and skills** | Careless handling and packaging of produce. | √ | √ | √ | √ | √ | √ |
| | Lack of training facilities for the horticulture workforce | √ | √ | √ | | | |
| | Lack of labour in the picking season. | | √ | | | | |
| | Cost of labour for small and medium scale producers | √ | √ | | | | |
| | Logistical issues (e.g., missing a time slot, incorrect consignment paperwork or shipping the wrong product). | | | | √ | | |
| **Product standard and specification** | Ineffective marketing activities. | | | | | √ | |
| | Price variation, change of consumer preferences and other market forces. | | | | | √ | |
| | Cosmetic standards for horticultural products (both for retailers and consumers) | | √ | √ | | √ | √ |
| **Lack of redistribution of food surplus** | Lack of food waste redistribution capacity and regulatory issues | √ | √ | | | √ | |
| **Lack of technological adoption and inadequate infrastructure** | Unavailability of, poor-quality or inadequate mechanised cultivators and harvesters. | √ | | | | | |
| | Improper storage (e.g., related to temperature, humidity, respiration, ethylene, etc.). | | √ | | √ | √ | √ |
| | Unavailability of, poor-quality or inadequate equipment for cleaning, waxing, packing and cooling facilities. | | √ | √ | | | |
| | Unavailability of, poor quality or inadequate containers and transports. | | | | √ | | |
| | Limited and cost-effective logistics for small producers and shippers. | | √ | | √ | | |
| **Lack of value adding facilities and collaboration** | Unavailability of value-added facilities development in the horticulture growing regions. | √ | √ | | | | |
| | Lack of functional collaborations between growers and other supply chain actors for value added product development. | √ | √ | √ | | √ | |

| Category of root causes | Root causes | Supply chain stage where food loss/waste often occurs | | | | | |
|---|---|---|---|---|---|---|---|
| | | Primary production | Post-harvest grading and packaging | Processing & manufacturing | Transportation & wholesale/ distribution | Retail | Consumption |
| **Inadequate Policy and Regulation** | Government food safety and other regulations and legislation. | √ | √ | √ | √ | √ | |

*Note. The root causes of horticulture food waste shown in Table 4 were discussed and cross-checked in Stakeholder Workshop 2 and through stakeholder interviews. The findings are presented in Table 5.*

**Table 5:** Common root causes of horticultural loss/waste as observed by study interview and workshop participants

| Category of root causes | Stakeholder's perceptions |
|---|---|
| **Lack of food waste measuring and monitoring systems** | • Food waste has not been measured on a regular basis.<br>• Most people see food waste but do not know how it happened.<br>• No food waste monitoring system.<br>• Lack of actions and awareness of food waste prevention and management systems that can reduce food waste.<br>• Lack of food waste data base for each of the commodity. |
| **Agronomy and environmental causes** | • Inappropriate agronomic practices, such as management of diseases, pests or nutrition that affect crop yield/quality.<br>• Varieties choice/availability and growing location can reduce product quality and increase risks.<br>• Difficulty in predicting periods of high supply due to environmental causes, such as weather, moon cycles.<br>• Diseases/pests attacks.<br>• Some horticulture varieties are very soft, can ripen quickly and are easily damaged.<br>• Fresh food is not stable and has short storage/shelf life (especially if the product is cut).<br>• Time from paddock to plate is short, especially when the product ripening is not controlled, and when it is impacted by temperature changes.<br>• Unexpected weather events, such as floods, droughts, cyclones, cold/hot temperature or sunlight occur.<br>• Products have a short shelf life, and some are already old when received by retailers.<br>• Damage during production (marked products).<br>• A significant number of initiatives have been identified to address agronomical and environmental challenges. |
| **Over production** | • Poor production planning: Growers in the same region growing same crops, doing the same thing and planting the crops roughly the same time.<br>• Systematic over-production (over growing, maximising yield per acre) in order to ensure meeting customer specifications and order volumes.<br>• Producing massive amounts of the product and it being uneconomic to harvest at that time.<br>• Grower behaviour/grower management incapability (growers might not be managing the crop optimally).<br>• Most food waste occurs by planting too much in the first place.<br>• There are not enough disincentives for planting too much.<br>• There is not clear and transparent information about supply and demand.<br>• Market fluctuation occurs due to weather, fashion, marketing, retailers' specification and price policies or grower behaviours.<br>• The pandemic caused changes in shopping arrangements and a drop in demand.<br>• The product is over-ordered by stores, which leads to market oversupply.<br>• There is contract farming but no 'whole of crop' harvest strategy.<br>• Price fluctuation/variance due to a supply and demand mismatch.<br>• When the price of the product is lower it is not viable to pick.<br>• Undersupply in the market causing empty spaces in the shop shelves often attracts media attention.<br>• Growers are planting without a plan, a particular customer or a market outcome in mind for that product. However, there are a lot of variables that can come into play between when that crop goes into the ground and when it goes to market. |

| | |
|---|---|
| | • Consumer driven selling: Consumer behaviour is unpredictable due to many reasons such as changes in cost of living, COVID lockdowns and buying online. High price may lead to low consumption.<br>• Lack of market opportunities or no alternative market for out of spec products. |
| **Lack of workforce availability and skills** | • On the farm: Lack of staff availability and variability, excessive cost of labour, workforce turnover and transience, lack of staff with skills/experience and lack of staff training, which leads to the crop being left behind, damaged, or inappropriately graded or packed.<br>• Harvest inefficiency that damages produce in field due to skill levels of labour undertaking harvesting and picking up.<br>• Product damage due to cracking, damage through trims due to skill levels of labour undertaking packing, grading, sorting and stock handling.<br>• The product can be damaged by people on the farms, in the sheds, during transporting products or in supermarkets due to bad techniques or poor timing.<br>• In the supermarket: Workforce transience, age and rostering models can make staff unconfident in the displaying and handling of horticulture products.<br>• Lack of labour in terms of availability/performance and high labour cost.<br>• Lack of knowledge about the product shelf life and the value of the product in the biomass if transformed.<br>• Lack of systematic management so all staff involved in those processes understand and follow the rules. |
| **Product standard and specifications** | • Continued compliance requirements (e.g., ethical growth and harvesting, ethical sourcing, fresh care, etc) putting more pressure on growers.<br>• Specific product requirements set by retailers.<br>• Different requirements at different state borders.<br>• Minimum life on receipt (MLOR) requirements at warehouses.<br>• Food safety requirements for cut/processed products.<br>• Visual consumer expectations of produce.<br>• Other grading and quality control issues.<br>• Rejection of products based on aesthetic standards and specifications but not taste and freshness of the product.<br>• Retailers believe that consumers have high aesthetic and quality standards. So, they require these from growers (and other supply chain entities). As a result, substandard product is rejected on farm, in packing/grading or retail.<br>• Specified uniformity in produce.<br>• Product expectations in Australia are currently too high and over a long period of time. People are looking for 'perfection' and buying on appearance, not necessarily on taste or nutrition. |
| **Lack of redistribution of food surplus** | • Limited food waste redistribution network, systems and facilities, including cold storage.<br>• Lack of social acceptance to collect or buy food from the charitable food bank. |
| **Lack of technological adoption and inadequate infrastructure** | • Lack of adoption of modern technology in the storage, temperature control or transport in the cold food chain.<br>• Many entities are involved between production and marketing phases in the supply chain, but the responsibilities and relationship between the entities are not clearly defined in terms of reducing food waste.<br>• Poor shelf-life management and cold chain practices, and packaging for good looking fresh products only.<br>• Wholesalers do not have space to physically store the produce for long periods.<br>• Lack of cold chain infrastructure. |
| **Value adding facilities & collaboration** | • Lack of adoption and innovation of value-added product development.<br>• Lack of collaborative initiatives to build value-added facilities near to the producing region. |

| | |
|---|---|
| **Policy and regulation** | • Contract farming: There are farming/supply contracts and commercial arrangements between retailers, growers, and others, and they need to fully fill the particular order.<br>• Market power imbalance among retailers, growers and buyers.<br>• Lack of regulation that can prevent or minimise food waste.<br>• Lack of policy tools, such as tax incentives to utilise food waste for human consumption. |

Finally, a triangulation of the findings gathered from the literature review, interviews and workshops was applied to validate and confirm information related to root causes of horticultural waste in Australia. Key findings from the literature review (secondary data) (Table 4), interviews and workshops (Table 5) are summarised and presented in Table 6a and 6b.

**Table 6a:** Triangulation of the key findings: Root causes as identified in the literature review, interviews and workshops

| Root causes | Source 1: Literature review | Source 2: Interviews | Source 3: Workshops |
|---|---|---|---|
| **RC 1 – *Lack of food waste measuring and monitoring systems***: A Lack of knowledge, business priority and data has meant that the horticulture industry has only implemented ad hoc food waste reduction initiatives in periods when food waste is increasing significantly; however, this remains unsatisfactory and food waste levels have increased | √ | √ | √ |
| **RC 2- *Agronomy and environment causes:*** Pests and diseases, unsuccessful varieties, poor water and fertiliser regimes, weather damage, such as sunburn/frostbite/wind or rain or hail damage. | √ | √ | √ |
| **RC 3 - O*ver production***: Speculative growing to manage viability risk; lack of adequate forecasting and market understanding; weather and climatic implications, such as quick flushes; and supply and demand mismatch. | √ | √ | √ |
| **RC 4 – *Lack of workforce availability and skills***: Lack of skilled labour in the harvesting season, and lack of attractiveness and minimal employee career pathways, and limited vertical integration in the supply chain. | √ | √ | √ |
| **RC 5 – *Product standards and specifications:*** Cosmetic specifications, contract farming, price variation, change of consumer preferences, etc. | √ | √ | |
| **RC 6 – *Lack of Redistribution of food waste:*** Lack of redistribution network and facilities, and lack of social acceptance. | √ | √ | √ |
| **RC 7 – *Lack of technology adoption and inadequate infrastructure***: Lack of modern and cost effective, harvesting, grading, storing and cooling facilities, and lack of innovation and use of technologies. | √ | √ | √ |
| **RC 8- Lack of value adding opportunities and collaboration: L**ack of value adding facilities near to the producing regions, lack of vertical and horizontal collaboration to develop commercially viable value-added facilities. | √ | √ | √ |

| Root causes | Source 1: Literature review | Source 2: Interviews | Source 3: Workshops |
|---|---|---|---|
| **RC 9 - *Policy and regulation:*** Red tape, interjurisdictional inconsistency, and absence of regulation or financial incentives that can prevent food waste. | √ | √ | √ |

**Table 7b:** Triangulation of the key findings: Root causes and hotspots across the supply chain

| Root causes | Primary production | Post-harvest grading and packaging | Transport | Warehouse and distribution centre | Retail |
|---|---|---|---|---|---|
| **RC 1 – *lack of Food waste measuring and monitoring systems:*** A lack of knowledge, business priority and data has meant that the Horticulture Industry has only implemented ad hoc food waste reduction initiatives in periods when food waste is increasing significantly | ✓ | ✓ | | ✓ | ✓ |
| **RC 2- *Agronomy and environmental causes:*** Pests and diseases, unsuccessful varieties, poor water and fertiliser regimes, weather damage, such as sunburn/frostbite/wind or rain or hail damage. | ✓ | ✓ | | | |
| **RC 3 - O*ver production***: Speculative growing to manage viability risk; lack of adequate forecasting and market understanding; weather and climatic implications, such as quick flushes; and supply and demand mismatch. | ✓ | | | ✓ | ✓ |
| **RC 4 -*Lack of* workforce availability and skills**: Lack of skilled labour in the harvesting season, and lack of attractiveness and minimal employee career pathways, and limited vertical integration in the supply chain. | ✓ | ✓ | ✓ | ✓ | ✓ |
| **RC 5 – *Product standards and specifications:*** Cosmetic specifications, contract farming, price variation, change of consumer preferences, etc. | | ✓ | | | ✓ |
| **RC 6 – *Lack of Redistribution of surplus food:*** Lack of redistribution network and facilities, and lack of social acceptance. | ✓ | ✓ | | | ✓ |
| **RC 7 – *Lack of Technological adoption and inadequate infrastructure***: Lack of storing and cooling facilities, and lack of innovation and use of technologies. | ✓ | ✓ | ✓ | ✓ | ✓ |
| **RC 8- *Lack of value* adding opportunities and collaboration:** Lack of vertical and horizontal collaboration to develop commercially viable value-added facilities. | ✓ | ✓ | ✓ | | |
| **RC 9 - *Policy and regulation:*** Red tape, interjurisdictional inconsistency, and absence of regulation or financial incentives that can prevent food waste. | ✓ | | ✓ | | ✓ |

# 6. ACTION PLAN

## 6.1 Priority Actions to Reduce Food Loss/Waste in the Horticulture Sector

Developing an action plan is complex for a sector as horticulture. As outlined above, we have examined a range of root causes and developed key actions in response. The actions identified were informed by reviewing the existing research and literature, stakeholder interviews and stakeholder Workshops 1, 2 and 3 (Table 6), and we have focused on key game changing actions rather than addressing every issue. Table 7 outlines the 9 key actions, and the root causes they respond to. These actions can be broadly split into 3 strategies: enabling, preventing and repurposing. There are four enabling actions, three prevention actions and two repurposing actions along with their respective causes. It should be noted that actions can cover multiple root causes and root causes can require multiple actions.

**Table 7:** Summary of actions and root cause mapping

| **Actions** | **Root Cause No.** |
|---|---|
| **Enable it -** Make it easier to reduce food waste | |
| E1. Identify root causes of food waste and develop sector action plans for key horticultural commodities. | RC 1, RC 2 and RC 3 |
| E2. Establish mechanisms for data collection, monitoring, measuring and reporting to generate evidence about food waste in the horticulture industry. | RC 1 and RC 9 |
| E3. Institute an effective policy and regulatory environment for food waste minimisation across the horticulture sector. | RC 9 |
| E4. Accelerate and incubate innovation and technology solutions in the horticultural industry for food waste minimisation. | RC 2 and RC 7 |
| **Prevent it** - Stop food waste occurring in the first place | |
| P1. Apply mechanisms for managing overproduction and balancing the demand and supply of horticultural products. | RC 2 and RC 3 |
| P2. Address labour and skill shortages across the horticultural supply chain for different commodities cycles of production and distribution. | RC 3 and RC 4 |
| P3. Reduce the impact of product specifications on food waste. | RC 5 |
| **Repurpose it** - From food waste to resource | |
| R1. Explore ways to value add to surplus or waste produce. | RC 3 and RC 8 |
| R2. Implement effective mechanisms for food donation. | RC 6 and RC 9 |

The research team selected the actions through a five stage SAP Review-Plan-Do process (see Section 4). Eleven actions were then presented in the final solution workshops. Then through an in-depth discussion with the stakeholders, we used four criteria (volume, financial feasibility, technical feasibility, and best and highest use principle) for prioritising the actions. The actions also follow a ReFed continuum of prevention, repurpose (i.e., rescue and recycle or value add). Finally, these were consolidated into nine strategic areas of actions, with key objectives, how to achieve the objectives, the desired outcomes, and potential indicators for impacts. The actions suggested are also derived from enablers of change. These include planning, policy and regulatory levers, capacity building and

training, sharing information, research and innovation, awareness and behaviour change, collaboration and evaluation and use of technologies.

It is anticipated that the interventions will yield outcomes at different paces. For this reason, the actions are allocated a timeframe for realisation. These timeframes are defined as:

- Short term (ST): 2024-2026
- Medium term (MT): 2026-2027
- Long term (LT): 2027-2030

The roadmap (see Section 6.2) shows the progression of actions against the indicated timeframes.

## **Strategy 1: Enable it** - *Make it easier to reduce food waste.*

**ACTION E1**

**E1. *Identify root causes of food waste and develop sector action plans for key horticultural commodities.***

- This action addresses food waste root cause **RC 1, RC 2, and RC 3.**

Objective: To understand root causes of food waste in key horticultural industries and drive action towards food waste reduction.

| How will we achieve this? | Outcomes | Timeframes* | Potential Indicators |
|---|---|---|---|
| E1.1 Develop food waste action plans (FWAPs) to address root causes for key horticultural commodities to reduce food waste. | Root causes of food waster identified across a range of horticultural commodities.<br>Commodity specific food waste action plans developed for key horticultural commodities.<br>Targets and pathways for food waste reduction identified for key horticultural commodities. | MT | • Quality information about root causes of food waste developed targeted to relevant horticultural commodity.<br>• Number of commodities for which root cause analysis is conducted.<br>• FWAPs developed reflect value to food waste reduction in tonnes, dollars or GHG. |
| E1.2 Implement FWAPs through collaboration across the horticultural supply chain. | Actions identified in the FWAPs in place.<br>Commodity specific and horticultural industry collaboration efforts are intensified to reduce food waste.<br>Horticultural FWAPs implementation contribute to reduction of up to 50% of food waste | LT | • Number of actions initiated across horticultural commodities.<br>• Level of buy-in and participation in FWAP.<br>• Implementation across the supply chain.<br>• Assessment of outcomes from actions initiated towards food waste reduction in key sectors.<br>• No of collaborations across the supply chain.<br>• Qualitative assessment of the progress of FWAPs.<br>• Broader measures such as participation in the Australian Food Pact. |
| E1.3 Support ongoing dissemination of latest science on agronomic (e.g., pest, disease, soil), environmental (e.g., climate, temperature), and other knowledge (e.g., cold chain, storage and transport) relevant to specific commodities, and include food waste reduction as an impact of best practice. | Latest science is disseminated to improve production and handling. | Ongoing | • Number of dissemination activities that link best practice to FW reduction.<br>• Links with science agencies for information.<br>• Filtration and uptake levels of knowledge. |

* ST = Short Term (2024-26) | MT = Medium Term (2026-27) | LT = Long Term (2027-30)

*Potential Lead Agencies*

- Hort Innovation
- Specific commodity peak industry bodies
- End Food Waste Australia
- AgriFutures
- State governments

**ACTION E2**

***E2. Establish mechanisms for data collection, monitoring, measuring, and reporting to generate evidence about food waste in the horticulture industry.***

- This action addresses food waste root cause **RC 1 and RC 9.**

Objective: To develop and implement techniques to understand the level and volume of waste across the horticultural industry sectors and develop an evidence base for good practice and policy to reduce food waste.

| How will we achieve this | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| E2.1 Review horticultural food waste measurement and reporting, including existing processes, systems and methodologies, current research, gaps in evidence and best practices for data collection. | Sound understanding of the evidence base for food waste data collection and reporting methodologies and for the horticultural industry are in place. | ST | • Literature review conducted. Analysis of the benefits of different methodologies identified.<br>• Data collection gaps and challenges determined. |
| E2.2 Conduct trials of commodity-specific data collection and reporting techniques on food waste across the supply chain to ascertain a unified method. | Data gaps are identified and mechanisms for data generation and reporting on food waste are established. | ST | • Working party established to collaborate on data and evidence.<br>• Data collection mechanism established.<br>• Data collection systems are tested to fill in data gaps. |
| E2.3 Commission relevant research on critical topics relating to food waste reduction via measurement and reporting across the supply chain in key horticultural industries. | Strong evidence base to support food waste reduction is developed on relevant topics. | MT | • Number of research projects commissioned.<br>• Utilisation of research.<br>• Knowledge sharing. |
| E2.4 Create a framework to collect and report food waste data annually by providing incentives for business/grower participation in data collection and recording process. | Baseline data on food waste is collected by 2027 across key horticultural industries.<br><br>Systems are in place for ongoing data collection and reporting on food waste. | MT-LT | • Baseline data is collected.<br>• Data is available on type and volume of food waste.<br>• Quantification of horticultural food waste.<br>• Training and development incentives in relation to data collection is achieved.<br>• Participation of stakeholders across the supply chain in data collection. |
| E2.5 Report on food loss research and data (type and volume) in the horticultural industry annually including regional and seasonal mapping. | Improved transparency about food loss by sharing research findings and data.<br><br>Industry dissemination, training and development incentives are achieved with external parties. | LT | • Data is available publicly on an ongoing basis.<br>• Regular reporting of food waste types and volumes.<br>• Industry dissemination.<br>• Use of data in decision making across the supply chain. |

*Potential Lead Agencies*

- Hort Innovation
- Specific commodity peak industry bodies
- End Food Waste Australia
- Federal and state agencies
- CSIRO
- ABARES
- Universities

**ACTION E3**

***E3. Institute an effective policy and regulatory environment for food waste minimisation across the horticulture sector.***

- This action addresses food waste root cause **RC 9.**

Objective: To ensure an optimum regulatory and policy environment is in place to support food waste prevention and reduction.

| How will we achieve this | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| E3.1 Identify, quantify and implement the impact of current policy and regulatory requirements on food waste. | Greater understanding of the positive and negative impacts of policy/regulatory measures on food waste. A global policy scan undertaken, enhancing policy inhibitors on exports and market dynamics. | ST | • Impacts of policy on food waste identified and quantified. |
| E3.2 Revise the Freshcare *Food Safety & Quality Standard* to include options for food waste certification and training. | Industry owned self-regulation and food safety mechanisms support food waste reduction. | ST | • Food safety measures support food waste reduction.<br>• Industry standards are providing certification process for food waste. |
| E3.3 Review Food and Grocery Code and Horticulture Code of Conduct to include recognition of food waste impact and support better practice from supply chain to reduce food waste. | Industry code of conduct guidelines include food waste impact and best practice guidelines. Improved cooperation and relationships between retailers, wholesalers and producers in reducing food waste. | MT | • Codes of conduct reviewed.<br>• Industry support for the code of conduct.<br>• Awareness and adherence to the Code across the supply chain.<br>• Improved collaboration across horticultural stakeholders. |
| E3.4 Work with government and industry to scope effective policy/regulatory levers to incentivise waste reduction behaviours across the supply chain. | Policy/regulatory environment improved by 2027 to support positive food waste behaviour across the supply chain. | MT | • Policy incentives across supply chain in place.<br>• Number of policy measures changed. |
| E3.5 Advocate for the development of standards for food waste, including support for the development of ISO standards, compliance with Upcycled Certification and alignment with global certification and sustainability requirements for trade. | Development and adoption of food waste standards.<br><br>Upcycled food certification in place.<br><br>Global certification and sustainability requirements are in place to support exports. | MT-LT | • Standards for food waste developed and adopted. |
| E3.6 Review and address contract's farming terms and conditions (T&C) and cross-jurisdictional policy harmonisation impacts on food waste. | Revised T&C for contract farming<br>Food waste policy/regulation harmonised across jurisdictions in Australia. | LT | • Food waste reduction identified by revised T&C for contract farming<br>• Lack of policy harmonisation impacts on food waste identified.<br>• Cross-jurisdictional harmonisation is achieved. |

*Potential Lead Agencies*

- Relevant Australian Government agencies
- Relevant state/territory government agencies
- Peak industry bodies
- End Food Waste Australia

- FreshCare
- ACCC
- Standards Australia

**ACTION E4**

***E4. Accelerate and incubate innovation and technology solutions in the horticultural industry for food waste minimisation.***

- This action addresses food waste root cause **RC 2 and RC 7.**

Objective: To develop innovative and technological solutions to reduce food waste.

| How will we achieve this? | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| E4.1 Conduct research to explore the barriers to uptake of technologies that reduce food waste in key horticultural commodities. | Research conducted on key commodities highlighting barriers to uptake of technologies.<br><br>Greater insights guide future initiatives for technology adoption for stopping food waste. | ST | • Barriers to technology adoption that stops food waste are identified.<br>• Benefits of technology are assessed and shared across the industry.<br>• Research guides used in future initiatives on technology adoption. |
| E4.2 Undertake an audit of the digital and technological capacity of stakeholders across the supply chain in key horticultural commodities. | Identification of digital and technological skills needs across the supply chain in key horticultural commodities. | ST | • Understanding of skills needs for digital and technological innovation. |
| E4.3 Explore the benefits of new apps and demonstrate their impact on food waste and costs. | New apps developed.<br><br>Uptake of apps and their efficacy in reducing food waste is verified. | ST | • Report regarding new apps.<br>• Case studies, such as the Refresh apps.<br>• Quantitative data on use, impact and cost outcomes of new apps. |
| E4.4 Develop forecasting and decision support tools to reduce environmental damage and increase value adding opportunities. | Reduced food loss at harvest from environmental and weather events.<br><br>Bureau of Meteorology (BOM) measurement and forecasting better utilised for minimising crop damage.<br><br>Increased value adding opportunities | MT | • Forecasting tool developed.<br>• Uptake and use of tool across commodities.<br>• Evidence of the use of tool in minimising crop damage and increase value adding opportunities |
| E4.5 Accelerate and incubate emerging innovation and technologies that support food waste minimisation across the horticultural supply chain (e.g., extreme weather events detection, shelf-life extension, cold chain and perishable goods, packaging, labelling, IT systems, transportation, logistics software and value adding). | Improved innovative technology solutions are utilised to address food waste across the horticultural supply chains. | LT | • Level of investment in new technologies.<br>• Number of innovations emerging to support food waste.<br>• Overall level of reduction of food waste due to innovation/technology adoption. |

*Potential Lead Agencies*

- Hort Innovation
- Government agencies
- AgTech companies
- Research agencies
- Food Manufacturers

## **Strategy 2: Prevent it** - *Stop food waste occurring in the first place.*

**ACTION P1**

***P1. Apply mechanisms for managing overproduction and balancing the demand and supply of horticultural products.***

- This action addresses food waste root cause **RC 2 and RC 3.**

Objective: To limit overproduction of horticultural produce and achieve a better financial return on a higher proportion of the crop.

| How will we achieve this? | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| P1.1 Establish and share a dynamic platform to support commodity specific supply and demand analysis and forecasting (including provision of location and time specific information). | Tools support increased planned production and decrease speculative production.<br>Improved skills in utilising forecasting tools across the key horticultural sectors. | ST<br>MT | • Forecasting platform/tools developed.<br>• Rigour and accuracy of the demand supply analysis.<br>• Level of skills development in using tools.<br>• Rates of utilisation of tools and information to manage production levels. |
| P1.2 Run awareness programs to enhance the understanding of the operation of the market, at different levels of fruit/crop maturity, its drivers, and the implications for production, profitability and food waste in key horticultural commodities. | Improved market information and awareness across the supply chain.<br>Trend towards balanced demand and supply of horticultural products. | MT | • Information and tools available.<br>• Dissemination mechanisms and number of outreach activities.<br>• Number of stakeholders reached.<br>• Utilisation of information.<br>• Assessment of levels of awareness. |
| P1.3 Trial Whole Crop Purchasing arrangements with producers and retailers in selected commodities and share learnings from trials. | Improved planned production and overcoming supply/demand challenges. | LG | • Number of trials conducted.<br>• Participation levels by producers and retailers.<br>• Dissemination activity levels of lessons identified from trials. |
| P1.4 Develop incentives to improve communication and share information and transparency of price and market data within commercial/competition parameters. | Increased market knowledge and transparency to balance the forces of supply and demand more effectively. | MT | • Types of incentives for transparency identified and implemented.<br>• Increased communication of market data shared.<br>• Improved transparency.<br>• Improvements in demand supply fluctuations. |
| P1.5 Explore the feasibility of alternative market options for the sale of oversupply of produce, including boosting exports. | Alternative markets have been developed across key horticultural products.<br>New export markets identified and supplied. | LT | • Types of alternative market options developed.<br>• Efficacy of these options in sale of surplus production.<br>• Exports market identified and exports boosted. |

*Potential Lead Agencies*

- Hort Innovation
- Specific commodity peak industry bodies
- End Food Waste Australia
- Federal and state agencies of environment and agriculture

- Major retailers
- Wholesale market peak bodies
- Australian Competition and Consumer Commission (ACCC)

**ACTION P2**

**P2. *Address labour and skill shortages across the horticultural supply chain for different commodities' cycles of production and distribution.***

- This action addresses food waste root cause **RC 3 and RC 4**.

Objective: To ensure workforce availability and appropriate skills to minimise food waste.

| How will we achieve this | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| P2.1 Undertake research into impacts of workforce on food waste across the supply chains of key horticultural industries including cost of labour and production, skills gaps, labour market supply and demand, overseas and domestic sources of workforce, school career pathways and training and education solutions. | Deep insights into the impacts and options of labour market dynamics on food waste in key commodities and the overall horticultural industry. | ST | • Assessment of the impact of workforce and skill shortages on food waste of different commodities and across the supply chain completed.<br>• Mapping of critical workforce skills to reduce food waste in key horticultural industries. |
| P2.2 Develop tools and resources to train and educate the workforce in food waste reduction skills and decisions across the supply chain in field and packing, transport and storage, retail stock and inventory management. | The number of staff trained/educated in the food waste reduction is doubled by 2026 across the supply chain in areas such as field/packaging, transport/storage/retail stock and inventory management. | ST-MT | • Enhanced training for staff across the supply chain to improve food waste reduction. |
| P2.3 Support the development of forward-looking commodity-specific, regional, and overall industry workforce plans aligned with industry growth forecasts. | Labour market demand and supply options for key horticultural industries analysed and regional/industry workforce plans developed. | MT | • Number of workforce plans developed. |
| P2.4 Undertake trial projects for innovative workforce models in selected horticultural industries to minimise food waste through matching skill needs to opportunities in food waste businesses. | Innovative workforce models trialled in selected industries to stop food waste.<br><br>Workforce skills are identified for business opportunities in food waste businesses. | LT | • Ideation of new workforce models.<br>• Trials of innovative workforce supply measures undertaken.<br>• Sharing of learnings across horticultural industry. |
| P2.5 Undertake assessment of the potential impact of automation, AI and real time quality assessment tools on the horticultural workforce and food waste and identify adaptive strategies for the long term. | Automation and AI workforce impacts are analysed and adaptative workforce for future food waste reduction identified. | LT | • Automation and AI impact on workforce and food waste identified.<br>• Adaptive workforce strategies determined. |

*Potential Lead Agencies*

- Relevant Australian Government agencies
- Relevant state/territory government agencies (e.g., education, employment and training, agriculture, environment)
- Specific commodity peak industry bodies
- Peak jobs networks agencies
- Relevant education and training providers
- Industry skills bodies

- Research Agencies

**ACTION P3**

***P3. Reduce the impact of product specifications on food waste.***

- This action addresses food waste root cause **RC 5.**

Objective: To ensure product specifications do not lead to food waste.

| How will we achieve this | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| P3.1 Establish a multistakeholder working group to conduct a general and commodity specific product specification review including the following:<br>- Origin, rationale, and validity of specification.<br>- Regularity and methods of specification review.<br>- Conditions for widening of specifications.<br>- Process for rejection of produce.<br>- Cost/benefits in tonnes and dollars of altering specifications to growers, consumers, wholesalers, retailers and hospitality<br>- Identify product specification levers to reduce food waste across the supply chain. | Granular understanding of product specifications and potential levers for food waste reduction.<br><br>Better understanding of the link between product specification, production supply and food waste in 10 key commodities by 2024. | ST | • Multistakeholder party established.<br>• Review report finalised and shared.<br>• Key commodities specification reviews conducted.<br>• Increased awareness and understanding of product specifications and levers across the supply chain. |
| P3.2 Promote benefits of non-standard produce, including nutritional, environmental and economic sustainability to growers. | Enhanced consumer awareness and food literacy. | MT | • Measurement of levels of consumer awareness.<br>• Consumer awareness materials and promotion.<br>• Increased uptake of rejected produce by consumers. |

*Potential Lead Agencies*

- Horticultural supply chain stakeholders (growers, retailers, wholesalers and distributors)
- Consumer bodies
- End Food Waste Australia
- Food and Grocery Council

## Strategy 3: Repurpose it - *From food waste to resource.*

**ACTION R1**

***R1. Explore ways to value add to surplus or waste produce.***

- This action addresses food waste root cause **RC 3 and RC 8.**

Objective: To value add to surplus or waste horticultural produce and create new revenue streams for industry.

| How will we achieve this | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| R1.1 Instigate market feasibility studies for value-added products from surplus produce with a focus on scale of implementation, import substitution, financial viability, risk and investor analysis. | Identification of options for value adding opportunities in key commodities.<br><br>Markets for upcycled products achieved. | ST | • Existing studies reviewed.<br>• New studies completed across key commodities for value adding, examining secondary market opportunities, constraints, enablers, trade-offs and financial viability.<br>• Options for value adding, challenges and enablers in the ecosystem identified and addressed. |
| R1.2 Undertake small-scale trials in key commodities for innovative value-added products, commercialisation, profitability and share lessons. | New value-added products trialled and developed using surplus produce. | ST-MT | • Successful demonstration projects utilising surplus produce for create new value.<br>• Lessons from product development and marketing shared across industry.<br>• Awareness and knowledge improved about value adding across the horticultural supply chain. |
| R1.3 Improve capabilities of supply chain stakeholders to value add to suboptimal produce that do not meet product specifications. | Improved capability to repurpose rejected produce. | LT | • Improved capacity of supply chain stakeholders to handle suboptimal produce.<br>• New product lines or sales mechanism. |
| R1.4 Develop partnerships with food manufacturers, investor and trade agencies to explore new market(s) and opportunities for value added products. | New markets are explored including demand analysis, barriers to entry and profitability. | MT-LT | • Partnerships are in place for market development for value added products.<br>• Business case is established for each product/market. |
| R1.5 Explore the development of regional hubs for food processing and developing secondary markets through partnerships across supply chain actors, government, investors and enterprises. | Regional food waste processing hubs developed for commodity specific and cross commodity food processing facilities by 2030.<br>Increased food waste utilisation in the higher value destinations. | LT | • Regional hubs established.<br>• Partnerships in place for regional hub outcomes.<br>• Secondary markets established and expanded. |

*Potential Lead Agencies*

- Hort Innovation
- Specific commodity peak industry bodies
- End Food Waste Australia
- Federal and state agencies of environment and agriculture and industry

**ACTION R2**

***R2. Implement effective mechanisms for food donation.***

- This action addresses food waste root cause **RC 6 and RC 9.**

Objective: To expand and enhance the food donation ecosystem to facilitate effective redistribution of horticultural produce to charities.

| How will we achieve this? | Outcomes | Timeframes | Indicators |
|---|---|---|---|
| R2.1 Address the current challenges for food donation across the supply chain as identified in the SWFA Food Rescue Sector Action Plan. Including but not limited to:<br>- Creating and delivering training assets targeted at "first responders" in donor organisations.<br>- Developing and implementing an integrated stakeholder engagement strategy to grow horticulture donations.<br>- Targeting wholesalers to explore possibilities to use them for cross-docking and packhouses, as gateways into regional supply.<br>- Facilitating growers to access to available logistics (such as bins, transport and cold storage). | Challenges for food donation are identified and options and partnerships for food recovery are improved.<br>Ecosystems for food donation established across 50% horticultural produce. | ST | • Challenges identified.<br>• Actions initiated to overcome the challenges.<br>• Partnerships forged for toward food donation.<br>• Amount of surplus produce donated.<br>• Number of innovative projects linking with circular economy, value added and other waste stream management initiatives. |
| R2.2 Leverage food security initiatives to increase donation of surplus horticultural produce. | Horticulture industry contributes to national food security through donation of surplus produce. | ST | • Food security initiatives identified.<br>• Mechanisms established for food donation to food insecure communities.<br>• Amount of surplus produce donated. |
| R2.3 Develop a recognition program for producers, marketers and retailers who contribute to food rescue organisations. | Good practice is recognised and rewarded. | ST | • Recognition systems are in place.<br>• Regular awards promote and showcase good practice, achievement and impact. |
| R2.4 Increase education for donors on the regulatory framework, liability protection, labelling and safe handling of donated food. | Improved education for food donors in relation to legal and regulatory frameworks. | MT | • Number of education activities.<br>• Level of awareness of food donors.<br>• Risks of food donation minimised for the donors. |
| R2.5 Advocate for tax credits and other incentives for improved food donation activities to cover cost of harvest, packaging, and transport. | Advocacy for tax incentives to support costs of donation will be successful by 2024. | ST | • Number of advocacy activities.<br>• Nature of advocacy.<br>• Regulatory and incentives in place for improved food donation. |

*Potential Lead Agencies*

- Hort Innovation
- Specific commodity peak industry bodies
- End Food Waste Australia
- Food rescue organisations

- Department of Health (re. food security)
- Federal and State Governments

## 6.2 Roadmap for *Horticulture Food Waste Sector Action Plan*

The following roadmap (Figure 9) highlights a potential journey for the horticulture industry to undertake so as contribute to the goal of halving Australia's horticultural food waste by 2030. Ongoing communication and support from all horticultural supply chain organisations, the food rescue sector, not-for-profit organisations (e.g., End Food Waste Australia) and all tiers of governments can ensure effective delivery of solutions to meet this target. The 'how', or sub-actions, have been clustered into four groups that represent items that are to occur at approximately the same time.

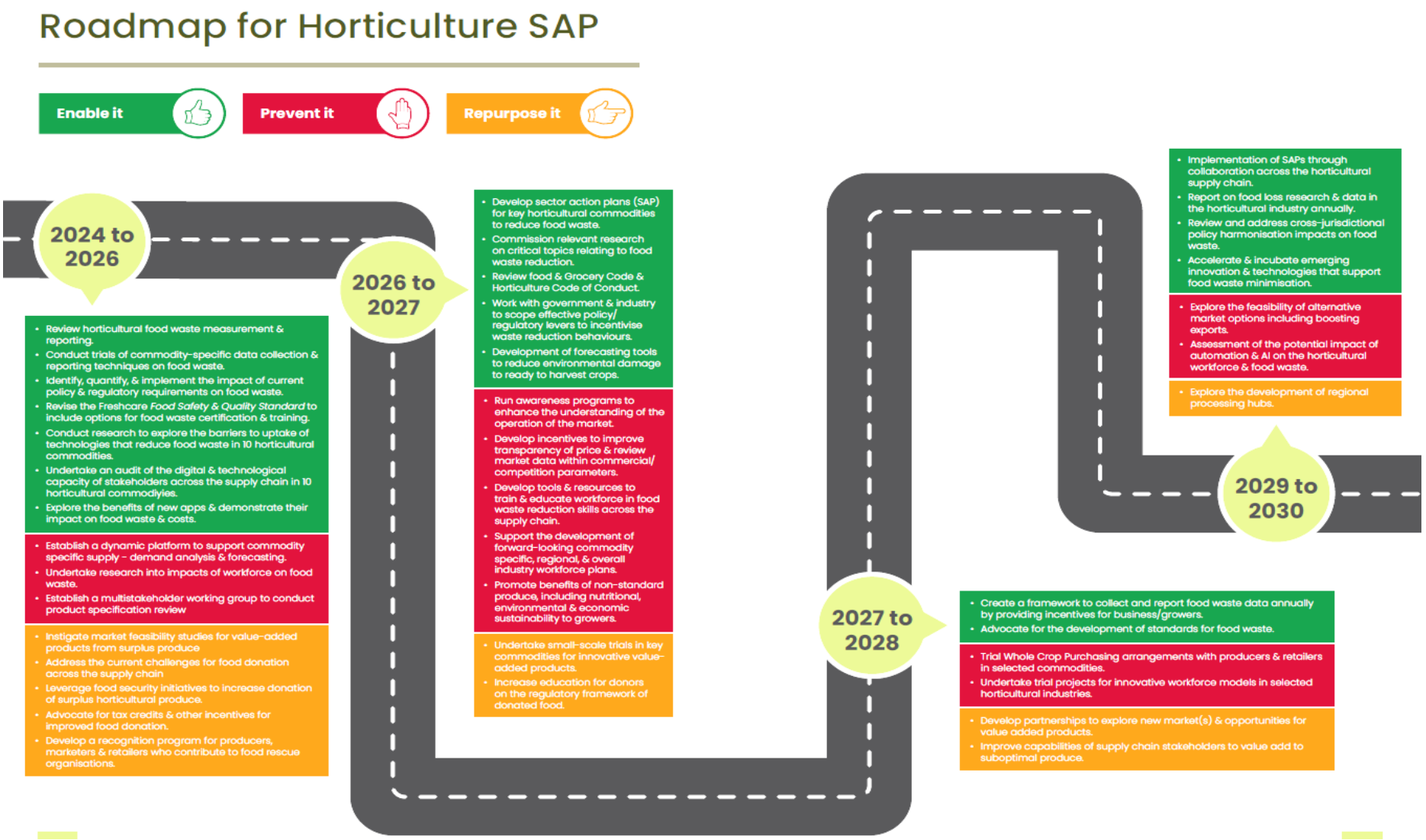



**Figure 9:** Horticulture sector food waste action plan implementation roadmap

# 7. MEASURING IMPACTS AND OUTCOMES OF *HORT SAP*

Achieving food waste outcomes and impact is a complex process, which involves the participation of diverse stakeholders across varied production and distribution cycles. It is important to develop a monitoring, evaluation, reporting and improvement (MERI) plan to demonstrate impact, support learning and improvement, and meet accountability requirements. The MERI plan will incorporate the following:

- *Monitoring:* Continuous and systematic observations of how the programs are being implemented, the effect of strategies used for addressing waste, and indicators of outcomes.
- *Evaluation and reporting:* Evidence-based assessment of the impact of the programs, including social, economic, environmental, and cultural impacts, which focuses on factors such as effectiveness, efficiency, appropriateness and impact.
- *Learning (i.e., for improvement):* Creation and sharing of knowledge, generation of insights and information, and program delivery about lessons learned to inform future practice, policy and program development.

While a MERI Plan is not presented in this report, a full monitoring and evaluation plan will be implemented at the outset of the implementation of the FWAP. The MERI plan will include the following:

- *A theory of change:* Drawing on the food recovery hierarchy, it will outline how the implementation of the FWAPs will facilitate change towards desired outcomes of reducing/preventing food waste.
- *Program logic:* A framework of undertaking the MERI will be established by providing a link between FWAP strategies and program inputs, activities, outputs and outcomes that need to be measured. In implementing the program logic, a systemic approach to the evaluation will be adopted. This approach encourages a critical and holistic analysis of opportunities, constraints, and relationships between different parts within a system, and of impacts of the system as a whole.
- *Indicators:* Qualitative and qualitative measures will be used to outline progress and gauge what impact the implementation of the FWAP is having on food waste reduction.
- *Data sources:* What data is needed for the different indicators and how this will be collected will be identified. Data collection often targets diverse data sources, utilising a mixed methodology approach to gather both qualitative and quantitative data.
- *Waste measuring methodologies:* Because measuring food waste is complex, consideration of a wide range of waste measuring methodologies will be undertaken, including direct measurement and weighing (volumetric assessment), material flow analysis (the way materials are used, re-used, and lost), mass balance analysis (input-output assessment), and waste composition analysis (examination of waste details), etc. There is also analysis related to economic value and nutritional aspects. This analysis can be applied to a single stage of the supply chain or across the whole chain of a distinct produce or in the horticultural industry as a whole.

# 8. CONCLUSION AND FUTURE STUDY

This study has identified nine strategic actions with key objectives, desired outcomes and potential indicators for achievement. Anticipated short, medium, long and longer-term outcomes are also specified. Over 100 stakeholders across the horticulture supply chain, such as growers, farm managers, wholesalers, transporters and distributors, retailers, experts and policy makers, were involved in preparing this action plan.

This *Hort SAP*, involving a co-designed and bottom-up research-based approach, establishes a vision for moving forward, while recognising challenges in the production and distribution stages of the supply chain. The *Hort SAP* sets out a whole-of-sector perspective to identify opportunities and targeted interventions, that will make an impact and bring about multiple benefits. Further, a roadmap to implement the actions has been suggested for the horticulture industry to assist in achieving the target of halving Australia's horticultural food waste by 2030.

Opportunities for future research include the quantification of economic, environmental, and social impacts in each of the nine strategic action areas, and the adoption of new technologies and initiatives, such as the Foodbank Hunger Map.

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# APPENDICES

Please note that the following appendices were either cited in the main text of this report or completed as part of the research process and methods undertaken for this study. We tried not to repeat the literature that we presented in the text between Sections 1 and 5.

# Appendix A1. Literature review: Key findings

## 1. Food waste in horticultural supply chains

### 1.1 Methods for measuring horticultural waste and loss

There are many methods for evaluating horticultural waste and loss, due to the great diversity of horticultural products as well as their associated supply chains and handing requirements. In using any method for measuring the loss and waste, it is important to consider a clear definition of terms, categorisation of waste or loss, measurement unit, as well as data collection and analysis tools (Yahia et al. 2019). Regarding measurement unit, for instance, food loss and waste can be reported in terms of weight, volume, quantity, cost, calorific value, greenhouse gas impact, or lost input (e.g., nutrients and water) (Geislar, 2020). CEC (2021), in addition, suggests that an appropriate method for measuring food waste and loss may depend on the context, the objectivity of data collection, availability of information, access to food loss and waste, level of accuracy needed, time and resources available, and whether tracking causes of waste and loss and progress overtime is needed.

Food loss and waste can be evaluated using quantitative and qualitative methods. Quantitative methods often help answer questions of 'what' and 'how much', as they can leverage large amounts of data to identify food waste hotspots. Qualitative methods are useful to answer questions of 'how' or 'why', as they can help uncover new hypotheses or processes for improving predictive models (Geislar, 2020).

Drawing on a review of recent literature (e.g., Amicarelli & Bux, 2020; CEC, 2021; Geislar, 2020; Thyberg, 2015; Xue & Liu, 2019; Xue et al., 2017), we present some common methods for measuring food waste and loss, as well as advantages and disadvantages of using each method, as shown in Table A1.1. These methods are applicable to not only horticultural products, but also other types of food in general.

Table A1.1: Common methods for measuring food waste and loss

| Method name | Description | Advantages | Disadvantages |
|---|---|---|---|
| Mass balance<br>(e.g., Amicarelli & Bux, 2020; CEC, 2021) | - The approach measures food loss and waste by comparing inputs with outputs and accounting for changes in stock levels.<br>- It represents a fundamental and transparent basis for decision makers and a well-grounded inventory of other methodologies. | - It is not necessary to get direct access to food loss and waste.<br>- It can economically return a series of estimations on food loss and waste that would otherwise not be obtainable.<br>- Low level of resources (e.g., time and cost) is required.<br>- It can be used to track progress overtime. | - It cannot be used to track causes.<br>- Results are at a medium level of accuracy and reliability. It is often difficult to get reliable data. |
| (Material flow) modelling<br><br>(e.g., Thyberg, 2015) | - This methodology relies on industrial production data for materials and products in waste streams.<br>- The model breaks the overall estimate into specific waste categories, including food waste, by how much generated waste is treated by specific approaches, such as recycling or composting. | - It is not necessary to get direct access to food loss and waste.<br>- It can be used to track progress overtime.<br>- Updates to materials flow models are relatively inexpensive once the analytical structure is in place. | - It cannot be used to track causes.<br>- It is difficult to obtain complete production data for every item discarded as solid waste.<br>- It may only be applied to national-level data; rather than to regional or state situations.<br>- Results are at a low level of accuracy and reliability (e.g., it is difficult to assess many assumptions and sampling errors). |

| | | | |
|---|---|---|---|
| | | | - Many principles of the model may not be applied to some organic wastes. |
| Proxy/literature data<br><br>(e.g., CEC, 2021; Thyberg, 2015; Xue & Liu, 2019) | - This method uses data from food supply systems, discussions with experts, or other published sources, and applies loss factors to the amount of food available for human consumption. | - This is a cost-effective and feasible method.<br>- It is not necessary to get direct access to food loss and waste.<br>- Low level of resources is required.<br>- Results are at a high level of objectivity.<br>- It can be used to track progress overtime. | - Results are at a low level of accuracy.<br>- Loss factors may be understated or overstated due to limitations in underlying published studies that data are derived from.<br>- Data may not be available for all types of food.<br>- It cannot be used to track causes and provides little information on how much food waste needs to be managed.<br>- It cannot be used to track progress overtime. |
| Direct measurement<br><br>(e.g., Amicarelli & Bux, 2020; CEC, 2021) | - This methodology comprises various methods such as direct counts and weight and/or volumetric assessment.<br>- Direct measurement can also include *waste characterization sorts* which is used to analyse waste streams, and involves the representative sampling, sorting, and weighing of wastes originating in a target waste shed to determine the proportion of various materials in the samples. | - It involves standard methods.<br>- Results are at a high level of accuracy.<br>- It enables objective measurement.<br>- It can be used to track causes and reasons behind waste/loss.<br>- It can be used to track progress and updates overtime. | - Direct access to food loss and waste is needed.<br>- High level of resources is required (e.g., labour intensive; high cost, time and expertise requirements).<br>- Waste characterisation sorts in particular cannot provide detailed pictures of specific types of food waste; and sampling may lead to uncertainties such as skewing due to atypical circumstances or specific local situations; it can also exclude waste disposed via other disposal routes. |
| Waste composition analysis<br><br>(e.g., Amicarelli & Bux, 2020; CEC, 2021; Geislar, 2020) | - This is a methodology of physically separating, weighing and sorting food waste streams from other materials that are not considered as food waste, such as packaging or other solid waste items.<br>- It can be used to evaluate existing sorting behaviours, provide baseline<br>data from which to design, test waste management policies and schemes, or calculate environmental impact. | - Results are at a high level of accuracy.<br>- It can provide information on food waste (e.g., for packaged or unpackaged food as well as vegetables or fruits), which can help with further analysis of financial costs and nutritional content.<br>- It can be used to track progress overtime. | - Direct access to food loss and waste is needed.<br>- Significant level of resources is required (e.g., it is costly, and requires large sample sizes, staff time, materials, logistics,<br>and facilities).<br>- It cannot be used to track causes/ reasons of food waste. |
| Diaries<br><br>(e.g., Amicarelli & Bux, 2020; CEC, 2021; Thyberg, 2015) | - Diaries involve measuring and recording food wastage by waste generators themselves.<br>- The method refers to individuals or groups living in a certain geographical area who are asked to measure and self-report food waste occurring during their daily life. | - It is not necessary to get direct access to food loss and waste.<br>- Food wasted through all methods of disposal can be identified together.<br>- It can be used to track causes/reasons of waste.<br>- It can be used to track progress overtime.<br>- It can be used to collect background data on socio-demographics, behaviour, and attitudes. | - Data are at a low to medium level of accuracy (information cannot be generalised, sometimes data quality is poor due to undervaluation and approximation).<br>- Medium level of resources is required (e.g., it requires participants to expend considerable amounts of time, it is often hard to recruit participants).<br>- Data are often subjective (e.g., participants may forget or choose not to record some of their waste generated; participants may be reactive or altering their behaviours due to the study or moral/social drivers). |

| | | | |
|---|---|---|---|
| Records<br><br>(e.g., CEC, 2021; Xue et al., 2017) | This method is used to determine the amount of loss and waste via the routinely collected information that is not initially used for food loss and waste record, and usually used for the retailing and food manufacture stages. | - It is not necessary to get direct access to food loss and waste.<br>- Low level of resources (time and cost) is required.<br>- It can be used to track progress overtime. | - Results are at different levels of accuracy (depending on the type of record used).<br>- It cannot be used to track causes. |
| Surveys and interviews<br><br>(e.g., Amicarelli & Bux, 2020; CEC, 2021; Geislar, 2020; Thyberg, 2015) | - Surveys and interviews are used to collect either quantitative or qualitative data from a large number of subjects, involving asking participants direct questions about their food wastage in order to better understand food waste generation and disposal practices. | - It is not necessary to get direct access to food loss and waste.<br>- It can be used to track detailed information about why food is wasted, different specific types of food wasted, as well as behaviours, awareness, motivators related to waste, etc.<br>- It can be used to track progress overtime.<br>- The methodologies are cost-effective, standardised, and can reach high numbers of people. | - Results are at a low to medium level of accuracy (due to possible low response rate, difficulties in recruiting participants).<br>- Responses/information can be subjective (e.g., responses may be culturally-driven moral implications of wasting food).<br>- It is not suitable for generating information on quantities generated.<br>- Medium to high level of resources is required (e.g., investment of time and effort by respondents). |
| Digital photography/ Radio frequency identification<br><br>(e.g., Geislar, 2020) | - Digital photography methods capture a photograph of food and or food waste that researchers use to derive estimates<br>of quantity, weight, or type.<br>- Sensors and imaging technologies measure sorting accuracy, bin-fill levels, moisture, energy, and odours. Some sensors automatically weigh and transmit food waste data.<br>- Radio frequency identification uses a tag equipped with a wireless microchip and antenna which communicates directly to a reader, typically affixed to the collection vehicle. | - Digital photography methods reduce participant burden and error from self-report estimates, while increasing the granularity of data and the speed of collection, analysis, and feedback.<br>- Collecting granular data on food waste types and sites using digital photography<br>methods can aid in appropriately<br>targeting behavioural and infrastructural interventions.<br>- Radio frequency identification can be used to trace not only information on waste generators (e.g., address), but weight, volume, and type of food.<br>- Using radio frequency identification can reduce the labour needed in manually recorded pay-as-you-throw systems. | - Current scope of digital photography<br>methods use is somewhat narrow as they have largely been used to capture plate waste, omitting household food waste arising from over-preparation or poor storage, for instance. |

**1.2 Hotspot identification approaches in horticulture supply chains**

In order to define and understand with the scale of horticultural waste and loss, it is necessary to identify where the waste matters most and where attention should focussed across the supply chain (WRAP, 2020). For the purpose of the present study, that is, identifying hotspots in terms of food waste occurring across the supply chain is used as the basis for our hotspot discussion. UNEP, in addition, suggest two approaches to define thresholds which can be used to identify and map food wastage hotspots (compared with warmspots and coldspots):

First, a supply chain stage can be seen as a hotspot if its waste impact is larger than the average distribution of all stages across the chain (for example, if there are 5 stages in the supply chain, a hotspot is defined as the stage whose impact is larger than 20% of the total chain impact).

Second, a hotspot is found if all supply chain stages collectively contribute to a significant amount of food waste (UN, 2017) (see Figure A1.1). In the present study, we apply this approach to identify waste hotpots at different stages of Australia's horticultural supply chains.

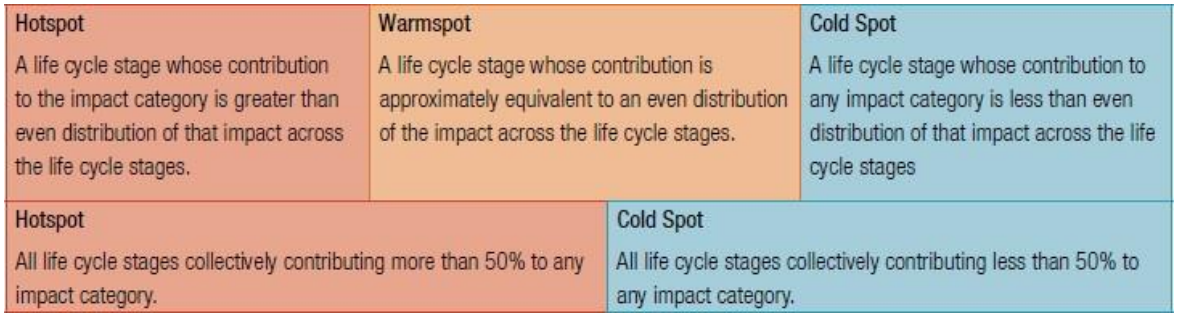


*Figure A1.1: Two approaches for identifying waste hotspots in a supply chain (Source: UN, 2017)*

## 2. Root causes analysis

### 2.1 Defining root causes

Root causes are the fundamental or structural reasons behind food waste and loss (Møller et al., 2014; Moragues-Faus et al., 2017), and are often location-specific (Van Berkumet al., 2018). The Canadian Commission for Environmental Cooperation (CEC, 2021), however, distinguishes between causes and root causes, suggesting that there are two layers to identifying the cause of food waste and loss: (1) an immediate/proximate reason why food is wasted or lost, namely "cause or apparent causes" and (2) the underlying factor that that plays a role in creating that reason, namely "driver or root causes". For example, if one of the causes of food loss is "cosmetic or physical damage", its driver can be "poor harvesting technique/inadequate equipment". Nevertheless, considering the definition of root causes as mentioned by Møller et al. (2014) and Moragues-Faus et al. (2017), "root causes" are closer to "drivers" than "causes" in CEC's explanations. Thus, root causes of food waste and loss which we focus in the present study can be understood as fundamental factors contributing to waste/loss.

### 2.2 Methods for tracking causes and root causes of food waste and loss

CEC (2021) reviews whether some methods can be used for identifying and tracking causes of food waste and loss (which are incorporated into food loss and waste quantification methods), how to best apply, and suggests three useful methods, as in Table A1.3. This suggests that some (not all) methods for measuring horticultural waste and loss can also be used for tracking root causes of the loss and waste.

*Table A1.3: Tracking causes by method (Source: CEC (2021, p.22))*

| Method | Can it track causes? | How to track causes with the method |
|---|---|---|
| Direct weighing | Yes | Although direct weighing provides only numerical data, staff can be instructed to log causes while weighing the food loss and waste. This provides an additional data point about how the food loss and waste occurred. |
| Waste composition analysis | No | A waste composition analysis does not directly provide information on causes of food loss and waste, as the waste is being analysed after it has been discarded. For this reason, waste composition analyses are often paired with a survey or process diary to generate qualitative data on causes and drivers assessed in tandem with the waste analysis. |
| Records | Not usually | Because records are kept for purposes other than food loss and waste quantification, they are less likely to contain information relating to food loss and waste causes and drivers. However, some records will have information that can help identify causes.<br>Usually, a diary or survey will need to be implemented to generate qualitative data. |
| Diaries | Yes | A diary can be used to determine causes and drivers of food loss and waste. The diarist can be asked to provide information on why the food loss and waste occurred while recording it. |
| Interviews/surveys | Yes | A survey can be used to determine causes and drivers of food loss and waste. The respondent can be asked to provide information about why food loss and waste occurs within those boundaries. |

| | | |
|---|---|---|
| Proxy data/mass balance | No | Because inference by calculation is a mathematical operation based on material flows and proxy data, it cannot provide information about causes and drivers of food loss and waste. It provides only a quantitative estimate of the amount of food loss and waste occurring within a given sector or commodity type. An additional analysis of the relevant sector or commodity will be necessary to understand the causes of food loss and waste. |

In addition, it is important to apply root cause analysis methods to identify root causes—the underlying factors that create and drive causes of food waste and loss. Root cause analysis methods allow us to go through a problem-solving process in order to understand and anticipate causes of food loss and waste and develop strategies for preventing such waste and loss. There are a number of cause analysis methods which have been used to determine root causes of different issues across different manufacturing, industry, management and home sectors , such as Cause-and-Effect diagram (fishbone/Ishikawa diagram), Fault Tree Analysis, Nominal Group Technique, Check Sheet, the DMAIC process, Delphi Technique, Control Chart, Cause Map, Histogram, Five Whys, Pareto chart, Designed Experiments, Scatter plot/diagram, Failure Mode Effects Analysis (FMEA), Run chart, etc. There is no method which applicable to identify causes of all issues in all incidents and situations, although some methods are more commonly used than others. Table A1.4 describes some of the most common tools for root cause analysis in food supply chains and manufacturing, including tools for determining causes of food loss and waste:

*Table A1.4: Common methods for identifying root causes*

| Root cause method | Description |
|---|---|
| 3 to 5 Whys<br>(e.g., Bulsuk, 2011) | - The basis of this approach is to ask “why” three to five times to explore the cause-and-effect relationship for a food waste problem.<br>- The process can be repeated more than 5 times - as many as necessary to determine the root cause(s). |
| Fishbone (Ishikawa) diagram<br>(e.g., Stevenson & Hojati., 2007) | - These bones in the diagram show the relationship between major causes and the effect. Medium size bones secondary causes, while small bones can be seen as root causes.<br>- Researchers need to brainstorm to define the major causes of the problem. |
| Pareto chart<br>(e.g., Sertkaya | - Pareto chart is a bar graph, which can be used as a a technique for ranking items (causes of waste in this case) in descending order of their importance (e.g., frequency of causes, most significant waste streams) from left to right. |
| Scatter plot/diagram<br>(e.g, Okazaki, 2006) | - A scatter plot/diagram was used to show the relationship/correlation between the two variables, which can be population and waste generation. |
| Failure mode effects analysis (FMEA)<br>(e.g., Chairany et al., 2022) | - FMEA is a systematic and proactive method to identify and mitigate possible food waste risks and causes of waste in the food supply chain. - FMEA can be used to evaluate and prioritize risks, that is useful to find the right strategies to address the waste. |
| DMAIC process<br>(e.g., Kolawole et al., 2021) | - DMAIC process is a problem-solving method which comprises of five phases: Define, Measure, Analyze, Improve and Control.<br>- DMAIC can be a useful tool to investigate food waste reduction at the pre-consumption stage. |
| Fault tree analysis (FTA)<br>(e.g, Liu et al. 2012) | FTA is a deductive analysis approach for resolving an unwanted or unexpected issue into its causes in a top-down manner. The assumed issue is often listed at the top. Other factors in the system that could be a cause of the issue are listed as subsequent branches until the root cause is determined. |

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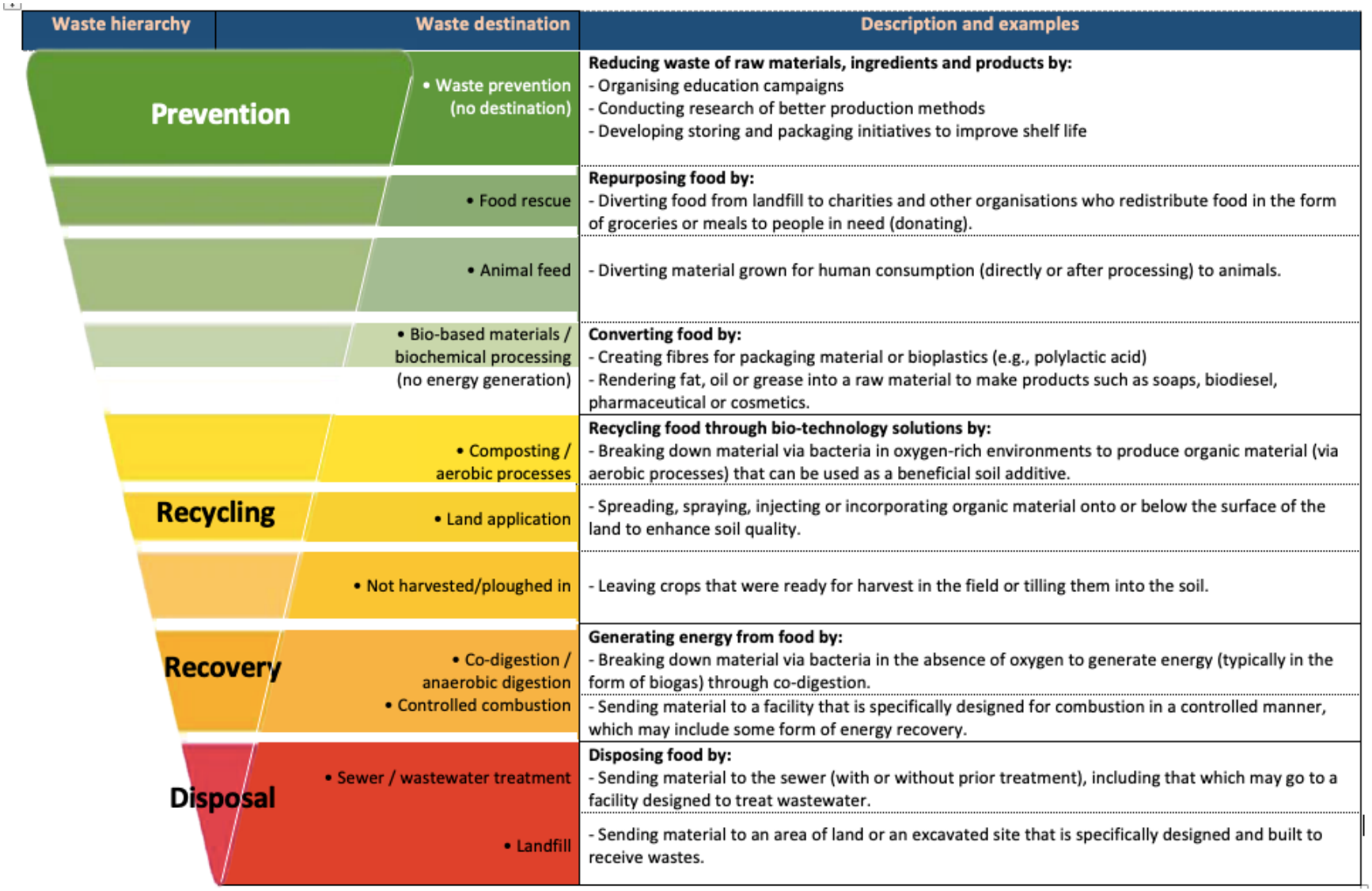
## 3. Food waste hierarchy and good practice

### 3.1 Prevention and management of food waste and loss: a hierarchy

When there is no loss or waste, there will be no negative social, environmental and economic impacts, and no loss/waste management is needed. In a food waste hierarchy, prevention of waste and loss should be the

prioritised as the foremost goal. It is important to first consider end-of life destinations for the waste to help manage negative impacts. The Australian Government (2017), in their National Food Waste Strategy, for instance, proposes a food waste hierarchy, which suggests 6 main approaches of preventing and managing food waste, including: avoid, reuse, recycle, reprocess, energy recovery, and dispose. Heinrich et al. (2022), in their Bread and Bakery SAP report, suggest an updated hierarchy which includes 4 main approaches, namely prevention, recycling, recovery, and disposal. Among the approaches, “prevention” seems to involve “avoid”, “reuse” and “reprocess” in the Australian Government’s (2017) hierarchy, while “recycling”, “recovery” and “disposal” can be compared with “recycle”, “energy recovery”, and “dispose”, respectively, of the Government’s hierarchy. “Prevention” or “avoid” is considered as the most preferred and “disposal” or “dispose” is seen as the less preferred approach. Drawing on Heinrich et al.’s (2022), hierarchy, we present different waste destinations associated with each waste prevention/management approach, as well as description and examples of each waste destination, as in Figure A1.3.



| Waste hierarchy | Waste destination | Description and examples |
|---|---|---|
| Prevention | • Waste prevention (no destination) | **Reducing waste of raw materials, ingredients and products by:**<br>- Organising education campaigns<br>- Conducting research of better production methods<br>- Developing storing and packaging initiatives to improve shelf life |
| | • Food rescue | **Repurposing food by:**<br>- Diverting food from landfill to charities and other organisations who redistribute food in the form of groceries or meals to people in need (donating). |
| | • Animal feed | - Diverting material grown for human consumption (directly or after processing) to animals. |
| | • Bio-based materials / biochemical processing (no energy generation) | **Converting food by:**<br>- Creating fibres for packaging material or bioplastics (e.g., polylactic acid)<br>- Rendering fat, oil or grease into a raw material to make products such as soaps, biodiesel, pharmaceutical or cosmetics. |
| Recycling | • Composting / aerobic processes | **Recycling food through bio-technology solutions by:**<br>- 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. |
| | • 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. |
| Recovery | • Co-digestion / anaerobic digestion | **Generating energy from food by:**<br>- Breaking down material via bacteria in the absence of oxygen to generate energy (typically in the form of biogas) through co-digestion. |
| | • 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. |
| Disposal | • Sewer / wastewater treatment | **Disposing food by:**<br>- 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. |

*Figure A1.2: Description and examples of horticultural waste destination in relation to the waste hierarchy (Source: The Authors, adapted from Australian Government (2017), Heinrich et al. (2022) and ARCADIS (2019)).*

**3.2 Prevention and management of horticultural waste and loss: case studies of good practice**

WRAP (2022, pp 2-8), in a recent report, outlines the key existing good practice guidance and interventions (as well as examples) for reducing food waste and loss across the UK's horticultural supply chain, including:

- Encouraging retailers and the supply chain to provide appropriate pack sizes and loose options.

- Not attaching date labels to fresh produce.

- Guiding consumers to store produce correctly at home.

- Applying technologies to extend the product shelf-life, including modified atmosphere packaging, ethylene absorbers, barriers to prevent gas/moisture exchange, etc.

- Developing a food waste reduction roadmap.

- Upskilling industry on how growers can be supported to undertake in-field measurement.

- Having more transparent and accountable quality specifications for fresh fruit and vegetables.

- Forecasting supply and demand.

- Purchasing whole crop.

- Adding value lines for product that was previously wasted.

- Redistributing surplus food.

- Accessing to alternative markets.

- Feeding fruit and vegetable waste to insects to produce insect protein that can then be sold as sustainable animal feeds.

- Developing horticultural clusters to create a concentration of effort and collaboration to help deliver sustainable solutions and resource efficiency.

WRAP (2022), however, did not associate these good practice interventions with different approaches in their food waste hierarchy. It seems that most of the good practice interventions mentioned by WRAP are about prevention rather than management of waste. In this section, we provide twelves case studies of good practice in preventing and managing food waste and loss, which are associated with four approaches described in the food waste hierarchy, namely prevention, recycling, recovery, and disposal. Each approach includes cases from Australia and other cases from international contexts. It is important to note that many case studies are applicable to not only horticultural waste, but also to other types of food waste in general. For waste disposal in particular, although it is often considered as the less preferred approach in the hierarchy and may not be seen as a "good practice", we provide examples of applying "landfill tax" as an effort of reducing waste disposal and encouraging better food waste management approaches.

***3.2.1. Prevention***

***<u>Avoiding/reducing food waste</u>***

CASE STUDY 1

Angus Soft Fruits Ltd (The UK) was established in 1994 with the ambition to sell fruit directly to retailers and continually improve the product quality for consumers.

They have taken steps to ensure that their operations within the packhouse are as efficient as possible and minimise food waste. Their biggest success so far has been the purchase of a new optical blueberry grader, which uses high tech image analysis to specifically grade out only the blueberries which are not fit for human consumption. This has led to a 27% reduction in blueberry grade out compared to their previous blueberry grader.

Their packer training has also been a priority, reducing waste by ensuring staff have good awareness of customer specifications and only fruit which is not fit for human consumption is disposed of as waste. The staff act as a bridge between their packhouse and suppliers, making sure that growers receive feedback on fruit quality. This enables the bulk of the grading to be done on farm and reduces transport costs and food waste. They also work closely with wholesalers and retailer customers to agree temporary specifications and redistribute surplus fruits. (Source: WRAP, 2021a, pp.2-3)

### CASE STUDY 2

Nelle and Scott Baird, co-owners of the Real Food Grocer (Melbourne, Australia), have contributed to preventing vegetable/fruit waste change by lowering aesthetic vegetable standards in selling the products. They work directly with farmers to sell produce that is rejected for being too small, too big, or too ugly. Nelle and Scott sold at least 150 tonnes of farmer-grade produce per year, saving it from being wasted or heading to landfill. This is good for farmers who could sell their imperfect produce for a fair price. This switch to 'ugly' fruit could also contribute substantially to reducing greenhouse gases. The Real Food team buy exactly what they need direct from suppliers so there is no wastage in their warehouse.

The team believed that as a result of these activities, there was a considerable shift in consumer opinion over the past few years, with the demand for ugly produce higher, and the need to educate customers about food waste lower. Chefs are even embracing odd-looking produce for its unique aesthetic and for their customers seeking fresh, local, seasonal and sustainable meals. (Source: Victoria Government, 2021, p.37)

## ***Repurposing food***

### CASE STUDY 3

The Foodbank is the largest food relief organisation and also the largest hunger relief charity in Australia, which currently provides support to more than one million vulnerable Australians every month. The organisation works with the food and grocery industry including farmers, wholesalers, manufacturers and retailers. They act as a bridge between this sector and frontline charities, community organisations and schools which provide critical food relief to people in need. The organisation is also the pantry to the charity sector, linking surplus food and groceries to people in need. Last year they sourced 88 million meals for their charity partners.

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. 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. Thus, they have contributing to reused and redistributed fresh produce to those in need, which may otherwise be wasted due to many reasons. (Sources: ARCADIS, 2019, p. 84; Food Bank, 2022, p.2).

## ***Value adding***

### CASE STUDY 4

In Australia, Augustin's research team conducted a project on optimising the value from edible waste in the vegetable supply chain by creating healthy food ingredients and products.

The research team worked with the vegetable industry (in collaboration with Hort Innovation) to develop an understanding of the issues and interests of vegetable growers (Brassica and Carrot); and undertook extension activities with farmers and stakeholders across the value chain. First, they extracted health promoting components from broccoli and carrot. Second, they processed and formulated value-added products using a combination of selected pre-treatment and drying process to optimise retention of natural colour, flavour and nutrient composition. The extruded broccoli and carrots were made from either 100% vegetable powder or combined with rice flour for formulations containing 80, 60, 40, 20 % broccoli or carrot powder. Finally, a commercial vegetable fermentation starter culture was selected for the fermentation of carrot and broccoli puree. (Source: Augustin, 2019, p.8)

### *3.2.2 Recycle*

#### CASE STUDY 5

A couple of years ago, Eliska and Tom in Sydney, Australia started the ShareWaste project to enable people with waste they could not recycle (donors) to give it to those (hosts) who wanted more compost for their gardens, as well as better connect within their community by sharing their skills and resources. Their website is also a social platform to promote sustainable life choices and projects, community gardening, growing your own food and demonstrating examples of good practice and community or sustainability projects. Eliska and Tom hoped that their project could help address the problem of food waste and help all renters and apartment dwellers play a larger role in reducing the human environmental footprint. Their donors are not only apartment dwellers, but also residents owning a bokashi system or people who are travelling and are looking for a place to drop off their organic waste ecologically. Compost hosts include residents with their own composting system or a worm farm, community gardens and people with chickens. (Source: SGA, 2022, p.1)

### *3.2.3 Recovery*

#### CASE STUDY 6

Mackay Sugar, Australia's second largest sugar milling company, has a 'nothing is wasted' business approach, and is committed to ensuring their operations are done in an environmentally responsible manner. Recognising the growing market opportunity and interest in renewable energy, Mackay Sugar has worked to create value from sugar milling by-products molasses and bagasse.

Mackay Sugar producing 690,000 tonnes of raw sugar a year. Sugar milling produces valuable by-products which Mackay Sugar is processing for its 'green projects' focused on bioenergy. The two main by-products of sugar production are biomasses - bagasse, the fibre left over from crushing the sugarcane, and molasses. Bagasse is used for biofuel and molasses is used as supplementary stock feed.

Through using bagasse, Mackay Sugar is largely energy self-sufficient with excess energy produced being redirected to the national electricity grid. Their 38-megawatt Racecourse Cogeneration Plant (situated at their Racecourse Mill) produces enough renewable electricity to power about 30 per cent of Mackay year-round. (Source: KPMG, 2020, pp. 27-28).

### *3.2.4 Disposal*

#### CASE STUDY 7

The landfill tax and refund scheme in Catalonia (Spain) is an impressive example of how a public authority can promote separate collection of bio-waste in a structured and continuous way. Despite not having a national landfill tax, Article 16 of the Spanish Waste Act allows waste authorities from autonomous communities (regions) to apply economic incentives, to promote waste prevention and separate collection. Catalonia set up an incentive scheme managed by the Waste Agency of Catalonia (ARC), based on the idea that bio-waste collection and treatment costs must be made cheaper than disposal into landfill or incineration. The tax is increasing (for landfill it is €47.1/t in 2020, planned to increase to €70/t in 2024) to encourage separate collection of biowaste; municipalities that do not present an implementation plan pay a higher tax. (Source: Favoino & Giavini, 2020, pp. 18-19).

#### CASE STUDY 8

In Australia, the Queensland Organics Strategy and Action Plan was published in 2022. In late 2021, the CoMSEQ SEQ Waste Management Plan was launched with endorsement by Redland City Mayor Karen Williams which commits all SEQ Councils to implement a Food Organics Garden Organics FOGO food waste collection service by 2030. Additionally, changes to the Queensland Government landfill levy was announced in December 2021 and will result in Council paying increasing amounts of landfill tax each year if we do not reduce household waste from ending up in landfill. (Source: Redland City Council, 2022, p.1).

## 4. Potential interventions

Interventions for reducing the loss and waste of a particular horticultural product need to draw on information about (1) the product waste hotspots, (2) (root) causes of the waste, and (3) preferred waste prevention/management approaches applicable to the product.

In order to identify food waste hotspots in the supply chain, it is important to apply reliable measurement techniques for quantifying on-farm waste, during-handling and transporting waste, or during-consuming waste. Once hotpots are recognised, relevant interventions for reducing waste at the hotspots can be developed and implemented. Some updated measurement techniques which can be considered include: the WWF Food Loss Metric in the US, the Cool Farm Tool, and WRAP's Grower Guidance and Reporting Template.

It is suggested from our example about waste rates of the fruit and vegetable (root, non-root and brassicas) sub-sectors across stages of the supply chain in Australia in 2021, for instance, that Primary (Production), Household, and Hospitality represented three major food waste hotspots of this chain. As Household and Hospitality are beyond the scope of the present study, potential interventions which we would recommend here are mainly for the Primary Production stage of horticultural supply chains.

As the control of food loss and waste often depends on the nature of the causes (Yahia et al., 2019), understanding root causes of the waste is key to develop and implement interventions for reducing the waste. We observe that waste occurring at the Primary Production stage can be associated with a number of causes including bio-chemical & environmental causes, behavioural & managerial causes, technological and infrastructural causes, operational & organisational causes, and commercial & legal causes, which are associated with different root causes. Interventions for reducing food loss and waste, thus, need to focus on addressing these root causes.

In addition, interventions for reducing horticultural waste and loss need to prioritise the most preferred waste prevention/management approaches in the food waste hierarchy. That is, interventions need to emphasise first on Prevention. However, when waste occurs, Recycle and Recovery interventions are necessary to help reduce negative impacts of the waste, although kinds of interventions may vary depending on characteristics of the product.

Accordingly, we suggest several potential interventions for reducing horticultural waste, considering common root causes and waste prevention as a preferred approach as follows:

Encouraging sustainable farming: It is necessary to encourage producers to use cultivars (varieties) with longer postharvest life. An integrated crop management system would allow producers to gain maximum yield with highest quality (Papargyropoulou et al., 2014). Sustainable farming can help minimise negative environmental impacts, prevent the plants and products against unwanted pests and diseases, and reduce the use of chemicals on the product. Cargill Australia, for example, has programs to help farmers grow crops in the most environmentally responsible ways. This intervention will contribute to address natural constraints root causes of food waste.

Preventing food surplus: As food surplus is one of the major causes of horticultural waste in Australia, preventing overproduction and oversupply of food beyond human nutritional needs is of critical importance. Producers and sellers should work together on contract farming to find the best solutions to prevent food surplus. However, due to the possible power imbalance between producers and sellers, this may not be achieved until there are regulatory interventions by state and national governments to create an equal level playing field. In addition, it is also significant to develop policies that empower farmers in contractual negotiations, as this will assist them in avoiding overproduction and, as a result, reduce on-farm food waste. A recent amendment to Treasury Laws – the More Competition, Better Prices Bill 2022 that increases penalties for unfair contracts, for instance, would have implications in reducing food waste. This intervention will contribute to address management failure root causes of food waste.

Applying new agricultural technologies: In order to effectively reduce food loss and waste and be competitive in the market, it is important to apply compatible new agricultural production technologies. This may include

improved agricultural infrastructure, modern agronomic practices, or more efficient handling and storage techniques (Papargyropoulou et al., 2014). Robots and drones, for example, can be useful to scan crops, assess crop development and provide better yield forecasts. In New South Wales, the Department of Primary Industries has been working with various industry and academic partners to develop products such as aerial drones, decision support tools, or satellite-based irrigation management systems. This intervention will contribute to address management failure root causes of food waste.

Encouraging collaboration among supply chain entities and enhancing chain management effectiveness: As small producers do not often have good access to the supply chain, it is necessary to explore and promote schemes that enhance and build on social capital among supply chain entities. As we discussed earlier, however, due to issues related to power imbalance, distrust and information sharing, it is not easy to organise effective supply chain collaboration. Thus, regulatory interventions by state and national governments are needed to create an equal level playing field and facilitate collaboration across supply chain levels. This will enable a more reliable logistics relationship between growers and transporter or sellers, and thus prevent food waste due to unharvesting or not reaching consumers. Natural Evolution run by the Watkins family, for instance, has developed a unique program that traces bananas from paddock to factory, thereby preventing waste. It is, in addition, important to effectively implement agri-production knowledge and transmit the knowledge from one generation of producers to the next (Yahia et al., 2019). This intervention will contribute to address management failure root causes of food waste.

Forecasting product supply and demand: As previously indicated, price variation, change of consumer preferences, and other market forces are among commercial causes of food waste. If it is possible to provide good forecasting of supply and demand, this will minimise market uncertainties and balance the amount of product supply and demand, thus help reduce food waste due to overproduction, oversupply and non-consuming. Some examples of good practice in forecasting product supply and demand come from Omniorder Australia and the G's Fresh IceCAM project. This intervention will contribute to address mega-trends and management failure root causes of food waste.

Establishing common principles of product qualities: In order to avoid waste of "non-standard" or "ugly" produce while still maintaining minimum qualities, common principles of product qualities, where both standard and non-standard produce can be collected and accepted for different purposes, should be established. WRAP Guidance on principles of setting and maintaining quality specifications is an example of this good practice. This intervention will contribute to address management failure root causes of food waste.

Providing better education and training: One of the key interventions for reducing food loss and waste is education and training. It is important that people in the horticultural supply chain are well trained with knowledge relevant to their job in producing and handling food, as this will contribute to minimising waste due to low skills and bad practices. Workshops for small-scale horticultural farmers, for instance can be useful to provide them with information about how to effectively harvest their product. Similar workshops and courses for other workers in the supply chain can also be organised. The Australian Institute of Parking, for instance, has developed training courses focusing on the Role of Packaging in Minimising Food Waste to those in need. It is also necessary to effectively transmit knowledge from one generation of workers to the next in the supply chain (Yahia et al., 2019). In addition, proposing national campaigns and movements to raise people's awareness of food waste and sensitize them to reduce waste is also important in bringing the issue to wider public attention. The Youth Food Movement Australia who aim to connect young people for trainings, reducing-waste activities, and community food project development is a good example of these organised campaigns. This intervention will contribute to address management failure root causes of food waste.

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# Appendix A2. Stakeholder interviews: Key findings

## 1. Introduction

This appendix summarises findings from stakeholder interviews (Data Collection Phase I) about horticultural food waste hots spots, apparent and root causes, and existing and possible intervention (i.e., solution) to reduce food waste.

### 1.1 Stakeholder interviews

The purpose of stakeholder interviews was to collect information about food waste across the horticultural supply chain by having in-depth conversations with stakeholders, that was useful to design poll questions and discussion topics in Workshop 1.

A member of the research team recruited, contacted and interviews stakeholders who are a representative of different actors/entities across the horticultural supply chain. Nineteen stakeholders participated in 18 interviews in total (See Table A2.1). The interview participants were from different government and non-government agencies, industry peak body, marketing and transporting companies.

*Table A2.1: Interview participants groups*

| Participant group | Number | Percent |
|---|---|---|
| Industry representative | 6 | 31.6 |
| Retailer representative | 3 | 15.8 |
| Government representative | 3 | 15.8 |
| Producer representative | 2 | 10.55 |
| Researcher representative | 1 | 5.25 |
| Processor representative | 1 | 5.25 |
| Marketer representative | 1 | 5.25 |
| Distributor representative | 1 | 5.25 |
| Transporter representative | 1 | 5.25 |
| **Total** | **19** | **100** |

Prior to each of the interviews, the interviewer introduced themselves and discussed the purpose of the project and requested permission to record the conversation. The interviewer also clarified the concept food waste, and if necessary, provided a definition of food waste. Interview questions/ discussions focused on multiple themes related to horticultural food waste (See Table A2.2).

*Table A2.2: Ideas guiding the stakeholder interviews*

| Topics | Guidelines |
|---|---|
| **Definition of food/horticultural waste** | - Food waste includes all food intended for human consumption that never reaches us and edible food that consumers throw away.<br>- Horticultural waste includes fruit and vegetables that are not harvested for whatever reason (e.g., weather, labour, price) or are discarded for quality issues.<br>- Horticultural waste includes fruit and vegetable that are ploughed in/left in field/fed to livestock (not intended original use – human consumption).<br>- Food waste does not include produce that is sold as a lower grade for other uses in the human food chain (e.g., second grade produce, juicing, processing for other uses e.g., banana bread/flour). |

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| **Major themes covered in the interviews** | - Actions for food waste reduction.<br>- Food waste data/amount<br>- Strategies for food waste mitigation<br>- Supply chain stage(s) where waste occurs<br>- Causes of food waste and loss<br>- Waste destination<br>- Second grade produce<br>- Food waste agreements and policies |

### 1.2 Tools for stakeholder engagement

The following tool (Table A2.3) was used for collecting data during the stakeholder interview. The data collection process was approved by the CQUniversity Human Research Ethics Committee. Most of the interview was conducted via zoom and some were in face-to-face mode.

*Table A2.3: Stakeholder engagement tool for interviews*

| **Interview questions (finding solutions)** |
|---|
| 1. In your opinion, at what stage of the horticulture supply chain the most food waste occurs? (e.g., production and harvesting, processing, and packaging, wholesale and distribution, retail)<br>2. How could we minimize overproduction in the horticulture industry? Is there any mechanism to signal the accurate (near accurate) demand for horticulture products?<br>3. What strategy is required to divert the oversupplied horticulture products to new markets (including export)?<br>4. Do you think inefficient cold supply chain management is the key reason for food waste in the horticulture sector? How could we increase the efficiency of the cold supply chain?<br>5. What strategy is required to ensure that maximum edible discarded food can be sent to food rescue and/or food banks?<br>6. Do we need more energy recovery plants in Australia to process waste food from the horticulture sector?<br>7. What new technology could be used in the horticulture supply chain to reduce food waste?<br>8. What types of training is required to educate the supply chain actors and consumer about food waste in horticulture?<br>9. In your opinion, is there any legislative framework that leads to increased food waste? What types of change are required to minimize food waste without compromising the purpose of such a framework?<br>10. What else could be done to reduce the horticulture food waste to half by the year 2030? |
| **General question to identify the hotspots and root cause** |
| Production and harvesting stage<br>11. What is your primary produce? What is the size of the land of production? What is the average yield (kg/ha)?<br>12. What are the main reasons for product loss on the field?<br>13. During the harvest, what percentage of horticulture products are damaged?<br>14. What is the main reason for the waste during harvesting? (e.g., mechanical operation, storage, handling etc.)<br>15. How do you treat these wastages (e.g., compost, energy recovery, stockfeed etc.)?<br>16. Is there any option/opportunity to produce value-added products from these wastages?<br>17. Do we have appropriate logistics and infrastructure for producing value-added products?<br>18. What types of support are required for the value-added products industry? |
| Processing<br>19. During the processing stage, what percentage of waste occurs for horticultural commodities? What is the nature of such loss (expiration dates, trims, Final product rejection)?<br>20. Do you have any agreement in place with the wholesaler and retailer to minimize food waste? |
| Wholesale and distribution: |

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| 21. How much (percentage) of food waste take place during transportation and distribution? What are the main reasons behind such waste (Excess stock, storage facilities, labour shortage, temperature management)?<br>22. What support could government provide you to minimize food waste during distribution? |
| Retail<br>23. What percentage of horticulture products are rejected at the retail stage because of cosmetic specifications? Is there any opportunity to market such out-of-specification products at the retail stage?<br>24. What are the destinations of discarded horticulture products at the retail stage? Is there any restriction to send the discarded products to the food bank? |

## 2. Key findings

### 2.1. Horticultural waste hotspots

In this section, horticultural waste hotspots are discussed referring to FIAL's (2021) seven main points of food waste for these sub-sectors across the supply chain, including: Primary, Processing, Distribution, Retail, Household, Hospitality and Institutional. The interview participants suggested that waste could occurs at all stages of the horticultural supply chain, and each of the stages can be a potential waste hotspot. It was widely agreed that on-farm (production/harvesting/ grading & packing) is the biggest source of food waste. Consumption (the end of the product life cycle) was seen as second biggest source, followed by retailing, marketing and transporting. It was also suggested by the stakeholders that the decision point "progress to sale" versus "send to waste" occurs several times along the supply chain. Table A2.4 provides a summary of the participants' observation of horticultural waste in Australia:

*Table A2.4: Interview participants' observation of horticultural waste across supply chain stages.*

| Supply chain stage | Waste relating to | Brief description |
|---|---|---|
| **Primary** | Overproduction | - Waste occurs due to overproduction (and speculative growing). |
| | Product specifications and market factors | - This is the first occasion where (tight) food specifications do not meet the reality, and the point that determines whether a product leaves the farm or not, which is probably where the most waste occurs. For example, if the price of the product is low, it is uneconomic to harvest. |
| | Harvesting and handling practice | - Harvesting practice can lead to waste (mechanical sorting/harvesting can reject an amount of the product).<br>- Sometimes fresh produce is not moved to storage place right after it is picked. |
| | Producers' awareness | - Many growers are not aware of the issue of food waste. |
| | Adverse environment | - Other factors that have an impact on waste may include growing conditions or weather/climate. |
| **Processing (including handling and storage)** | Product specifications | - Processing industry tends not to have tighter specifications for some products, and is more receptive to nonstandard products than fresh food markets.<br>- There may be no second-grade product in the processing sector. |
| | Handling practice and technical issues | - There can be waste during the refrigeration storage/manufacturing process.<br>- Some loss can occur at grading and packing, e.g., if the fruit is too small or blemishes, it may go to animal feed. |
| **Distribution** | Transportation issues | - There may be not much loss during the transporting process, as long as nothing unforeseen happens (e.g., road accident, refrigeration breakdown). However, trucking and shipping can sometimes be where damage or waste occurs. |

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| | Food rejection | - There may be rejection of food at distribution centres. |
| **Retail** | Retailers' quality control | - Level of waste at supermarkets may be fairly low as the quality control along the supply chain often rejects any unsaleable product before it gets to the store. In store, product is ordered according to need, and is often rotated and stored well. |
| **Household, hospitality, and institutional** | Consumers/ food services' behaviours | - Consumers are throwing a lot of food away, but this attitude toward food has been changing.<br>- Food services sector would have a lot of waste. |

It is suggested from the interviews that primary (on-farm) seemed to be the stage where there was substantial food waste because of produce standard and specification set by the markets.. It should be noted here that household, hospitality, and institutional are beyond the scope of the present study.

### 2.2. Causes of waste

The interview participants observed that there were a number of factors which can be causes of horticultural waste. It is suggested from the findings that the causes of wastes mentioned are associated with all nine categories of common causes of horticultural waste/loss discussed presented in main body of the report (Section 5.2). As revealed in the participants' discussion, root causes are summarised in Table A2.5.

*Table A2.5: Common causes of horticultural loss/waste as observed by interview participants.*

| Classification of root causes | Description |
|---|---|
| ***Characteristics of perishable products*** | ▪ Some horticulture varieties are very soft, can ripe quickly, and are easily damaged.<br>▪ Fresh food is not stable and has short storage/shelf life (especially if the product is cut).<br>▪ Time from paddock to plate is short, especially when the product ripening is not controlled, and when it is impacted by temperature changes. |
| ***Product issues during production*** | ▪ Flushes of peas, papaya/ banana full moon peaks, that made the product outputs inconstant and unaligned to demand or expectation.<br>▪ The product is attacked by diseases/pests (insects, grubs, birds). |
| ***Weather issues*** | ▪ Unexpected weather events such as floods, droughts, cyclones, cold/hot temperature, or sunlight occur. |
| ***Pandemic issues*** | ▪ The pandemic caused changes in shopping arrangements and a drop in demand. |
| ***Overproduction*** | ▪ Most food waste occurs by planting too much in the first place.<br>▪ There are not enough disincentives for planting too much. |
| ***Inappropriate agronomic practices*** | ▪ Poor management of diseases, pests or nutrition that damage the crop.<br>▪ Choosing the wrong varieties or the place to grow the product, that reduce the product quality and increase risks. |
| ***Improper product handling*** | ▪ Sometimes the product can be damaged by people on the farms, in the sheds, during transporting products, or in supermarkets due to bad techniques or poor timing.<br>▪ Poor storage, temperature control, or transport in the cold food chain. |
| ***Labour force issues*** | ▪ On the farm: Lack of staff availability and variability, excessive cost of labour, workforce turnover and transience, lack of staff with skills/experience, and lack of staff training, that leads to the crop being left behind, damaged or inappropriately graded or packed.<br>▪ In the supermarket: Workforce transience & age and rostering models can make staff unconfident in the displaying and handling of horticulture products. |

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| ***Limited vertical integration in the supply chain*** | ▪ There can be lots of entities hands involved in the product in the supply chain, but the role and responsibilities of each entity in the chain are limited/unclear. |
| ***Aesthetic/quality standards and specifications*** | ▪ Retailers believe that consumers have high aesthetic and quality standards. So, they require these from growers (and other supply chain entities). As a result, substandard product is rejected on farm, or in packing/grading, or retail.<br>▪ Specifications look for uniformity in produce.<br>▪ Product expectations in Australia are currently too high over a long period of time. People are looking for 'perfection' and buying on appearance not necessarily taste or nutrition. |
| ***Market issues*** | ▪ There is not clear and transparent information about supply and demand.<br>▪ Market fluctuation occurs due to weather, fashion, marketing, retailers' specification and price policies, or grower behaviours. |

## 3. Recommended strategies and interventions for reducing waste

### 3.1 Constraints to reducing food waste

During the conversations, the interview participants randomly mentioned different issues and constraints in efforts of preventing and managing horticultural waste. These constraints need to be considered, as interventions for addressing the constraints may be seen as important strategies for eliminating root causes of food waste. Some of the typical constraints are described in Table A2.6.

*Table A2.6: Constraints in preventing and managing horticultural waste, as observed by interview participants.*

| Constraint | Brief description |
|---|---|
| **Unclear definition of food waste** | - Sometimes it is difficult to determine whether a kind of horticultural products/parts of the products is food waste or not, for example: banana or melon skin, melons that are grown as super propagators and were not intended to be consumed by human, produce that for some reasons does not meet food safety, etc. |
| **Lack of infrastructure and capital** | - There is not enough infrastructure to further process or value-add mass of food waste (e.g., logistics which growers can approach, or processing facilities/distribution centres proximate to the waste). This is due to many reasons, such as the wide distribution of horticultural production in different Australian regions (including regional areas), that makes it expensive to build infrastructure for waste management in all regions.<br>- Major capital investment is needed to develop this infrastructure which should operate via a profitable business model. However, innovation is often expensive, and capital is often tight. With interest rates increasing, funding for waste reduction strategies may be low. |
| **Lack of reliable data and information** | - There is a shortage of reliable data on food waste at different supply chain stages. Collecting food waste data can be expensive and resource intensive.<br>- Direct grower-to-supermarket relationships and confidential supply agreements have reduced the transparency and openness of information.<br>- There is a lack of research evidence for decision and policy making.<br>- People may be reluctant to disclose honestly due to risks of embarrassment or blaming. |
| **Lack of collaboration, consistency and responsibilities** | - Some do not have knowledge or the food supply chain or are not inclined to collaborate with others, being afraid of losing their competitive advantages in a competitive environment. Cooperation is difficult where self-interest is concerned.<br>- There is sometimes a culture of "not my problem" occurring in the food supply chain.<br>- It is not clear about who actually owns the crop (farmer or retailer).<br>- There is no consistency in dealing with food rescue options e.g., Food Bank Qld does things differently to Food Bank National and Foodbank NSW, that makes it difficult for the supply chain to support them. |

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| **Power imbalance and market control** | - There is a power imbalance between growers and retailers (is supermarkets).<br>- There are not enough regulations to build a free horticultural market.<br>- We are in a sector that is powered by driving prices down rather than driving quality up. |
| **Waste transition risks and paradoxes** | - Some growers recognise improved financial benefit (or other incentives) of utilising their waste for human consumption, but are reluctant to do that as there may be risks in transiting to alternative uses of waste.<br>- Disposal of excess food waste on farm is fairly cost effective and good for the farm soil. Other waste management options are more costly for growers. Thus, the food waste system needs to be a nil cost to growers. |

Most of strategies and interventions discussed by the interview participants focus on **prevention** – the most preferred approach in the food waste hierarchy. It is suggested from Table A2.7 that the participants mentioned all the six potential interventions suggested in the Literature Review of Horticultural Waste (see Appendix 1), including *encouraging sustainable and effective farming*, *preventing food surplus*, *applying new agricultural technologies*, *encouraging vertical collaboration among supply chain entities*, *forecasting product supply and demand*, and *establishing common principles of product qualities*.

They, in addition, suggested some additional interventions which are mainly about **prevention**, although a few of them also mentioned interventions related to **recovery** of and **recycling** waste. These include *providing better education and training, utilising superfluous and imperfect food*, *improving food chain management*, and *effectively dealing with waste*. The participants did not discuss strategies and interventions associated with the **disposal** approach. This is understandable, as disposal is the least preferred approach in the waste hierarchy. The strategies and interventions recommended by the participants, however, do not necessarily aim to address all causes of waste mentioned in Section 2.2.

*Table A2.7: Potential strategies and interventions for reducing food waste as suggested by interview participants*

| Approach | Strategy/ intervention | Examples |
|---|---|---|
| Prevention | *Encouraging sustainable and effective farming* | - Encouraging producers to do crop breeding to provide products which are closer to specifications, less prone to damage, or have longer shelf life.<br>- Exploring protective cropping (ie glasshouses and vertical growing) to enable greater control over the growing environment. This is usually more viable with high return crops. |
| | *Preventing food surplus* | - Encouraging planned production among producers, that means, growing only what they can sell, less speculative growing, and more alignment between demand forecasting and what is grown. |
| | *Applying new agricultural technologies* | - Monitoring and improving the cold food chain using temperature bar codes.<br>- Studying and applying different ripening or shelf-life extension technologies to address the issue of short-shelf life.<br>- Exploring and applying technologies in picking and packing products.<br>- Using big data, internet of things, and sensors/drones etc. to manage and monitor the health and growth of crops. |
| | *Forecasting product supply and demand* | - Increase demand for horticultural products in both domestic or export markets by educating people about health benefits associated with fruits/vegetables, and promoting Australian brands with clean, green, healthy, and high-quality products.<br>- Building a data driven approach for forecasting consumer demand. |

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|---|---|---|
| | *Establishing common principles of product qualities* | - Streamlining and uniforming the chain processes and product expectations across state boundaries.<br>- Harmonising jurisdictional expectations of import/export products. |
| | *Utilising superfluous and imperfect food* | - Branding and selling second-grade products to consumers at a lower price.<br>- Addressing barriers in relation to food rescue and donations, (e.g., accessibility and efficiency, connection between local food-rescue with local communities, leadership).<br>- Encouraging meal plans and partnering with other bodies/organisations to increase the use of fresh produce in their offering (e.g., Hello Fresh).<br>- Organising partnerships between markets and processing facilities to take any oversupplied or second-grade products.<br>- Using the product as animal food.<br>- Producing alternative kinds of food via value-adding or further processing: freezing/drying food, making jam, juice or flour, extracting nutrition for inclusion in other foods, or making cream, cosmetic or pharmaceutical products. |
| | *Encouraging collaboration among supply chain entities and improving chain management effectiveness:* | - Reviewing crop packaging to minimise damage in transporting and storing products.<br>- Reviewing the product use of use-by dates<br>- Taking leadership in the product and waste management (especially the industry).<br>- Increasing responsibility, ownership, and accountability in in terms of information sharing and power distribution.<br>- Following the waste hierarchy in preventing and managing waste, i.e., first giving priority to human consumption.<br>- Building networks and more holistic and collaborative food supply chains, using an integrated systems approach.<br>- Building grower collaboration to make food rescue options more viable.<br>- Tax/other incentives for good practices, considering that carrots are better than sticks. |
| Recycling and Recovery | *Effectively dealing with waste* | - Centrally locating processing facilities to take waste from a range of growers to achieve critical mass and consistent supply of the product.<br>- Using waste as fertiliser.<br>- Converting waste to energy |

# Appendix A3. Workshops 1-3: Key findings

## 1. Introduction

This appendix summarises findings from stakeholder workshops (Data Collection Phase II) about horticultural food waste hotspots, root causes, solution and prioritise solutions.

### 1.1 Stakeholder workshops

The purpose of stakeholder workshop was to collect information about food waste across the horticultural supply chain and identifying key hotspots and root causes for food waste. The solution identification and developing action plan was also the purpose of the workshops. Based on the key findings from the stakeholders' interviews, the research team collectively design three workshops with End Food Waste Australia (EFWA) experts. The same group of stakeholders attended in the consecutive three workshops. key findings from the interviews (Appendix 2) were discussed in Workshops 1 and 2 to identify key hotspots, root causes and then Workshop 3 is utilised for shortlisting the solutions. All the workshops were conducted online via Zoom. The first workshop was organised in February 2023, while the second and third workshop were held on March and May of 2023.

### 1.2 Tools for stakeholder engagement

The workshops were facilitated by the research team and the stakeholders were engaged in open floor discussion and group tasks in the breakout rooms. The data collection process was approved by the CQUniversity Human Research Ethics Committee. The stakeholder panel was formed with the consultation with the End Food Waste Australia (EFWA) experts and named as Project Advisory Group (PAG). The PAG members attended all three workshops. A list of the workshop participants is presented in Table A3.1.

*Table A3.1: Workshop participants groups*

| Participant group | Number of participants | | |
|---|---|---|---|
| | 1st Workshop | 2nd Workshop | 3rd Workshop |
| Industry representative | 4 | 5 | 5 |
| Retailer representative | 1 | 2 | 2 |
| Government representative | 2 | 3 | 3 |
| Producer representative | 2 | 1 | 1 |
| Researcher representative | 1 | 1 | 0 |
| Processor representative | 1 | 1 | 0 |
| Marketer representative | 2 | 2 | 1 |
| Distributor representative | 1 | 1 | 0 |
| **Total** | **14** | **16** | **12** |

Prior to each of the workshop, the facilitators introduced themselves and discussed the purpose of the project and requested permission to record the conversation. Workshop discussion's themes focused on horticultural food waste, hotspots, root causes and strategic actions. The following tools (Table A3.2 - A3.4) were used for collecting data during the stakeholder workshops.

*Table A3.2: Workshop 1 Runsheet and activities*

**Workshop 1: Horticulture Sector Waste Hotspots Analysis**

**Time, day and date:** 10am to 12pm, Wednesday 8 February 2023.

**Venue: Online (Zoom)**

**Facilitators**: Prof. Delwar Akbar (DA), Prof. Hurriyet Babacan (HB), Ms. Margaret Marty (MM), Carolyn Cameron (CC), and Melissa Smith (MS)

**Technical Support**: Dr. Azad Rahman (AR)

**Focus of the workshop**:

- Identify where are the hotspots in food waste in the horticultural sector across different stages of the supply chain?
- What are the causes of horticultural waste?
- What measures do organisations have in place to stop/minimise horticultural waste?
- Triangulation of findings from interviews

**CONTEXT NOTES**:

There will be three workshops with the participants during the project. This one focuses on hotspots and primary causes. The second one on root causes analysis includes causes beyond the apparent causes, measures, good practice and what is and is not working. The third one is to test the proposed solution and ideas in the draft strategy.

| Time | Key activity | Facilitator/s |
|---|---|---|
| 10.00 | • Opening & Welcome & Acknowledgements | DA |
| 10:05 | • Introductions including facilitators | HB & MM |
| 10.10 | • About the project<br>• Introduce structure of workshop | MS/CC |
| 10.15 – 10.30 | **Zoom Poll**<br>1.How are you involved in the horticultural industry?<br>• Primary production<br>• Grading and packaging<br>• Manufacturing<br>• Distribution<br>• Retail or Wholesale<br>• Industry body<br>• Government<br>• All of the above<br>• Others<br>2.What % (approximately) is there food waste in your operations or in the part of industry you work in (multiple choice –<br>• <10%,<br>• 11-30%<br>• 31-50%<br>• >50%<br>• Do not know<br>3. How urgent do you think it is to address food waste in the horticultural industry?<br>• Extremely urgent<br>• Very urgent<br>• Urgent<br>• Fairly urgent<br>• Not urgent<br>• Do not know<br>4.Is your organisation aware of the main sources of food waste within the agency?<br>• Fully aware<br>• Aware<br>• Fairly aware | HB & AR |

| | | |
|---|---|---|
| | • Vaguely aware<br>• Not aware at all<br><br>5. Are there measures/strategies in your organisation to address food waste that you are aware of:<br>• Extensive policy and measures<br>• Some limited measures<br>• Planned or potential measures being investigated<br>• No measures<br>• Do not know<br>6. Do you think these measures are effective<br>• Exceptionally effective<br>• Very effective<br>• Effective<br>• Somewhat effective<br>• Not effective<br>• Do not know<br><br>Share the results of the poll back with participants | |
| 10.30-11.00 | Where are the potential food waste hotspots in the horticultural industry?<br><br>**Tease out:**<br>• Flows of activity across the horticultural value chain (production, packaging and processing, wholesale, retail)<br>• What is the evidence/data for food waste in your work- how do we know.<br>• What data will be helpful to have (gaps in knowledge about hotspots)<br><br>Mentimeter tool and discussion by participants | MM & HB |
| 11.00-11.30 | What are the causes of food waste in the horticultural industry – group discussion- walk across value chain.<br>What are some of the causes food waste in:<br>• Production-farm level (pest, disease, price and market factors, produce damage, buyer specification)<br>• Processing, manufacturing and packaging (trimming, contamination, buyer specification, spilling)<br>• Distribution (refrigeration, temperature control, transport)<br>• Wholesale marketing<br>• Retail<br>• Household<br>• Other<br><br>What are factors impacting food waste<br>i) within your control or ii) out of your control | HB |
| 11.30-12.00 | What type of measures are organisations putting in place to:<br>• Stop food waste<br>• Reuse food waste<br>Concluding the workshop with key summary and updates on next workshop. | HB & DA |

*Table A3.3: Workshop 2 Runsheet and activities*

**Workshop 2: Horticulture Sector Waste Root Causes Analysis**

**Time, day and date:** 10am to 12pm, Wednesday 15 March 2023.

**Venue: Online (Zoom)**

**Facilitators**: Prof. Delwar Akbar (DA), Prof. Hurriyet Babacan (HB), Ms. Margaret Marty (MM), Carolyn Cameron (CC), and Melissa Smith (MS)

**Technical Support**: Dr. Azad Rahman (AR)

**Focus of the workshop**:

- To confirm findings about hotspots in food waste in the horticultural sector across different stages of the supply chain
- What are the causes of horticultural waste?
- What are the measures that will help food waste in the horticultural sector?

**CONTEXT NOTES**:

There will be three workshops with the participants during the project. This one focuses on root causes and measures. The third one is to test the proposed solution and ideas in the draft strategy

| Time | Key activity | Facilitator/s |
|---|---|---|
| 10.00-10.10 | INTRODUCTION<br>• Opening & Welcome & House keeping<br>• Acknowledgement of Country<br>• Introduce participants<br>• Introduce Facilitators<br>• Quick recap on the project (Grower groups rather growers due to high level overview, not whole source of group, this is input from stakeholders)<br><br>Introduce the structure of the workshop | DA<br><br>HB |
| 10.10-10.25 | Summary of hotspots/root causes findings from literature, interviews and Workshop 1 | HB & MM |
| 10.25-11.00<br><br>11.00-11.10 | Breakout rooms – what are the root causes – walk across chain (HB & MM to facilitate)<br>Breakout by theme/supply chain:<br>1. Production and processing (MM)<br>2. Distribution (transport and logistics) & Market (retail and wholesale) (DA & MS)<br>Prompts (**pick a participant report back person**)<br>• What are roots causes of food waste (in hot spots priority and other)<br>• Why does waste occur (prompt for key issues)<br>• What is in their control and not<br>• Symptoms and deeper reasons (whys)<br>• Safety considerations<br>• How do actions at producer/retail end impact on each other- inter-relationships<br><br>Report Back on what are the key root causes | HB, MM, DA, AR<br><br>HB/MM |
| 11.10-11.45 | What strategies can be adopted to stop food waste in horticultural industry –<br>i) Walk across value chain: | HB/MM |

| | | |
|---|---|---|
| | • Production-farm level<br>• Processing, manufacturing and packaging<br>• Distribution<br>• Wholesale markets<br>• Retail (waste minimisation, consumer awareness, storage)<br>• Other<br>ii) Specific issues<br>• Overproduction and market demand<br>• Specifications<br>• Workforce availability<br>• Price factors (transport, other costs, per unit price of good)<br>• Packing<br>• Transport<br>• Weather<br>iii) What can be recovered/recycled?<br>iv) Who should play what role in food waste minimization (i.e. who is responsible for which part)<br>v) What time frames (short and long term) strategies<br><br>Now-quick wins, must do, impact, don't worry about longer term | AR |
| 11.45-12.00 | Concluding the workshop with key summary and updates on next workshop. | DA & MM |

*Table A3.4: Workshop 3 Runsheet and activities*

**Workshop 3: Horticulture Sector Waste reduction strategies**

**Time, day and date:** 10am to 12pm, Wednesday 10th May.

**Venue: Online (Zoom)**

**Facilitators**: Prof. Delwar Akbar (DA), Prof. Hurriyet Babacan (HB), Ms. Margaret Marty (MM), Carolyn Cameron (CC), and Melissa Smith (MS)

**Technical Support**: Dr. Azad Rahman (AR)

**Focus of the workshop**:

- To confirm findings about hotspots in food waste and the root causes in the horticultural sector across different stages of the supply chain
- Identifying solution to reduce food waste.
- Developing Horticulture sector action plan to reduce food waste.

**CONTEXT NOTES**:

1. A long list of solutions from the triangulation of key findings- by the research Team
2. Analysing and selecting the solutions- by the research team & SFWA (Melissa & Caroline- information sharing & feedback) [Criteria: volume, finance, complexity and feasibility- who and when to implement, timescale- quick wins, medium term and longer term, indicator of success]
3. Prioritising solutions: Rank them 1 to 5, (by the participants)
4. Application of the indicative MERI framework- performance criteria or how much likely food waste can be reduced.

| Time | Key activity | Facilitator/s |
|---|---|---|
| 10.00 -12:00 | INTRODUCTION<br>• Opening & Welcome, Acknowledgement to Country & Housekeeping (note the workshop is being recorded, use of chat function and hands up icon) | DA |

<table>
<tr><td>10.15am</td><td>• Introduce other Facilitators.<br>• Overview of workshop<br>• Introduce MS/CC to discuss:<br>✓ the competition statement,<br><br>Introduce the structure of the workshop</td><td>CC/MS<br><br>HB</td></tr>
<tr><td>10.15-10.40</td><td>1. Key findings (through a method of triangulation) (MM)<br>2. Action Plan Process (HB)<br>3. What we found so far (MM)<br>4. Shortlisting of solutions (HB)<br>5. Action Planning outcomes</td><td>HB & MM</td></tr>
<tr><td>10.40-11.50</td><td>Group activities<br>1. Ranking the solution<br>2. Prioritizing solution.<br><br>Tools for group activities.<br><br>1. A long list of solutions<br><br>
<table>
<tr><th>Strategic food waste issue & description</th><th>Hotspot(s) relating to</th><th>Solutions</th><th>Remark (research group)</th></tr>
<tr><td><u>Systematic:</u><br>a. Workforce<br>b. production system<br>c. market and pricing mechanisms<br>d. industry standard</td><td></td><td>1.<br>2.<br>3.</td><td></td></tr>
<tr><td><u>Policy and Regulatory</u><br>specification, accreditation, harmonisation (between the jurisdiction), reporting and compliance mechanisms, food safety standard</td><td></td><td></td><td></td></tr>
<tr><td><u>individual behaviour level</u><br>culture of production, knowledge and capacity, awareness</td><td></td><td></td><td></td></tr>
</table>
<br>2. Short listed solutions (three tables by time frame)<br><br>
<table>
<tr><th>Strategic food waste issue & description</th><th>Hotspot(s) relating to</th><th>Short listing solution based on four criteria</th><th>Who</th><th>When (time frame)</th><th>Expected outcome</th><th>Indicator of success</th></tr>
<tr><td rowspan="3">Workforce:</td><td rowspan="3"></td><td>1.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
<br>3. Prioritisation criteria<br><br>
<table>
<tr><th>Criteria</th><th>Description</th></tr>
<tr><td>1. Food waste volumes (and perishability)</td><td>Prioritise solutions that tackle large volumes of food waste. When evaluating performance against this criterion, consider whether the initiative is likely to reduce overall food waste, or just displace the issue (i.e., moving the food waste from one point in the value-chain to another).</td></tr>
</table></td><td>HB & MM</td></tr>
</table>

| | | | |
|---|---|---|---|
| | 2. Food recovery hierarchy | Prioritise solutions that move waste further up the hierarchy. For example, prioritising measures that 'prevent' food waste over initiatives that 'recycle' food waste. | |
| | 3. Replicability | Prioritise solutions that are applicable across the wider industry (rather than an individual organisation). | |
| | 4. Technical feasibility | Prioritise solutions that are low-tech and/or have been demonstrated to work elsewhere (rather than bleeding edge initiatives). | |
| | 5. Financial feasibility | Prioritise solutions that are likely to result in a positive financial return, based on industry experience with similar initiatives. | |
| | 6. Complexity | Prioritise solutions that are less complex to implement. including the number of stakeholders required to drive the change, alignment with existing policies/ legislation, etc. Also consider complexity within individual organisations to implement solutions given constraints (e.g., staff availability). | |
| | 4. Prioritisation of the solutions<br>• By three tables based on quick win, mid-term and long term. Ask them to rank 1 to 10/ by category of strategy [**systemic** (e.g., workforce, production system, market and pricing mechanisms, industry standard), **policy and regulatory** (e.g., specification, accreditation, harmonisation (between the jurisdiction), reporting and compliance mechanisms, food safety standard), **individual behaviour level** (e.g., culture of production, knowledge and capacity, awareness)]<br>• Choose top three from each group.<br>• Then discuss them about their feasibility. | | |
| 11.50-12.00 | Concluding the workshop with key summary and updates on report submission. | | DA & MM |

## 2. Key findings

### 2.1. Horticultural waste hotspots

In this section, horticultural waste hotspots are discussed referring to FIAL's (2021) seven main points of food waste for these sub-sectors across the supply chain, including: Primary, Processing, Distribution, Retail, Household, Hospitality and Institutional. The workshop participants suggested that waste could occurs at all stages however the volume can vary. It was widely agreed that on-farm (production/harvesting/ grading & packing) is the biggest source of food waste followed by retail and distribution centre. Table A3.5 provides a summary of the participants' observation of horticultural waste in Australia:

*Table A3.5: Workshop participants' observation of horticultural waste across supply chain stages.*

| Supply chain stage | Percentage of waste | Comments |
|---|---|---|
| On farm - growing and harvesting | • 26-40 %<br>• 16%- 25% | Depends on which product, given the wide variety of products |
| On farm/ shed - grading, packing | • 16%- 25%,<br>• 6% - 15% | |
| At retailer +<br>At the market, warehouse or the distribution centre | • 16%- 25%,<br>• 6% - 15% | |

### 2.2. Causes of waste

The interview participants observed that there were a number of factors which can be causes of horticultural waste. It is suggested from the findings that the causes of wastes mentioned are associated with all nine categories of common causes of horticultural waste/loss discussed in the literature review section. Table A3.6 provides a summary of the participants' observation of horticultural waste root causes.

*Table A3.6: Common causes of horticultural loss/waste as observed by workshop participants*

| Classification of root causes | Description |
|---|---|
| ***Characteristics of perishable products*** | ▪ Products have short shelf life and some are already old when received by retailers.<br>▪ Damage during production (marked products). |
| ***Weather issues*** | ▪ Unexpected weather events such as floods, droughts, cyclones, cold/hot temperature, or sunlight occur.<br>▪ Weather conditions (e.g., floods, cyclones, droughts, hail, heat, La Nina, climate change more frequent and more severe weather) |
| ***Planting environment*** | ▪ Planting places, regionality, soil conditions, nutrition, water.<br>▪ ***Attack by*** pests (flies, birds, disease, bugs), disease, or abiotic stresses<br>▪ **Peak season:** At certain times of year when the product is oversupplied, and this is because natural growth cycle of the of the plant. |
| ***Overproduction*** | ▪ Poor production planning: Growers in the same region growing same crops, doing the same thing, planting it roughly the same time.<br>▪ Systematic over- production (over growing, maximising yield per acre) in order to ensure meeting customer specifications and order volumes.<br>▪ Producing massive amounts of the product and it's uneconomic to harvest at that time.<br>▪ There's grower behaviour/ grower management capability (growers might not be managing the crop optimally. |
| ***Inappropriate agronomic and management practices*** | ▪ There are preharvest agronomic factors<br>▪ There is no "whole of crop" harvest strategy.<br>▪ Harvest inefficiency that damage produce in field due to skill levels of labour undertaking harvesting and picking up.<br>▪ The product is over-ordered by stores, that leads to market oversupply. |
| ***Improper product handling*** | ▪ Product damage due to cracking, damage through trims due to skill levels of labour undertaking packing, grading, sorting, and stock handling<br>▪ Packing for fresh only.<br>▪ Poor shelf-life management and cold chain practices (e.g., uncontrolled/failed ripening processes, the variability/inconsistency in level of refrigeration control creating significant risk to shelf life decline of fresh produce, in the transportation and logistics and delivery, the product can sit at outside refrigeration in some commodities for quite long periods of time, Product shock through the transport process leading to shortened shelf life, products out in open at markets for hours and then be downgraded).<br>▪ At retails: poor rotation practices, poor store compliance and stock presentation<br>▪ Customer mishandling in store. |
| ***Infrastructure issue*** | ▪ Wholesalers do not have space to physically store the produce for long periods.<br>▪ Lack of cold chain infrastructure. |
| ***Labour force issues*** | ▪ Lack of labour in terms of availability/performance, high labour cost. |
| ***Limited vertical integration in the supply chain*** | ▪ Lack of knowledge about the product shelf life, and the value of the product in the biomass if transformed.<br>▪ Lack of compositional and quality data, |

| | |
|---|---|
| | ▪ Lack of systematic management so all staff involved in those processes understand and follow the rules. |
| ***Aesthetic/quality standards and specifications*** | ▪ Continued compliance requirements (e.g., ethical growth and harvesting, ethical sourcing, fresh care, etc) putting more pressure on growers.<br>▪ Specific product requirements set by retailers.<br>▪ Different requirements at different state borders<br>▪ Minimum Life on Receipt (MLOR) requirements at warehouses<br>▪ Food safety requirements for cut/processed products.<br>▪ Consumer expectations of produce visual.<br>▪ Other grading and quality control issues. |
| ***Contract farming*** | ▪ There are farming/supply contracts and commercial arrangements between retailers, growers and others, and they need to fully fill the particular order.<br>▪ There is market power imbalance among retailers, growers, buyers. |
| ***Market issues*** | ▪ Price fluctuation/variance due to a supply and demand mismatch.<br>▪ When the price of the product is lower it's simply just not viable to pick.<br>▪ When there is an undersupply in the market and gaps in the shelves and this often attracts media attention.<br>▪ Growers are planting without a plan, a particular customer or a market outcome in mind for that product. However, there's a lot of variables that can come into play between when that crop goes into the ground and when it actually goes to market.<br>▪ Consumer driven selling: Consumer behaviour is unpredictable due to many reasons such as changes in cost of living, COVID lockdowns, buying online. High price may lead to low consumption.<br>▪ Lack of market opportunities or no alternative market for out of spec products. |

## 3. Recommended strategies and interventions for reducing waste

Most of strategies and interventions discussed by the interview participants focus on **prevention** – the most preferred approach in the food waste hierarchy. Table A3.7 represents the list of interventions suggested by the workshop participants.

*Table A3.7: Potential strategies and interventions for reducing food waste as suggested by workshop participants*

| Strategy/ intervention | Examples |
|---|---|
| Applying new agricultural technologies | - Having support tools for growers such as farm management software, thermal processing technologies, or new technologies for air dried chips of fruit and veg commodities. |
| Forecasting product supply and demand | - Providing forecasting tools, market analysis options<br>- Making plans and forecasts about the market with direct suppliers<br>- Ensuring market price transparency: better information what prices are being paid in other markets by other buyers will allow growers to make better decisions about other options they might have for their produce. |
| Establishing common principles of product qualities | - Reviewing product specifications<br>- Having an interstate certification agreement (e.g., in terms of biosecurity) to streamline the movement of fresh produce across different state barriers. |

| | |
|---|---|
| Providing better education and training | - Investing in and providing consumers with education about produce quality to shift their sentiment and preference of buying products. There should be strategies for changing consumers' behaviour at the national level (such as increasing vegetable consumption). |
| Weather forecasting | - Providing longer-term weather forecast to growers. |
| Utilising superfluous and imperfect food | - Building food rescue programs: organising regional food waste hubs, providing more financial and tax incentives to donating and using surplus food<br>- Processing un-used food to product high-valued products (e.g., fried fruits and chips/snacks, fruit and veggie powder, pre-biotic/functional fruit and veggie), and ensuring market access for such products. |
| Encouraging collaboration among supply chain entities and improving chain management effectiveness | - Building good relationships with marketing companies, direct suppliers, retailers, working together, and building production plans.<br>- Working with the carriers to improve the cold chain.<br>- Enhancing communication and improving information flow across the supply chain, that allows better data driven grower coordination and supply chain optimization.<br>- Investing in infrastructure and exploring additional processing and facility opportunities (such as on farm processing, distributed processing, centralized facilities, cross commodity processing facilities)<br>- Ensuring labour availability.<br>- Providing growers with more support in terms of financing, engaging with investors and the food industry, looking for alternative markets, and production feasibility.<br>- Having more government funding, tax incentives and support for food waste research, whole crop purchase, and different market arrangements for various-grade products. |
| Measuring and evaluating food waste | - Having consistent definitions of food waste, waste classifications, and waste and loss measuring standards, so data can be compared and measured.<br>- Measuring volumes of waste to have accurate waste quantification and root causes of waste.<br>- Providing better data on root causes of losses and waste - e.g., harvesting damage, pests and diseases, grade out, cold chain losses, MLOR rejection, etc.<br>- Providing incentives that motivate supply chain actors to measure waste<br>- Ensuring commitment from all entities in the supply chain in measuring waste (e.g., growers can do actual measurement of waste on farm by using quadrants to sample field crop losses post-harvest, growers can audit estimates of food waste in farm using management software, packhouses can measure waste volume by product; retailers and wholesalers can anonymously share waste information in an aggregated commodity database).<br>- Having policies that ensure supply parties to measure and quantify food waste in terms of quantity, quality and location.<br>- Encouraging market- or investor-driven waste upcycled products. |

## 4. Triangulation of the key findings

Three data collection tools (i.e., literature review, stakeholder interviews, and workshops) were concurrently applied to gather data and information about horticultural waste stages/hotspots, (root) causes of the waste, and key interventions and strategies that can reduce food waste across horticultural supply chains in Australia. A triangulation of the findings gathered from the literature review, interviews and workshops was conducted to validate and confirm information related to waste stages/hotspots, (root) causes of waste, and potential strategies/interventions for reducing horticultural waste in Australia. Key findings from the literature review

(secondary data), interviews and workshops were summarised and presented in Appendix 1, 2, and 3. Table A3.8 was prepared based on the common findings for all three data sources. This triangulation validated the findings and proposed action plan.

*Table A3.8: Key common findings for strategies and innovation from the triangulation of three information sources*

| Area of inquiry | Specific item | Source 1: Literature review | Source 2: Interviews | Source 3: Workshops |
|---|---|---|---|---|
| **Strategies and interventions** | - ***Encouraging sustainable and effective farming***: such as crop breeding to provide products which are less prone to pests and damage; or exploring protective cropping to enable greater control over the growing environment, etc. | √ | √ | √ |
| | - ***Preventing food surplus***: such as working together to build production plans; encouraging growers to produce what they can sell only; providing growers with more production feasibility, etc. | √ | √ | √ |
| | - ***Applying new agricultural technologies***: such as having support tools for growers, picking and packing processing technologies, or new technologies for new processed products, etc. | √ | √ | √ |
| | - ***Encouraging collaboration among supply chain entities and improving chain management effectiveness***: such as building networks and collaborative food supply chains; enhancing chain information flow; or more governmental support, etc. | √ | √ | √ |
| | - ***Forecasting product supply and demand***: such as providing forecasting tools and market analysis options; or building a data driven approach for forecasting consumer demand, etc. | √ | √ | √ |
| | - ***Establishing common principles of product qualities***: such as uniform supply chain processes and product specifications across state boundaries, etc. | √ | √ | √ |
| | - ***Providing better education and training***: such as sharing information about farming, handling and processing practice; or organising promotional campaigns about food waste and food behaviours, etc. | √ | √ | √ |
| | - ***Utilising superfluous,imperfect and surplus food***: such as addressing barriers in relation to food rescue; having processing facilities to take any oversupplied products and create new value-adding products, etc. | √ | √ | √ |
| | - ***Effectively dealing with waste***: such as centrally locating processing waste facilities; or using waste as fertiliser, etc. | √ | √ | |
| | - ***Weather forecasting***: such as providing longer-term weather forecast to growers, etc. | √ | | √ |
| | - ***Measuring and evaluating food waste***: such as having consistent definitions of food waste, and measuring standards; or providing better data about waste and root causes of waste, etc. | √ | | √ |

# Appendix A4. Stakeholder engagement plan

International best practice standard for stakeholder engagement is provided by the International Association of Public Participation, IAP2. Their frameworks and guidance have informed effective stakeholder engagement for over twenty years. Allocation of stakeholders to the IAP2 Stakeholder Spectrum illustrates the impact and influence of the stakeholder on the Project. The IAP2 promise indicates the type and focus of engagement. These are matched with tools and initiatives for delivering effective stakeholder engagement.

Table A1: Stakeholder Engagement Plan to support the Horticulture Sector Food Waste Action Plan

| | | | |
|---|---|---|---|
| **Project name** | Stakeholder Engagement Plan to support the Horticulture Sector Food Waste Action Plan | **Commencement Date:** | December 2022 |
| **Impact** | Stakeholder impact increases along the spectrum | | |

| **INFORM** | **CONSULT** | **INVOLVE** | **COLLABORATE** | **EMPOWER** |
|---|---|---|---|---|
| **Promise:** | **Promise:** | **Promise:** | **Promise:** | **Promise:** |
| We will keep you informed. | We will keep you informed, listen to and acknowledge concerns and provide feedback on how your input influenced the decision. | We will work with you to ensure that your concerns and aspirations are directly reflected in the identification of root causes and provide feedback on how your input influenced the decision | We will look to you for direct advice and innovation in formulating solutions (strategies/actions) and incorporate your advice and recommendations into the decisions to the maximum extent possible. | We will implement what you decide. |
| **Stakeholders:** | **Stakeholders:** | **Stakeholders:** | **Stakeholders:** | **Stakeholders:** |
| • Relevant government departments<br>• Rural and food media | • SFWA and FFW CRC partners<br>• RDCs<br>• ARC<br>• Transport Industry Assoc<br>• Wholesalers/retailers | • Transport/logistics/wholesale Companies<br>• Food Retailers<br>• Hort Innovation<br>• QDES | • The Project Advisory Group (PAG)<br>• Major Food Retailers such as Coles & Woolworths<br>• Horticulture wholesalers<br>• Horticulture growers<br>• Major horticulture farmers/corporate operators. | • SFWA / FFW CRC<br>• Hort Innovation<br>• Horticulture growers |

| | | | | |
|---|---|---|---|---|
| | | | • Known expert in this area (if there is one) | |
| **Tools:** | **Tools:** | **Tools:** | **Tools:** | **Tools:** |
| • Website<br>• Information updates<br>• Media release | • Website<br>• Information updates<br>• Sharing information - being told what's happening with option to respond. | • Website<br>• Information updates<br>• Share drafts with clear pathway to respond (could include topical workshops if sufficient interest?) [1] | • Advisory meetings<br>• Agreement on Design Principles<br>• Co-Design workshops<br>• Initial Review of Drafts<br>• Collaboration in developing collateral for others in supply chain. | Board Briefings<br><br>Co-Design workshops |



[1] CONSULT & INVOLVE – if a stakeholder interested, with good advice – can move within the Spectrum, e.g., some SFWA partners may seek higher engagement.