

Banana Industry Sector Action Plan for Food Waste Reduction 2024

Technical Report



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



Acknowledgements

This research has been supported by End Food Waste Australia (EFWA), whose research activities are funded by the Australian Government's Cooperative Research Centre (CRC) Program, and Sector Action Plans Program is funded by the Australian Government's Department of Climate Change, Energy, Environment and Water, in conjunction with Central Queensland University, Royal Melbourne Institute of Technology (RMIT) University, University of Southern Queensland, and Hort Innovation's Banana R&D levy. Foundational funding for the research was provided by the Queensland Government's Recycling and Jobs Fund. We also acknowledge the in-kind support of the project's partners, research, and industry participants.

Disclaimer

The Centre for Regional Economies and Supply Chains (CRESC) of CQUniversity has made every attempt to ensure the accuracy and validity of the information contained in this document, however, CRESC cannot accept any liability for its use or application. The user accepts all risks in the interpretation and use of any information contained in this document. The views and interpretations expressed in this report are those of the author(s) and should not be attributed to the organisations associated with the project.

Project leader:

Prof. Delwar Akbar

Centre for Regional
Economies and Supply Chains
(CRESC),
CQUniversity,
Rockhampton, Qld 4702
Email: d.akbar@cqu.edu.au

Research team:

- Delwar Akbar, Margaret Marty, Hurriyet Babacan, Azad Rahman, Prem Chhetri, Kwok Hung Lau, Yujuan Li, Jeremy De Valck

Project Partners:

- CQUniversity (CQU)
- Royal Melbourne Institute of Technology (RMIT)
- University of Southern Queensland (USQ)
- James Cook University (JCU)
- End Food Waste Australia (EFWA)

This report should be cited as follows: Akbar, D., Marty, M., Babacan, H., Rahman, A., Chhetri, P., Lau, C., Li, Y., & De Valck, J. (2024). *Banana industry Sector Action Plan for Food Waste Reduction 2024: Technical report*. End Food Waste Australia, pp. 75.

Cover photo credit: Authors' own.

Table of Contents

Acknowledgements	2
Disclaimer.....	2
List of Figures.....	5
List of Tables	5
Abbreviations	6
EXECUTIVE SUMMARY	7
1. INTRODUCTION.....	10
1.1 Project Overview and Scope.....	10
1.2 Definition of Food Waste.....	11
1.3 Project Aims and Expected Outcomes	11
1.4 Project Impacts	11
1.5 Participants	12
1.6 Report Structure.....	12
2. BACKGROUND OF THE STUDY	13
2.1 The Australian Banana Industry.....	13
2.2 The Banana Supply Chain and Food Waste	13
2.2.1 Pre-harvest.....	14
2.2.2 Post-harvest.....	15
2.2.3 Warehousing.....	15
2.2.4 Retail.....	16
3. METHODOLOGY.....	17
4. FINDINGS AND ANALYSIS.....	22
4.1 Banana Food Waste and Hotspots.....	22
4.2 Root Causes	23
4.3 Root Causes of Banana Food Waste and Mitigation Opportunities: A Summary	26
5. ACTION PLAN.....	27
5.1 Banana Sector Waste Prevention and Reduction Actions	27
5.2 Roadmap for <i>Banana Industry Sector Action Plan for Food Waste Reduction</i>	38
6. MEASURING IMPACTS OF OUTCOMES	39
6.1 Towards a MERI Plan	39
6.2 Theory of Change	39
6.3 Program Logic.....	39
6.3 Indicators of Outcome and Impact.....	40
7. CONCLUSION AND FUTURE STUDY	45
References	46
APPENDICES	50

Appendix A1. Literature review: Key findings	50
Appendix A2. Stakeholder Engagement: Key findings	61
Appendix A3. Stakeholder Engagement Plan	73

List of Figures

Figure 1: Schematic map of banana producing regions in Australia	13
Figure 2: Simplified banana industry supply chain	14
Figure 3: General appearance criteria of a class one ripened Cavendish banana as per FreshSpecs	16
Figure 4: An iterative process-based WRAP methodology for food waste reduction	17
Figure 5: Horticulture specific food recovery hierarchy	18
Figure 6: Development stages of sector action plan for the banana industry	21
Figure 7: Proportion of waste in banana industry compared to other fruits and nuts	22
Figure 8: Summary of the Australian banana supply chain, waste drivers and waste mitigation opportunities	26
Figure 9: Strategies and actions in <i>Banana Industry SAP for Food Waste Reduction</i>	28
Figure 10: <i>Banana SAP</i> Implementation Roadmap	38

List of Tables

Table 1: Methods and activities for <i>Banana Industry Food Waste Sector Action Plan</i> and targeted milestones	19
Table 2: Apparent causes and root causes of banana food waste: Developed by project team based on a triangulation of key findings (literature, interviews and workshop)	24
Table 3: Indicators of outcomes and impacts	40

Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABGC	Australian Banana Growers Council
ARC	Australian Research Council
Banana SAP	Banana Industry Sector Action Plan for Food Waste Reduction
BMP	Best Management Practice
BRP	Banana Reference Panel
CQU	Central Queensland University
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSR	Corporate Social Responsibility
DC	Distribution Centre
DCCEEW	Department of Climate Change, Energy, Environment, and Water
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
FSC	Food Supply Chain
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
PRP	Project Reference Panel
QDES	Queensland Department of Environment and Science
RC	Root Cause
RDC's	Research Development Corporations
RPS	Reusable Packaging Container
SAP	Sector Action Plan
SDG	Sustainable Development Goals
SFWA	Stop Food Waste Australia
WRAP	Waste and Resources Action Program

EXECUTIVE SUMMARY

This report provides a whole-chain food waste reduction sector action plan (SAP) for the Australian banana industry to achieve halving food waste by 2030. A mixed methodologies approach, including a literature review and stakeholder engagement, was employed. The WRAP UK whole chain food waste reduction plan toolkit (WCP) was used for the development of this action plan entitled the *Banana Industry Sector Action Plan for Food Waste Reduction (Banana Industry SAP)* through a five-stage process, including initiate, plan, solution, actions, and monitoring. The review of literature and engagement with key stakeholders across the banana supply chain were designed to achieve the following:

- Identify hotspots of waste in the banana supply chain from primary production to retailing stage (i.e., before consumption). This project did not deal with consumption /household waste.
- Explore root causes of waste in the banana supply chain.
- Examine and prioritise banana waste management strategies using a food recovery hierarchy.
- Prioritise management options (i.e., proposing actions for managing waste).
- Develop a banana industry food waste sector action plan.
- Propose an outline of measuring the impacts of outcomes of this plan.

This report presents findings regarding hotspots and root causes of food waste in the Australian banana industry through triangulation of the results from a literature review, stakeholder interviews and stakeholder workshops. Through stakeholder engagement, solutions to reduce banana food waste were identified. Shortlisted strategies and actions were tested in a stakeholder workshop and are presented in this report. Finally, the report outlines indicators for assessing the impacts and outcomes of the actions using a waste monitoring and evaluation framework.

Nine strategies were identified, including four supporting preventions, two for repurposing food waste and three for the enabling environment. Multiple actions were also listed under each strategy with potential outcomes in different time frames. The identified strategies are outlined below.

PREVENTION STRATEGIES

P1. SUPPLY AND DEMAND ALIGNMENT

- ***Align banana production quantities more closely with consumer demand.***

The objective is to reduce overproduction and align supply with demand. Key actions include establishing a supply and demand forecasting mechanism, providing education on market operations, experimenting with whole crop purchasing arrangements, analysing the impact of contract growing, reviewing quality specifications, promoting non-traditional products, providing market data, increasing banana demand, and exploring export opportunities for Australian bananas.

P2. BEST MANAGEMENT PRACTICE AND EXTENSION

- ***Support banana growers to continue best practice production.***

The objective is to increase the saleable proportion of the banana crop to optimise return on the investment in banana production. Key actions include commissioning research on pest management,

nutrition, and optical grading; supporting best practices and innovation through increased industry and research facility support; investing in genetic breeding for waste reduction and resilience; developing risk management strategies based on predictive climate models and collaborating with the Bureau of Meteorology for weather information.

P3. TRANSPORT

- ***Improve the transportation of bananas to minimise damage and transit times.***

The objective is to minimise damage and transit times during transportation. Key actions include researching on-farm transportation improvements, utilising real-time monitoring, reducing multi-commodity loads, implementing packaging techniques to delay ripening, and enhancing training and supervision of long-distance truck drivers to reduce on-farm damage and improve banana quality during transportation.

P4. LABOUR

- ***Facilitate a consistent supply of skilled labour for the banana industry and supply chain***

The objective is to ensure a reliable workforce for the banana industry. Key actions include providing resources for efficient staff training, educating retail staff on banana handling, facilitating worker availability, developing a workforce plan, and promoting the banana industry as an employment option.

REPURPOSING STRATEGIES

R1. VALUE ADD

- ***Increase the quantity of bananas being processed and incorporated into value added products for human consumption***

The objective is to create value, secondary markets, and income streams from surplus/waste bananas. Key actions include conducting feasibility studies and trials for innovative banana value-added products, assessing current value-adding activities, supporting regional processing hubs, collating research and exploring mobile processing plants for smaller and remote producers to enhance value adding in the banana industry.

R2. FOOD RESCUE

- ***Increase the quantity of bananas donated to food rescue organisations***

The objective is to facilitate excess banana utilisation for Australian food security via rescue organisations. Key actions include identifying regional hubs and partners for banana recovery, recognising contributors to food rescue organizations, advocating for financial incentives, engaging high-profile champions, and addressing barriers to increase waste banana deployment to food rescue organizations.

ENABLING STRATEGIES

E1. DATA COLLECTION

- ***Develop and encourage the widespread implementation of improved waste data collection and analysis tools to inform business strategies.***

The objective is to acquire accurate information on banana food waste to inform reduction and monitoring. Key actions include reviewing waste data collection methods globally, recommendations for Australian industry, developing specific data collection tools/processes, promoting consistency,

producing a biannual report on the banana industry's food waste status, and measuring and evaluating the impact of reduction initiatives.

E2. EDUCATION

- ***Implement an educational campaign and supply chain communication/coordination activities.***

The objective is to empower banana supply chain actors for informed food waste reduction. Key actions include developing and promoting an educational campaign on banana food waste, collaborating with other horticultural groups for food waste reduction techniques, supporting standards aligned with existing industry standards, adding optional food waste reduction certification, disseminating information, developing resources, showcasing champions, providing training for attractive display and consumer education.

E3. POLICY

- ***Calibrate policy and regulatory settings to support banana food waste reduction.***

The objective is to ensure that the regulatory and policy environment supports banana food waste reduction. Key actions include maintaining quarantine vigilance, reviewing interjurisdictional arrangements, advocating for waste reduction regulation/incentives and supporting biosecurity control/containment measures.

Each strategy is described through objectives and key actions. Anticipated short, medium, and long-term outcomes are also specified. A roadmap for the banana industry food waste action plan is proposed as a blueprint for developing, assessing, supporting, implementing, and reviewing the strategic actions. The plan establishes a vision for moving forward, while recognising challenges in the production, processing, and distribution stages of the banana supply chain. The plan identifies opportunities and suggests targeted interventions designed to make an impact and bring about multiple benefits. This plan is complemented by a summary document that presents both the background to the plan and the banana industry food waste action plan itself in a concise, graphically designed format. (All of these documents are available through the End Food Waste Australia website.)

1. INTRODUCTION

Australia produced 374,033 tonnes of banana valued at \$501.6M in 2022 (Hort Innovation, 2022). The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) defines crop loss/waste as primary production outputs that were intended for human use but ended up either not being harvested, being disposed of, or being recovered for alternative uses (cited in Downham, 2022), and the 2021–22 ABARES horticulture survey reported banana crop loss/waste as occurring at an average of 29% per farm.

Australian bananas also contribute towards the national inventory of fruit loss and wastage across its supply chain stages. A recent ABARE's survey suggested that on average banana farms have crop wastage of about 28.6% per farm on a national level. If we hypothesise that the industry total production in 2021/22 mentioned earlier, of 374,033 tonne with a value of \$501.6M, could have been 29% greater if that amount of crop was not wasted, there would be an increase of over 100,000 tonnes produced at a value of over \$145M. Whilst there are a lot of assumptions behind—and counter arguments to—the feasibility of that increase in crop sale and therefore return, it does serve to illustrate the tangibility of on farm food waste, without including banana food waste at other points in the supply chain.

The aim of this project was to develop an action plan for the banana industry to reduce food waste across the industry and supply chain. This section describes the project's overview and scope, aims, expected outcomes and anticipated impacts. The project was funded by the Queensland Department of Environment and Science, the Fight Food Waste Cooperative Research Centre (FFW CRC), and the Hort Innovation Australia (HIA) Banana Fund. The project formally commenced with the signing of the deed on 26th November 2022 and a start-up meeting on 7th December.

1.1 Project Overview and Scope

This project is part of a larger project that consists of an overall *Horticulture Sector Action Plan for Food Waste Reduction (Hort SAP)*. This report represents a commodity specific action plan, one of two undertaken as part of the larger project. This project applied Waste and Resources Action Program's (WRAP) whole chain food waste reduction plan toolkit (WRAP, 2020a, 2020b) to complete a *Food Waste Reduction Action Plan* for the banana industry from on-farm production to retail sale. The study did not include banana waste at the consumer and/or institutional level.

Initial research focused on identifying waste hotspots, followed by a deep dive into root cause analysis. Using the food recovery hierarchy, the project identified and prioritised a range of practical solutions through co-designed workshops to facilitate industry buy-in and adoption as well as drawing from best practices and effective solutions from comparable industries.

Benefits of the project include establishing a vision for increased profitability, increased supply chain resilience and improved environmental outcomes through reducing food waste, while recognising challenges in the production, processing, and distribution stages of the banana supply chain.

Project outputs include a published technical and a summary report along with stakeholder engagement sessions.

Commodity specific action plans provide a systems-based approach to reducing food loss and waste, while realising multiple benefits for supply chain partners and collaborators (FIAL, 2020). The *Banana*

Industry SAP was co-designed with the key stakeholders who were most able to directly control or influence the root cause(s) of food waste hotspots and to take action to reduce or eliminate food waste across the supply chain.

1.2 Definition of Food Waste

The following definition of food waste, taken from the *National Food Waste Strategy* (2017 p.8), is applied throughout this report. Food waste includes:

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

The term *crop/food loss* is a generic term used in some jurisdictions to differentiate from food waste, either describing where losses occur in the supply chain (e.g., in production and manufacturing) or the reasons why the food is lost (e.g., due to events such as disease or weather). The *National Food Waste Strategy* adopts *food waste* as defined above as an inclusive term to address both food loss and food waste (Arcadis, 2019 p.2) and is the terminology used for this report.

1.3 Project Aims and Expected Outcomes

This project aims to develop an action plan for the banana supply chain. The expected outcomes of the project are as follows:

- Input providers, farmers, packaging, processing and distribution companies, and retailers across the banana supply chain are informed and empowered to undertake effective food waste reduction measures.
- Increased transparency along the banana supply chain with respect to where and why food waste occurs.
- Greater understanding of the reasons behind banana food waste can inform potential interventions in the banana supply chain.
- Businesses can be committed to taking action to reduce food waste in their own operations, and work in partnership with actors across the banana supply chain.
- Identification of banana waste, 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).
- Management of banana food waste in line with the food recovery hierarchy.

1.4 Project Impacts

The main output of this project is a Sector Action Plan that will assist actors across the banana supply chain to reduce their banana waste. The impact from this project will be realised through subsequent projects that are recommended in the plan. The potential impact is described below:

- A significant decrease in banana food waste across the supply chain. Project participants identified the aspirational goal of a 50% reduction of the current food waste over the period of the action plan.
- Industry profitability: Reduction in disposal costs and/or increase in product to market, leading to higher profitability.
- Rescued food distributed: Increase in rescued fruit and fruit security for Australians in need.
- Greenhouse gas (GHG) emission savings: Potential to enable GHG reductions due to reduced biomass and reduced food waste disposed of as landfill.
- Circular economy jobs created: Identification of valorisation opportunities to convert by-products and secondary streams into new products will enable circular economy jobs relating to sorting, processing, stabilisation, and transportation and preparation for market.
- Industry people trained: Industry people aware of food waste issues and sharing knowledge on how to address these through their community of practice.

1.5 Participants

Incorporating the perspectives and experience of a diverse range of stakeholders is fundamental to the development and subsequent implementation of this *Banana Industry SAP for Food Waste Reduction*

WRAP in its Grower Guidance (2020 a) stresses that collaboration is key and suggests that successfully delivering a 50% reduction in food waste requires collaborative action across the whole supply chain. Customers and supply chain partners have a responsibility for supporting their suppliers, just as farmers and growers have a responsibility for taking action(s) in their own businesses.

A banana reference panel was established, including corporate, large, medium, and small grower representatives along with packaging/distribution, wholesale, processor, and retail actors, and was supported by ABGC, Stop Food Waste Australia and CQU researchers. The panel members participated in online workshops and provided individual interviews with the project engagement officer.

Details of the banana reference panel are available in Appendix 2.

1.6 Report Structure

The report is structured around three key topics that integrate the deliverables.

1. A description of the project, including an overview of the banana industry supply chain and the banana waste issue, and the methodology to be utilised in this research project.
2. Results and discussion obtained from the literature review, stakeholder interviews and workshops.
3. Presentation of the action plan with proposed roadmap to implement the actions.

2. BACKGROUND OF THE STUDY

2.1 The Australian Banana Industry

In Australia, bananas are grown in both tropical and subtropical regions. This ensures the industry is diverse in terms of the geographical location of banana farms, farming practices, the size and type of farms that grow bananas, the varieties of bananas grown and their flavour. The tropical banana-growing regions of North Queensland, mainly around the Atherton Tablelands, the Cassowary Coast (Tully, Innisfail and Kennedy) and Lakeland, produce 94% of Australia's bananas. Other tropical production areas are in the Northern Territory and in northern Western Australia, at Kununurra (see Figure 1).

Subtropical bananas are grown between Coffs Harbour in northern New South Wales and Bundaberg in southern Queensland, and in Carnarvon in Western Australia. There are no imports of bananas due to the threat that exotic pests and disease would pose to the local industry—all fresh bananas available in Australia are locally grown. Australian Banana Growers Council (ABGC,2024)



Figure 1: Schematic map of banana producing regions in Australia.

Source: ABGC, 2024

2.2 The Banana Supply Chain and Food Waste

A banana supply chain involves a series of steps to grow and deliver a product to the customer (Figure 2). Due to their particular characteristics, such as high perishability and short shelf life, bananas are often degraded in harvest and post-harvest handling activities, such as picking, washing, sorting, packing, and transporting (Xia & Nelson, 2018).

Whilst there are some core steps, the detail of the banana supply chain is influenced by farm location and distance from markets, production scale, enterprise sophistication and resources, management preferences and contractual arrangements. For example, a small farm might (a) transport their crop straight from the paddock to a cooperative packing shed nearby; (b) it may be packed in the home shed but transferred to a local warehouse to be consolidated with other farmers' product before transport to a larger shed or warehouse for on forwarding or ripening; (c) they may have sold their produce at a local market; or (d) using established contracts with major supermarkets, their product goes direct from farm to the retailer's warehouse or distribution centre, by-passing the central market system (Marty and Akbar2023).

The Australian banana supply chain is largely contained within Australia with no fresh bananas imported and only a few growers, representing less than 1% of production, exploring the export market. (Hort Innovation, 2022). This differs to many other countries, where there are substantial investments in the trade of bananas and a more complex supply chain. For example, in 2020, the US imported 4.14 million metric tonnes of banana (Karst, 2021). For this report the following simplified supply chain framework (Figure 2) is used, noting that stages 2 and 3 may vary for some growers. This is further discussed below.

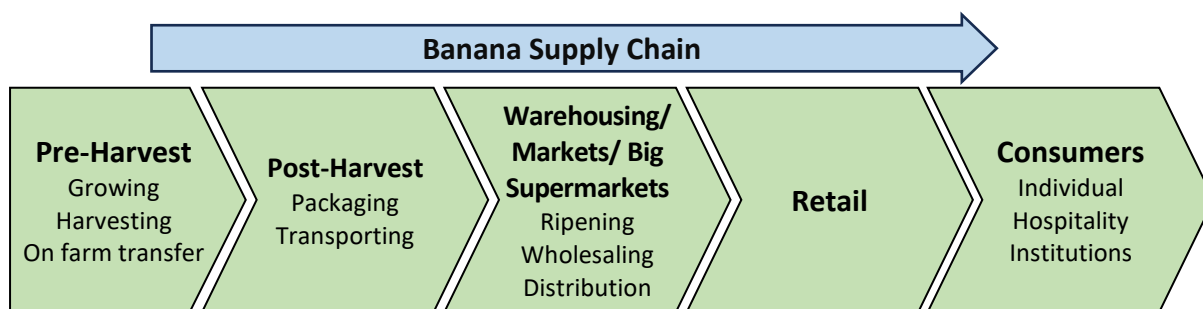


Figure 2: Simplified banana industry supply chain

Data collection both qualitative and quantitative are critical aspects underpinning food waste reduction. However, growers and other supply chain stakeholders, in discussions with the research team, have questioned the validity and reliability of current data published on banana food waste. They expressed concerns with the representativeness of the research cohort and the impact of timing on survey results as some of the data did not intuitively align with their experience.

The causes of banana food waste along each of the supply chain stages is described below.

2.2.1 Pre-harvest

Pre-harvest food waste (i.e., crop waste) is the main hotspot for banana food waste across the supply chain. Ekman et al. (2011), McKenzie et al. (2017) and Beausang et al. (2017) found a range of agronomic practices caused on-farm food waste. Farmer's choice of crop variety, pest and disease management, fertilisation and water supply can all contribute to product quality and quantity at harvesting and can impact the fruit's aesthetic and nutritional value.

Management decisions regarding market price and supply, or overproduction of contracted crops can see fruit left to go to waste in the paddock or in on-farm dumps before it even reaches the packaging shed. Similarly, awareness of retail standards results in non-conforming fruit being discarded on-farm. While this creates waste it saves the grower the additional costs of packing and transport that would not be recouped if the product was rejected at market. White et al. (2011) found that between 10% and

30% of the North Queensland banana crop is discarded on-farm. Of this, 78% was found to be due to cosmetic imperfections. The estimates from White et al. (2011) have been contemporised by ABARES with their 2102–22 survey, concluding that the average percentage of crop waste for bananas in Australia was 29% per farm in 2021-22.

The natural environment, in particular wind and water events, have been known to destroy crops. This factor was highlighted in the recent ABARES survey. McKenzie et al. (2017) provide an alternative perspective, suggesting that “pre-harvest loss such as weather or pest related damage is about maximising potential, as opposed to addressing losses of material ready for harvest or in subsequent steps of the supply chain.”, If the fruit is not optimal, it will become waste regardless of the cause or the intent.

Often studies on food waste focus on the amount of waste arising and not the reasons why the waste occurs. In Beausang et al.’s 2017 study, “Food Waste and Losses in Primary Production: Qualitative Insights from Horticulture”, they revealed that “many farmers do not consider food waste to be an issue of primary concern and perceive food waste to be an intrinsic part of farming.” The stakeholder engagement component of this project confirmed this attitude.

The harvest stage also presents waste creation opportunities, especially given the labour-based nature of the work. The variable skills and experience levels of staff carrying out this task and, in some cases, the lack of staff availability can impact waste levels in field work. Once cut, the banana bunch begins the first of many transport stages, all of which have the potential to cause damage to the fruit, increasing the likelihood that it will become waste (Marty and Akbar 2023).

2.2.2 Post-harvest

Research by Eckman et al. (2011), into improved handling in banana supply chains, suggests that it is possible to significantly reduce damage to bananas occurring during the transport, ripening and distribution stages. Although this trial was over 10 years ago and there have been significant improvements in the packaging and transport of bananas since then, some of the follow up investigations suggested may still be worthy of consideration. Depending on the specifics of an individual grower’s supply chain, the fruit may be transported on-bunch or in-carton several times, each time increasing the risk of damage. Time and distance to market have also been recognised as contributing to fruit spoilage although as cold chain processes improve this may be reduced.

Retailer standards and the associated consumer expectations create a very limited view of a quality banana. A case study undertaken by White et al. (2011) on the NQ banana industry demonstrated that the “unnecessary waste of edible food due to cosmetic standards results in an increase in the cost of production, a loss of potential nutritional benefits and a waste of the resources embodied in the fruit”; such aesthetic standards contribute to banana waste across the supply chain—at the farm, the packing shed, the wholesaler and the retailer. The paper suggested further research to quantify the waste occurring throughout the supply chain that can influence policies and programs for waste minimisation.

2.2.3 Warehousing

The warehousing stage of the supply chain is taken to include the ripening process and the distribution to retail or point-of-sale outlets. For those growers who supply direct to the major supermarkets this stage may not be as complex or have as many points of potential spoilage, due to the minimisation of stock movement and handling. Agriculture Victoria (cited in SFWA 2022) identifies causes of horticulture waste at the storage stage to include spillage, spoilage and contamination, delayed logistics and lack

of cold chain capacity. The relative perishability of bananas and fluctuations in the level of supply (possibly creating a glut) can affect the price paid for the fruit and increase the rejection rate, adding further to the waste problem (SFWA, 2022).

2.2.4 Retail

The retail stage, along with household consumption, tends to receive attention in the food waste discussion as it is more visual and measurable. A high percentage (70%) of total banana production is sold to the major Australian retailers (White et al., 2011), which results in the standards set by these retailers having a significant impact on both the banana industry and the waste agenda.

To illustrate the detail of the specifications that determine the suitability of a fresh banana for retail sale, Figure 2 shows an excerpt from specifications used by Fresh Markets Australia (FMA) and major retailers. The specifications are heavily focussed on fruit cosmetics. If bananas sent to retailers do not meet all the standards, they are rejected and sent back to the grower at the grower’s expense, unless supply is low, in which case the specifications are reviewable.

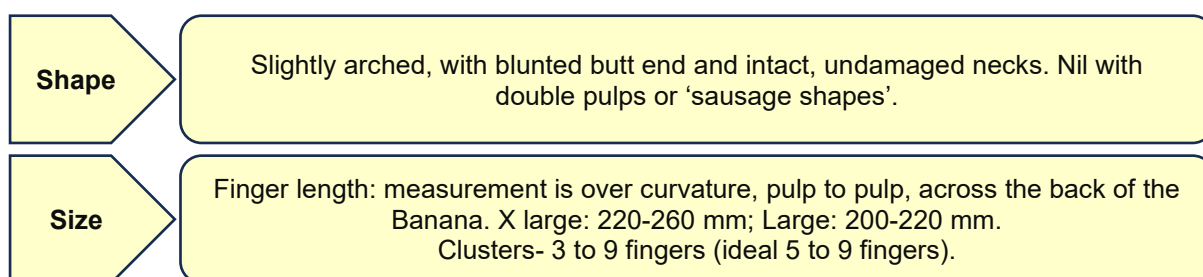


Figure 3: General appearance criteria of a class one ripened Cavendish banana as per FreshSpecs

Source: Fresh Markets Australia (2016)

An academic interviewed by McKenzie et al. (2017) suggested that “supermarkets have gained a lot of power and with that power they are imposing their own rules and standard – they demand from their wholesalers and primary suppliers exactly what they want”. Consumers have become accustomed to fruit with a near-perfect appearance and can associate anything below this standard as undesirable. Retailers are bound by consumer preferences, which reinforces the cycle of high aesthetic expectations, leading to unsaleable and therefore wasted fruit. Whilst nature produces in all its variety, retailers and customers have defined, tight expectations; an extension officer quoted by McKenzie et al. (2017) likened the supermarkets standards to “like expecting produce to conform like Arnott’s biscuits”.

3. METHODOLOGY

WRAP UK's whole chain food waste reduction plan toolkit informed development of the Sector Action Plan. It is built on the premise that food waste is an end-to-end challenge, requiring an end-to-end solution. The five-stage process illustrated below (Figure 4) provides the basic structure of this project, which has brought together stakeholders across the banana supply chain from farm to retail (Table 1). This project has addressed the first three processes (i.e., where is the waste? why is the waste occurring? and what solutions (i.e., actions) may prevent the waste from occurring?) and developed a proposed road map to implement the actions. As mentioned, the project does not deal with household waste. 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). The banana industry, as illustrated throughout this paper, tends to use weight (tonnes) or value (dollars).



Figure 4: An iterative process-based WRAP methodology for food waste reduction

Source: WRAP, 2020a p.3

This study used a sequential mixed methodology to structure the research and triangulate the key findings. The study then prepared actions based on the key findings. The study team first completed the literature review, then key findings (Appendix 1) from the literature review were discussed individually (i.e., in stakeholders' interviews) with each of the members in the banana reference panel. Subsequently, key findings from the interviews (Appendix 2) were discussed in Workshops 1 and 2 to identify key hotspots, root causes, solutions and to shortlist the solutions. This study employed the following four steps for shortlisting proposed solutions for banana food waste reduction:

- Sequential triangulation of findings about root causes, existing interventions and proposed solutions. Within the above mixed methods, a qualitative 3 x 5 Whys analysis was used to identify and validate root causes in this project.

- Identifying common areas of strategic actions consistent with the framework for the National Food Waste Strategy (2017) adopted by the Australian Government, identifying sub-areas of strategic actions.
- Understanding the feasibility of interventions based on four mutually agreed (between the research team and the banana stakeholders panel) criteria: volumes of waste, economics (financial feasibility), technological complexity (technical feasibility), and best and highest use (based on food waste prevention hierarchy (Figure 5)). This study used the food waste prevention and management hierarchy (Figure 5) to prioritise all actions proposed in this report. It should be noted that only actions within the green sections, that is, 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. This approach is consistent with the idea of a circular economy where resources are kept in use for as long as possible while also minimising negative impacts (DCCEEW, 2017).
- The study then used the four criteria to prioritise short-listed solutions into actions as well as involving expert judgement and industry consultation.

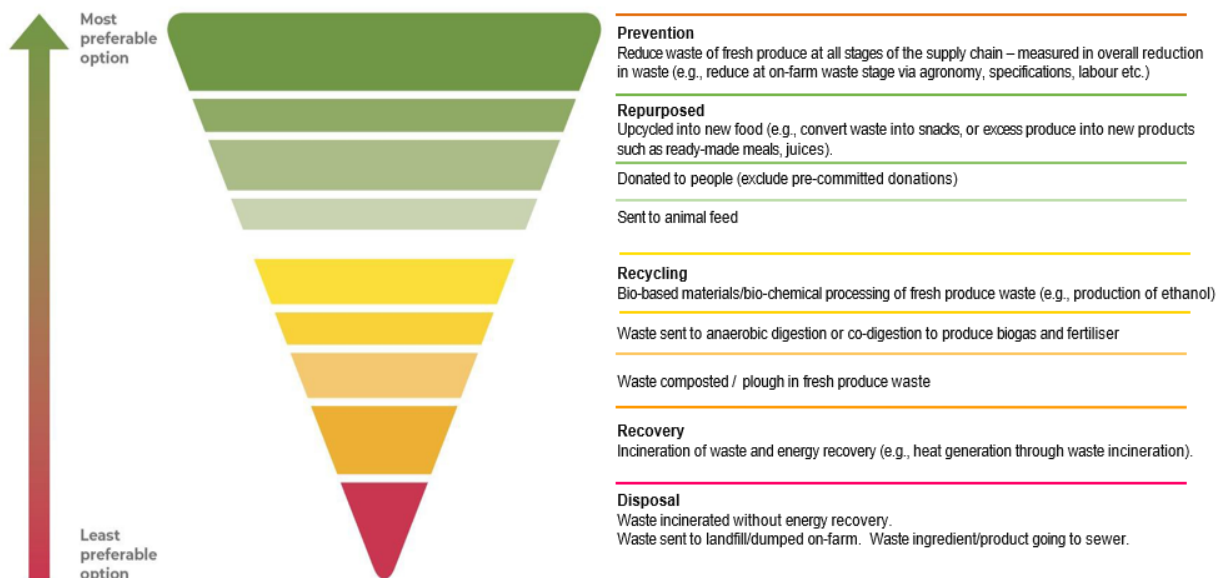


Figure 5: Horticulture specific food recovery hierarchy

Source: SFWA, 2023; FIAL, 2021

Therefore, the final key actions were developed from the triangulated key findings based on the above four-step process (and not based on individual findings, e.g., a unique root cause identified in the literature). A detailed description of the methods and activities for the *Banana Industry SAP for Food Waste Reduction* are presented in Table 1.

As mentioned earlier, a sequential mixed method has guided all the tasks required for developing the action plan and described in Table 1. The development stages and tasks (i.e., tasks and time) of the sector action plan for the banana industry are presented in Figure 6.

Table 1: Methods and activities for *Banana Industry Food Waste Sector Action Plan* and targeted milestones

WRAP whole chain food waste reduction plan (WCP) toolkit	WCP Description for <i>Banana SAP</i>	<i>Banana</i> Industry SAP	<i>Banana</i> Industry SAP Milestones
Initial meeting	<ul style="list-style-type: none"> Present the project’s overview and objectives. Share project engagement and operation. Create a project scope. Identify data to be gathered. 	<p>Phase 1: Commodity and project partners selection</p> <p>Project partners selected:</p> <ul style="list-style-type: none"> SFWA QLD DES The Australian Banana Growers Council Hort Innovation Australia (HIA) <p>Industry partners:</p> <ul style="list-style-type: none"> Transport: Cold chain Australia Retailers Farmers, wholesalers, and distributors <p>Project scoping.</p> <p>Develop a stakeholder engagement plan.</p>	<p>Phase 1 Milestone:</p> <ul style="list-style-type: none"> <i>Banana Industry</i> food waste scoping report and a stakeholder engagement plan. Application of ethics for two workshops and stakeholder consultation. Data management plan.
<p>Planning meeting</p> <p>Site visit(s)/stakeholder consultation</p>	<ul style="list-style-type: none"> Review next steps. Finalise/sign off the project scope. Review data to identify hotspots. Agree on an agenda for site visit(s) <ul style="list-style-type: none"> Walk the chain, end-to-end, identifying banana food waste. 	<p>Phase 2a: Defining and identifying waste.</p> <ul style="list-style-type: none"> Define the banana supply chain. Conduct a literature review to document a high-level account of banana waste along the supply chains. Identify past and present interventions to minimise food waste. <p>Phase 2b: Stakeholder consultation</p> <ul style="list-style-type: none"> Draft a high-level account of banana waste along the supply chains. Identify likely waste hotspots. Undertake stakeholder consultation to get a broader picture of hotspots, root causes 	<p>Phase 2a Milestones</p> <ul style="list-style-type: none"> A draft report of methods, and literature review analysis of current banana waste, identifying hotspots, causes and interventions. <p>Phase 2b Milestones</p> <ul style="list-style-type: none"> A draft summary report on stakeholder interviews.

WRAP whole chain food waste reduction plan (WCP) toolkit	WCP Description for <i>Banana SAP</i>	<i>Banana Industry SAP</i>	<i>Banana Industry SAP</i> Milestones
		and effectiveness of existing interventions	
Root causes analysis (Workshop 1)	<ul style="list-style-type: none"> • Share observations. • Review findings. • Identify root causes. • Identify solutions. 	Phase 3: Root Cause Analysis-Workshop1 <ul style="list-style-type: none"> • Share observations. • Review findings. • Identify root causes and identify solutions. 	Phase 3 Milestone <ul style="list-style-type: none"> • A draft report on root cause analysis methods and tools.
Solution and action (Workshop 2)	<ul style="list-style-type: none"> • Hold an idea generation session. • Prioritise solutions to trial. 	Phase 4: Final solutions Workshop 2 <ul style="list-style-type: none"> • Hold an expanded session (to inform key findings from phases 2 & 3) • Prioritise solutions. 	Phase 4 Milestone <ul style="list-style-type: none"> • A draft report on Workshop 1 findings.
Final report with implementation mechanisms and further research	<ul style="list-style-type: none"> • Propose actions. • Identify KPIs/indicators to monitor outcome and impacts. 	Phase 5a: Draft Action Plan <ul style="list-style-type: none"> • Co-create an action plan with timing, responsibility, and implementation road map. • Proposed indicators to monitor future outcome and impacts. • Send draft report to banana reference panel for feedback. Phase 5b: Final Action Plan <ul style="list-style-type: none"> • Final presentation to stakeholder's forum 	Phase 5a Milestones <ul style="list-style-type: none"> • A draft report on Workshop 2 findings and drafted action plan. Phase 5b Milestone <ul style="list-style-type: none"> • Final report with action plan, proposed implementation roadmap and impact monitoring indicators.



Figure 6: Development stages of sector action plan for the banana industry

This study utilised seven development stages of the Banana Industry SAP, as shown in Figure 6. Fifteen stakeholders and researchers attended the initial project inception and scoping meeting. The study team then prepared a stakeholder engagement plan, research design and scope, and formed a banana reference panel consisting of industry, governments, producer, retailers and distributors. A literature review on horticulture food waste, hotspots, root causes and interventions were then undertaken.

Based on the key findings from the literature review, the study team prepared stakeholder interview questions. The interview questions were first piloted before 10 stakeholders from a wide range of relevant fields, including industry, retailer, government, marketer/distributors, transporter, and food waste management experts, were interviewed, with the interviews taking place between January and March 2023 (see Appendix 2). Based on the key findings from the stakeholders' interviews the team designed two workshops with End Food Waste Australia (EFWA) experts. The same group of stakeholders (including researchers and facilitators) were invited to attend Workshops 1 and 2. The number of participants in workshops 1 and 2 were 16 and 17 respectively. The second workshop generated and prioritised the solutions. The actions were then articulated by the research team and further consultation with the same stakeholders was conducted to further test the validity of the actions and ascertain who could implement which action(s) (see Figure 6).

The interview and workshop processes and tools 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.

4. FINDINGS AND ANALYSIS

4.1 Banana Food Waste and Hotspots

The *National Food Waste Strategy Feasibility Study* (FIAL, 2021) found that Australia produces 7.6 million tonnes of food waste per annum, or 312 kg per capita. Prior to the FIAL (2021) study, the *National Food Waste Baseline* (Arcadis, 2019) provided detailed data describing food waste across the fruit and vegetable sector, including banana food waste (Figure 7). It suggested that national on-farm loss of bananas in 2016/17 was more than 40,000 tonnes, which is a significant proportion when compared to other commodities considered in the fruit, nuts and wine grapes category, as illustrated in Figure 7.

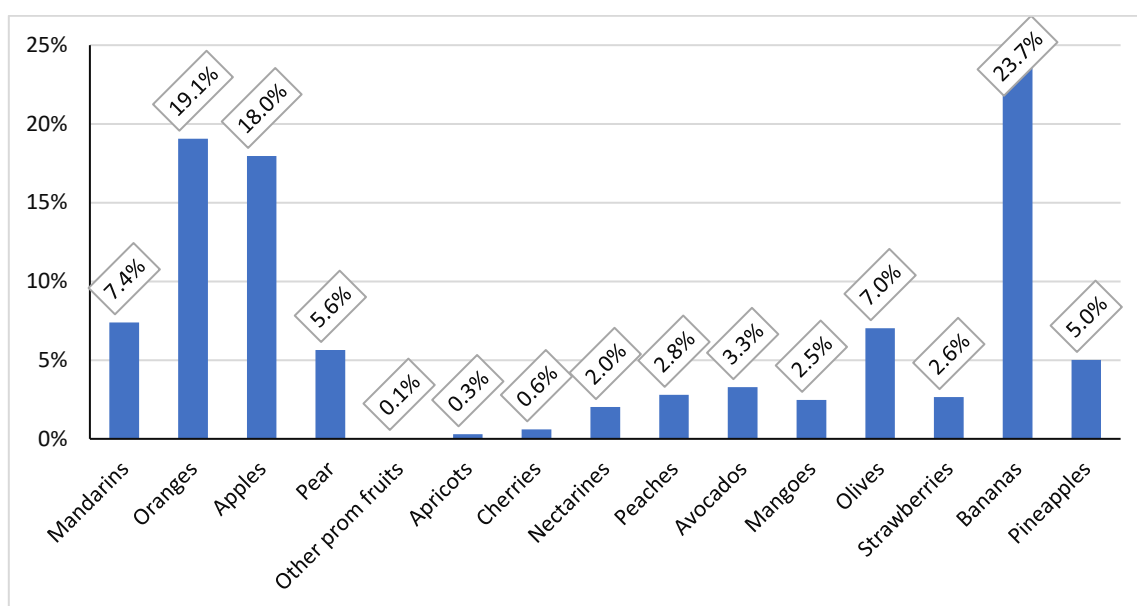


Figure 7: Proportion of waste in banana industry compared to other fruits and nuts.

Source: Arcadis, 2019

CSIRO also undertook a mapping of Australian fruit and vegetable pre-retail losses in 2019 that concluded that total losses (on farm plus processing facilities, including pack houses) ranged from 18 to 22% of the total Australian fruit and vegetable production. However, the study utilised a survey-based methodology and no responses were received from the banana industry (Ambiel et al., 2019).

In 2022, data describing crop waste on Australian horticulture farms was collected through the ABARES horticulture survey (Downham, 2022). The results are based on a weighted sample of 2,692 horticulture farms across Australia, selected by region and farm size to be representative of the total population of 11,004 farms, which were surveyed by telephone. The average percentage of crop waste for bananas in Australia was 29% per farm in 2021-22—19.3% pre-harvest and 9.0% during or after harvest, while only 0.2% were recovered for an alternative use. Hotspots for pre-harvest food waste are on-farm, and post-harvest hotspots include transport and cold chains, wholesale or distribution centres, retailers and consumers (consumer food waste is out of the scope of this project). These banana waste figures and hotspots were discussed during the stakeholder interviews and in the Workshop 1, and the majority of the stakeholders agreed with a range between 15% to 19% for on-farm banana food waste.

4.2 Root Causes

Root causes are a fundamental consideration behind food waste (Møller et al., 2014; Moragues-Faus et al., 2017), and are often location-specific (Van Berkum et al., 2018). The Canadian Commission for Environmental Cooperation (CEC, 2021), however, distinguishes between apparent causes (reasons) and root causes (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 loss is cosmetic or physical damage, the root causes can be poor harvesting technique/inadequate equipment, along with a range of other contributing factors.

By synthesising the research and the outcomes of stakeholder engagement three reasons (apparent causes) of food waste have been identified (Herzberg, Trebbin and Scheider, 2023; CEC, 2021; Feedback & the Rockefeller Foundation, 2017; FAO, 2011):

1. The fruit is physically damaged or not within the produce specification, that is, the fruit does not make the criteria for sale.
2. Crop damage, that is, the crop—fruit and/or plants—are rendered unusable, usually in field.
3. Fruit is unviable and does not warrant progressing further in the supply chain, often the result of an oversupply.

These can be traced back to six root causes (Appendix 2):

1. Agronomy
2. Climate and weather events
3. Packaging, transport and warehousing
4. Commercial and legal
5. Management and planning
6. Market conditions

This project does not address waste at the consumer level, hence the associated causes and root causes of food waste of that point in the supply chain have not been included. The apparent causes and root causes were initially drawn from the literature review. These were discussed with the banana reference panel members through one-to-one interviews and workshops (Appendix A2) and have been summarised in Table 2.

Table 2: Apparent causes and root causes of banana food waste: Developed by project team based on a triangulation of key findings (literature, interviews and workshop)

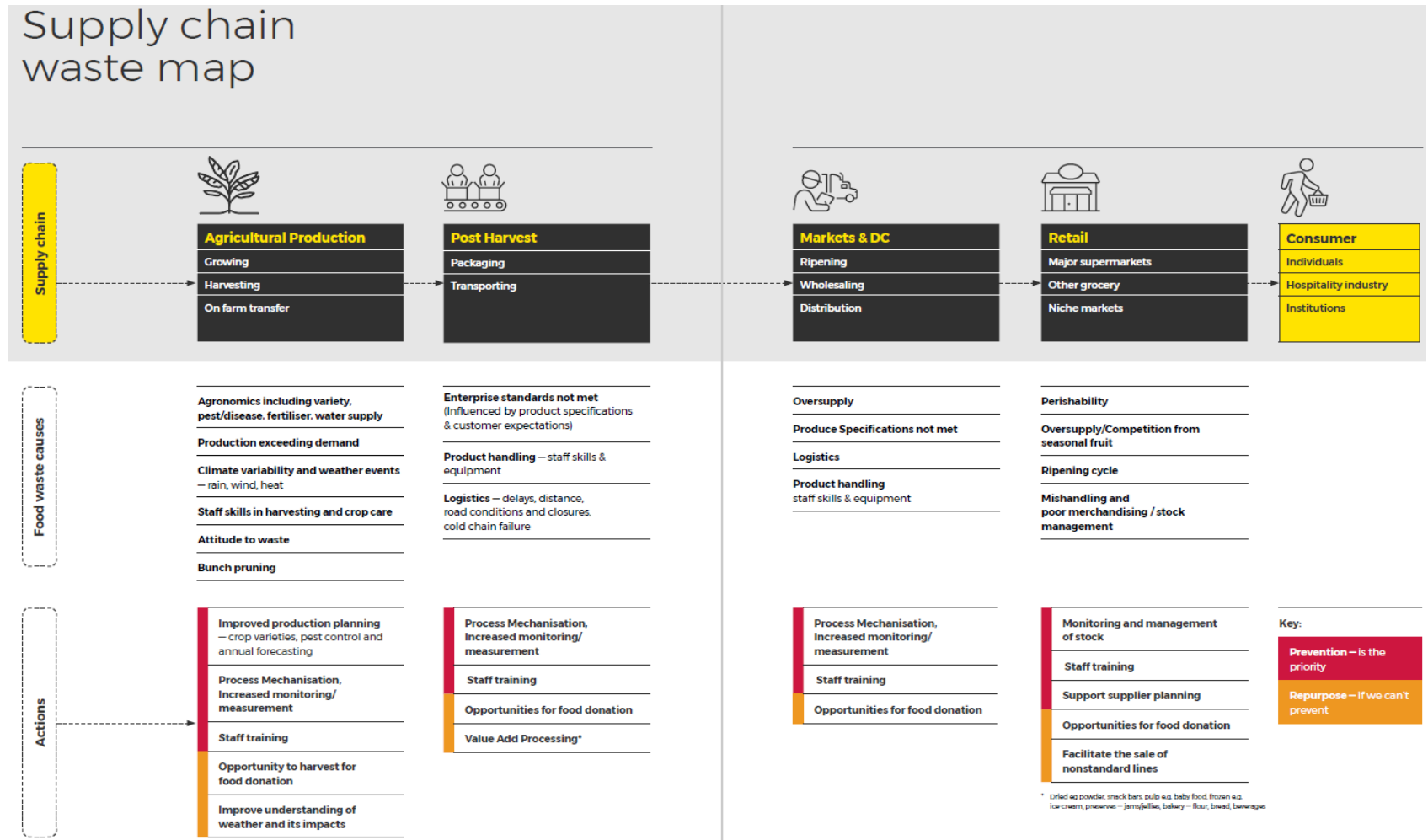
Apparent causes	Root causes	Supply chain point of occurrence			
		Primary Production	On farm Post-Harvest	Transport, Warehousing and Markets	Retail
Cosmetically or physically nonstandard or damaged fruits	RC 1 Agronomy				
	Attack of diseases, microorganisms, bacteria, or fungi.	√	√		
	Attack of insects, pests, or animals.	√			
	Negative reactions to/effects by chemicals applied.	√	√		
	Poor choice of crop variety.	√			
	Soil or fertiliser issues.	√			
	Water or irrigation issues.	√			
	RC2 Climate and weather events				
	Extreme weather events, such as high temperature, humidity, sunburn, air, wind, hail; natural disasters, such as flood and bush fire.	√			
	RC3 Packaging, transport, warehousing				
	Improper storage management (e.g., related to temperature, humidity, respiration, ethylene, etc.).		√	√	√
	Inadequate planning, malfunction, and poor maintenance of equipment or facilities.	√	√	√	√
	Poor inventory management (e.g., not moving the oldest fruit first)	√	√		
	Unavailability, poor-quality or inadequate equipment for cleaning, waxing, packing and cooling facilities.		√		
	Unavailability of, poor quality or inadequate containers and transports.		√	√	
	Lack of skilled labour in the paddock or packing shed causing damage to crop.	√	√		
	Logistical issues (e.g., missing a time slot, incorrect consignment paperwork or shipping the wrong product).		√	√	
	RC4 Commercial and legal				
	Cosmetic standards for horticultural products. Markets/supermarkets.	√	√	√	√
Government regulations and legislations.					
Crop damage	Natural disaster (e.g., flood, cyclone, fire).	√	√		

Apparent causes	Root causes	Supply chain point of occurrence			
		Primary Production	On farm Post-Harvest	Transport, Warehousing and Markets	Retail
	Disease (e.g., Panama TR4, or alternative).	√			
	Change in management practices and use of land.	√			
Nonviable production system—not worth progressing further in the supply chain	RC 5 Management and planning				
	Forecasting issues—mismatch between supply and demand.	√		√	√
	Unplanned surplus production.	√			
	Poor inventory management (e.g., not rotating stock correctly).	√		√	√
	RC 6 Market conditions				
	Large quantities/varieties of the product or competitors at retailers (i.e., too many options for consumers/ retailers due to oversupply).	√			√
	Price variation, change of consumer preferences and other market forces.			√	√

4.3 Root Causes of Banana Food Waste and Mitigation Opportunities: A Summary

The following supply chain waste map (Figure 8) provides a conceptual mapping of the identified root causes of waste along with current and potential waste mitigation opportunities.

Figure 8: Summary of the Australian banana supply chain, waste drivers and waste mitigation opportunities.



5. ACTION PLAN

5.1 Banana Sector Waste Prevention and Reduction Actions

The study identified various actions to prevent and reduce food waste in the banana supply chain based on the sequential mixed methods (for details see Section 3). The study used a four-step process (for details see Section 3), which was involved expert judgement to prepare the action plan. The action plan was subsequently validated through consultation with the Banana Growers Association and other stakeholders. Through this process, eleven actions were presented in the final solution workshops, where an in-depth discussion for finalising the actions was undertaken, and four criteria were used to validate and prioritise them (volume, financial feasibility, technical feasibility, and best and highest use principle). Based on this discussion, the research team identified nine strategic areas of actions, including four prevention strategies, two repurposing strategies and three enabling strategies. All nine strategies and corresponding actions are presented in this section with brief descriptions. Figure 9 gives a brief description of the strategies and their position in the food waste hierarchy.

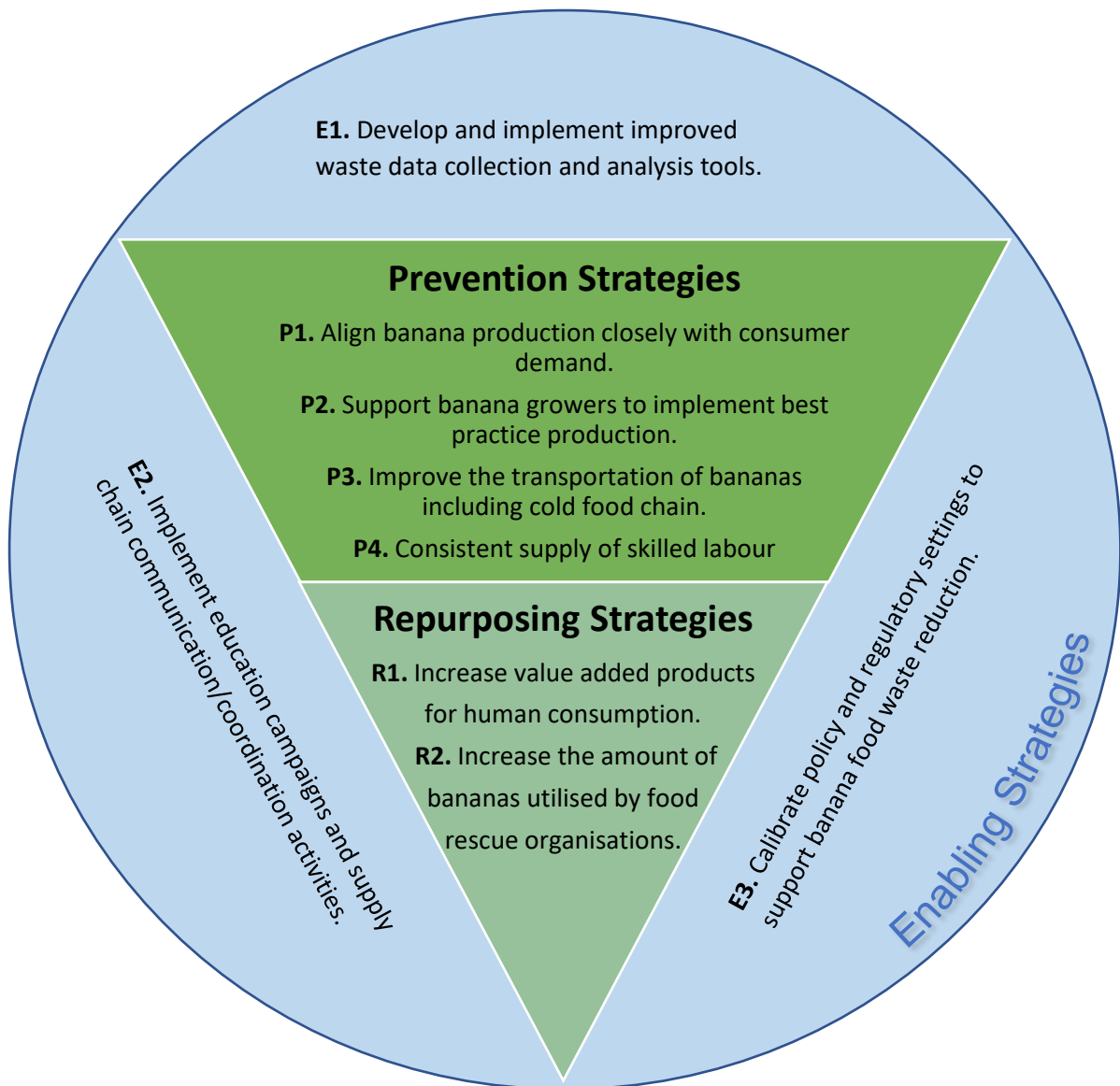


Figure 9: Strategies and actions in *Banana Industry SAP for Food Waste Reduction*

PREVENTION STRATEGY P1 - SUPPLY AND DEMAND ALIGNMENT

Align banana production quantities more closely with consumer demand

Objectives:

- *Manage banana production levels and achieve better market equilibrium.*
- *Improve farm business viability by decreasing the amount of the crop that does not provide a return to the producer.*

Actions

P 1.1 Provide resources to enhance the understanding of producers about the operation of the market, its drivers, and the implications for their profitability, levels of production and food waste.

P 1.2 Establish a mechanism to provide commonly available and understood supply and demand forecasting to inform banana production levels.

P 1.3 Develop a mechanism to provide widely available and cost effective, transparent market sales and price data.

P 1.4 Establish a multistakeholder working group to review the current quality specifications used by the markets and retailers to facilitate the sale of bananas with diverse aesthetic characteristics.

P 1.5 Establish a business case and EOI process to identify growers and retailers interested in trialling whole crop purchasing arrangements and conduct trial and share lessons.

P 1.6 Undertake an analysis of the impact of contracted growing on the levels of waste in the banana industry.

P 1.7 Encourage the promotion of product lines that utilise fruit that does not meet the traditional retail specifications, for example, kids' lunch sized, odd sized bunches and the development of new lines.

P 1.8 Promote the versatility and associated health benefits of banana consumption and deliver campaigns to increase demand for bananas especially at times of traditionally high supply, for example, September.

P 1.9 Explore the potential for increasing the export of Australian bananas, including identifying the barriers and constraints, and an internationally attractive value proposition.

Expected Outcomes

Short term outcomes	Medium term outcomes	Long term outcomes
Increased grower knowledge and understanding of the market and the forces of supply and demand.	Increased planned production—decreased speculative production.	Minimal in-paddock wastage resulting from oversupply.
Banana market specifications reviewed, and report issued.	Increased banana consumption.	

Potential Lead Agencies

- Australian Banana Growers Council
- Australian Bananas
- Hort Innovation
- Retailers

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

PREVENTION STRATEGY P2 - BEST MANAGEMENT PRACTICE

Support banana growers to continue to move towards universal industry best practice production

Objective:

To Improve the return on the resources (money, time, land and energy) invested in producing a banana crop by increasing the proportion that is saleable.

Actions

P 2.1 Continue to identify needs around, and commission and disseminate, research on pest and disease management and plant nutrition.

P 2.2 Increase support to the banana industry and research facilities to encourage best practice production and innovation, including the use of technology.

P 2.3 Support research into genetic technologies to improve banana germplasm that minimises waste and increases crop resilience.

P 2.4 Identify and share practices that minimise in-shed damage to fruit (e.g., knife damage, bruising and exposure to bacteria or disease).

P 2.5 Undertake research and industry-based trials on the application of mechanisation and technology to grade, sort and pack bananas.

P 2.6 Develop a relationship with the Bureau of Meteorology to provide training and information about climate and weather patterns that will impact banana resilience.

P 2.7 Investigate the expected impacts of climate change models on the banana industry and undertake risk assessments and develop recommendations for building the resilience of production practice.

Expected Outcomes

Short term outcomes	Medium term outcomes	Long term outcomes
Reduction in the volume of banana waste caused by agronomic and handling issues.	Technological options available for banana grading and sorting.	Australian banana industry has developed/adopted best global practice production, and majority of growers implementing best practice guidelines.

Potential Lead Agencies

- Hort Innovation
- Australian Banana Growers Council
- State Governments' Department
- CSIRO
- Bureau of Meteorology

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	-	-	-

PREVENTION STRATEGY P3 TRANSPORT

Improve the transportation of bananas to minimise damage and transit times

Objective:

To significantly reduce transport damage that leads to banana rejection pre-packing or at the market or distribution centre.

Actions

P 3.1 Research, trial and implement options for improving on-farm transportation and reducing on-farm damage, including mechanisation, automation and improved work practices.

P 3.2 Increase real time monitoring to track loads to identify temperature and humidity issues and implement strategies to address.

P 3.3 Reduce multi-commodity (mixed) loads, for example, through adjustments to scheduling, truck sizes and routes.

P 3.4 Increase the use of packaging techniques that delay the ripening process.

P 3.5 Enhance the training and supervision of long-distance truck drivers.

Expected Outcomes

Short term outcomes

Reduction in damaged fruit arriving at the markets or DC.

Increased information available about transport conditions in real time.

Medium term outcomes

Introduction of innovative on-farm transport practices that reduce damage between the paddock and the box.

Long term outcomes

Near elimination of damage to bananas in transport.

Potential Lead Agencies

- Australian Food Cold Chain Council
- Logistics companies
- Australian Banana Growers Council
- Research organisations and farm technologists

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	-	√	√	-

PREVENTION STRATEGY P4 - LABOUR

Facilitate a consistent supply of skilled labour for the banana industry and supply chain

Objective:

To ensure that the banana industry has a reliable supply of appropriately skilled workers.

Actions

P 4.1 Develop and distribute resources/tools to support growers to train field and shed staff in food waste mitigation efficiently and effectively.

P 4.2 Develop and distribute resources to train and support retail staff regarding stock control and merchandising.

P 4.3 Develop an industry level workforce plan to forecast skill requirements over a 5-year horizon.

P 4.4 Facilitate the sourcing and retention of workers from other countries.

P 4.5 Support the employment of backpackers and other travellers through place-based collaboration and industry referral.

P 4.6 Promote the banana industry and the range of available roles as an employment option.

Expected Outcomes

Short term outcomes

Training resources available for grower/retailer use.

Minimal banana food waste caused by lack of staff.

Medium term outcomes

A consistent supply of skilled workers is available for on farm tasks.

Long term outcomes

Industry workforce plan developed.

Potential Lead Agencies

- Australian Banana Growers Council
- Hort Innovation
- Employment providers
- Local businesses, for example, hostels
- State and local governments

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	-

REPURPOSING STRATEGY R1- VALUE ADD

Increase the quantity of bananas being processed and incorporated into value added products for human consumption

Objective:

To create new value, secondary markets, and new income streams from surplus and waste bananas

Actions

R 1.1 Collate existing research into current and past banana value adding initiatives, and communicate these through a range of channels, including forums/conferences, field days and online.

R 1.2 Assess current banana value adding activities to identify opportunities for expansion, the barriers to be addressed and the prerequisites for expansion.

R 1.3 Undertake feasibility studies and small-scale trials of innovative banana value added products and nutritional supplements.

R 1.4 Seek the support of investors, marketers and growers for the commercialisation of banana value added products.

R1.5 Support a regional hub approach to the establishment of processing facilities and encourage the collaboration of banana supply chain actors, government, private enterprise, innovators and the financial sector to realise these opportunities.

R 1.6 Explore mobile processing plants as a way to provide access to value adding to smaller and more remote producers.

Expected Outcomes

Short term outcomes

Existing research on processing options is widely available,

A minimum of one feasibility study is under way on value added products and nutritional supplements respectively

Medium term outcomes

Several new processing options are available and being actively used by industry.

Long term outcomes

All producers have a local value-add option for their food waste that provides an acceptable return.

Potential Lead Agencies

- Universities
- Australian Banana Growers Council
- Australian Government
- Hort Innovation

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√		√	√

REPURPOSING STRATEGY R2 FOOD RESCUE

Increase the quantity of bananas donated to food rescue organisations

Objective:

To facilitate the use of excess bananas to provide food security for Australians through the network of food rescue organisations.

Actions:

R 2.1 Develop a recognition program for banana growers, marketers and retailers who contribute to food rescue organisations.

R 2.2 Identify a team of high-profile champions who promote the use of food rescue organisations and facilitate connections across the banana supply chain.

R 2.3 Work with the food rescue sector and its supporters to identify, analyse and address the barriers to the increased deployment of waste bananas to food rescue organisations.

R 2.4 Advocate for financial incentives, including tax incentives to offset the costs incurred by banana supply chain actors in supporting food rescue organisations.

R 2.5 Identify regional hubs and recruit supply chain partners (including volunteer workers) willing to support banana recovery as a corporate social responsibility opportunity.

Expected Outcomes

Short term outcomes

Recognition program and industry champions in place.

Financial incentives are available to offset costs incurred in donating fruit.

Medium term outcomes

Regional recovery hubs are established in locations that cover the majority of the banana industry.

Long term outcomes

All growers have an option to send waste product to food rescue.

Potential Lead Agencies

- Hort Innovation Australia
- Australian Banana Growers Council
- End Food Waste Australia
- Food Rescue Organisations
- State and local government (through circular economy policy and activity)

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√		√	√

ENABLE STRATEGY E1- DATA COLLECTION

Develop and encourage the widespread implementation of improved food waste data collection, reporting, and analysis

Objective:

To acquire comprehensive accurate information on the quantum, nature and causes of banana food waste as a basis for further waste reduction activity and the monitoring and reporting of the impact of initiatives.

Actions

E 1.1 Undertake a review of waste data collection methodologies used internationally in the banana industry (and other similar commodities) and produce recommendations for the Australian industry and supply chain.

E 1.2 Develop banana industry specific data collection tools and processes and encourage the consistent utilisation across the supply chain.

E 1.3 Produce a biannual report on the status of food waste in the Australian banana industry measuring and evaluating the impact of reduction initiatives.

Expected Outcomes

Short term outcomes

Data models research complete, banana industry waste data collection tools developed and being trialled.

Medium term outcomes

Regular reporting on banana food waste reduction.

Data is being used to inform action on waste issues/opportunities.

Long term outcomes

The banana industry and supply chain have access to reliable, relevant, and current data, which is used to produce beneficial outcomes.

Potential Lead Agencies

- End Food Waste Australia
- Australian Banana Growers Council
- Hort Innovation Australia
- Freshcare

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	-	√	√

ENABLE STRATEGY E2- EDUCATION

Implement a food waste education campaign and supply chain communication/coordination activities

Objective:

To empower banana supply chain actors to individually and collaboratively contribute to the food waste reduction agenda from an informed position.

Actions

E 2.1 Disseminate information and research on banana waste to encourage the conversation and commitment of supply chain actors to the food waste agenda and to improving waste transparency.

E 2.2 Develop and promote a banana industry education campaign that highlights the level of banana food waste, the costs to the industry and the benefits to be gained by reducing food waste.

E 2.3 Develop banana food waste reduction information and resources that can be made available to supply chain actors and showcased at field days/extension activities and shed talks.

E 2.4 Identify and showcase food waste champions and innovative waste reduction strategies in the banana supply chain.

E 2.5 Work with other horticultural industry groups to identify and promote transferrable waste reduction techniques.

E 2.6 Support the incorporation of optional food waste reduction certification within existing (e.g., Freshcare) standards to facilitate waste reduction while minimising the burden on growers.

Expected Outcomes

Short term outcomes

All banana supply chain actors are cognisant of the level of banana food waste and are actively engaged in initiatives to reduce.

Food waste standards are in place.

Medium term outcomes

New food waste reduction strategies are proposed and implemented by banana supply chain actors.

Long term outcomes

All banana supply chain stakeholders are informed and educated in food waste factors that are within their sphere of control; the supply chain is actively communicating and collaborating on minimising food waste.

Potential Lead Agencies

- Australian Banana Growers Council
- Hort Innovation Australia
- End Food Waste Australia
- Retailers

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

ENABLE STRATEGY E3 - POLICY

Calibrate policy and regulatory settings

Objective:

To ensure that the regulatory and policy environment facilitates the reduction of banana food waste.

Actions

E 3.1 Review interjurisdictional quarantine arrangements to improve harmonisation and minimise interstate transport delays.

E 3.2 Support biosecurity control/monitoring and containment measures"

E 3.3 Maintain biosecurity vigilance to prevent the incursion of new pests and diseases across international and jurisdictional borders.

E 3.4 Drive advocacy to all levels of government for waste reduction policies and incentives to support the reduction and repurposing of banana food waste.

Expected Outcomes

Short term outcomes

Jurisdictional review and harmonisation complete.

Medium term outcomes

No further detection of Panama TR4 or any other biosecurity threats that would lead to crop destruction.

Long term outcomes

Government policies are supportive of banana food waste reduction.

Potential Lead Agencies

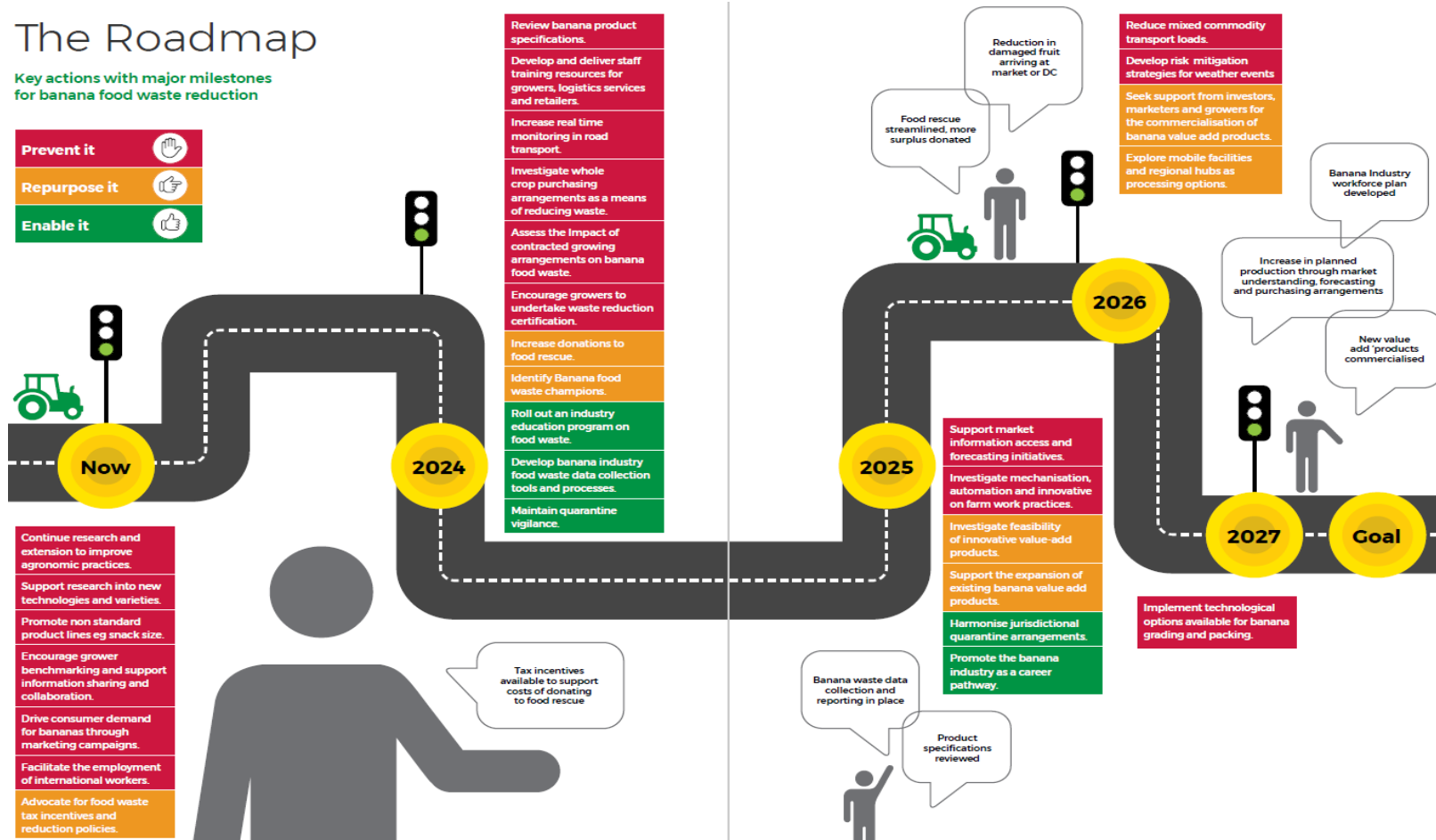
- End Food Waste Australia
- Federal and state governments
- Australian Banana Growers Council

Supply chain point of impact				
In paddock	On-farm/in-shed	Logistics	Market/DC	Retail
√	√	√	√	√

5.2 Roadmap for *Banana Industry Sector Action Plan for Food Waste Reduction*

The following roadmap (Figure 10) highlights the potential journey for the banana industry to reach the 2030 target of halving Australia’s horticulture food waste. Ongoing communication and support from all banana supply chain organisations, the food rescue sector, not-for-profit organisations (e.g., Stop Food Waste Australia) and all tiers of government can ensure effective delivery of solutions to meet the 2030 target.

Figure 10: *Banana SAP* Implementation Roadmap



6. MEASURING IMPACTS OF OUTCOMES

6.1 Towards a MERI Plan

Achieving food waste outcomes and impact is a complex process, involving diverse stakeholders and 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. While a MERI Plan is not presented in this action plan, a full monitoring and evaluation plan can be developed at the outset of the implementation of the action plan. The MERI plan will incorporate the following:

- **Monitoring:** Continuous and systematic observation of how the programs are being implemented, the effect of strategies they are intended to address and indicators of outcomes.
- **Evaluation:** Evidence-based assessment impact of the programs and can include social, economic, environmental, and cultural aspects, often focusing on factors such as effectiveness, efficient, appropriateness and impact.
- **Learning:** Creation of knowledge and the generation of insights and information program delivery and sharing of knowledge about the lessons learned to inform future practice, policy and program development.

The MERI process needs to start with a theory of change.

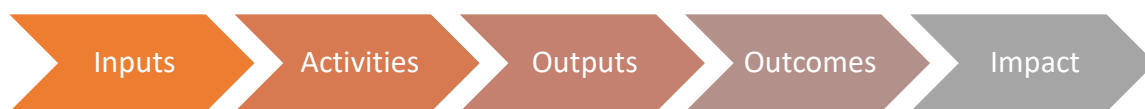
6.2 Theory of Change

The theory of change starts with the food recovery hierarchy with the pillars of prevention, recycling, recovery and disposal. The theory of change adopted for the *Banana Industry* SAP takes into consideration the wider context of food waste. The key elements of the theory of change are as follows:

- There is a need to take into consideration the broader context of food production and distribution systems in developing banana food waste interventions.
- Food waste can occur across the different points of the banana supply chain and will need strategic actions across different dimensions.
- Any change process will require collaboration and information sharing across diverse stakeholders.
- Knowledge and capability development for banana food waste reduction will enable well informed, proactive and innovative approaches to food waste minimisation and transformation.
- If banana food waste can be quantified via appropriate data across the supply chain, this will enable better management of food waste.
- The scale of interventions will be at different levels, including systemic, policy/regulatory, and individual/business behaviour levels. The outcomes will emerge from a combination of industry self-regulation, community behaviour change and policy parameters.
- Banana food waste reduction will require effective planning, coordination, and leadership.
- Banana food waste reduction can have economic, social, cultural, and environmentally positive outcomes and can potentially provide strong returns on investment.

6.3 Program Logic

The program logic is a tool that sets out to show the link between resources (inputs), activities, and intended outcomes and impact. The MERI plan will outline a program logic and identify a systemic approach to the evaluation.



This approach encourages a critical and holistic analysis of the opportunities, constraints and relationships of parts within a system, analysing the system/impacts within wider considerations and holistically. Data collection will rely on diverse data sources, utilising a mixed methodology for both qualitative and quantitative data. Measuring food waste is complex, and a range of methodologies are available, such as 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). Different international methodologies may be used and adapted to measuring Australian banana waste. There are also analyses relating to economic value and nutritional aspects. This kind of analysis can be applied to any single stage of the supply chain or across the whole chain for the banana industry. The methods for data collection and analysis will form part of the MERI plan.

6.3 Indicators of Outcome and Impact

Indicators are measures that show if the outcome and impact are being achieved. It is a metric that provides information to monitor performance and measure achievement against outcomes and impact of the intended action or activity.

Table 3: Indicators of outcomes and impacts

Strategy	Actions	Indicators
<p>P1 Align banana production quantities more closely with demand.</p>	<ul style="list-style-type: none"> • Provide resources to enhance the understanding of producers about the operation of the market, its drivers and the implications for their profitability, levels of production and food waste. • Establish a mechanism to provide commonly available and understood supply and demand forecasting to inform banana production levels. • Develop a mechanism to provide widely available and cost effective, transparent market sales and price data. • Establish a multistakeholder working group to review the current quality specifications used by the markets and retailers to facilitate the sale of bananas with diverse aesthetic characteristics. • Establish a business case and EOI process to identify growers and retailers interested in trialling whole crop purchasing arrangements and conduct trial and share lessons. • Undertake an analysis of the impact of contracted growing on the levels of waste in the banana industry. • Encourage the promotion of product lines that utilise fruit that does not meet 	<ul style="list-style-type: none"> • Forecasting and information tools in place and rates of utilisation. • Improved awareness and understanding about food waste across the banana supply chain. • Improved collaboration across the supply chain about supply and demand • Improved transparency in the market about prices and sales. • Alternative sales mechanisms in place for oversupply of bananas.

Strategy	Actions	Indicators
	<p>the traditional retail specifications, for example, kids' lunch sized, odd sized bunches and the development of new lines.</p> <ul style="list-style-type: none"> • Promote the versatility and associated health benefits of banana consumption and deliver campaigns to increase demand for bananas especially at times of traditionally high supply, for example, September. • Explore the potential for increasing the export of Australian bananas, including identifying the barriers and constraints and an internationally attractive value proposition. 	
<p>P2 Support banana growers to continue best practice production.</p>	<ul style="list-style-type: none"> • Continue to identify needs, and commission and disseminate, research on pest and disease management and plant nutrition. • Increase support to the banana industry and research facilities to encourage best practice production and innovation including the use of technology. • Support research into genetic technologies to improve banana germplasm that minimises waste and increases crop resilience' • Identify and share practices that minimise in-shed damage to fruit (e.g., knife damage, bruising and exposure to bacteria or disease). • Undertake research and industry-based trials on the application of mechanisation and technology to grade, sort, and pack bananas. • Develop a relationship with the Bureau of Meteorology to provide training and information about climate and weather patterns that will impact banana resilience. • Investigate the expected impacts of climate change on the banana industry and undertake risk assessments and develop recommendations for building the resilience of production practice. 	<ul style="list-style-type: none"> • Improved research and extension support services to growers. • Increased awareness and adoption of new and emerging technologies. • Better knowledge about banana crop resilience. • Evidence base developed for climate adaptation in the banana industry.

Strategy	Actions	Indicators
<p>P3</p> <p>Improve the transportation of bananas to minimise damage and transit times.</p>	<ul style="list-style-type: none"> • Research, trial and implement options for improving on-farm transportation and reducing on-farm damage, including mechanisation, automation and improved work practices. • Increase real time monitoring to track loads and to identify temperature and humidity issues and implement strategies to address. • Reduce multi-commodity (mixed) loads, including through adjustments to scheduling, truck sizes and routes. • Increase the use of packaging techniques that delay the ripening process. • Enhance the training and supervision of long-distance truck drivers. 	<ul style="list-style-type: none"> • Efficiencies introduced as best practice into transportation of bananas. • Improved use of real time monitoring to track loads and conditions of transport of bananas. • Adoption of innovation in packaging and ripening technologies • Development of and uptake of driver and relevant staff training
<p>P4</p> <p>Facilitate a consistent supply of skilled labour for the banana industry and supply chain.</p>	<ul style="list-style-type: none"> • Develop and distribute resources/tools to support growers to train field and shed staff in food waste mitigation efficiently and effectively. • Develop and distribute resources to train and support retail staff regarding stock control and merchandising. • Develop an industry level workforce plan to forecast skill requirements over a 5-year horizon. • Facilitate the sourcing and retention of workers from other countries. • Support the employment of backpackers and other travellers through place-based collaboration and industry referral. • Promote the banana industry and the range of available roles as an employment option. 	<ul style="list-style-type: none"> • Assessment of workforce and skill shortages on food waste across commodities and the supply chain completed. • Detailed labour market supply and demand options for the banana industry analysed, and workforce plans developed within 3 years. • Number of trials of innovative workforce supply measures. • Developing industry or enterprise level managerial and technical training facilities to train or retrain existing and future staff across the supply chain to improve food waste reduction. • Initiatives undertaken to link job/training networks and banana industry for place-based collaboration.

Strategy	Actions	Indicators
<p>R1</p> <p>Increase the quantity of bananas being processed and incorporated into value added products for human consumption.</p>	<ul style="list-style-type: none"> • Collate existing research into current and past banana value adding initiatives and communicate these through a range of channels including forums/conferences, field days and online. • Assess current banana value adding activities to identify opportunities for expansion, the barriers to be addressed and the prerequisites for expansion. • Undertake feasibility studies and small-scale trials of innovative banana value added products and nutritional supplements. • Seek the support of investors, marketers, and growers for the commercialisation of banana value-added products. • Support a regional hub approach to the establishment of processing facilities and encourage the collaboration of banana supply chain actors, government, private enterprise, innovators and the financial sector to realise these opportunities. • Explore mobile processing plants as a way to provide access to value adding to smaller and more remote producers. 	<ul style="list-style-type: none"> • Feasibility studies of banana value add products completed. • Options and trials of banana value added products undertaken. • Secondary markets identified for banana waste value added products. • Regional and mobile processing hubs options explored and/or established to support the development of secondary products. • Capacity of supply chain actors developed to undertake value added products.
<p>R2</p> <p>Increase the quantity of bananas donated to food rescue organisations.</p>	<ul style="list-style-type: none"> • Develop a recognition program for banana growers, marketers and retailers who contribute to food rescue organisations. • Identify a team of high-profile champions who promote the use of food rescue organisations and facilitate connections across the banana supply chain. • Work with the food rescue sector and its supporters to identify, analyse and address the barriers to the increased deployment of waste bananas to food rescue organisations. • Advocate for financial incentives, including tax incentives to offset the costs incurred by banana supply chain actors in supporting food rescue organisations. 	<ul style="list-style-type: none"> • Increase in the number of food rescue and distribution points and activities. • Challenges and barriers to food rescue identified and interventions in place to address them. • Recognition system established for banana rescue efforts. • Advocacy activities for tax incentives or rewards; incentives in place. • Good practice showcased and shared. • Number of innovative projects linking with circular economy, value add and other waste stream management initiatives.

Strategy	Actions	Indicators
	<ul style="list-style-type: none"> Identify regional hubs and recruit supply chain partners (including volunteer workers) willing to support banana recovery as a corporate social responsibility opportunity. 	
<p>E1</p> <p>Develop and encourage the widespread implementation of improved waste data collection, reporting and analysis.</p>	<ul style="list-style-type: none"> Undertake a review of waste data collection methodologies used internationally in the banana industry (and other similar commodities) and produce recommendations for the Australian industry and supply chain. Develop banana industry specific data collection tools and processes and encourage the consistent utilisation across the supply chain. Produce a biannual report on the status of food waste in the Australian banana industry, measuring and evaluating the impact of reduction initiatives. 	<ul style="list-style-type: none"> Review of data collection methodologies finalised. Tools and systems in place for data collection. Baseline data collected. Participation in data collection across the supply chain. Incentives in place to support data collection. Bi-annual reports published. Mechanisms in place to disseminate, share and utilise data and knowledge across the industry.
<p>E2</p> <p>Implement an education campaign and supply chain communication/ coordination activities.</p>	<ul style="list-style-type: none"> Disseminate information and research on banana waste to encourage the conversation and improve waste transparency. Develop and promote a banana industry education campaign that highlights the level of banana food waste, the costs to the industry and the benefits to be gained by reducing food waste. Develop banana food waste reduction information and resources that can be made available to supply chain actors and showcased at field days/extension activities and shed talks. Identify and showcase food waste champions and innovative waste reduction strategies in the banana supply chain. Work with other horticultural industry groups to identify and promote transferrable waste reduction techniques. Support the incorporation of optional food waste reduction certification within existing standards (e.g., Freshacre) to facilitate waste reduction while minimising the burden on growers. 	<ul style="list-style-type: none"> Number of educational activities and tools/materials shared. Standards reviewed through waste reduction lens. The level of training and information support provided to retailers to minimise food waste. Level of collaborative activities across the industry regarding food waste. Food waste champions established and promoted. Good news stories showcased.

Strategy	Actions	Indicators
<p>E3</p> <p>Calibrate policy and regulatory settings to support banana food waste reduction.</p>	<ul style="list-style-type: none"> • Review interjurisdictional quarantine arrangements to improve harmonisation and minimise interstate transport delays. • • Support biosecurity control/monitoring and containment measures. • Maintain biosecurity vigilance to prevent the incursion of new pests and diseases across international and jurisdictional borders. • Drive advocacy to all levels of government for waste reduction policies and incentives to support the reduction and repurposing of banana food waste. 	<ul style="list-style-type: none"> • Cross jurisdictional biosecurity and quarantine laws reviewed and harmonised. • Policy incentives to reduce food waste developed. • Increasing monitoring and controls in place for disease control.

7. CONCLUSION AND FUTURE STUDY

This report has presented findings about hotspots and the root causes of food waste in the Australian banana industry through a triangulation of the results gathered from the literature review, stakeholder interviews and stakeholder workshops. Nine strategies were identified, including four supporting preventions, two for repurposing food waste and three for the enabling environment. Multiple actions were also listed under each strategy with potential outcomes in different time frames. In addition, a roadmap for the implementation of the *Banana Industry SAP for Food Waste Reduction* has been provided. It outlines key actions and major milestones for banana food waste reduction through a combination of prevention, repurposing and enabling strategies.

In conclusion, by aligning production with demand, improving transportation, repurposing surplus bananas and implementing supporting measures, the banana industry can make significant strides towards reducing waste and achieving the target of halving banana food waste by 2030. Future research can be conducted into each of the nine strategic action areas; seek to quantify the economic, environmental and social impacts of banana food waste, and can explore initiatives such as utilising the Foodbank Hunger Map for the distribution of surplus bananas.

References

- Acevedo, A. S., Carrillo, Á.J. D., Flórez-López, E., & Grande-Tovar, C.D. (2021). Recovery of banana waste-loss from production and processing: A contribution to a circular economy. *Molecules*, 26(17), 5282. <https://doi.org/10.3390/molecules26175282>
- Ahmad, T., & Danish, M. (2018). Prospects of banana waste utilization in wastewater treatment: A review. *Journal of Environmental Management*, Vol 206, pp 330–348. <https://doi.org/10.1016/j.jenvman.2017.10.061>
- Ambiel C., Adell A., Sanguansri P., Krause D., Gamage T., Garcia-Flores, R., & Juliano P. (2019). *Mapping Australia fruit and vegetable losses pre-retail*. CSIRO, Australia.
- Arcadis. (2019). *National food waste baseline- Final assessment report*. AGNESP, Canberra.
- Australian Banana Growers Council (ABGC). (2024). *Key facts*. <https://abgc.org.au/our-industry/>
- Australian Banana Growers Council (ABGC). (2023b). *Australian bananas media kit*. <https://abgc.org.au/wp-content/uploads/2023/01/2023-Australian-Bananas-Media-Kit-FINAL.pdf>
- Australian Banana Growers' Council (ABGC). (2022, December). *Australian Banana Magazine*. <https://abgc.org.au/wp-content/themes/abgc/assets/lib/magazine/magazine.html?file=https://abgc.org.au/wp-content/uploads/2022/12/Issue-66-DECEMBER-2022-WEBSITE.pdf#magazineMode=true>, accessed on January, 2023.
- Australian Banana. (2023). *The banana story*. <https://australianbananas.com.au/Pages/all-about-bananas/the-banana-story>
- Australian Government. (2017). *National food waste strategy*. DAAF, Canberra.
- Beausang C., Hall C., & Toma L. (2017). Food waste and losses in primary production: Qualitative insights from horticulture. *Resources, Conservation and Recycling*, 126, 127–185
- Biryabarema, E. (2021). *Uganda start-up bets big on banana waste*. <https://www.reuters.com/business/environment/uganda-start-up-bets-big-banana-waste-2021-04-16/>, accessed on January 2023.
- Brodribb, P., McCann, M., Motaballian, J., (2020) *A study of waste in the cold food chain and opportunities for improvement*. Canberra
- Commission of Environmental Cooperation (CEC). (2021). *Why and how to measure food loss and waste: A practical guide - Version 2.0*. Montreal, Canada.
- Cugala, D., Tostao, E., Affognon, H., Mutungi, C., (2012) *Postharvest losses in Africa _ Analytical review and synthesis: the case of Mozambique African Insect Science for Food and Health*
- Davis. R. (2017). *Increasing productivity through decreasing food waste in the value chain, particularly pre-farm gate*. Rural Industries Research and Development Corporation (RIRDC) report. <https://www.agrifutures.com.au/wp-content/uploads/2017/08/RIRDC-Report-February-2017.pdf>
- Downham, R. (2022). *Crop loss/waste on Australian horticulture farms 2021–22* (research report), ABARES, DAFF, Canberra. <https://www.agriculture.gov.au/abares/research-topics/surveys/horticulture-crop-loss#daff-page-main>, accessed on January, 2023.
- Ekman J., Lindsay S., & Gething K. (2011). *Improved handling in banana supply chains*. Horticulture Australia: Sydney.
- FAO. (2021). *Reduce, reuse, recycle: A mantra for food packaging*. <https://www.fao.org/fao-stories/article/en/c/1441299>
- FAO Stat. (2023). *Crops and livestock products*. <https://www.fao.org/faostat/en/?#data/QCL> , accessed on February 2023.

- Feedback & the Rockfeller Foundation, (2017). Causes of food waste in international supply chains. London: Feedback and the Rockfeller Foundation. England. <https://feedbackglobal.org/wp-content/uploads/2017/02/Causes-of-food-waste-in-international-supply-chains.pdf>, accessed on February 2024.
- Fernando, I., Fei, J., Stanley, R., Enshaei, H., & Eyles, A. (2019). Quality deterioration of bananas in the post-harvest supply chain—An empirical study. *Modern Supply Chain Research and Applications*, 1(2), 135–154. <https://doi.org/10.1108/MS CRA-05-2019-0012>
- Food Innovation Australia Ltd. (FIAL). (2019a). *A roadmap for reducing Australia’s food waste by half by 2030*. FIAL, NSW.
- Food Innovation Australia Ltd. (FIAL). (2019b). *Resources for Implementing the national food waste strategy*. FIAL, NSW.
- Food Innovation Australia Ltd. (FIAL). (2021). *The national food waste strategy feasibility study: Can we halve Australia’s food waste by 2030?* FIAL, NSW.
- Food Loss and Waste (FLW). (2016). *Food loss and waste accounting and reporting standard*. <https://flwprotocol.org/flw-standard/>, accessed on 1/03/2023.
- Fresh Market Australia (2006). Banana-Combined all FreshSpecs, <https://www.freshmarkets.com.au/wp-content/uploads/Banana-Combined-All-FreshSpecs.pdf>, accessed on January, 2023.
- Ghantous, N. (2022). *Cool bananas: Efficient cold chain technology for a clean agriculture boom*,
- Global Fruit Protection Pty Ltd. (2023). *ClipSlip®: Reduce wastage, increase profit*. <http://www.clipslip.com.au/>.
- Harvey, S., Cook, S., & Poggio, M. (2016). *Economic assessment of best management practices for banana growing: Report to the Department of Environment and Heritage Protection through funding from the Reef Water Quality Science Program: RP140B Initial synthesis report*. Department of Agriculture and Fisheries (DAF), Queensland.
- Heising, J.K, Claassen, G.D.H., & Dekker, M. (2017). Options for reducing food waste by quality-controlled logistics using intelligent packaging along the supply chain. *Food Additives & Contaminants: Part A*, 34(10), 1672–1680. <https://doi.org/10.1080/19440049.2017.1315776>
- Hort Innovation. (2022). *Australian horticulture statistics handbook 2021/22*. Hort Innovation, Sydney. <https://www.energymonitor.ai/sectors/heating-cooling/cool-bananas-efficient-cold-chain-technology-for-a-clean-agriculture-boom/>, accessed on 1/03/2023.
- IFCO system. (2023). *Success stories: PENNY eliminates waste from organic banana supply chains*. <https://www.ifco.com/success-story-penny-eliminates-waste-from-organic-banana-supply-chains/>.
- Itelima, J., Onwuliri, F. O., E., Onyimba, I., & Oforji, S. (2013). Bio-ethanol production from banana, plantain and pineapple peels by simultaneous saccharification and fermentation process. *International Journal of Environmental Science and Development*. 4(2), 213–216.
- Jedermann R., Nicometo M., Uysal, I. & Lang, W. (2014). Reducing food losses by intelligent food logistics. *Philosophical Transactions of the Royal Society A*, 372(2017), 20130302. <http://dx.doi.org/10.1098/rsta.2013.0302>
- King, N. (2021). *Banana best management practices: Environmental guidelines for the Australian banana industry – V3*. https://abgc.org.au/wp-content/uploads/2021/11/BMP-Review-V3_WEB-VERSION.pdf, accessed on January, 2023.
- Kneebone, M. (2010). *Investigating alternative banana distribution channels*. Horticulture Australia Ltd. (HAL).

- Kukulies, T., & Veivers, S. (2017). *Banana best management practices: On-farm biosecurity*. Australia, Agri-Science Queensland, Department of Agriculture and Fisheries, The Queensland Government.
- Lemin, C., Johnstone S., & Piper R. (2007). *The Clippisip - Field trial summary report*. Australia, Queensland Department of Primary Industries and Fisheries; Scientific Advisory Services Pty Ltd.
- Lu S., Cheng G., Li T., Xue L., Liu X., Huang J., & Liu G. (2022). Quantifying supply chain food loss in China with primary data. *Resources, Conservation and Recycling*, 177, 106006.
- Macheka, L., Ngadze, R.T., Manditsera, F.A., Mubaiwa, J., & Musundire, R. (2013). Identifying causes of mechanical defects and critical control points in fruit supply chains: An overview of a banana supply chain. *International Journal of Postharvest Technology and Innovation*, 3(2), 109–122.
- Macnish A. (2019). *Supply chain monitoring and improvement to reduce banana quality loss*. FFWCRC, Brisbane.
- Marty, M., Akbar, D., (2023), Small scale Banana growers supply chain- Field observation from 2013 to 2023, north and far north Queensland.
- McKenzie, T.J., Singh-Peterson, L., & Underhill, S.J.R. (2017). Quantifying postharvest loss and the implication of market-based decisions: A case study of two commercial domestic tomato supply chains in Queensland, Australia. *Horticulturae*, 3(44), 1–15.
- Møller, H., Hansen, O. J., Svanes, E., Hartikainen, H., Silvennoinen, K., Gustavsson, J., et al. (2014). *Standard approach on quantitative techniques to be used to estimate food waste levels: Project report*. FUSIONS.
- Moragues-Faus, A., Sonnino, R., & Marsden, T. (2017). Exploring European food system vulnerabilities: Towards integrated food security governance. *Environmental Science & Policy*, 75, 184–215.
- Naim F. (2019). *BananaWax*. CSIRO. <https://www.csiro.au/-/media/About/Files/Impact-case-studies/One-pagers/ICS--BananaWax-2019-1.pdf>, accessed on January, 2023.
- Nieto-Montenegro, S., Brown, J.L., & LaBorde, L.F. (2008). Development and assessment of pilot food safety educational materials and training strategies for Hispanic workers in the mushroom industry using the health action model. *Food Control*, 19(6), 616–633.
- Rana, G. K., Singh Y., Mishra S. P., & Rahangdale, H. K. (2018). Potential use of banana and its by-products: A review. *International Journal of Current Microbiology and Applied Sciences*, 7(6), 1827–1832.
- Rolker, H., Eisler, M., Cardenas, L., Deeney, M., & Takahashi, T. (2022). Food waste interventions in low-and-middle-income countries: A systematic literature review. *Resources, Conservation and Recycling*, 186, 106534. <https://doi.org/10.1016/j.resconrec.2022.106534>
- Spence A. (2020). *Banana waste technology begins to bear fruit for Adelaide company*.
- Ssenoga F., Mugurusi G., & Oluca P.N. (2019). Food insecurity as a supply chain problem: Evidence and lessons from the production and supply of bananas in Uganda. *Scientific African*, 3, e00076. <https://doi.org/10.1016/j.sciaf.2019.e00076>
- Stop Food Waste Australia (SFWA). (2022). *Understanding on-farm food loss - Roundtable with states and territories* (unpublished manuscript).
- Stop Food Waste Australia (SFWA). (2023). *Sector action plans: Working together to reduce food loss and waste* (unpublished manuscript).
- TexFad. (2023). *TexFad, skills and training academy*. <https://texfad.co.ug/index.php>
- United Nations (UN). (2022). *Tracking progress on food and agriculture-related SDG indicators 2022*. <https://www.fao.org/3/cc1403en/online/cc1403en.html#/>

- White A., Gallegos D., & Hundloe T. (2011). The impact of fresh food specification on the Australian food and nutrition system: A case study of the north Queensland banana Industry. *Public Health Nutrition*, Vol 14 No8, 1489–1495.
- WRAP. (2020a). *Whole chain food waste reduction plan toolkit*. WRAP & IGD, UK.
- WRAP. (2020b). *Whole chain food waste reduction plan toolkit: Quick start guide*. WRAP & IGD, UK.
- WRAP. (2022). *The Courtauld commitment 2030: Progress and insights report 2022*, <https://wrap.org.uk/resources/report/courtauld-commitment-2030-progress-and-insights-report-2022#download-file>, accessed on January, 2023.
- Xia, C., & Nelson, R. (2018). Exploring Australia’s comparative advantage for exporting fresh produce. *Agricultural Commodities*, 8(1), pp 176–198.
- Yahia, E. M. (2019). Introduction. In E. M. Yahia (Ed.), *Postharvest technology of perishable horticultural commodities* (pp. 1–41). Woodhead Publishing, UK.
- Young, C. (2021). *Uganda startup makes carpets, hair extensions out of banana waste*. <https://interestingengineering.com/science/uganda-startup-makes-carpets-hair-extensions-out-of-banana-waste> , accessed on 22/12/2022.
- Yusof, N. A. A. N., & Yusoff, M. (2020). Investigation of chemical analysis and physical properties of bio-polymer waste banana peel fibre composite. IOP Conference Series: *Earth and Environmental Science*, 596(1), 012042.

APPENDICES

Appendix A1. Literature review: Key findings

1. The food waste reduction agenda and its application to the banana industry: global, national and industry insights

Food waste and loss is a global issue and one that has been gathering international momentum over the twenty-first century. In 2011 the Food and Agriculture Organisation (FAO) of the United Nations released the report, *Global Food Losses and Food Waste* which detailed how one-third of the food produced for human consumption is lost or wasted globally. Lost or wasted food also represents hundreds of millions of megalitres of wasted fresh water and massive amounts of wasted energy – on top of the ineffective use of over a quarter of the world's arable land (Lapidge, 2015)

Australia and its oceanic neighbours New Zealand and North America have the unfortunate title of being the worst food wasters in the world. (Lapidge, 2015)

Whilst sceptics might suggest that these aggregated international and national figures are not relevant, it should be noted that bananas are the second most produced fruit worldwide, after citrus and contribute around 16% of world fruit production. It is estimated that after harvest almost 60% of banana biomass, including fruits, leaf and stem, are left as waste. Australia produces about 40,000 tonnes of banana waste-loss, while about 114.08 million metric tonnes of banana waste-loss are produced annually worldwide (Acevedo 2021). These figures substantiate the importance of minimising waste in the Australian banana industry and signal the potential scaled impact that could be influenced worldwide.

In response to the need for urgent action a global food waste reduction target was adopted in 2015 and included in the United Nations Sustainable Development Goals (SDG). It aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses by 2030 (UN, 2022).

In the United Kingdom, the Courtauld Commitment has driven research and more importantly action across industries and supply chains to reduce food waste and the associated resources. Led by WRAP this initiative has seen 300 Food businesses commit to the Food Waste Reduction Roadmap including all of the major grocery retailers. Further details of actions and achievements can be found in the Courtauld Commitment 2030 Progress and Insights Report 2022 (Wrap, 2022)

Australia's National Food Waste Strategy has the ambitious target to halve Australia's food waste by 2030. Through FIAL (Food Innovation Australia Limited) a Roadmap for reducing Australia's food waste by half by 2030 (The Roadmap) documents a clear path forward identifying the main steps and initiatives required to reach the Australian target. The importance of commitment, collaboration, and funding from all levels of government, industry and key stakeholders is highlighted (DCCEEW, 2017).

In its Roadmap, FIAL (2019 p.4) suggests that Australia produces 7.3 million tonnes of food waste per year which represents approximately \$20B. Of this waste, primary production accounts for 31%. Further clarity on Australia's entry benchmark, The National Food Waste baseline (Arcadis 2019) presents detailed data describing food waste across the fruit and vegetable (F&V) sector noting that "food waste across the F&V supply and consumption chain is among the highest of all primary production segments" (FIAL, 2019, p.30). It suggested that national on-farm loss of bananas in 2016/17 was in excess of 40,000 tonnes.

One of the key learnings of The National Food Waste Strategy Feasibility Study was that that " industry led initiatives provide the most cost-effective approach to reducing food waste, once a supportive framework is in place " (DCCEEW, 2017, p.11) This project through the development of a food waste

action plan for the banana industry is one of the initiatives that will contribute to a change in practices and behaviour to support the reduction of banana food waste.

The Roadmap (FIAL 2019 p.14) endorses this process and suggests that Sector Action Plans are an opportunity to target interventions to reduce food loss and waste, while realising multiple benefits for supply chain partners and collaborators. Sector action plans are well placed to embody systems thinking and a circular economy approach.’

Sector Action Plans are currently under development for a range of industries, including horticulture, and this project will capitalise on the learnings gained through these processes.

2. Food waste hierarchy and good practices

The National Food Waste Strategy notes that the volume and value of wasted food presents a number of opportunities to identify where the greatest benefits can be achieved in avoiding food waste or where it can be repurposed. The following waste hierarchy (Figure A1.1) taken from Stop Food Waste Australia (SFWA) prioritises waste management practices that prevent or avoid food waste over recycling, recovery and as a last resort waste disposal.

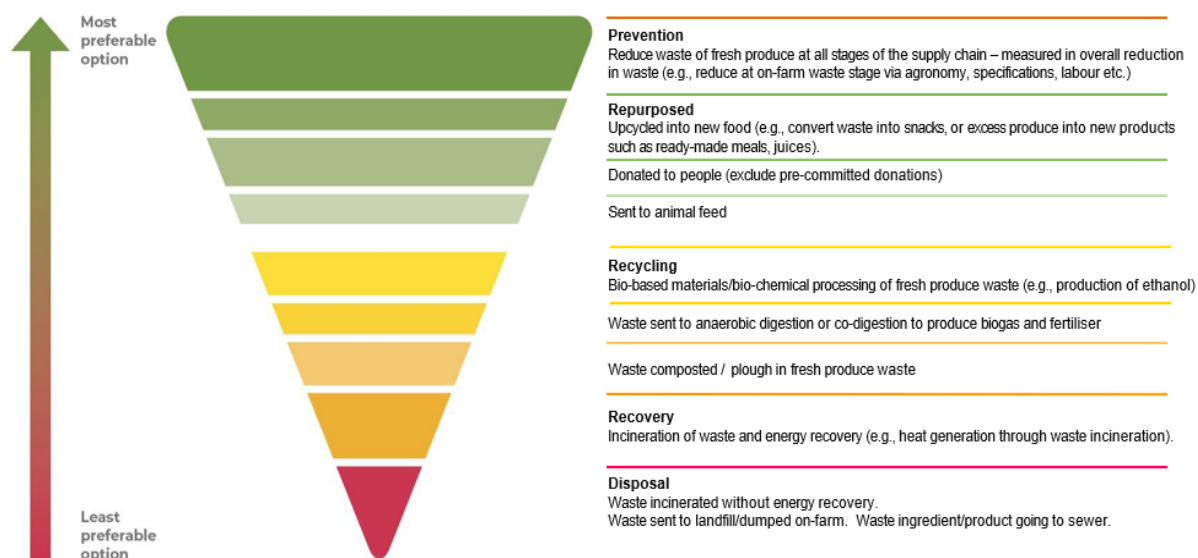


Figure A1.1: Horticulture specific food recovery hierarchy

For the purpose of this report waste mitigation strategies are discussed using the key hierarchy levels - prevent, recycle, recover and disposal - as illustrated above. Interventions articulated in the National Food Waste Strategy Feasibility strategy will be described in the appropriate part of the hierarchy and dually acknowledged.

The ABARE survey previously discussed, asked participants about what they did with their waste. Most horticulture farms indicated that their crop loss/waste in 2021–22 was left on the ground (44% of farms) or ploughed into the ground (26%). Crop loss/waste was also recovered for compost (18% of farms), recovered for animal feed (10%), buried on farm (5%), recovered for use in other products (4%) and recovered for fuel (<1%). At this point the data is unable to be interrogated to identify the respondents from the banana industry, however this can be explored in the future and supplemented with data collected through the stakeholder engagement process.

2.1 Prevention

2.1.1 Limit waste creation

Initiatives that prevent crop and food waste are proactive and designed to limit the waste creation in the first place. In the production stage this could involve improved agronomics including pest and disease control, crop fertilisation and irrigation technologies to produce optimum fruit. (Beausang 2017)

Research into the Banana supply chain has identified a series of packing, packaging and transport innovations whose implementation has prevented an amount of fruit waste. (Eckman 2011) Lessons can also be learned from investigations into food waste prevention with other horticultural products. McKenzie's case study of the tomato supply chain identified temperature management along with transport routes and timings as opportunities to prevent wastage in the distribution phase of the tomato supply chain.

Weather forecasting and disaster preparedness strategies can also help to manage crop damage. After the crop devastation of cyclones in north Queensland some growers have relocated or diversified their farming operations to regions with reduced natural disaster risks. Whilst the motivator for these actions may have been financial viability a positive secondary benefit is the prevention of cyclone created waste (Marty and Akbar 2023).

Growers suggest that improved staff skills through training and use of mechanisation and technology to monitor crops in the paddock and in transport may prevent waste caused by damage (Marty and Akbar 2023).

A supply chain monitoring and improvement project (Macnish, 2019) currently being conducted in conjunction with Pacific Coast Eco bananas aims to reduce waste and economic loss in export markets. The project has a target to reduce fruit waste from 10% to 2 % and save an estimated \$1.4m in losses. It features the monitoring of shipments to quantify the cause of fruit quality loss and identify improved practices and develop a decision-making tool that predicts fruit quality utilising temperature monitoring and modelling.

On-farm innovations including the ClipSlip, a unique plastic clip attached to a slipsheet to control damage during growing phase can reduce wastage to 1% to 3%. It can accommodate many varieties of bananas and a broad range of other fruits (Global Fruit Protection Pty Ltd. 2023). A ClipSlip can be reused up to ten times, so a return on investment is high. Compared to traditionally grown bananas, the fruit grown with ClipSlips applied had: 25 times less tip scarring (old and fresh), 34% less bag rub, 30% less fresh handling damage, 23% less fresh knife cuts, 53% less animal damage and 11 times less field sap staining (Lemin, Johnstone et al. 2007). In total, the fruit grown with ClipSlips had 44% less wastage than that grown traditionally (Lemin, Johnstone et al. 2007).

2.1.2 Controlled Storage Conditions for Bananas

Monitoring and controlling factors associated with the storage of bananas and the impact of these factors on the bananas shelf life and ability to meet standards can reduce the amount of damage and food waste.

Temperature – Bananas are typically stored at about 56°F-58°F for long-term storage and transport. Once they are ready for ripening, they are warmed slightly to about 59°F-68°F. Bananas should not be subjected to temperatures below 55°F because they are very susceptible to chill damage with green fruit actually more vulnerable than ripe fruit.

Relative Humidity – Optimum relative humidity is about 90%-95%.

Handling – Bananas should be very carefully handled. Dropping them, scuffing them, or bruising them will damage the fruit, could contribute to water loss, and may also cause premature decay.

Shelf Life – The shelf life of bananas will vary significantly based on harvest conditions and storage conditions. Tree ripened fruit only lasts about 7-10 days while fruit picked green and cooled and stored correctly typically lasts about 3-4 weeks. Bananas that undergo controlled atmospheric conditions may even last up to 40 days, or almost 6 weeks.

2.1.3 Improvement in utilisation

Food waste can also be prevented by initiatives that see the product that will not make it to the commercial customer in its intended form, used as a food for people or animals through value adding, upcycling or an alternative process.

Food Rescue initiatives whether by large scale operators such as Foodbank, Oz Harvest or Second Bite or local, community-based churches and charities are an example of redistribution strategies where the 'waste banana' is consumed by people. Although small-scale roadside stalls, food cooperatives and local donations exemplify the prevention of food waste. This is a core element of the National Food Waste Feasibility Plan (2021) and will be actively pursued during this project.

Upcycling, that is repurposing and value adding to create a new food product is another strategy that can prevent bananas from going to waste. Recent innovations in this space include banana flour, ice cream or gelato (Stanley, 2017), health bars (Boelter 2017). These add to traditional uses of dried bananas, banana chips, frozen banana, banana slices in syrup, jams/jellies, beverages, baby food and food flavour additives. Research continues on alternative uses for many horticultural products including bananas. However, for many of these products their feasibility, scalability, and the securing of economically viable supply chains and investment requires further investigation to validate their profitability and their role as a waste reduction strategy.

Opportunities to use banana waste in its natural state or following a degree of processing for animal fodder are currently being pursued both at local levels and more systemic scales.

2.2 Recycling

Strategies that divert wastage by taking what was destined as human (or animal) food and applying a different use to it are classed as recycling.

Davis (2017 p.3) investigated European practices in the value-add of graded out (waste) horticultural product pre-farm gate. She notes that 'waste' is not a considered word in the European food vernacular and the use of by-products/co streams has enabled a maximising approach to the use of food generally. While her research focussed on potatoes, she identified a range of viable options for transforming 'waste' into valued added products especially for human consumption, some of which maybe applicable to the Banana industry.

It has become common practice for excess fruit to be composted on-farm either in paddock or in compost piles thereby returning organic matter and the associated nutrients to the soil and supporting future crops.

The use of banana waste along the supply chain for animal feed as advocated by the National Food Waste Strategy Feasibility Study (FIAL,2021) is also an area being explored by some current growers and warrants further exploration.

Avecedo (2021) reviewed options for banana waste to contribute to the circular economy and suggests that the agro-industrial waste produced in the banana supply chain has potential uses and applications in organic fertiliser, bioenergy production, wastewater treatment, nanotechnology, and bioplastics production. His work includes the utilisation of wasted banana fruit, leaves, and stems and demonstrates environmental and economic benefit of circular economy activities.

Banana pseudostems have also been identified for waste diversion. An Adelaide company, Papyrus Australia has spent over twenty years perfecting its system of turning banana plantation waste into wood and paper products while a research team support through CSIRO’s ON program has successfully demonstrated laboratory scale extraction of high value banana wax from banana waste. (Naim, undated)

2.3 Recovery

Some of the alternative uses of banana waste identified by Avecedo (2021) include bio-energy which provides secondary benefits in terms of a sustainable power source and environmental benefits through the reduction of the carbon emissions created by disposal.

This study described investigations into the use of banana biomass for the creation of a range of bio-fuels from biogas, to alcohol, hydrogen and biodiesel and concludes that “it has been shown that leaves, rachis, pseudostems and banana peel have a high potential for use, which can be used in various recovery process.” (Avecedo, 2021, p.22)

The chemical composition (Yusof and Yusoff 2020) of the waste banana peel fibre (WBPF) can be found from the Figure below. Lignin, holocellulose, and alpha-cellulose can be used as feedstock for value-adding products like composite biopolymers, antifungal, antibiotic medication production, and biosorbent to remove nitrites from wastewater (Rana, Singh et al. 2018, Yusof and Yusoff 2020) (Figure A1.2).

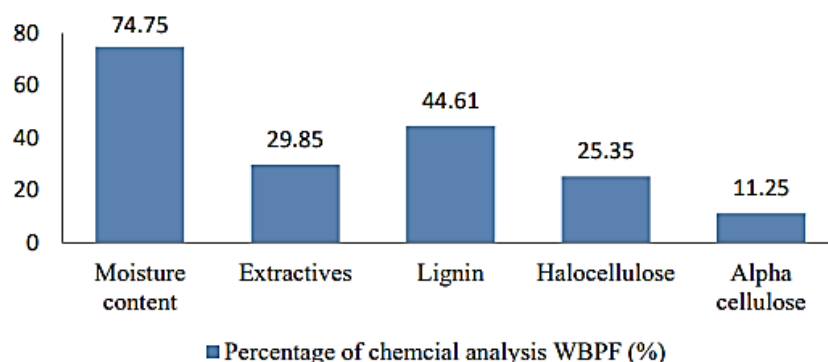


Figure A1.2: Chemical analysis of waste banana peel (Yusof and Yusoff 2020)

On the other hand, currently Australian banana producers discard the banana plants and other left-over biomass as garbage to the land and allow those to decompose with the soil, which is a major concern due to methane emissions and loss of opportunity to recover value adding products. This -significant amount of biomass can be used as feedstock for production of bioethanol, polymer fibres, biogas, and various biotechnological products through proper collaboration with specialised investors (J. Itelima 2013, Rana, Singh et al. 2018).

2.4 Disposal

Disposal is the least preferable option in the waste hierarchy and involves the wasted product being included in landfill and or incinerated without energy recovery. As indicated by ABARES (Downham 2022) this is currently the most common waste treatment by banana growers – with 44% of respondents leaving the crop on the ground and a further 26% ploughing it into the ground. Disposal is not only an issue in terms of food waste, but it has serious environmental impacts in terms of greenhouse gas emissions.

Brodribb et al. (2020 p. 45) provides an illustration of the comparative scale of emission intensity based on kg CO₂-e/kg of food waste. An excerpt is included below to demonstrate banana waste's impact relative to other fruit and vegetables (Table A1.1).

Table A1.1: Emission intensity of CO₂ for different agricultural commodities

Food type	Agricultural impacts (kg CO ₂ -e/tonne)	Landfill impacts (kg CO ₂ -e/tonne)	Total (kg CO ₂ -e/tonne)
Fruit & Vegetable	212.5	1,265.4	1,477.9
Apple	112.7	1,350.1	1,462.8
Banana	207.8	2,345.9	2,553.7
Carrot	101.7	1,094.9	1,196.6
Grape	217.6	1,819.5	2,037.1
Lettuce	160.3	469.4	629.7
Tomato	475.1	512.4	987.5

Source: Brodribb et al. 2020

3. Review on the past, present and proposed interventions

Interventions are specific actions that can be utilized at one or more than one stages of the supply chain to reduce waste. These interventions may be categorised based on the stage of the supply chain or by the types of interventions. Rolker et al (2022) categorised the intervention based on the mode of delivery and these categories are machinery, materials, methods, people (knowledge and abilities), and (5) environment (factors external to the food value chain such as infrastructure and legislation) (Figure A1.3).

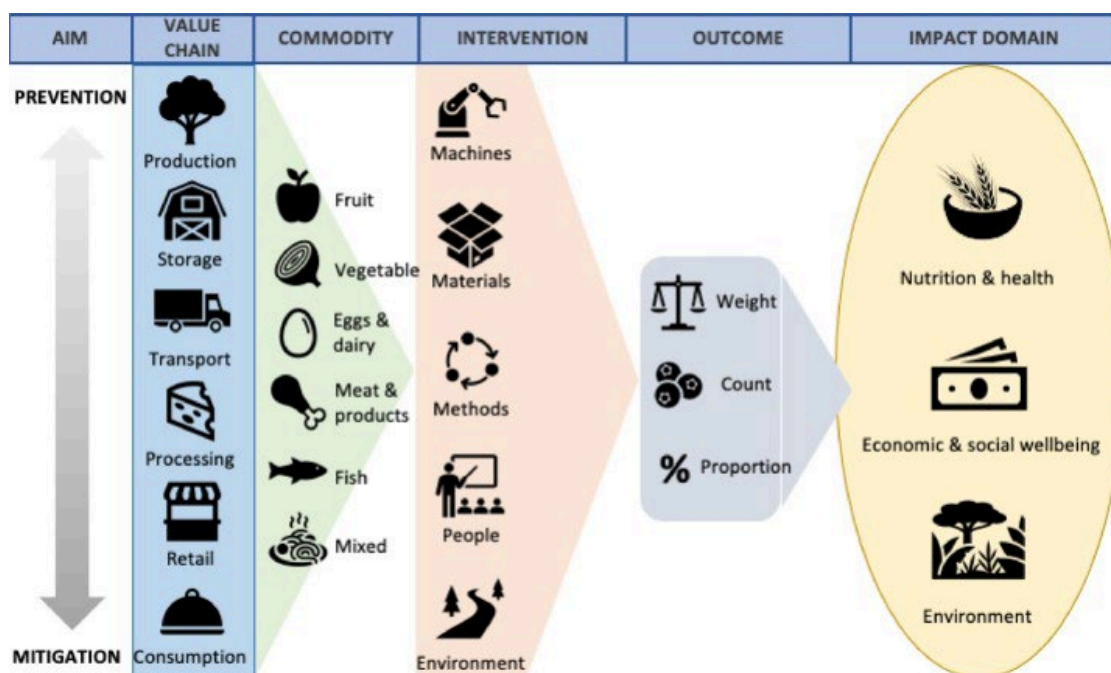


Figure A1.3: Key intervention in food supply chain and their impact (Rolker et al 2022)

The research team has investigated numerous interventions that are applicable to the fruits and vegetable supply chain. A comprehensive literature review of the interventions has been included in the Horticulture Sector Action Plan for Food Waste Reduction (referred here is Hort SAP) report and the Sector Action Plan for the banana industry. In this section, we are focusing on the specific interventions that are applicable to the Banana supply chain. It should be noted that some of the interventions included in the other reports that have been produced as outputs of this project that is the Horticultural Sector Action Plan for Food Waste Reduction and the commodity specific Melon Industry SAP for Food Waste Reduction are generically relevant to the banana supply chain, but they are not included in this report to minimize duplication. Such interventions are the on-farm measurement of waste, Specification review of the fresh products, forecasting demand, tax incentive reforms etc.

Within the banana supply chain, wastage occurs in the form of fruit damage. There are numerous causes behind the fruit damage including, mishandling, packaging material, inappropriate temperature environment during transport and storage etc. (see Figure A1.4, Fernando et al 2019). This wastage can be minimized with attention to detail and applicable interventions. The wastage produced in the field during the cultivation is difficult to minimize and can be redirected to energy production and wastewater treatment (Alzate Acevedo et al., 2021, Ahmad and Danish 2018). In the following section, we discussed some specific interventions in the banana supply chain that are currently in practice or in the research stage.

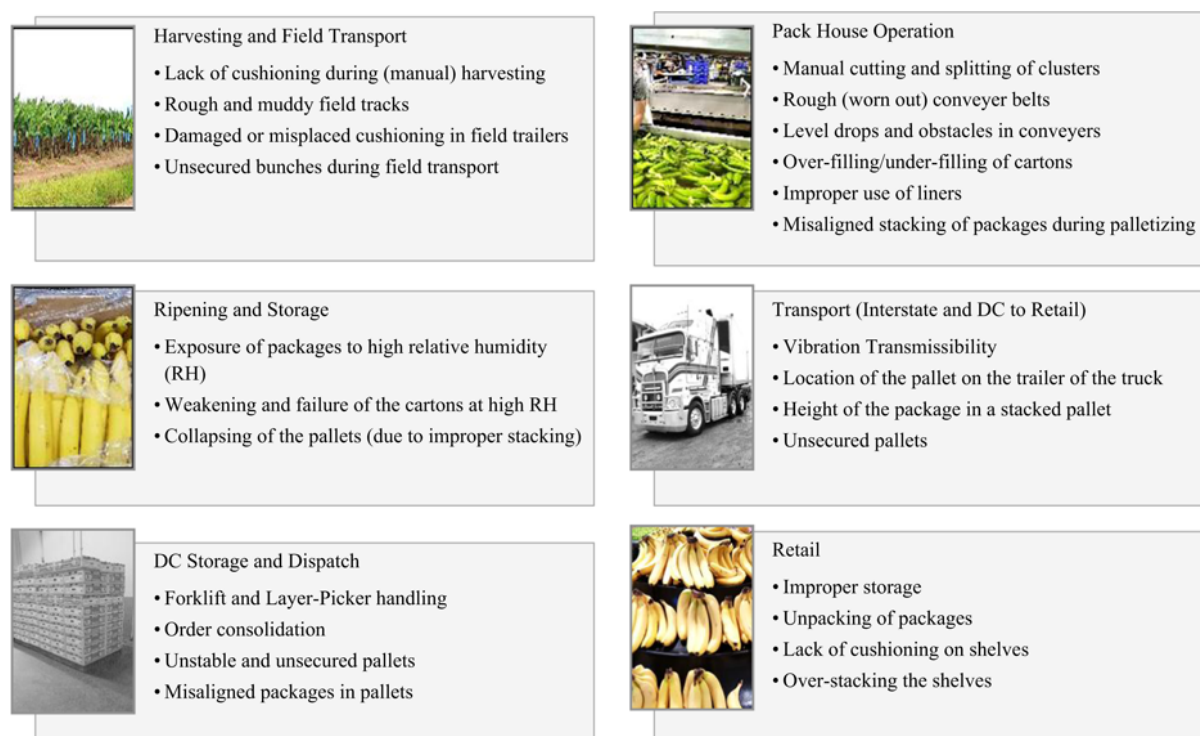


Figure A1.4: Key reasons behind fruit damage in different stage of banana supply chain (Fernando et al., 2019)

3.1 Best management practice (BMP)

Best management practice (BMP) is one of the key interventions in banana production to reduce waste. QLD government and Hort Innovation Australia jointly published the best management practice guidelines for banana producers which consists of a self-assessment checklist and guidelines to improve current practice (King, 2021). This report is focusing on the reuse of banana branch covers and waste bananas during production and indicates the environmental benefits of such practices. Some of the key recommendations were to reuse bunch covers where possible, mulch and spread waste fruits and stalks back into the banana paddock and use waste fruits as stock feed. These BMP guidelines

are an extension of the previous work from DAF on the economic assessment of the BMP in the banana industry (Harvey, et al. 2016). These reports provide the basic intervention at the farm level to ensure a sustainable production practice.

The Australian banana industry is vulnerable to pests and diseases. Growers need to ensure they are not reactive to a disease incursion but proactive in their biosecurity management practices, minimising the risk to their business. On-farm biosecurity management requires a consistent and sustained approach, and best management practices (BMP) need to become routine in daily farming operations (Kukulies and Veivers 2017).

3.2 Collaboration and coordination as an intervention

The Banana supply chain has multiple stakeholders who are actively involved with the movement of the products. Collaboration and coordination among the actors in the supply chain would help to reduce waste. A cooperative union of banana producers would allow them to share resources and transport systems to become more active in the market system (Ssennoga et al. 2019). Understanding the demand and coordinating the supply of bananas could be one of the key roles of such a collaborative effort. The collaboration among the producers would possibly attract government investment for infrastructure in the region. This intervention would potentially increase the profit margin for smallholders and reduce waste at the production processing and transportation stage of the supply chain.

3.3 Modified atmosphere packaging (MAP)

The packaging of banana could be controlled by Modified Atmosphere Packaging (MAP) which reduce the oxygen level inside the pack below 8%. This can be achieved by using Microperforated films which have the ability to exchange gases at a certain temperature. A more dynamic approach is to use special material in packaging which controls gas exchange with variable temperatures. One such example is BreatheWay® and Chiquita, one of the largest banana brands in the world, has exclusive rights to this technology. This would create a controlled environment for the banana during long-haul transport, export and a long stay at the distribution centre (Kneebone, 2010).

3.4 Packaging crate material

Banana is very delicate fruit and can easily damage during transportation because of poor bulk packaging or improper handling. FAO recommended reusable plastic crates which can provide much protection to the fruits. These plastic crates are easily stackable, shock absorbing and good for cool air circulation during a cold supply chain. These plastic crates can be used over and over after proper cleaning and sanitising. The usage of plastic crates could potentially reduce the waste in the supply chain by up to 61% (FAO, 2021).

3.5 Education and training

Human error during harvesting is a key reason for damage to bananas which end up as waste. One of the interventions to reduce this source of damage is education and training. Such training will allow the employee to recognise the quality standard and how to meet this standard. This will also train the employee in the best practice, for example how to prune bananas from the tree without a neck injury to the fruits. Training could also be provided for packhouse workers for proper packaging techniques, and loading-unloading techniques. Macheke et al. (2013). Such training intervention coupled with management support and supervision would lead to the best practice in the harvesting and packaging (Nieto-Montenegro et al. 2008).

At the retail stages the following education and training programs can help reducing generation of more wastes,

- Develop consumer understanding of the effects of nature on the fruit as they are produced in the field.
- Educating customers about the processes of increasing shelf life of the purchased products at home.
- Training workforce personnel from retail departments and DCs so that they can handle with care and follow guidelines accordingly.
- Storing and displaying bananas in controlled environments as appropriate to the ripening stages of the banana.
- Inform customers of food waste management initiatives undertaken by the retailers
- Promote the 'odd bunch'/ 'I'm perfect'/ 'Second bite' programs to encourage the customers to accept fresh produce based on the quality rather than rejecting them based on aesthetic appearances.

3.6 Artificial intelligence (AI) and technology as intervention

Banana produces a large amount of heat after being harvested which needs to be controlled by using an efficient cooling system. One such intervention is to introduce intelligent containers or pallets which is equipped with a wireless sensor. An IoT platform and mathematical modelling could be used to identify the critical point at which the risk of a pallet becoming a hotspot is maximum. One study identified that the bananas at the centre load of the pallet were receiving only about 10% of the cooling capacity of the cold unit (Jedermann et al 2014). Another proposed intervention is the Dynamic expire date (DED) which allows changes in the expiration date based on the product quality which is continuously monitored. In addition to DED, dynamic pricing can be implemented where the price will be lowered as the products approach the expiration date. These interventions can only be possible with intelligent packaging connected with the Wireless sensor networks (Heising et al, 2017)

The banana is very stable during its green life, a period when the peel remains completely green. A temperature profile history of banana's green life would be a good indicator for the ripening process and identifying the shelf life. This temperature profile history could be developed using remote sensing devices and AI.

Ethylene sensing during the banana supply chain is crucial to understand the quality state of bananas. However, obtaining high-resolution measurements and gas detection could be very expensive. A miniature gas-chromatography system along with infrared sensing could be a potential future intervention in the banana supply chain to detect Ethylene. This system could be an installer in cold transportation containers, warehouses, and depots where excess ethylene could speed up the ripening process (Jedermann et al 2014).

4. Case studies

Published case studies on the implementation of strategies to address food waste reduction, specifically in the Banana industry are limited in the literature. However, we documented a few specific relevant case studies in this section for the readers.

4.1 Case study 1: Waste reduction initiatives by Chiquita, one of the largest global banana companies.

Chiquita is one of the largest global banana companies with operations across 25 countries and over 18,000 employments. Chiquita has implemented numerous efforts to reduce food waste in banana production and to support sustainability practices. Their zero-waste practices include updated farming methods, establishing national banana donation partnerships and recycling programs. The

sustainability initiatives developed by Chiquita involved all stakeholders in the supply chain along with consumers and targeted to create a healthier environment.

At the farm level, unsold bananas and bananas that are not exported from farms are directed to the processing plant in Costa Rica to produce value-added products including banana puree and banana flour. These practices allowed the company to reduce the unsaleable banana to 50% in just two years. The company collaborated with Feeding America to contribute to the food bank and send their unsold bananas to families and children in need. A huge amount of perfectly good quality bananas with minor bruises and premature browning were sent to the food banks through this program. At the retail store, the company promoted the “Fruits for Kids” program, which offers free bananas to kids in the retail store, to reduce the number of unsold bananas going to bins.

Under the sustainability program, the Chiquita company organised national and local community events including New York City Marathon, and Disney Marathons to increase public awareness to reduce food waste. In such events, the company donates bananas to the participants and encourages them to dispose of banana peels in designated recycling bins. These banana peels were then sent for recycling and recovering by turning them into fertilizer and electricity. The company also ran a consumer awareness and participation program to include them in the fight food waste journey. They promote tasty recipes for over-ripened bananas to create banana bread, ice cream and smoothies. The company also encourage families to create their own compost station at home under the instruction of the environmental protection agency in the US.

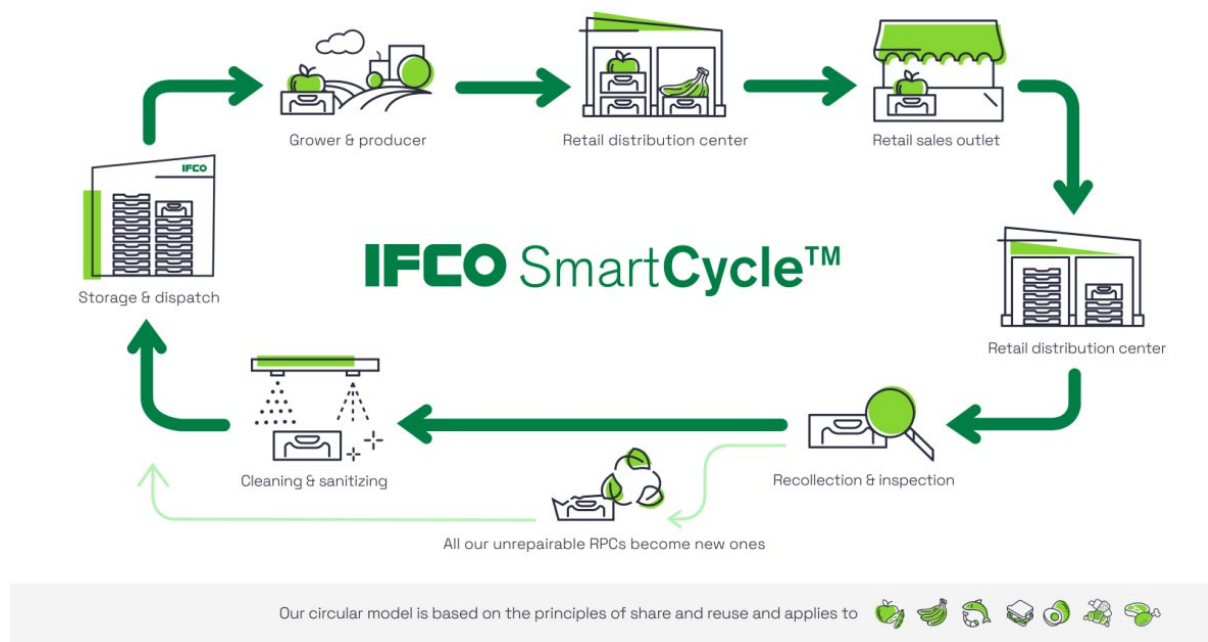
4.2 Case study 2: Efficient cold supply chain to reduce food waste in Indian banana supply chain.

India is the largest banana-producing country in the world and one of the biggest banana-exporting countries. One of the key challenges for the banana supply chain is transportation due to the hot and humid climate. The cold supply chain, which includes the refrigeration of bananas during transportation, is used to transport bananas to domestic and export destinations. However, the fragmented food system and inefficient supply chain caused about 45% waste of produced food in India and never reach the consumer. Danfoss, a leading supplier of electronics and technologies in different industries, developed a collaboration with the confederation of Indian industry to fight food waste by enhancing the cold supply chain efficiency. This initiative not only aims to reduce food waste it also mitigates carbon emissions during transportation. Danfoss developed two interventions in the banana cold supply chain, which are the pre-cooling of freshly picked bananas and the implementation ripening chamber during transportation. Pre-cooling helps to increase the shelf-life and quality of bananas and the ripening chamber allows the bananas to be kept at an appropriate temperature during transportation. These interventions reduced the post-harvest loss by about 20% while the shelf life of bananas increased from one week to about 35 days (Ghantous, 2022).

4.3 Case Study 3: Usage of Reusable Packaging Container (RPC) to eliminate waste from organic banana supply chain.

PENNY, a discount supermarket chain in Germany, is using a Reusable Packaging Container (RPC) for the banana to reduce wastage during transportation. PENNY moved away from the single-use packaging for organic bananas and used RPC, also known as Banana Lift Lock, for the international export of bananas. Through these initiatives, PENNY reduced about 154,700 MT of CO₂ emissions along with the reduction in energy and water usage. The RPC is used throughout the IFCO smart cycle (Figure A1.5) to ensure the quality of the banana is preserved throughout the supply chain and the containers can be used over and over again. The Banana Lift Lock is designed for more secure staking and superior ventilation which is very essential in a cold transportation system. Also, the superior load weight support of these containers minimizes the chance of compression-related damage. Controlling the temperature during transportation while using RPC allows the bananas to ripen evenly. The entire

process eventually increases the shelf life for banana and increase the efficiency of the supply chain (IFCO system, 2023).



FigureA1.5: IFCO smart cycle for Reusable Packaging Container

Note: Reference of the intext citation can be found in the reference list of the technical report.

Appendix A2. Stakeholder Engagement: Key findings

1. Introduction

The present study aims to develop a sector action plan to address food loss and waste in the Banana industry. This document summarises findings from stakeholder engagement through interviews and workshops (Data Collection Phases) about loss and waste in this sector.

1.1 Stakeholder interviews and workshops

The purpose of stakeholder interviews and workshops was to collect information about food waste across the banana supply chain by having in-depth conversations with stakeholders. All the interviews were conducted in January and February 2023. The data collected from the interview was utilized to design poll questions and discussion topics in Workshop 1. Discussion topics of Workshop 2 and proposed action plan was developed from the data collected through interviews and Workshop 1. The list of participants for the stakeholder engagement is listed in the Table A2.1. During the workshops the research team and funding agencies participated along with the other stakeholders.

Table A2.1: list of participants

Participant no.	Participants	Participation in stakeholder engagements		
		Interview	Workshop 1	Workshop 2
1.	Primary producer 1	✓	✓	✓
2.	Primary producer 2	✓	✓	✓
3.	Primary producer 3	✓	✓	✓
4.	Producer and processor 1	✓	✓	✓
5.	Producer and processor 2	✓	✓	
6.	Wholesaler and marketer	✓	✓	✓
7.	Wholesaler	✓		
8.	Marketing agency 1	✓		✓
9.	Marketing agency 2	✓	✓	✓
10.	Retail	✓	✓	✓
11.	Industry representative	✓		✓
12.	Horticulture sector representative	✓		
13.	State government representative	✓		

Prior to each of the interviews, the interviewer introduced themselves and discussed the purpose of the project and requested permission to record the conversation. Interview questions/ discussions focused on multiple themes related to food waste in the banana industry. A similar approach was taken for both workshops.

1.2 Tools for stakeholder engagement

The following tools (Table A2.2 – A2.4) were used for collecting data during the stakeholder engagement. The data collection process was approved by the CQUniversity Human Research Ethics Committee. The workshops were facilitated by the research team and the stakeholders were engaged in open floor discussion and group tasks in the breakout rooms. All the workshops utilised the online platform Zoom.

Table A2.2: 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)
2.	How could we minimize overproduction in the horticulture industry? Is there any mechanism to signal the accurate (near accurate) demand for horticulture products?
3.	What strategy is required to divert the oversupplied horticulture products to new markets (including export)?
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?
5.	What strategy is required to ensure that maximum edible discarded food can be sent to food rescue and/or food banks?
6.	Do we need more energy recovery plants in Australia to process waste food from the horticulture sector?
7.	What new technology could be used in the horticulture supply chain to reduce food waste?
8.	What types of training is required to educate the supply chain actors and consumer about food waste in horticulture?
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?
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	
11.	What is your primary produce? What is the size of the land of production? What is the average yield (kg/ha)?
12.	What are the main reasons for product loss on the field?
13.	During the harvest, what percentage of horticulture products are damaged?
14.	What is the main reason for the waste during harvesting? (e.g., mechanical operation, storage, handling etc.)
15.	How do you treat these wastages (e.g., compost, energy recovery, stockfeed etc.)?
16.	Is there any option/opportunity to produce value-added products from these wastages?
17.	Do we have appropriate logistics and infrastructure for producing value-added products?
18.	What types of support are required for the value-added products industry?
Processing	
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)?
20.	Do you have any agreement in place with the wholesaler and retailer to minimize food waste?
Wholesale and distribution:	
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)?
22.	What support could government provide you to minimize food waste during distribution?
Retail	
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?
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?

Table A2.3: Workshop 1 Runsheet and activities

Workshop 1: Banana Hotspots and Root Causes Analysis

Time, day and date: 10am to 12pm, Tuesday 28 February 2023

Venue: Online (Zoom)

Facilitators: Prof. Delwar Akbar (DA), Ms. Margaret Marty (MM), Prof Hurriyet Babacan, (HB), 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 Banana industry across different stages of the supply chain?
- What are the causes of Banana industry waste?
- What initiatives do organisations have in place to stop/minimise Banana industry waste?
- Triangulation of findings from interviews

CONTEXT NOTES:

This is the first of two workshops with the banana Reference Panel during the project. It focuses on **hotspots and root causes** while the second workshop will test the proposed solution and ideas in the draft strategy.

Time	Key activity	Facilitator/s
10.00	<p>INTRODUCTION</p> <ul style="list-style-type: none"> • Opening & Welcome & House keeping • Introduce Facilitators • Introduce Mentimeter - participants to log in and complete first question "what is your preferred name?" • Use the Mentimetre word cloud to ask people to say hi and describe their role in the Banana industry. <p>• Introduce Melissa/Carolyn</p> <p>About the project, competition statement, definition of food waste, note that for the purpose of this project the supply chain goes from paddock to purchase. Food waste in households or the service industry are not being investigated.</p>	<p>DA</p> <p>CC/MS</p>
10.14am	Introduce structure of workshop	MM / DA
10.15-10.30	<p>ICEBREAKER POLL – quick responses to a series of multiple-choice questions using Mentimetre. (slides 3-8) Responses to be displayed as vertical bar graph – limited discussion.</p> <ol style="list-style-type: none"> 1. How are you involved in the Banana industry? Choose whichever are applicable. 2. What % (approximately) of food waste is there in your operations or in the part of the industry that you work in. 3. How urgent do you think it is to address food waste in the banana industry? 4. Is your organisation aware of the main sources of food waste within it? 5. Are there strategies/interventions in your organisation to address food waste? 6. Do you think these strategies/interventions are effective? i.e., are they reducing food waste? 	DA / MM / AR

10.30-11.10	<p>ACTIVITY 1 IDENTIFYING THE POTENTIAL FOOD WASTE HOTSPOTS IN THE BANANA SUPPLY CHAIN, THEIR RELATIVE QUANTUM, AND CAUSES.</p> <p>1. Mentimetre activity to identify the top 3 waste hotspots in the banana supply chain stages. Take each of these individually and approximate the amount of waste (multiple choice) and describe the causes. (Slides 9-15)</p> <p>Through discussion tease out:</p> <ul style="list-style-type: none"> • Flows of activity/responsibility across the Banana supply chain • Common causes of food waste across the supply chain • Food waste causes that occur but don't manifest until later stages of the supply chain. • Triggers/contributions of top-level causes • Connectivity between causes <p>ACTIVITY 2 ROOT CAUSES Use Mentimetre Slides 16-19 to identify which of the factors impacting banana food waste is within their control or they have no control over and to dig into deeper root causes.</p> <p>Through discussion tease out:</p> <ul style="list-style-type: none"> • What causes a cause of waste? • Is there a potential to influence if not control – how to influence? • What do we see across the industry in terms of influence control? • Lessons from other crops re causes or control/influence. 	MM & DA
11.15 -11.30	<p>ACTIVITY 3 DATA</p> <p>1. Mentimetre activity to identify nature/reliability of data (slides 19-20) Through discussion tease out:</p> <ul style="list-style-type: none"> • The importance supply chain actors place on data • How data is used to inform practice/decision making. 	MM & DA
11.30-11.45	<p>ACTIVITY 4 FOOD RESCUE</p> <p>Quick discussion via Mentimeter slide 21 about the constraints/barriers to utilising food rescue organisations.</p> <ul style="list-style-type: none"> • In discussion try to turn this to how to enable more contribution – e.g. so this is the problem how do we overcome? 	HB
Only if time permits	<p>OPTIONAL ACTIVITY</p> <p>Mentimetre slides 22-25 provide additional questions that might be worth exploring – if time permits</p> <ul style="list-style-type: none"> • It is suggested that waste is caused because banana growers grow as much as they can and try to find a market for it. A supply-driven model. Comment? • It is suggested that banana waste is increased because the costs of value adding/processing in Aus is uncompetitive internationally. Comment. • Supermarket specifications set the benchmark for what is saleable - in terms of waste is the problem the specification or the product qty & qlty? • In terms of on farm waste- what can we do to control - agronomic and management issues, damage on farm and damage in the shed? 	MM/HB
11.45-12.00	<p>ACTIVITY 5 FOOD WASTE STRATEGIES/INITIATIVES</p> <p>What type of initiatives are organisations putting in place to:</p> <ul style="list-style-type: none"> • Stop food waste. • Reuse food waste • What can you differently to reduce food waste? <p>Is there information/communication and collaboration points and feedback looks across the value chain around food waste.</p> <ul style="list-style-type: none"> • Concluding the workshop with key summary and updates on next workshop. 	DA/HB & MM

Table A2.4: Workshop 2 Runsheet and Activities

Workshop 2: Banana Hotspots and Root Causes Analysis		
Time, day and date: 10am to 12pm, Tuesday 2nd May 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:		
<ul style="list-style-type: none"> • To present the key findings that obtained through content triangulation from literature review, interviews and workshop 1. • To present the process that led to shortlisting the solutions to reduce food waste from Banana supply chains (farm to retail) • To discuss and priorities the short-listed solutions with an agreed time frame 		
NOTE:		
There will be two workshops with the participants during the project. This one focuses on <u>hotspots and root causes</u> . The second one is to test the proposed solution and ideas in the draft		
Time	Key activity	Facilitator/s
10.00	INTRODUCTION <ul style="list-style-type: none"> • Opening & Welcome & House keeping • Introduce other Facilitators and around the Board of those in attendance. • Introduce Melissa/Carolyn 	DA /MM
10.10 am	About the project, competition statement, definition of food waste, note that for the purpose of this project the supply chain goes from paddock to purchase. Food waste in households or the service industry are not being investigated.	MS/CC
10.14	✓ Introduce structure and focus of workshop	MM
10.15-10.30	Key Findings Through Triangulation of Research Methodologies Presentation with opportunity for group to comment. <ul style="list-style-type: none"> • Hot spots and root causes – in the supply • Systemic waste causes • Interventions – Prevention • Interventions – Value Add Other key messages	MM
10.30-10.45	Strategies and action plan <ul style="list-style-type: none"> • Shortlisting process and methods Activity <ul style="list-style-type: none"> • Mentimetre activity • Ranking shortlisted solutions 	HB & MM
10.45-11.50	ACTIVITY 2 Presenting ranking activities result from Mentimeter Open floor discussion on all the shortlisted solution and their standings after the ranking activities Through discussion tease out: <ul style="list-style-type: none"> • The importance supply chain actors place on data • How data is used to inform practice/decision making. 	
11.45-12.00	Is there information/communication and collaboration points and feedback looks across the value chain around food waste. Concluding the workshop with key summary	DA/HB & MM

2. Key Findings from banana industry stakeholders panel

This summary was prepared by collating interview and workshop insights for use by the research team during the data analysis and triangulation phases.

2.1 Where are the hotspots?

- It is very clear that the largest point of food waste in the banana supply chain is on farm. This usually occurs in sheds when the crop is picked and brought in for packing. There is a major decision point at this time – is it worth sending? This decision is made by evaluating criteria for saleability including ripeness, level of damage/disease, size and shape etc. Quantification of waste at this level generally tends to be around 20% (between 10-30% at the extremes)
- Growers are very cognisant of what they will be paid for and what they won't and given that they have already invested in the whole crop, further investment in packing/packaging/transport etc needs to provide a return.

Quote “There is a lot that doesn't make the box”.

- The second waste hotspot is also on farm – in the paddock and although under normal circumstances not a lot of bananas are left in the field unless there are shortages of labour or obvious early damage, or the market is so oversupplied it is not worth the cost of picking and transporting to the shed. Weather events can create massive amounts of in-paddock waste – floods, cyclones or even strong winds, heat waves and cold snaps can all render the crop unsaleable, so losses are minimised by not investing any further including not taking to the shed.
- Other hot spots where banana food waste is created include:
 - Retail – where 'singles' remain unsold on the shelf, fruit is damaged through handling by staff and customers, fruit becomes too ripe due to time on shelf or storage/display conditions.
 - At markets or the Distribution Centre if the fruit arrives and does not make quality standards or there is an oversupply. In these cases, efforts are made to find an alternative home for the produce even if it is at a reduced cost. Damage caused during transport often becomes evident at this stage or later in the supply chain.
- In the banana industry the product is owned by the grower until it is accepted by the retail purchaser. Even product that is contracted to retail chains can be rejected at entry to the DC (usually for quality issues) and it is the responsibility of the grower to find an alternative home for the fruit. Marketers/agents tend to work very hard to ensure that all fruit is sold – to someone, even if it means accepting a price reduction.

Quote “Good growers have always tried to minimise waste and improve profitability by finding a home for rejected fruit.”

- The decision point 'progress to sale v send to waste' occurs several times along the banana supply chain each with its own contextual causes – but in short, the grower is striving to get a return that is greater than the investment already sunk.
- Retailers are also trying to get the best return and want to minimise waste which is fruit purchased but not saleable, hence the drive for quality and shelf life and fruit that meets the customers expectation and supports their brand proposition.

2.2 What causes Banana food waste?

- Growers grow more than they need to, to make sure that enough is saleable. The Banana industry is traditionally a 'push' model whereby growers produce and then try to find a market, as compared to a 'pull' model where consumer demand dictates the supply.
- Most food waste occurs by **planting too much** in the first place. Not enough disincentives for planting too much.
- Production waste can be caused **by weather** events like floods or droughts or cyclones or intensive heat and sunburn. The Atherton Tablelands is now the largest banana producing region

in Australia – the move to the hinterland was a result of coastal weather and disease (Panama TR4) and managing risks that lead to crops with no return.

- **Agronomic issues/ practices** e.g., crop disease, bunch rub, pest management (insects, grubs, wild pigs), plant nutrition, poor management practices that damage the crop can all cause damage which makes it unacceptable for sale. Bananas are grown in very large paddocks outside - subject to the elements and a lot of factors can't be controlled in this type of environment. There is a suggestion that the restriction of insecticides (for health reasons) has had a detrimental effect on banana production and quality.
- Bananas can be **unpredictable in production** level (impacted by temperature, hours of daylight)– the output is not constant and not necessarily aligned to demand or grower expectation. A flush can create increased waste due to oversupply.
- **Labour force issues on the farm** including lack of staff availability and variability, excessive cost of labour, workforce turnover and transience and lack of skills/experience/ training all lead to crop being left behind or damaged or inappropriately graded or packed – before it leaves the farm. A lack of available staff is also cited as a reason for not engaging in processing of waste fruit – “have enough trouble finding staff for the growing and packing without trying to get people to process”.
- **Harvest loss/waste** can be human error (bad technique, mechanical damage, poor timing)
- **Inappropriate varieties or growing area.** Need to grow the right variety in the right place that produces the best quality and reduces risks.
- Bananas are **quite soft and are easily damaged** – which leads to waste occurring across the supply chain from paddock to shelf.
- Fresh food is not **stable and has a limited storage/shelf life**. Time from paddock to plate can be very short – esp. when ripening is not controlled, and the fruit is impacted by temperature changes. Bananas can be held green for approx. 3 weeks and once they are ripened, they have a shelf life of 3-7 days “that’s why it’s called fresh food.” Despite urban mythology to the contrary bananas cannot be held green for months and then ripened on demand.
- **Some growers focus on quality product while others focus on quantity** – the latter can flood the market with poor produce leading to a reduction in price/return for all – if the price is too low some growers will withdraw and not send – product goes to waste.
- **Poor storage or transport** esp. cold food chain – mixing products that have different temperature requirements in the one truck or cold room. Changes in temp caused by mechanical failure or human error.’ Need to maintain the integrity of the product temperature control’. Bananas don’t like to be colder than 12 or 13 degrees, if stored in retail cold rooms with other fruit that need cooler temperatures bananas can be damaged Ambient temperature in store display may also cause problems with freshness and quality. Temperature problems do not necessarily appear at the time of the problem – they often do not become apparent until after the event.
- Bananas can also be **damaged in transportation** – there is a variation in the ride between trailer A and trailer B – and if not packed properly loads can move.
- Retailers believe consumers have high **aesthetic and quality standards** (specifications) and require these from growers (and across the supply chain) so substandard product is rejected on farm, in packing/grading, retail. There is also an idea that as a society we have set our expectations too high over a long period of time and we are looking for ‘perfection’ and buying on appearance not necessarily taste or nutrition – need to change this culture.
- The specifications look **for uniformity in produce-** nature is not uniform e.g., the way a banana bunch is structured means that the fruit are different sizes and curvature so only 60% of a bunch is within the specifications anyway.
- **In house policies and practices of retailers.** Businesses large and small have standards that they expect for the fruit that they sell that align with the value proposition they are offering the consumer – these policies impact what they buy and how they sell. In house staffing practices and other aspects of the retailer’s business model can affect how well bananas are stored, displayed and what happens to the waste.
- Produce **damage caused by People** – on the farms, in the sheds, transporting products, in

supermarkets.

- **Labour force issues in the supermarket.** Workforce transience and age and rostering model can mean that the staff are not confident in the displaying and handling of horticulture product – this leads to damage and waste. The ABGC campaign to educate supermarkets about merchandising bananas and teaching customers which level of ripeness to purchase to meet their needs is a positive strategy.
- **Supply and demand are not necessarily transparent** and can create an incentive for growers to plant more which then creates more waste and/or lowers the price.
- **Market forces** – other products in supply, over supply of product driving price down or creating waste at PoS. Market forces can be influenced by weather, fashion, marketing etc none of which are controlled by the producers. The large retail chains can use specifications to influence supply and demand and regulate price.
- **Contracting arrangements** lead to an over production (Cumulative risk allowance) to ensure that contracted amount is achieved and when contract is surpassed product may not be sellable and therefore wasted. E.g., retailer requests 100, but really only needs 90 (managing risk) – farmer grows 110 managing risk – we now have 20 more than needed.
- Very little **vertical integration of the supply chain** – so there can be lots of hands involved in the product each with limited responsibility. Intuitively bigger companies that grow, pack and market may have less food waste but no data to substantiate.
- **Different rules in different states re import** e.g. fumigation which can delay fruit to store and create waste. This is cumbersome paper-based process that takes time and resources and delays produce reaching the consumer.

3. Strategies to reduce Banana food waste

3.1 Prevention

- **“Planned production”** Grow what you can sell – less speculative growing and more alignment between demand forecasting and what is grown. The suggestion is to work with ‘good’ growers’ those who strive for quality not quantity. It was noted that younger educated growers tend take up new ideas better and quicker than older or multigenerational farmers with no off-farm experience.
- **Agronomic improvements.** Conducting research and trials into better farming practices e.g. – pest control, fertiliser usage, irrigation, alternative varieties, crop rotation within a diversified farming system. Improved agronomics reduces waste caused by pests, disease, plant nutrition and water issues.

Quote: Good growers always have waste in mind and are continually trying to improve by conducting trials and changing their practices.

It is suggested that when the return on the banana crop is low farmers invest less in the growing which produces a poor crop and vicious cycle ensues.

- **Develop the capacity and knowledge of farmers.** Best practice farming generally produces higher yields and less waste. Best practice growers tend to be alert to emerging trends and initiatives and are willing to change/evolve – traditional and generational farms tend not to be so progressive in their thinking.
- **Crop breeding** to provide product closer to specifications, less prone to damage or with longer shelf life.
- Use big data and the sensors/drones etc to **manage and monitor the health and growth of crops.**
- **Cold food chain improvements** including real time load, location, temperature and humidity monitoring - this could include temperature bar codes.
- **Review crop packaging** to minimise damage in transport and storage.
- **Education of supermarkets** re handling displaying and communicating with customers on storing and using bananas. ABGC is working on this.

- Utilisation of **product lines like Imperfect /The Odd Bunch/ kids lunch bananas so that ‘seconds or small fruit’ are sold** for consumption at a lower price. There is some concern about the impact that this could have on the price and demand for first quality.
- Investigate **ripening technology or shelf-life extension technology** so that shelf-life issues can be reduced.
- **Harmonisation of jurisdictional expectations re import/export.** Streamline and uniform the processes and expectations across state boundaries.
- **Increase demand** for Bananas so that more production is utilised – either domestic or export. Potential for marketing to use Australia’s clean, green, healthy brand to sell quality bananas in export – likely to be at a higher cost than other countries but promote the differentiation of the quality. There is a small amount of this currently happening with Eco bananas is already working in this area.
- Another demand increase strategy is to educate the customer about the range of uses for bananas – they are many more options than just peeling and eating fresh – e.g. recipe cards, web-promotion. Promote the utility of the banana, its ease of eating, the nutritional benefit and how it aligns with a lot of popular dietary trends.

3.2 Value add usage

These activities need to be assessed for their viability. Some work has been done on this, but it may not be well known. Growers need to be convinced that it ‘will stack up’.

- Encourage **meal plans** and partner with these organisations to increase the use of fresh produce in their offering. (e.g., Hello Fresh)
- **Nutrition extraction** Bananas are a healthy source of fibre, potassium, vitamin B6, vitamin C, and various antioxidants and phytonutrients, explore processing to puree or powder for inclusion in other foods.
- **Alternative foods via further processing** (e.g., beverages/freezing/drying) or value add – jam/flour – processor specifications for fruit are not as tight as fresh food, shelf life of frozen/ dried or otherwise stable foods a lot longer than fresh. There is a gap in the market for Australian grown frozen or dried product – currently largely imported. If you purchase frozen banana puree it will come from S-E Asia via NZ and cost multiples of the fresh banana price. Hort Innovation Project BA09025 “Commercial Feasibility of banana waste utilisation in the processed food industry” – Roger Stanley outlines some of the options. Note that peeling bananas is currently a labour-intensive task that is time consuming and costly.
- **Non-food Pharmaceuticals** (e.g. creams, cosmetics e.g. PawPaw cream)
- Develop a **centrally located processing facility** that takes waste from a range of growers to achieve critical mass and consistent supply of product. The bulk of Australia’s bananas are grown in FNQ within a 400km footprint. long.
- **Animal fodder or processed animal food** or fertiliser or energy –many growers are currently feeding their excess bananas to cattle this would still be considered food waste. There is a dog biscuit that uses bananas.

Some consideration of options including **energy conversion**, such as the partnership between Melbourne Markets and Yarra Valley Water’s ‘Food waste to energy’ initiative could yield options for the use of excess bananas to create energy.

3.3 Food Rescue (FR)

- Nobody likes to see food go to waste – the number one priority is to sell and get a return on the investment but if that can’t happen interviewees are all happy to support food rescue themselves or see it supported by others in the supply chain. Of those interviewed who are in a role where they can donate to food rescue – they do, esp. marketers and retailers They see this

as an important Corporate Social Responsibility (CSR) action and is part of one major supermarket chain's zero food waste target. Of those interviewed for the project very few identified the environmental benefit of donating to Food Rescue while many spoke of the value of providing for food for those who are in need. This response was far more prevalent than a reference to reducing food waste or seeing a return for the investment in the crop. Bigger organisations are interested in being a good corporate citizen and being able to showcase this so Food Rescue helps with this goal.

- Generally, banana growers will try everything they can to find a sellable home for their fruit – agents/marketers also try to assist them with this – sending to a FRO would be only done if there is no option to gain any \$\$ from it.
- Sending bananas to food rescue is suited better to points in the supply chain in the metropolitan areas – it is usually packaged in easy-to-handle cartons and is close to Food Rescue organisations.

Those who have food waste that could be directed to FR, but it isn't explain that:

- FR needs logistics in place - growers are not always near the collection/distribution centre and not all can justify the cost to send – crops grown in regional/remote areas, food rescue in cities. Is there any opportunity to regionalise FR?
- The system needs to be a nil cost to grower (this is particularly the case for smaller growers) the bigger growers might wear a small cost in the interests of CSR. One banana grower in a remote area offered to send fruit to FR if their costs of packaging etc were paid (no profit just cost recovery) they didn't get a reply. Interestingly one grower suggested that it is important that growers look at the cost of disposing of their waste or excess product and compare that to the cost of sending to FR – i.e., labour to chop and spread versus labour to bin and send.
- Distance and the ripening process also create a risk of the fruit not arriving in good condition (needs logistics and infrastructure to facilitate)
- A tax incentive for Growers to donate to FRO would be well received and may offset the costs that are required to get the waste from the production site to the FRO.

Other comments

- There is an opportunity to utilise grower collaboration to make FR options more viable – e.g., regional collection points, modular solutions, shared infrastructure.
- Food suited for Food Rescue needs to be safe for human consumption – the priority of supply chain players is to sell as much fit for consumption product as possible and waste is only the parts that you can't eat anyway.
- Small scale local food rescue, like donations to Aged Care homes, hospitals, schools etc seems to be quite popular and easy for banana farmers to do. Most of them are well connected to their communities.
- One large banana producer regularly donates to food rescue – but it is 'in specification' fruit that they could have sold, not their premium line but certainly could have provided a cash return – not product that would have gone to food waste, they see this as a CSR donation not as a food waste alternative.

3.4 Other

- Measure – collect data so that the scope of the issue is clearly illustrated and understood, and any changes can have their impact measured.
- Explore technology to grade produce or pick or pack – maybe able to be more efficient and reduce costs and minimise damage and therefore waste.
- Use a systems approach to the food waste issue not individual crops or stages – a whole of supply chain approach. "Everyone has a responsibility for the whole thing [supply chain] no washing hands or pointing fingers at others".
- Industry needs to take the lead; this can't be government lead.

- Increase responsibility, ownership, and accountability.

4 Constraints to reducing banana food waste. (Overcoming these could be seen as potential strategies)

- **Some growers are not quantifying the cost or loss of income currently associated with banana waste and not recognising the potential improved financial benefit of utilisation of waste.** Decision making may not be evidence based. Transitioning to alternative uses of waste is a risk and, in many cases, growers are risk adverse, so this process needs to be de-risked. Some growers are also very traditional in their approach to farming and may not recognise ‘what they don’t know’ or have an appetite to do things differently.
- **Disposal of banana waste on farm is fairly cost effective-** if it goes to a waste plant that is costly so by decomposing and spreading on the paddock you are adding nutrients to the soil and disposing of waste all very cheaply – although it has been suggested that many growers are not aware of the cost of handling the waste. All other options incur greater costs or in the case of further processing it is a capital cost and risk.
- Encouraging collaboration in a competitive environment is difficult – risks of loss of competitive advantage. **“Competitive tension”** Like most horticulture producers banana growers can be very protective of their innovations and practices that give them a competitive advantage. There is however some sharing of ideas and cooperation between growers – Panama TR4 may have constrained this recently.

Relationships are at the heart of collaboration – need to build trust.

- **Knowledge of the supply chain and the opportunities** and how to pursue. Those who do know the supply chain esp. large players are not inclined to collaborate and risk loss of a competitive advantage.
- **Responsibility/ ownership across the supply chain** – we are all in this together. There is currently a culture of waste is not a problem – it’s a bi-product of doing business esp. for growers. Large overseas international exporters have full vertical integration while in Australia we have different parties and different systems.
- The **cost of the establishing a processing facility** is significant – even though a critical mass of waste bananas can be identified in FNQ.
- There are so many **factors beyond our control or influence** e.g., weather and climate can change the amount produced very quickly – “you can do as much planning as possible but there are still so many variables – so many things are out of our control”.

4.1 Other key messages

- **There is a shortage of reliable data on banana waste.** Most growers do not have accurate quantification of their waste or an understanding of the reasons for the waste and their relative contribution to the total. Some growers do ‘sampling’ or estimate but this is indicative, at best.
- **Questions re the definition of food waste** – is a banana skin food waste? What about produce that for some reason does not meet food safety – is this considered food waste? Should we distinguish between edible food waste and inedible?
- **Change management – what is the incentive** for supply chain actors to change their behaviour? Carrot is better than the stick – growers would push back against any regulation to reduce food waste, but they can also be very reluctant to change how things have always been done. Need to demonstrate the WIIFM, ‘what’s in it for me’ to go the growers to motivate them to change.
- Need to consider **who actually owns the crop and what are the implications (waste/financial/responsibility) for them and other supply chain actors** - In the banana industry it is the farmer until the retailer takes possession – is this appropriate, they own the crop but are not in a position to influence after it has left the farm?
- Do we have a **clash of business models?** If you consider the retailer as a large corporate with

shareholders and responsibility to turn as big a profit as possible and the grower as someone who wants to get maximum return on their inputs but is impacted by a lot of factors beyond their control. Is the clash of models a creator of waste?

- **Is the 'free' market working properly** if the fundamentals of an efficient market are transparency and equal information being available to both the buyer and seller, the suggestion is no it is not working properly. Direct grower to supermarket relationships and confidential supply agreements has reduced the transparency and openness of information. It has been suggested that we need to get around the market power imbalance of a few major retailers and lots of growers. In terms of competition policy, the pendulum has swung to the total free market, there is not much regulation in the F&V market. Need to question, does a free market domestically suit the Horticulture Industry? Is there potential to consider options to the free market.
- Do we fully understand the **nutritional composition of bananas** - this may provide insights for further usage in a processed form.
- **Grow what you know you can sell** – plan and forecast demand and then grow that – this is still fraught with problems esp. 'uncontrollable' like weather.
- Noted the irony that **we have so much food that is being wasted** and not consumed but we have a lot of people who don't have access to good quality fresh food – for social/economic reasons or geographic isolation.
- Food waste has become a social issue and industries and businesses that don't take positive steps to minimise food waste will suffer reputation damage. Consider the impact of the War on Waste program that highlighted the banana waste issue and the damage that did to the industries reputation.
- Concern was expressed that research and trials have been conducted that not everyone is aware of – leading to lack of evidence for decision making and the replication of activities, how do we make the knowledge bank available and encourage application? Refer to Roger Stanleys report on commercialisation of banana waste. There may also be value in looking at international best practice. Bananas are grown all around the world. There are lessons we can learn from other countries.
- We are in a sector that is powered by driving prices down – how do we change the paradigm so that it is about driving quality up? Demonstrate that it is worth paying more for a good product or a good job.
- There are issues in reducing food waste that actually increase other types of waste- like plastics waste. E.g., banana slips and cardboard/paper usage in cartons.
- Innovation is expensive, capital is tight and with interest rates increasing funding for waste reduction strategies may be difficult.
- The Pandemic caused a lot of food waste through staffing issues and changed shopping arrangements There was a massive drop in demand – product was already planted so ended up in waste. Need to be aware of other risks that can impact demand on a systems level.

Appendix A3. 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 A3.1: Stakeholder Engagement Plan to support the Banana Action Plan

Project name	Stakeholder Engagement Plan to support the Banana Action Plan	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 alternatives developed and provide feedback on how your input influenced the decision	We will look to you for direct advice and innovation in formulating solutions 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:
<ul style="list-style-type: none"> • Relevant government departments • Rural and food media 	<ul style="list-style-type: none"> • SFWA and FFW CRC partners • RDCs • ARC • Transport Industry Assoc • Banana Farmers 	<ul style="list-style-type: none"> • Transport Companies: e.g., TOLL, DHL, Fox, Nolan's • Food Retailers • Hort Innovation • QDES 	<ul style="list-style-type: none"> • Banana Reference Panel • Major Food Retailers such as Coles & Woolworths • Major banana wholesalers • Major banana farmers/corporate operators. • Known expert in this area (if there is one) 	<ul style="list-style-type: none"> • SFWA / FFW CRC • Australian Banana Grower's Council

Tools:	Tools:	Tools:	Tools:	Tools:
<ul style="list-style-type: none"> Website Information updates Media release 	<ul style="list-style-type: none"> Website Information updates Sharing information - being told what's happening with option to respond. 	<ul style="list-style-type: none"> Website Information updates Share drafts with clear pathway to respond (could include topical workshops if sufficient interest?)¹ 	<ul style="list-style-type: none"> Advisory meetings Agreement on Design Principles Co-Design workshops Initial Review of Drafts Collaboration in developing collateral for others in supply chain. 	<ul style="list-style-type: none"> Board Briefings Co-Design workshops

Table A3.1: Stakeholder Engagement Plan to support the Banana Action Plan

Project name	Stakeholder Engagement Plan to support the Banana Action Plan	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 alternatives developed and provide feedback on how your input influenced the decision	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

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

Stakeholders:	Stakeholders:	Stakeholders:	Stakeholders:	Stakeholders:
<ul style="list-style-type: none"> • Relevant government departments • Rural and food media 	<ul style="list-style-type: none"> • SFWA and FFW CRC partners • RDCs • ARC • Transport Industry Assoc • Banana Farmers 	<ul style="list-style-type: none"> • Transport Companies: e.g., TOLL, DHL, Fox, Nolan's • Food Retailers • Hort Innovation • QDES 	<ul style="list-style-type: none"> • Banana Reference Panel • Major Food Retailers such as Coles & Woolworths • Major banana wholesalers • Major banana farmers/corporate operators. • Known expert in this area (if there is one) 	<ul style="list-style-type: none"> • SFWA / FFW CRC • Australian Banana Grower's Council
Tools:	Tools:	Tools:	Tools:	Tools:
<ul style="list-style-type: none"> • Website • Information updates • Media release 	<ul style="list-style-type: none"> • Website • Information updates • Sharing information - being told what's happening with option to respond. 	<ul style="list-style-type: none"> • Website • Information updates • Share drafts with clear pathway to respond (could include topical workshops if sufficient interest?)² 	<ul style="list-style-type: none"> • Advisory meetings • Agreement on Design Principles • Co-Design workshops • Initial Review of Drafts • Collaboration in developing collateral for others in supply chain. 	<ul style="list-style-type: none"> Board Briefings Co-Design workshops

© International Association of Public Participation: www.iap2.org.

² CONSULT & INVOLVE – if a stakeholder interested, with good advice – can move within the Spectrum, e.g. some SFWA partners may seek higher engagement.