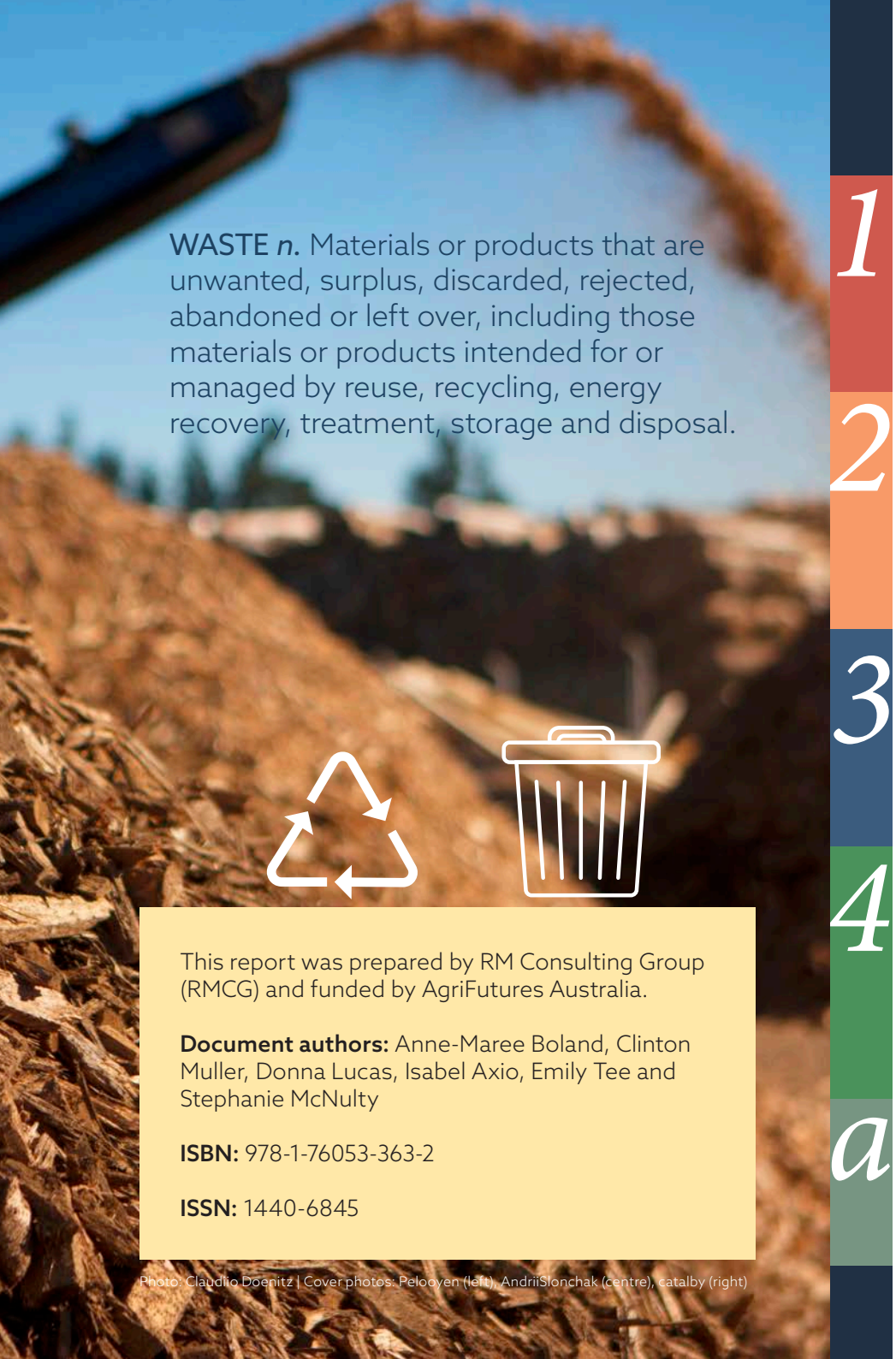
Agriculture, Fisheries and Forestry National Waste and Resource Recovery Roadmap

OCTOBER 2022

AgriFutures® Australia

RMCG



WASTE ***n.*** Materials or products that are unwanted, surplus, discarded, rejected, abandoned or left over, including those materials or products intended for or managed by reuse, recycling, energy recovery, treatment, storage and disposal.

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Document authors: Anne-Maree Boland, Clinton Muller, Donna Lucas, Isabel Axio, Emily Tee and Stephanie McNulty

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1
2
3
4
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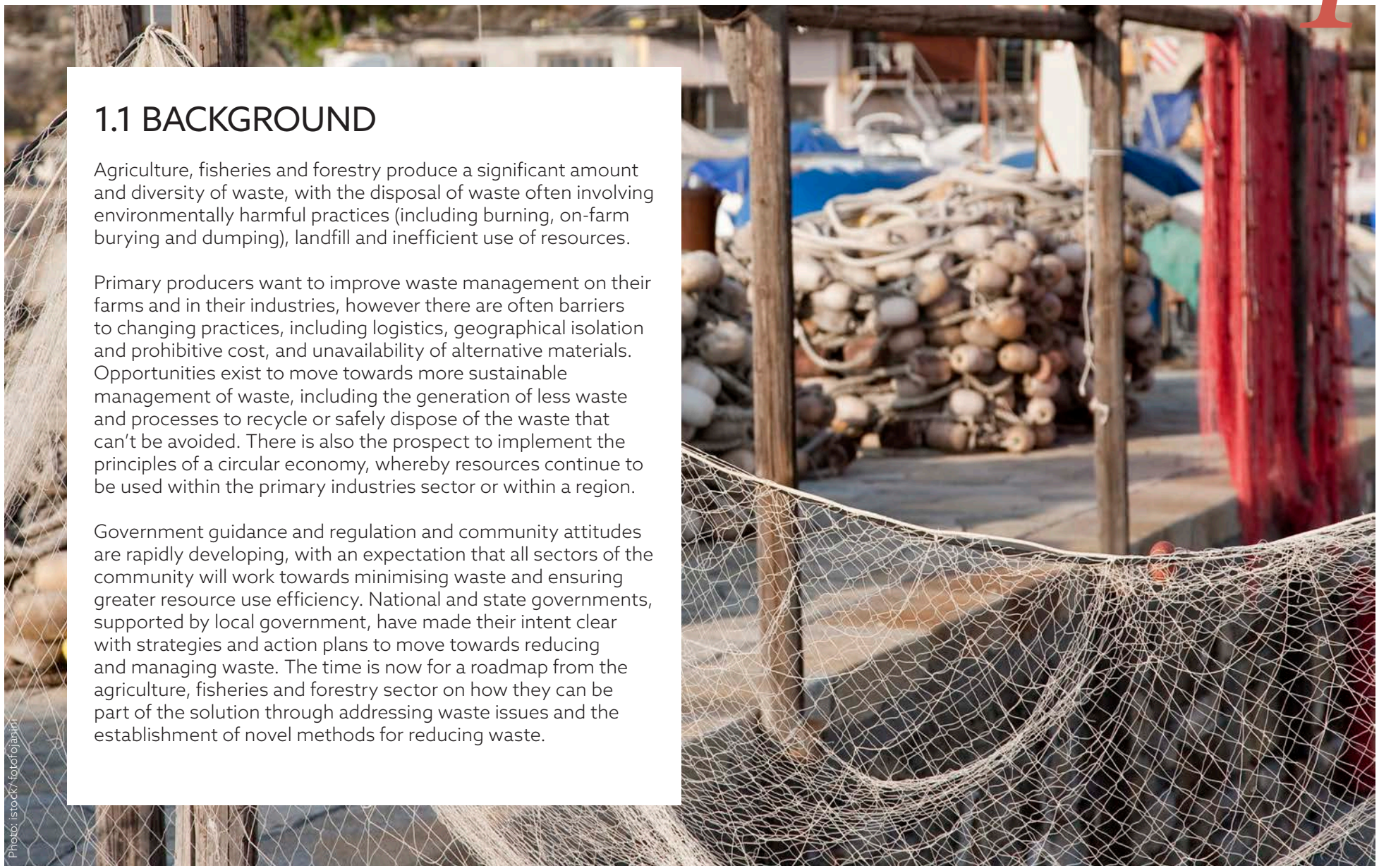
Contents

Context 1



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1.1 BACKGROUND

Agriculture, fisheries and forestry produce a significant amount and diversity of waste, with the disposal of waste often involving environmentally harmful practices (including burning, on-farm burying and dumping), landfill and inefficient use of resources.

Primary producers want to improve waste management on their farms and in their industries, however there are often barriers to changing practices, including logistics, geographical isolation and prohibitive cost, and unavailability of alternative materials. Opportunities exist to move towards more sustainable management of waste, including the generation of less waste and processes to recycle or safely dispose of the waste that can't be avoided. There is also the prospect to implement the principles of a circular economy, whereby resources continue to be used within the primary industries sector or within a region.

Government guidance and regulation and community attitudes are rapidly developing, with an expectation that all sectors of the community will work towards minimising waste and ensuring greater resource use efficiency. National and state governments, supported by local government, have made their intent clear with strategies and action plans to move towards reducing and managing waste. The time is now for a roadmap from the agriculture, fisheries and forestry sector on how they can be part of the solution through addressing waste issues and the establishment of novel methods for reducing waste.

1.2 WHAT IS THE PROBLEM?

The management of waste from primary industries is an emerging and significant issue which requires urgent attention. Agriculture, fisheries and forestry produce a large amount and diversity of waste, with the disposal of waste often involving environmentally harmful practices (including burning, on-farm burying and dumping), landfill and the unproductive use of single-use resources. Primary producers want to improve waste management on their farms and in their industries, however there are often barriers to changing practices, including logistics and geographical isolation.

Waste that is produced in the agriculture, fisheries and forestry sector includes:

- **Plastics (hard/soft)** – used in field production and greenhouses, and to store produce (silage)
- **Organic matter** – such as manure, animal mortalities and product loss
- **Workshop waste** – including machinery, fencing materials, oils, tyres and batteries.

Opportunities exist to move towards more sustainable management of waste where less waste is produced, and processes are in place to recycle or safely dispose of the waste that is produced in line with the waste hierarchy. There is also the prospect to implement the principles of a circular economy whereby resources continue to be used within the primary industries sector or within a region (Refer to Box on Waste Hierarchy and Circular Economy, page 11).

Government guidance, regulation and community attitudes are rapidly developing and there is an expectation that all sectors will work towards minimising waste and ensuring greater resource use efficiency. Governments (federal and state) have made their intent clear with robust strategies and action plans to move towards reducing and managing waste. However, a roadmap for how agriculture, fisheries and forestry can deal with waste issues and establish novel methods for reducing waste has been lacking.

Significant progress is being made nationally in dealing with urban and industrial waste and working towards a more sustainable circular economy with the implementation of the National Waste Policy (2018) and the National Waste Policy Action Plan (2019) (Refer to Box on Waste Policy Context, page 7). This action plan includes targets to reduce the total waste generated in Australia by 10% per person and ensure an 80% average resource recovery rate from all waste streams following the waste hierarchy by 2030.

The National Waste Policy Action Plan focuses on changing practices in the urban and industrial sectors but has limited guidance for the agricultural, fisheries and forestry sector. This roadmap, developed in partnership with industry, addresses this gap.

Photo: stock/Dante Castillo

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While the management of waste by the agriculture, fisheries and forestry sector is often harmful to the environment, including the unproductive use of some waste resources, there are innovative examples of industry dealing with waste and ensuring it is valued as a resource.

We need to understand the volume of waste that is being produced and the key barriers to it being productively managed. There are many different waste streams produced within each industry sector and these vary by industry and from region to region. To manage resources effectively we need to know the types and volume of waste produced and where it is located in relation to repurposing and recycling facilities. Knowledge of where these waste streams are produced and how they can be collected, aggregated and transported will aid in focusing on the significant waste problems and identifying solutions for their management.

While there are a number of technical solutions available to managing waste, substantial barriers exist to their ready implementation in our agriculture, fishery and forestry sector. This includes the ease and minimal costs associated with current management practices used by some of burning, burying or stockpiling on farm. These options are not feasible for the future. However, our solutions need to be focused on cost-effective practices that have alignment to current farming systems. Such aspects of waste management for consideration include:

- Available material with end-of-life options
- Biodegradability of materials
- Access to repair
- Preparation and collection of waste materials, including contamination management
- Transport logistics and aggregation
- Diversity of waste types and their suitability for recycling
- Access to treatment facilities.

As the landscape for waste management changes, industry is catching up with what practices are appropriate and meet state and federal regulations as well as community expectations. It is inevitable that during a phase of considerable change there will be uncertainly and inconsistencies in what industry should be doing. As a result, it is essential that industry has clarity in what it should be doing and can lift the bar in achieving best practice.

Increased understanding of the issues associated with waste management and awareness of what is possible is a core aim of this roadmap.

1.3 CHANGING EXPECTATIONS

The agriculture, fisheries and forestry sector aims to do the right thing when it comes to using resources efficiently and managing its waste. While there are many business drivers to manage waste, there are also changing external expectations from the community and consumers to reduce waste generation and manage resources more productively.

Society expects minimal environmental harm to land, water and the atmosphere. This includes an expectation that resources should be used efficiently and waste is managed effectively. Increasingly, the spotlight is on farmers to provide this evidence as a social licence and the 'right to farm'. This involves being able to demonstrate that appropriate care of the landscape and resources during production of food and fibre products has taken place.

Changing community expectations are also being reflected through business systems and requirements. Financial institutions require demonstration of sustainable farming practices and industries are responding with quality and environmental assurance programs that demonstrate positive environmental practices. Industry sectors are keen to promote their credentials through the development of industry sustainability frameworks and stewardship programs.

The challenge exists for the agriculture, fisheries and forestry sector to demonstrate its responsible management of resources and its contribution to reducing the production of waste. Primary industries need to build on current positive initiatives and meet changes in policy head on. Increased investment in research and development and infrastructure is essential for delivering cost-effective solutions.

By leading the charge on waste management, industry can align with the changing expectations of society as to how food and fibre is produced. This will ensure compliance with changing legislation and also reap financial and business rewards for the agriculture, fisheries and forestry sector in the long term.

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Photo: iStock/steve photo

1.4 THIS ROADMAP

The aim of this roadmap is to guide the future management of waste in the agriculture, fisheries and forestry sector applying the principles of a circular economy and the waste hierarchy.

This roadmap is for industry leaders, including Research and Development Corporations, industry representative bodies and policy makers in state and federal government. The roadmap will ensure the agriculture, fisheries and forestry sector is well-equipped to tackle waste issues sustainably, and that waste management initiatives are aligned with national and state approaches and supported by industry and the community.

The roadmap will ultimately assist individual sectors within agriculture, fisheries and forestry to take action – helping them identify what needs to be done, who needs to be involved and how they do it.

This roadmap is for the Australian agriculture, fisheries and forestry sector with a view to 2030. It has been developed with and for industry. It is about identifying solutions within industry that are pragmatic and realistic. To establish these priorities, we need a shared understanding of drivers

and barriers among primary industry, waste and government sectors. The roadmap has facilitated this process by connecting the right people, creating partnerships and establishing a common language and platform. The roadmap:

- Provides a **clear pathway** for how industries can **deal with waste issues** applying the principles of a circular economy and the waste hierarchy
- Highlights the **barriers to implementation** of improved waste management practices
- Identifies the **support that is required** for each industry at a regional level considering:
  - » Specific sector needs
  - » Different waste streams
  - » Regional variances

Photo: istock/RoniMeshulamAdamovitz

The agriculture, fisheries and forestry sector has some great success stories of dealing with waste challenges. However, there is limited awareness and current direction of what can be achieved and how the industries can work together to improve performance. This roadmap aims to be the vehicle for change.

Industry can benefit from the clear national focus on waste management with increased emphasis and investment support for activities that:

- Avoid the production of waste
- Increase the efficient use of environmental resources
- Promote the sustainable on-farm management of wastes
- Increase reuse, recycling and recovery
- Reduce waste going to landfill
- Reduce illegal and environmentally harmful activities
- Assist producers to meet their sustainability targets.

The national waste roadmap is about industry being on the front foot and leading the way in management of waste and working towards a circular economy. It presents a cross-sectoral approach and is complementary to activities already being undertaken by individual Research and Development Corporations, state and federal governments and the National Farmers' Federation.

The national waste roadmap has been developed and informed through a series of projects, delivered by RMCG, for AgriFutures Australia's Pre-Farm Gate Waste Program.

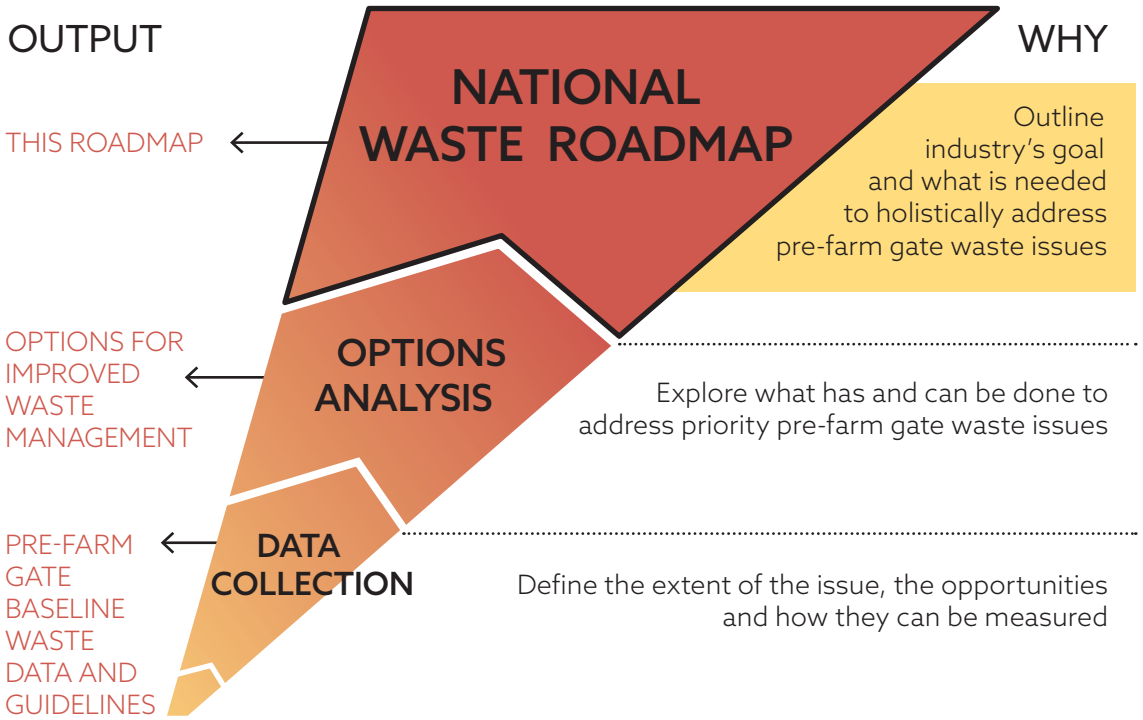

FIGURE 1 National Pre-Farm Gate Waste Program projects

Waste Policy Context

In 2015, Australia adopted the 17 Sustainable Development Goals (SDGs) set by the United Nations General Assembly. The SDGs were developed to end poverty, protect the planet, and ensure prosperity for all, and were intended to be delivered by 2030. **Sustainable Development Goal 12**[1] is specifically focused on responsible consumption and production patterns and has influenced Australia's waste management policies, strategies and standards.

In 2017, the Australian Government published the **National Food Waste Strategy**[2] to provide a framework to support collective action towards reducing food waste. In line with the requirements of SDG 12.3, the Strategy committed to a target of halving Australia's annual food waste by 2030. Australia's target is more ambitious than SDG 12.3 in that it specifies halving food waste and food loss (the SDG requires halving food waste but only requires a reduction in food loss). The Stop Food Waste Australia[3] consortium has been funded to deliver on the National Food Waste Strategy target through initiatives such as the Australian Food Pact and sector action plans.

The Australian Government, in partnership with the state and territory governments and the Australian Local Government Association, released the **National Waste Policy: Less Waste More Resources (2018)**.[4] The policy embodies a circular economy, shifting away from 'take, make, use and dispose' to a more circular approach where we maintain the value of resources for as long as possible and incorporating the waste hierarchy – avoiding, reducing, reusing, recycling and reprocessing materials. The development of this policy was also driven by a reliance on international waste markets and volatility with these markets, particularly in China and South-East Asia, such as import bans on recyclable waste plastics and glass.

The National Waste Policy Action Plan[5] was released in 2019 and outlines targets and actions to reduce the amount of waste going to landfill and increase resource recovery rates. The seven targets, described below, have varying relevance to agriculture, fisheries and forestry, as described further in Appendix 1:

1. Ban the export of waste plastic, paper, glass and tyres, commencing in the second half of 2020
2. Reduce total waste generated in Australia by 10% per person by 2030
3. 80% average resource recovery rate from all waste streams following the waste hierarchy by 2030
4. Significantly increase the use of recycled content by governments and industry
5. Phase out problematic and unnecessary plastics by 2025
6. Halve the amount of organic waste sent to landfill by 2030
7. Make comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions.

Photo: istock/Penny Britt

To support implementation of the Action Plan, the Australian Government has provided investment in several initiatives, including the:

- **Recycling Modernisation Fund**,[6] which aims to increase the capacity of recycling facilities around the country and capabilities locally, including focusing on projects in regional and remote Australia. Projects have specifically targeted addressing agricultural plastics in the regions.
- **Food Waste for Healthy Soils Fund**,[7] which endeavours to utilise organic waste for productive use in our agricultural soils, rather than going to landfill, with a focus on increasing organic waste recycling rate from 49% to 80% by 2030. The expected return of this investment is $400 million in industry value and avoidance of over two million tonnes of unnecessary greenhouse gas emissions each year.
- **National Product Stewardship Investment Fund**,[8] which was launched in 2020 and aims to increase the number of industry-led product stewardship schemes in Australia and the recycling rates of existing schemes. Of particular significance for primary industries are the NPSIF projects addressing agricultural plastics and silage wrap.
- **Circular Economy Roadmap**,[9] which was published by CSIRO in 2021 and explores research pathways in support of a circular economy, with an objective of reducing total waste generated in Australia by 10% per person and achieving an 80% average resource recovery rate from all waste streams applying the waste hierarchy by 2030.

All **state and territory governments** have developed (or are developing) waste management and resource recovery policies and/or strategies in line with the National Waste Policy, including implementing targets and embedding circular economy and waste hierarchy principles. State and territory governments play a particular role in setting relevant legislation and regulations that provide the necessary framework to:

- Encourage support for the legitimate recycling sector by setting of waste levies
- Prevent illegal disposal of waste
- Address potential harm to the environment and human health caused by inappropriate waste management and resource recovery activities
- Contribute to the strategic planning of waste management and resource recovery infrastructure and services.

Relevance to primary industries – legislation to prevent burying and burning of on-farm waste is variable across jurisdictions, with no blanket ban across Australia to dispose of such wastes in this way. The regulation of on-farm waste is largely administered through other environmental protection legislation, with many states moving towards implementation of the waste hierarchy with waste avoidance being at the top. While local authorities and environmental regulators encourage appropriate disposal (and particularly recycling) by primary producers in rural and regional communities, often the relevant services or infrastructure are lacking.

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[1] https://www.un.org/sustainabledevelopment/sustainable-development-goals/
[2] https://www.awe.gov.au/sites/default/files/documents/national-food-waste-strategy.pdf
[3] https://www.stopfoodwaste.com.au
[4] https://www.awe.gov.au/sites/default/files/documents/national-waste-policy-2018.pdf
[5] https://www.awe.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf
[6] https://www.awe.gov.au/environment/protection/waste/how-we-manage-waste/recycling-modernisation-fund
[7] https://www.awe.gov.au/environment/protection/waste/food-waste/food-waste-for-healthy-soils-fund
[8] https://www.awe.gov.au/environment/protection/waste/product-stewardship/national-product-stewardship-investment-fund
[9] https://www.csiro.au/en/research/natural-environment/Circular-Economy

Industry Activities

Primary industries are represented by several organisations, namely **peak industry bodies** and **Rural Research and Development Corporations** (statutory bodies or industry owned) that provide research and development (R&D) services. They undertake a range of activities, including developing policy positions (through the peak industry bodies), establishing strategic frameworks that set industry targets, demonstrating progress on critical industry issues and R&D programs, and supporting industry-based on-farm programs (e.g. quality assurance, best management practices).

The variability across the industries in their activities reflects the different **drivers** they currently face and where they need to focus their strategic efforts, including R&D investment. For all industries, the core divers of reducing production costs (such as feed costs), addressing product/food losses and seeking alternative energy sources (that may be derived from local or on-farm waste sources) are opportunities to reduce and/or recycle organic wastes on farm. For the extensive livestock and cropping industries, emissions/carbon neutrality, biodiversity impacts and animal welfare are key focus areas driven by supply chain, community and other stakeholders. For intensive animal and fisheries industries, drivers include the social licence to operate associated with animal welfare and biodiversity. These factors are important areas for their respective industry strategies that cover waste management.

The National Farmers' Federation's 2030 Road Map has identified the implementation of a cross-sectoral **Australian Agricultural Sustainability Framework (AASF)** by 2025 as a core action. The proposed framework uses an ESG (environmental, social and governance) reporting structure and sustainability framework descriptors to clearly support users with material principles and criteria. The purpose of the AASF is to establish a common set of sustainability principles for the agricultural sector that can be used over time to align sectoral and supply chain language with a common understanding of sustainability deliverables, and therefore effectively communicate the overall status of Australian agricultural sustainability.

Most primary industries have developed or are in the process of developing **sector sustainability frameworks**, mainly to facilitate industry-wide sustainability reporting. All frameworks align or refer to the UN's Sustainable Development Goals. The frameworks vary with respect to target setting, consideration of circular economy principles, consideration of the waste hierarchy and reference to the National Waste Policy. Industries are still in the early days of capturing and reporting on sustainability data.

Industries generally have voluntary **on-farm assurance** (quality, food safety, best management practices) programs that support producers in demonstrating good agricultural practices to stakeholders. They also feature independent certification, which is a supply chain/market requirement for many producers. Many of these programs include environmental management standards or practices that require participating producers to consider their environmental risks and implement actions to address these risks. Some standards require consideration of appropriate waste management, including waste minimisation and recycling.

There is considerable **R&D investment** in addressing waste management through the Department of Agriculture, Fisheries and Forestry's Rural R&D for Profit program, the Fight Food Waste CRC and each of the industry Research and Development Corporations, including projects that:

- Scope the waste issue for their industry
- Identify and trial potential solutions
- Test technologies that deal with on-farm waste.

This **roadmap** integrates and builds on these current industry activities.

Waste and resources 2

2.1 WHAT IS 'WASTE'?

National standard

The definition of 'waste', as defined by the national standard (right), has been refined and adapted for this roadmap. The definition considers whether a material or by-product at the point that it is 'generated' requires management or can be left where it is generated, in situ, to provide beneficial outcomes.

Management is considered an action such as consolidation, stockpiling, burying, burning, collecting, transporting, processing or sending to landfill. If a material is left in situ and has beneficial reuse outcomes at that location, then that material is not considered a waste. If a material requires active management at the place of generation, it is considered a waste and included in the program.

Some of the materials discussed in this roadmap are in fact resources (or secondary materials) as they have a value in the circular economy, and that value may increase over time. Examples include crop loss, metals or plastic that is recycled.

Photo: istock/ronstik

National standard for waste and resource recovery data and reporting (2021)[10]

WASTE DEFINITION: **Materials or products that are unwanted, surplus, discarded, rejected, abandoned or left over, including those materials or products intended for or managed by reuse, recycling, energy recovery, treatment, storage and disposal.**

Waste-derived materials cease to be waste and transition to being 'secondary materials' when the following conditions are met:

- They are to be used for a specific purpose
- A market or demand exists
- They fulfil the technical requirements for the specific purposes and meet the existing legislation and standards applicable to products
- Their use will not lead to overall adverse environmental or human health impacts

The transition from waste to secondary materials is generally deemed to occur at the out-going gate of a reprocessing facility when the outputs require no further processing prior to being returned to productive use.

Pre-farm gate

Pre-farm gate wastes are organic, plastic and/or workshop wastes that are generated in primary production (agriculture, fisheries and forestry) business operations up to the point of and including harvest, prior to leaving the farm or vessel. This may include some on-farm packing, e.g. vegetable packing sheds, but excludes processing, e.g. vegetable processing, fish processing, log (forestry) milling.

[10] https://www.awe.gov.au/sites/default/files/documents/standard-wrr-data-and-reporting-final-issued-v2.pdf

Waste hierarchy and circular economy

The 2018 National Waste Policy is underpinned by the waste hierarchy highlighting the key steps for avoiding the production of waste (Figure 2). The first and most preferable step is to consider whether the waste can be avoided altogether. The final and least preferable step is to dispose of the waste, and this should only be done where there is no opportunity for the previous six steps to be implemented.

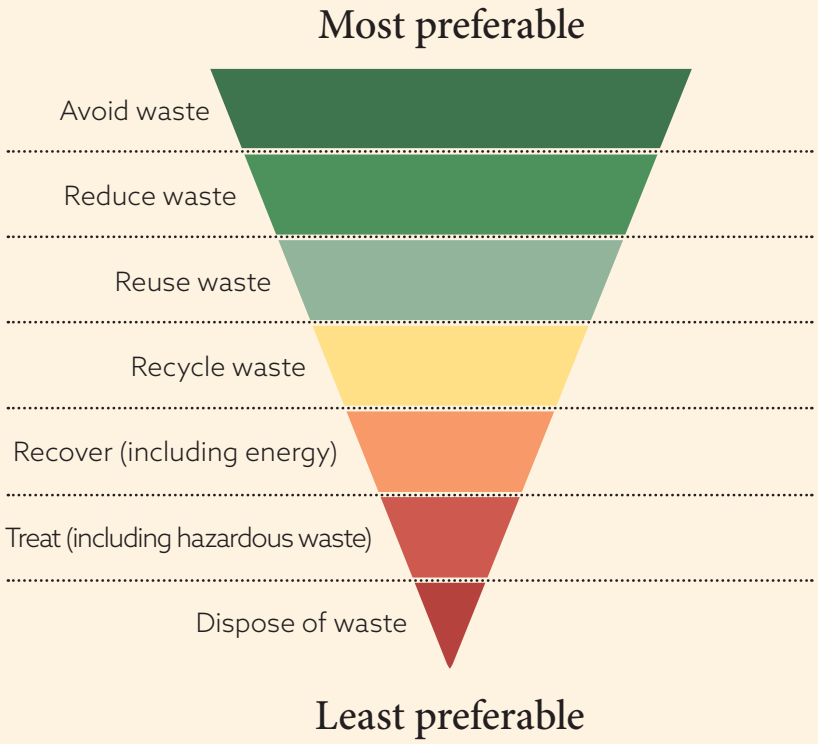


FIGURE 2 Waste Hierarchy (from 2018 National Waste Policy)

The policy also subscribes to five overarching principles relevant to waste management in a circular economy (Figure 3), including:

1. Avoid waste
2. Improve resource recovery
3. Increase use of recycled material and build demand and markets for recycled products
4. Better manage material flows to benefit human health, the environment and the economy
5. Improve information to support innovation, guide investment and enable informed consumer decisions.

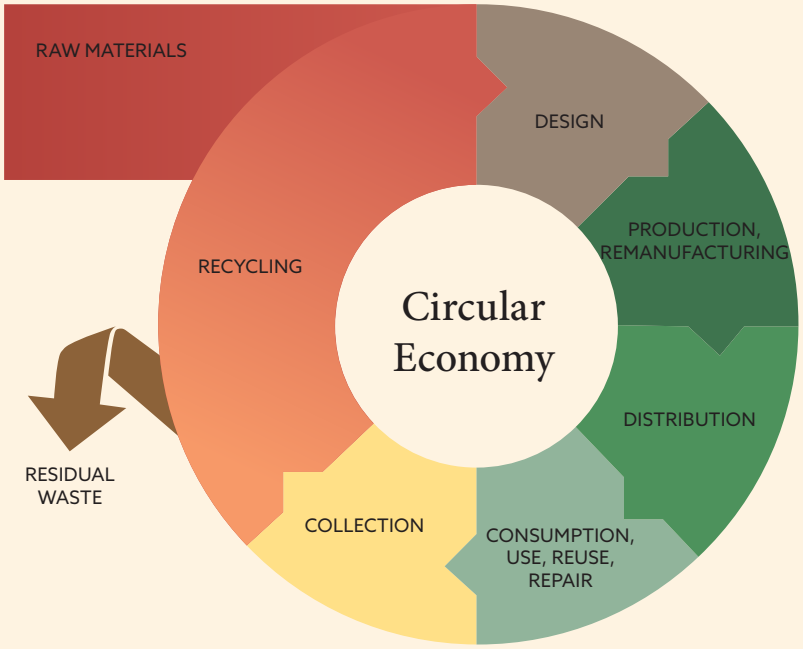


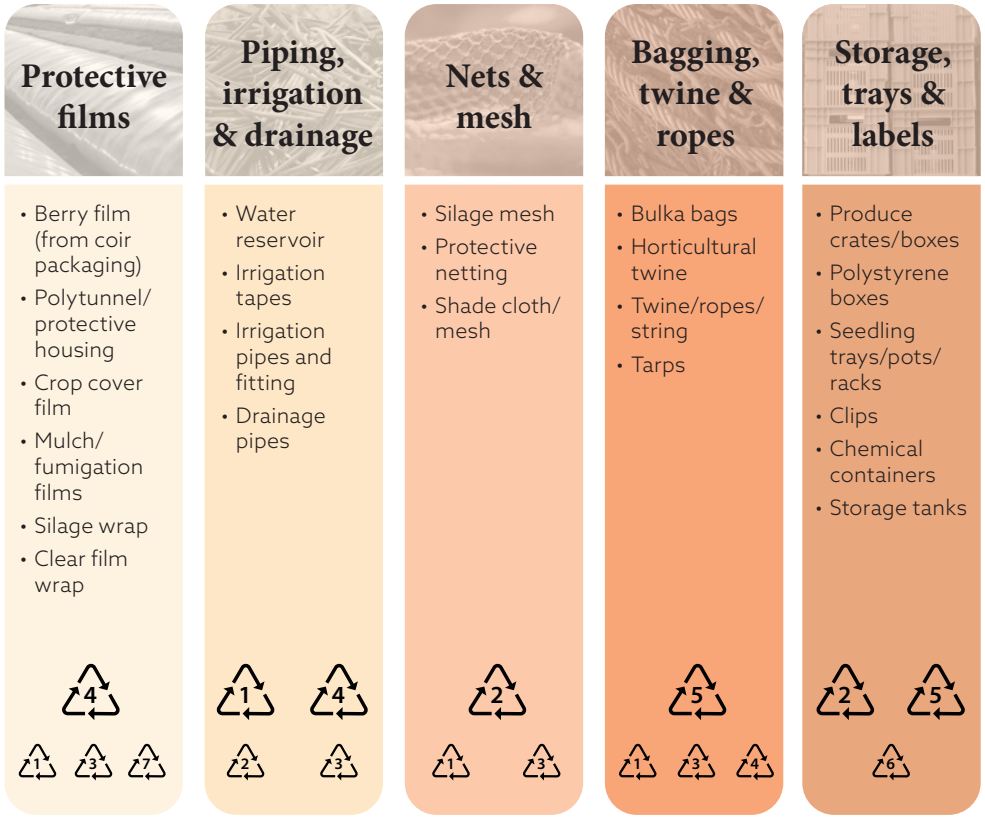
FIGURE 3 Circular Economy (from 2018 National Waste Policy)

2.2 WASTE CATEGORIES

Three categories of waste have been identified for this program: plastic, organic and workshop wastes.

A. Plastic waste

Plastic is a major waste generated in pre-farm gate agriculture, fisheries and forestry activities, with single-use plastics a significant component. Furthermore, recovery pathways are largely lacking, meaning plastic that is not disposed of appropriately can break down into microplastics, which contaminate land, waterways and oceans, or release GHG gases and noxious fumes if burnt. The scope of pre-farm gate plastic waste that has been identified for this program across agriculture and forestry is provided in Figure 4 below.



Plastic codes	Polymer type	Description
1	PETE	Clear, tough, solvent resistant, used for rigid sheets and fibres
2	HDPE	Hard to semi-flexible, waxy surface, opaque
3	PVC	Hard, rigid, can be clear, can be solvent welded
4	LDPE	Soft, flexible, waxy surface, translucent, withstands solvents
5	PP	Hard, flexible, wide property range for many applications, good chemical resistance
6	PS	Clear, glassy, rigid, brittle (PS); or foamed, light weight, energy absorbing (EPS)
7	OTHER	Other resins and multi materials of unknown composition, acrylic, nylon, polyurethane (PU), polycarbonates (PC) and phenolics

FIGURE 4 Scope of pre-farm gate plastic waste, showing the five (5) sub-categories of plastics in agriculture and forestry


Photo: istock/ pavelalexeev

B. Organic waste

Large volumes of organic waste/organic material are produced by industry activities across the primary industry sectors of agriculture, fisheries and forestry. The organic waste categories for this program have been divided into the following six sub-categories based on material type:

- Animal waste
- Sludges
- Wood and timber (untreated)
- Green waste
- Product loss and residues
  - » Packing shed loss (e.g. grading)
  - » Crop loss (unharvested crop/part of crops)
  - » Harvesting residues (left in field after harvest and requiring active management)
- Other organics

Photo: istock/redstallion

Photo: istock/ ChicoDodiFC

C. Workshop waste

Workshop waste includes waste that is not classified as plastic or organic and is generated in any space on a farm, at sea on fishing vessels, onshore, or in forests where light industrial work is undertaken related to pre-farm gate activities. This may include mechanical workshops, timber sheds, storage areas and on vessels. Workshop waste includes a range of materials that are often mixed (e.g. tools that include plastic, rubber, metal and electronics). It is a category based on activity or use rather than material type.

2.3 AGRICULTURE AND FORESTRY

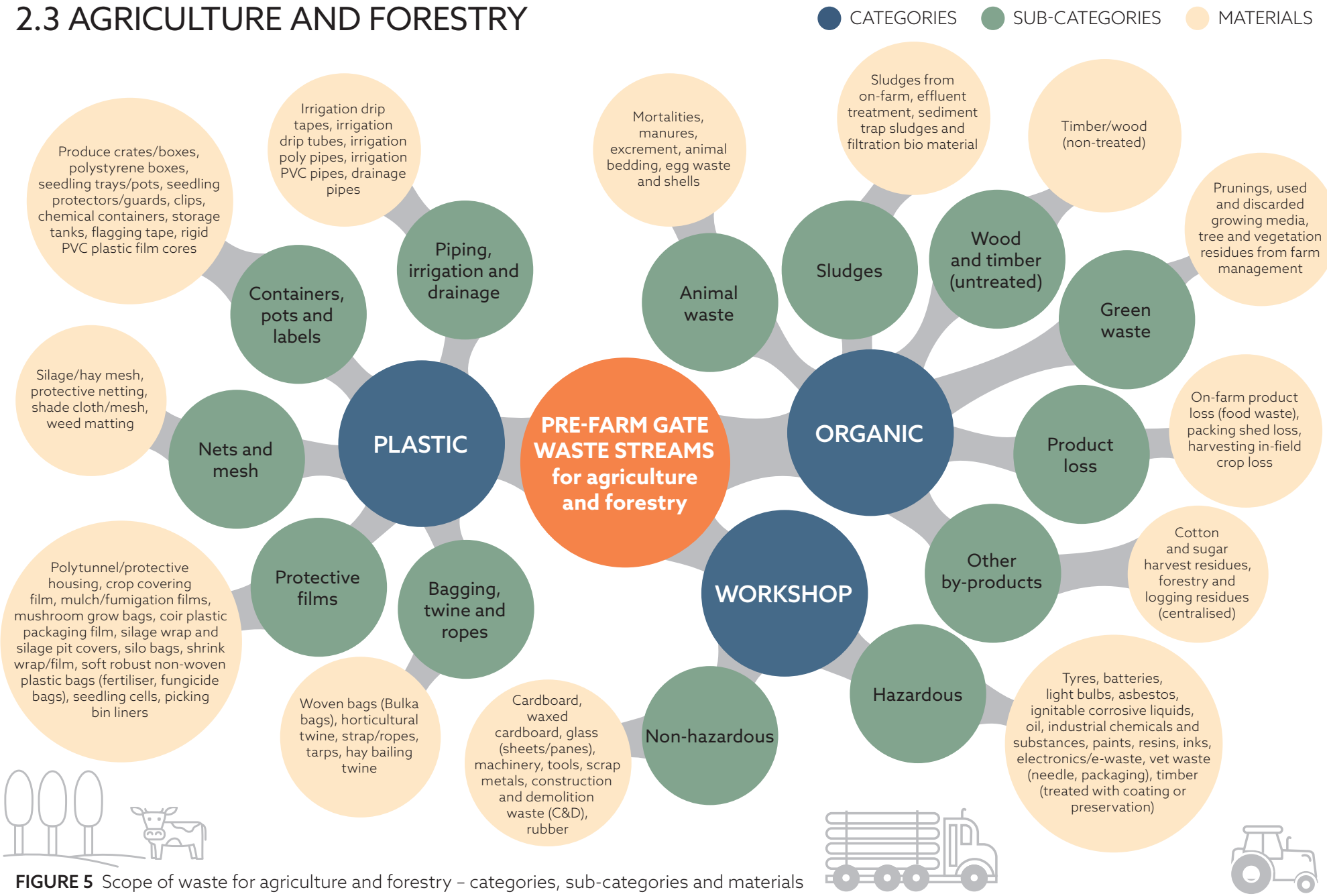


FIGURE 5 Scope of waste for agriculture and forestry – categories, sub-categories and materials

2.4 FISHERIES

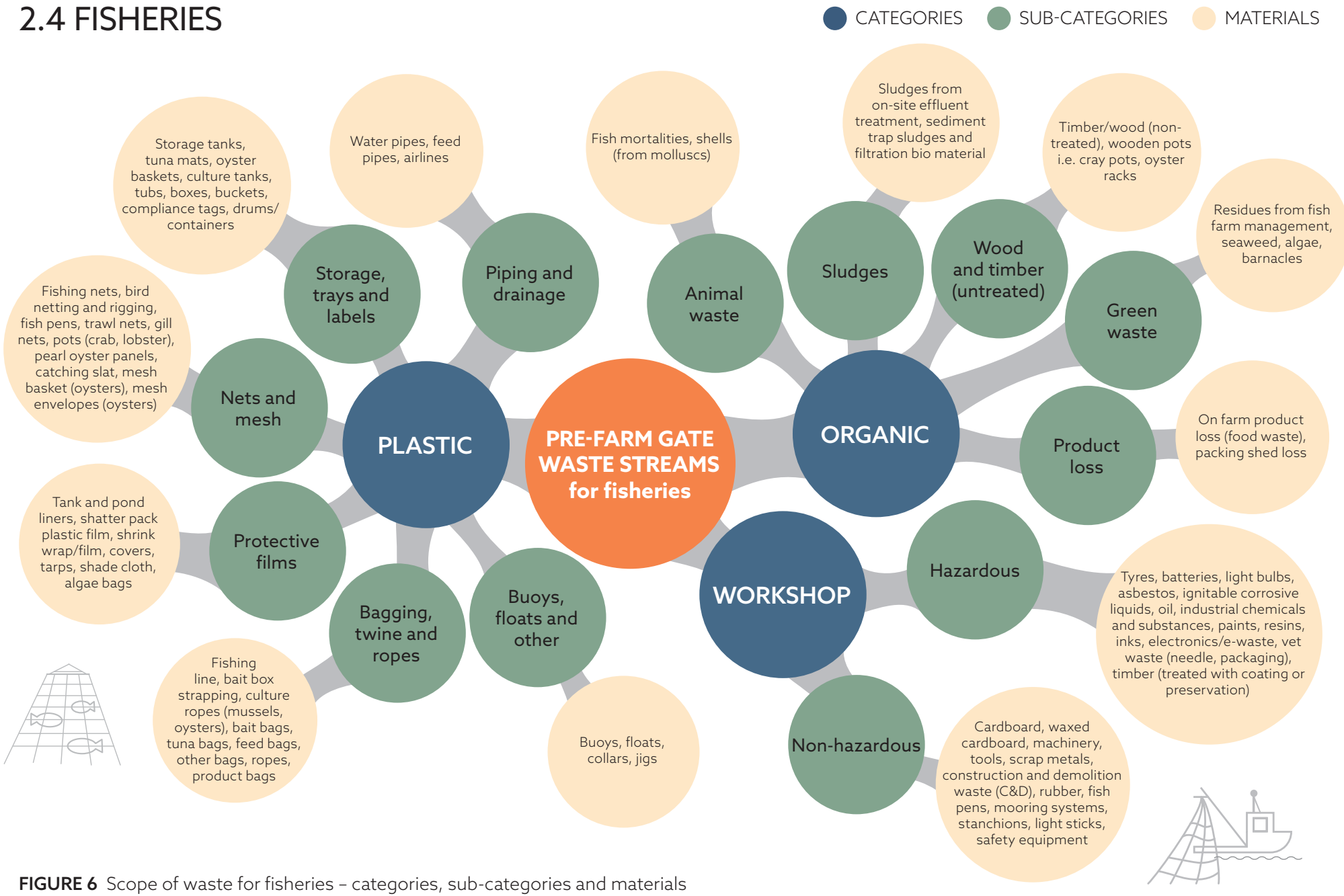


FIGURE 6 Scope of waste for fisheries – categories, sub-categories and materials

2.5 BASELINE WASTE DATA

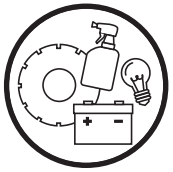
A baseline data study in 2022 identified that Australian agriculture, fisheries and forestry generated an estimated 9.8 million tonnes of pre-farm gate waste in 2020/21 comprising (Table 1):

9,553,713 tonnes ORGANIC MATERIAL

99,753 tonnes PLASTIC MATERIAL

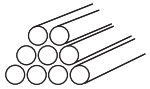
(estimate includes agriculture and forestry, not fisheries)

162,923 tonnes WORKSHOP MATERIAL



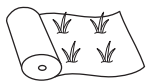
(estimate includes some, not all, workshop waste materials)

Organic material generation was substantially greater than plastic or workshop. However, organic material is often used beneficially on farm such as through returning to the soil for improved soil health or reducing soil erosion risk. Plastic material types with the largest annual volumes included:



IRRIGATION PIPES, TUBES & DRAINAGE 19,000 tonnes

SILAGE WRAP 14,000 tonnes



WEED MATTING 12,500 tonnes

SEEDLING TRAYS 10,000 tonnes

TABLE 1 Total pre-farm gate waste and recoverable resource generation

SECTOR	INDUSTRY SIZE/SCALE		TOTAL PRE-FARM GATE WASTE GENERATION		
	Hectares	Gross value of annual production	Organic (t/yr)	Plastic (t/yr)	Workshop* (t/yr)
Broadacre	28 million[1]	$25.2b[1]	1,279,303	12,286	88,231
Dairy	332 million ha used for grazing (45 million of this is improved pasture)[1]	$4.7b[1,2] for milk	2,095,430	7,797	678
Livestock		$26.2b[1]	3,616,917	15,471	27,866
Horticulture	513,000[1]	$14.7b[1]	2,305,442	63,228	46,149
Fisheries – wild caught	not applicable	$1.5b[3]	not applicable	insufficient data	insufficient data
Fisheries – aquaculture	not applicable	$1.6b[3]	12,705	insufficient data	insufficient data
Forestry	134 million[4]	$2.2b[4]	243,917	972	not applicable
TOTAL			**9,553,713**	**99,753**	**162,923**

* Workshop includes tyres, batteries and oils for all industries, plus treated timber for vineyards only | [1] ABS. (2022). *Value of Agricultural Commodities Produced, Australia – 2020-21* | [2] Value of meat from the dairy industry is include in the livestock sector value | [3] Steven, A. H. *et al.* (2021). *Australian fisheries and aquaculture statistics 2020* | [4] ABARES. (2022). *Australian forest and wood products statistics, September and December quarters 2021*

Total agricultural plastic was 100,000 tonnes. Horticulture accounted for 63,000 tonnes or 63% of agricultural plastic waste. This is due to the intensity of production systems and a relatively high rate of plastic waste per hectare compared to other sectors.

Broadacre accounted for 88,000 tonnes or 54% of agricultural workshop waste. This is due to the large number of hectares in broadacre production combined with the extent of machinery used on broadacre farms.

While some sectors generated more waste than others, it should be highlighted that some materials are recycled or reused and are considered a resource, and thus are not 'wasted'. In addition, the type of waste produced in each sector differs, so each sector cannot be directly compared to another without consideration of the context.

Estimates of management pathways are illustrated in the Sankey diagrams in Figure 7 and Figure 8 for organic and plastic material respectively. The width of the lines in the diagrams represents the annual volumes of waste material.

The majority (96%) of organic material was recycled or reused, e.g. used beneficially on farm, composted or used for livestock feed. Most materials are generated as part of normal practices, e.g. crop residues, animal waste. However, the volume of product loss, i.e., fruit and vegetables that do not meet market specifications, is substantial, and could be reduced or used for purposes further up the waste hierarchy.

The majority of plastic was either managed on site, e.g. stockpiled (59%), or landfilled (24%). Only 14% of plastic was recycled or reused. Agricultural plastic is often challenging to recycle due to limited recycling capacity or technology, logistics including distance to recyclers, as well as contamination.

Survey data for workshop waste was limited and therefore it was not possible to accurately estimate management pathways.

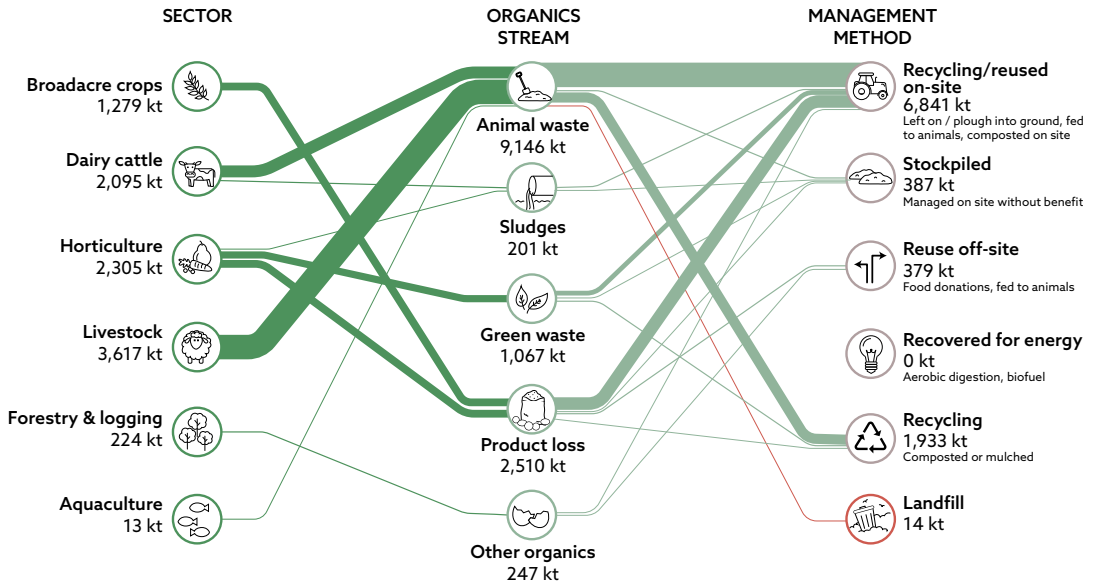


FIGURE 7 Management pathway of organic material

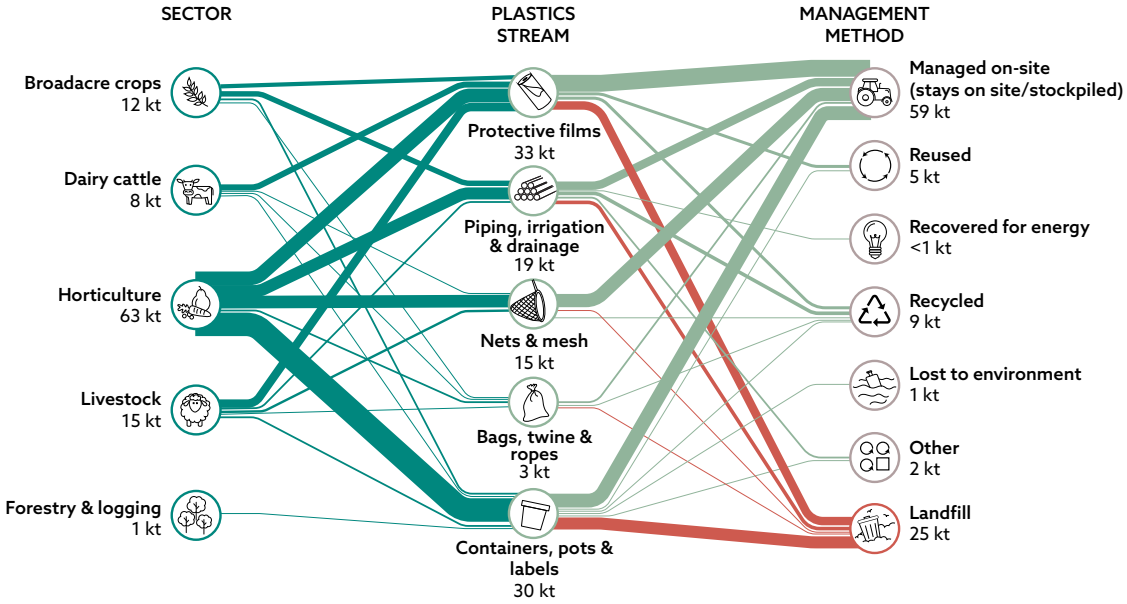


FIGURE 8 Management pathway of plastic material

What can industry do about waste? 3


Photo: istock/Sergei Telenkov

3.1 WHAT WE HEARD FROM INDUSTRY

In the development of this roadmap, we consulted extensively with growers, representatives and interested stakeholders across the agriculture, fisheries and forestry sector to understand their waste management issues and solutions. The priority issues raised through our discussions are summarised in the following section. Importantly, many industry members considered the definition of 'waste' to be unclear, often with a negative connotation. Language is an essential part of this roadmap and industry was consistent in wanting a focus on the value of the product emphasising that we are dealing with a 'resource', 'co-product' or 'material'. The agriculture, fisheries and forestry sector is also active in considering the circular economy at a sector level in particular regions. This roadmap provides an opportunity for a coordinated and collaborative approach across industries.

3.2 CURRENT PRACTICES AND WASTE ISSUES

Agriculture

Plastic waste was considered the primary waste issue for the majority of agriculture industries. Problem plastics include soil mulch films, poly tunnels, piping and irrigation, nets and mesh, bagging and twine, and storage, trays and labels. Some plastics are recycled, mainly through coordinated programs such as drumMUSTER or location-specific initiatives. There are significant stockpiles on farms, including irrigation piping, plastic mulch and silage. Plastics are sometimes buried or burned on site while some are landfilled in mixed waste collections.

Organic wastes include animal waste, sludges, green waste, product loss and harvest residues. Organic residues and animal manures from intensive livestock operations are often composted or mulched and used on farm. Harvest residues and product loss are often fed to animals or left in field. For farmers, organic waste is often not considered a waste as it can be used on farm as a practical organic amendment. There are also opportunities to convert organic wastes into valuable products like fertilisers, chemicals and renewable energy. Product that is unharvested (product loss) due to market specifications, impacts of climate, labour problems or collapse of market price is a significant issue in many horticultural industries. Organic wastes that are not properly managed can pose a biosecurity risk.

Workshop wastes include a range of materials that are highly dependent on the production system. These wastes include fencing wire and treated timber (including copper chrome arsenate posts), tyres, oils, machinery and other inert and hazardous waste. Material is often stockpiled in and around physical workshops. Scrap metal is sometimes repurposed on farm or recycled through collection services in regions where available. Oil is often recycled through collectors or at local council sites or is reused on farm. Most farmers apply waste hierarchy principles in their workshops, ensuring that materials are reused and waste is minimised.

Fisheries and aquaculture

Most fisheries operations occur in oceans and estuaries, apart from a small proportion of land-based aquaculture. The social licence to operate is very important for the fisheries industry and the industry is willing to innovate and trial new options, and improve sustainability and waste management practices.

Plastic is widely used and products are often a composite of several types of plastics. Netting, ropes, buoys, bollards, cages, baskets, pontoons and feed bags are some of the types of plastic products used. Individual fishing and aquaculture businesses have recycling programs set up for specific plastic products. However, most plastics used by the industry are landfilled or stockpiled. Importantly, many plastics make their way into oceans, including ghost nets, which can cause significant entanglement injuries and death to animals. A key barrier to recycling plastics is the mix of plastics that are used in products and the difficulty in separating these. Logistics and distance from fishing operations to recycling facilities also pose a significant problem.

Organic waste from fisheries is mainly from the animals, for example mortalities and shell. Most of this material is composted or land spread through controlled measures while shell is often landfilled.

Treated timber posts are a problematic workshop waste used in oyster growing. Steel framing for aquaculture and fisheries equipment is used but often reused and/or recycled through a range of scrap recyclers. Other types of waste include batteries, oils and motors.

Forestry

Plastic tape (for marking harvest, thinning, new prospecting areas and routes) and seedling protectors (corflute and netting) are currently most often left in situ.

There are significant organic harvest residues left in forests after harvest. These residues may be aggregated and collected for compost, stockpiled in coupes or burnt depending on the forestry and harvest system. Most organic residues are left in situ for beneficial reuse and therefore are not considered a waste.

Most forestry services are delivered by contractors who plant, spray, maintain and harvest crops resulting in the waste, e.g. plastic and workshop waste, being generated off site.

Photo: istock/pkphotoscom

3.3 DRIVERS FOR CHANGE

Australian primary producers are committed to improving the management of their waste, including taking part in innovative programs that promote avoidance, reuse and recycling options. The desire and appetite for improved practices is evident, but there is often a gap in the settings (knowledge, coordination, incentives, regulation) and practical alternatives to facilitate this change at scale.

The key drivers for positive change in waste management expressed by industries were:

1. **Environmental** – personal consciousness and desire to care for the land; alignment with industry sustainability frameworks; environmental responsibility; benefits of organic amendments to soil health; move to zero carbon; desire for circular economy
2. **Financial** – cost efficiency; efficient use of resources/materials; generation of new products (e.g. energy); replacement of resources (e.g. fertilisers); prohibitive cost of disposal; increasing value of secondary materials
3. **Social** – licence to operate; being responsible neighbours; meeting community expectations; considering materials as a resource rather than a waste
4. **Business** – access to specific markets (local and export) through supplier and quality assurance programs; meeting consumer expectations; responding to retailer requirements; general farm amenity and aesthetics; safe working environment
5. **Biosecurity** – improving hygiene and biosecurity measures; risk management for contamination and environmental conditions
6. **Regulatory** – legislation for waste management

Photo: istock/Maren Winter

3.4 BARRIERS TO POSITIVE CHANGE

Despite the willingness for change, there are several critical barriers to implementing improved practices to manage waste that industry has identified, including:

- **Logistics** – associated with aggregation, collection and transport, particularly in isolated regions
- **Capacity** – access to and capacity of recycling and upcycling options
- **Alternatives** – minimal existing options for end-use with established markets
- **Contamination** – of waste materials preventing recycling
- **Costs and time** – associated with alternative practices and a perception waste management has no financial benefit
- **Convenience** – difficulty dealing with waste materials and minimal on-farm pick up services
- **Awareness** – lack of information and knowledge as to available waste management options
- **Regulation** – understanding of requirements across states and enforcement
- **Monitoring** – lack of data available for tracing the flow of material
- **Local solutions** – market concentration and a lack of local suppliers, regional recycling facilities and community-based solutions.

Pre-farm gate waste roadmap 4

4.1 INDUSTRY GOAL

The waste hierarchy ranks waste management options according to what is best for the environment. It gives top priority to preventing waste in the first place. When waste is created, it gives priority to preparing it for reuse, then recycling, then recovery, and last of all disposal (e.g. landfill).

The National Waste Policy calls for the application of the waste hierarchy, prioritising waste avoidance and minimisation then considering repairing and reusing products and finally recycling resources. The options of recovery, treatment and disposal are the least preferred. The policy also embodies a circular economy, shifting away from 'take, make, use and dispose' to a more circular approach where we maintain the value of resources for as long as possible.

Waste hierarchy for agriculture, fisheries and forestry

The agriculture, fisheries and forestry sector are keen to adopt the principles of the waste hierarchy and a circular economy. These principles have been embodied into the goal of the roadmap, with success being measured by how these sectors can move the management of waste up the hierarchy.

Moving up the waste hierarchy will greatly increase the efficiency in resource use and reduce the environmental harm. Examples of how this can be achieved for the agriculture, fisheries and forestry sector are provided in Figure 9.

The goal for industries is for the management of materials to **move up the waste hierarchy**

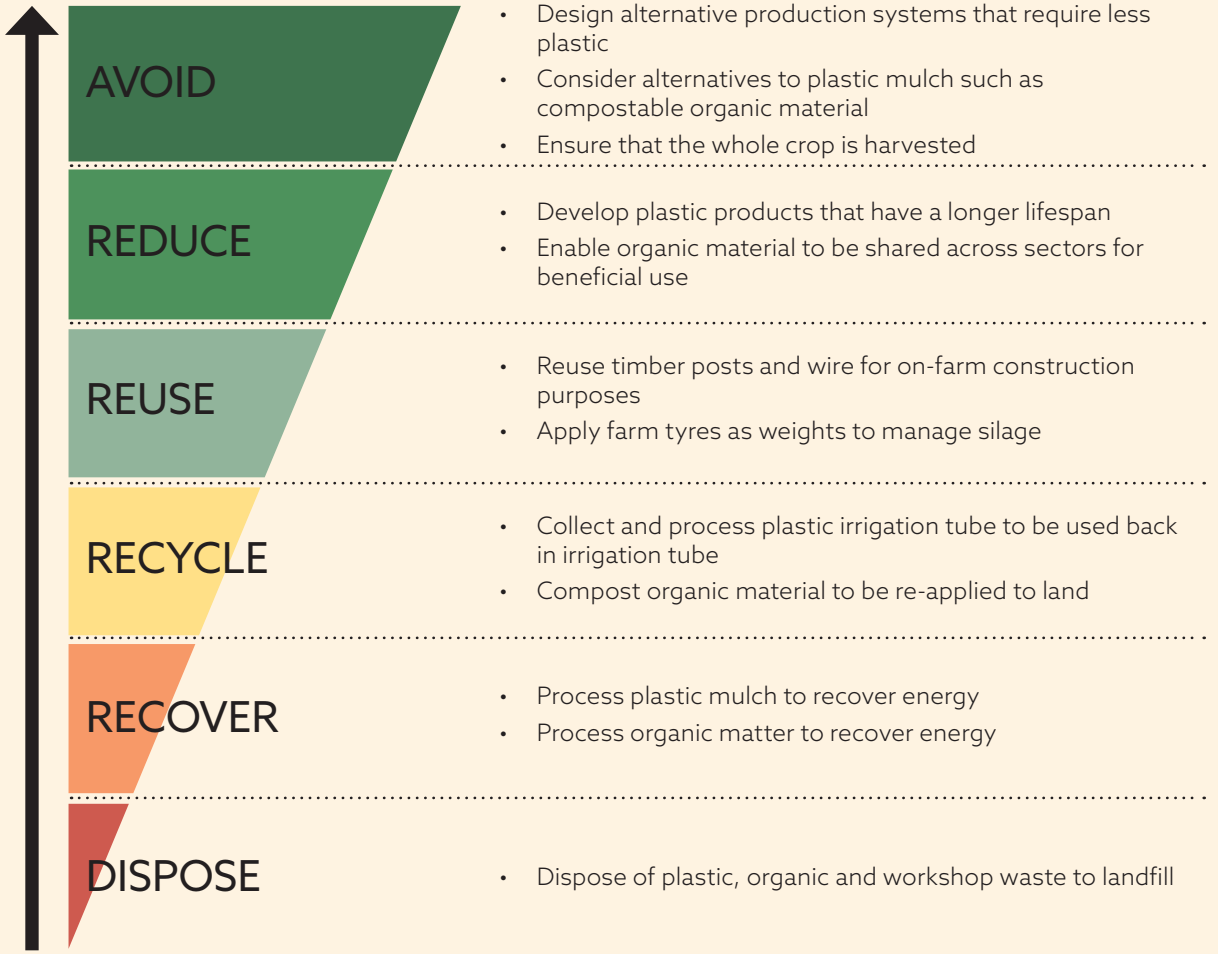


Figure 9 Options to enable improved pre-farm gate waste management

4.2 PRIORITY THEMES

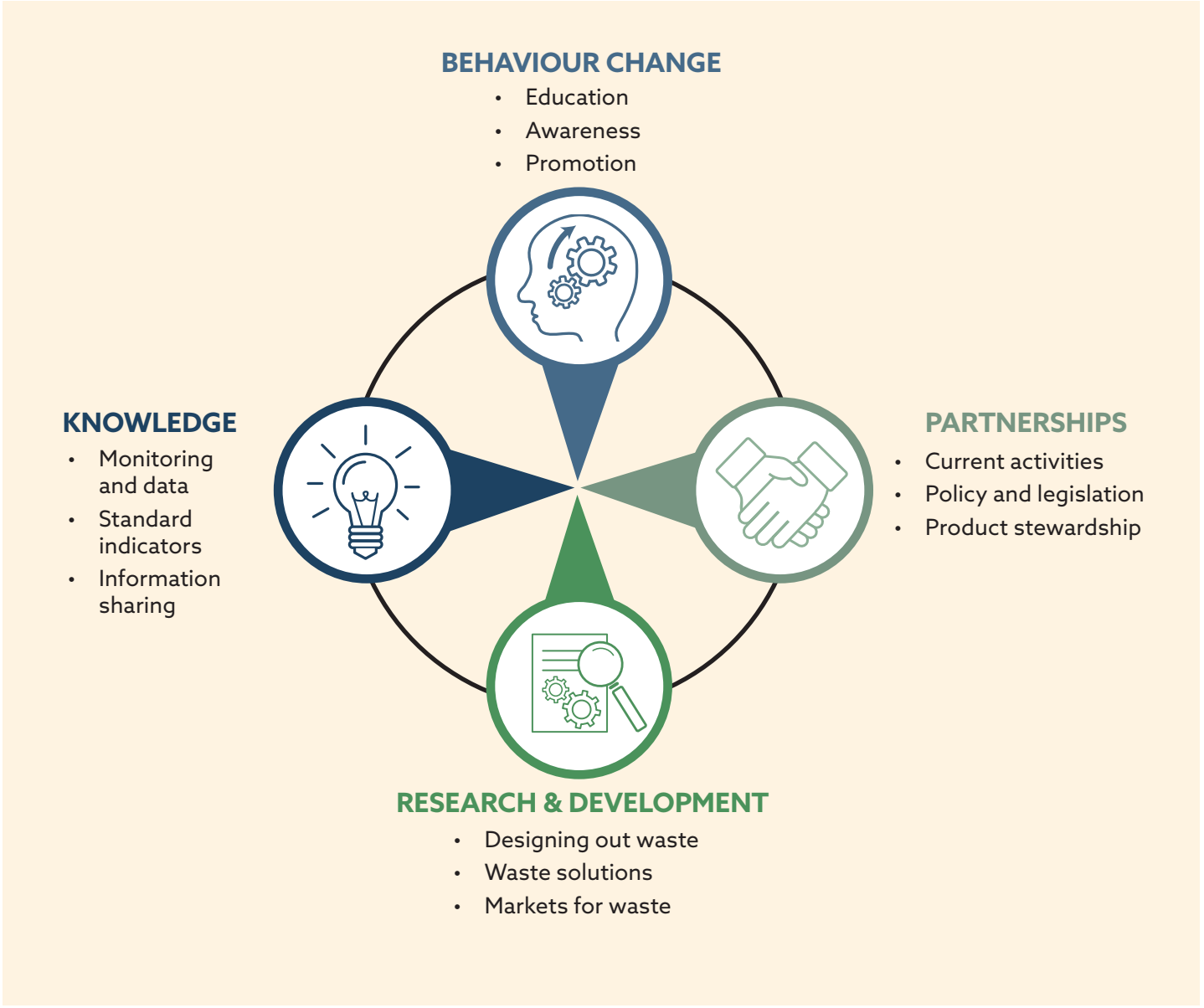


FIGURE 10 Roadmap themes for pre-farm gate waste

Across the agriculture, fisheries and forestry sector there is demonstrated effort associated with waste and resource recovery and a willingness of industry to adopt new technologies and practices. Often the solutions are there, however the awareness is lacking, or the feasibility has not been tested. In other cases, there is a gap in knowledge as to how practices and technology may fit with existing production systems.

It is also evident that partnerships across industry, government and community will greatly facilitate the uptake of better waste management practices, with significant activity that can benefit from shared understanding and experiences. In addition, in some areas, we will need to undertake further research and development to develop solutions and systems that fit within the Australian landscape.

To guide this roadmap, and to support the agriculture, fisheries and forestry sector with moving up the waste hierarchy, the four key themes shown in Figure 10 have been identified.

4.3 ACTIVITIES

1. KNOWLEDGE

- Monitoring and data
- Standard indicators
- Information sharing

Why

In order to manage our waste, we need to be able to measure the scale and distribution of various waste streams. This also requires the establishment of standard indicators and approaches for life cycle assessments. Sharing this information across primary sectors, with other industries and across government will ensure we have the best knowledge to tackle the biggest issues, and that our efforts are well targeted.

How

- Develop uniform metrics to quantify generation of each waste stream and best practice methods to collect data and measure progress achieved in managing these
- Collate waste information at a sector level to understand priority waste streams across agriculture, fisheries and forestry
- Link waste data and information to sector sustainability frameworks and organisational strategies
- Monitor the performance of individual industries and the agriculture, fisheries and forestry sector collectively against agreed metrics
- Provide whole-of-industry target setting and data reporting to ensure the scale of waste streams is understood
- Improve data collection to better understand the problems and help design potential solutions
- Improve knowledge sharing on waste management and initiatives relevant to on-farm waste to learn from each other
- Enable growers to have access to market demand and production data for specific commodities to produce more efficiently, avoiding generation of organic waste
- Identify opportunities for improvement and hot spots through consideration of:
  - » Waste stream
  - » Location/region
  - » Industry/sector

2. BEHAVIOUR CHANGE

- Education
- Awareness
- Promotion

Why

Interest in appropriately managing our waste has increased rapidly in recent years. There are many innovative solutions, however a key barrier to change is awareness of what is possible. A wider understanding of management options, including the costs and benefits (financial, social and environmental), would support increased uptake and behaviour change.

How

- Ensure awareness of existing stewardship programs that deal with batteries, tyres, chemical drums (drumMUSTER) and fertiliser bags (Big Bag Recovery)
- Promote awareness of industry and regional solutions to managing waste to ensure that industry knows what options are already available
- Identify what works well for successful programs, e.g. drumMUSTER
- Demonstrate the cost effectiveness of practices and technologies that incorporate recycling
- Enable industry to advocate on what is required to bring about positive change in relation to waste management, focusing on what is practical and feasible for producers
- Promote reuse and recycling of plastics
- Encourage management of organic material, including in-field incorporation and composting

Photo: istock/gkuna

3. PARTNERSHIPS

- Current activities
- Policy and legislation
- Product stewardship

Why

There are many groups working on addressing waste issues across Australia. In a rapidly changing policy environment it is essential that we learn from what each other is doing and develop productive partnerships across sectors, industries and governments. It is also important that the practical implementation of policy is tested and feedback to government to refine and ensure we are achieving intended outcomes. Understanding existing activities and programs (e.g. National Product Stewardship Investment Fund) is an important first step in developing these partnerships.

How

- Collaborate with all tiers of government and across the supply chain to address key on-farm waste challenges
- Engage with all RDCs to ensure alignment with existing programs and to facilitate adoption of this roadmap
- Work across industry sectors to address waste streams that are common
- Work across supply chains to establish extended producer responsibility (EPR) schemes and facilitate the ease of managing waste products at their end-of-life
- Engage with Stop Food Waste Australia on initiatives to reduce pre-farm gate food loss and waste
- Identify alternative input supply products that minimise waste and/or improve resource recovery options
- Engage with supply chains to consider how assurance programs can facilitate change in practices
- Encourage cross-industry collaboration to enable the movement of organic co-products between sectors
- Identify opportunities to support repairing of materials
- Consider expanding AgStewardship to include other waste streams
- Develop drumMUSTER collection sites to take other waste products
- Identify the resource recovery and recycling infrastructure and services required in regional areas
- Work with the recycling industry to provide mobile facilities for tape recoiling, tyre chipping and plastics baling to facilitate freight efficiency
- Establish trading (match-making) services for products to facilitate the movement of resources across commodities and between the primary and recycling industries
- Collaborate with local government to promote existing regional programs and local solutions
- Work with existing research and development institutions such as industry RDCs, universities, state government departments and the Fight Food Waste CRC

4. RESEARCH AND DEVELOPMENT

- Designing out waste
- Waste solutions
- Markets for waste

Why

There are many opportunities for innovations to achieve our goal of moving up the waste hierarchy. This includes ensuring our production systems minimise the amount of waste produced and/or that we develop waste solutions that have less environmental impact. We need to consider the practices and technologies appropriate for different production systems and geographic locations. Importantly, markets for the waste or recycled product are critical.

Additional opportunities for further research and development are presented in Appendix 3, including case studies on:

- Treated timber posts (refer to page 28)
- Whole crop purchasing (refer to page 28)
- Certified soil biodegrable plastics (refer to page 29)
- Establish facilities for fishing gear (refer to page 29)

How

All waste types

- Undertake research into alternative products to assist movement up the waste hierarchy through:
  - » Designing waste out – alternative products and/or modified production systems
  - » Reducing the amount of product used through increased life
  - » Reusing or repurposing products and developing markets for these
  - » Recycling products at the end of their life – for circularity this can involve recycling back into the same product
- Conduct life cycle analyses to avoid adopting unsustainable products

Plastic waste

- Design production systems that require less plastic use
- Develop plastics that have a longer life span and can be readily recycled
- Explore the costs and benefits of alternatives to plastic mulch, particularly certified soil biodegradable mulch (refer to case study on page 29)
- Consider options available for better recovery of plastic waste in the fisheries industry (refer to case study on page 29)
- Review opportunities to improve retrieval, pre-processing (e.g. baling) and logistics for agricultural plastics that can be mechanically recycled

Photo: istock/RoniMeshulamAbramovitz

- Review current collection and consolidation methods and work with local government to identify aggregation sites
- Develop solutions for recycling of problem plastics, including:
  - » Bird netting – due to physical structure
  - » Plastic mulch – due to difficulty with recovery and soil contamination
  - » Irrigation tube – due to metal contamination
- Consider emerging advanced technology to treat problem plastics to recover energy

Organic waste

- Consider opportunities for manures to be converted to fertilisers, chemicals and renewable energy
- Explore the potential of organic waste material to be upcycled (value-added) into powders, supplements and/or animal feed
- Assess the costs and benefits of composting organic material
- Assess the costs and benefits of minimal tillage and incorporating organic material into the soil
- Explore the potential for whole crop purchasing in appropriate commodities (refer to case study on page 28)
- Design consumer education programs considering consumer expectations and market quality specifications
- Explore opportunities to develop bioplastics and other materials from organic waste
- Explore value-adding opportunities for fisheries organic waste, including liquid fertiliser, fish oil/ supplements, pet food and fish meal

Workshop waste

- Explore alternatives to treated timber (CCA) posts (refer to case study on page 28)
- Design material for a longer life
- Consider opportunities for reusing and repurposing resources

4.4 CASE STUDIES

CASE STUDY 1: Whole crop purchasing

Whole crop purchasing (WCP) is an arrangement whereby buyers commit to purchasing the entire crop, rather than only graded product based on quality specifications, or set volumes. This arrangement is known to reduce on-farm waste and overproduction. Under whole crop purchasing, crop product that would have previously been unsuitable for fresh retail and hospitality markets has the potential to be 'upcycled' into new food products and other value-added products. Currently, whole crop purchasing arrangements are in place at Tesco supermarkets in the United Kingdom and are being trialled in Australia by the Open Food Network.

Crops potentially suited to whole crop purchasing arrangements are those that face strict aesthetic standards, face seasonal gluts, have a short shelf life and/or are susceptible to pest and disease impacts, and/or physical damage. Such crops include bananas, fresh market tomatoes and carrots. Whole crop purchasing arrangements have the potential to improve the sustainability and profitability of the Australian food system. The potential benefits of the arrangement were evaluated for the Australian banana industry, with preliminary findings indicating the industry could unlock an additional $75.2 million of revenue from the sale of lower-grade bananas. Retailers and wholesalers also benefit from whole crop purchasing through the creation of new products generating revenue streams, strengthening relationships with growers, and demonstrating extended producer responsibility (EPR) to customers.

Photo: istock/igoldsondesign

Photo: istock/ncox1585

CASE STUDY 2: Treated timber posts

Treated timber is commonly used for fence posts and trellising in vineyards and orchards, with the most prominent treatment option being copper chrome arsenate (CCA). CCA posts alone account for 65% of treated timber used in Australian vineyards. CCA posts cannot currently be recycled and must be sent to landfill at their end-of-life. If improperly disposed, CCA posts can impact human and animal health, and water, air, and soil quality due to the materials used in the timber treatment process.

Galvanised steel is the most viable alternative to CCA posts due to its cost effectiveness and practicality. Other alternative options include untreated timber posts encased in recycled plastic and wood-plastic composite posts. A whole-of-life cost analysis of galvanised steel posts over a 30-year period found steel to be a cheaper option than CCA by around $50 per hectare, with the cost saving attributed largely to the significantly cheaper disposal costs at end-of-life.

A major barrier to using an alternative is the high upfront cost compared with traditional CCA posts and the perceived risk the alternative will not perform as well as CCA posts. To address these barriers, there is an opportunity to move towards a more circular business model for the supply of posts, including leasing of posts, with suppliers responsible for post installation, maintenance, replacement and end-of-life management.

CASE STUDY 3: Certified soil biodegradable plastics

Field mulch is used worldwide in agriculture, particularly for annual horticulture crops such as vegetables and berries, to supress weeds, increase yield, maintain soil temperature, retain fumigation and/or improve water retention. This results in positive crop outcomes, including improved crop quality and quantity, and reduced need for herbicides.

The two main types of field mulch are:

- Conventional polyethylene plastic mulch (including fumigation films)
- Certified soil biodegradable mulch.

The problem with conventional plastic mulch is that growers need to remove the plastic mulch at the end of each crop cycle, requiring significant time and cost. In addition, for any plastic that isn't collected or is damaged, fragments can turn into microplastics, contaminating the soil and the environment.

Biodegradable mulch is an alternative option that does not need to be removed at the end of the crop cycle, leaving organic material and no microplastics. Although the cost of this alternative can be between 70% and 300% higher than the cost of plastic mulch, there are significant savings from avoided disposal and reduced environmental damage. There are also a range of non-financial benefits of using biodegradable mulch, such as reduced landfill, soil benefits from the increased organic matter and significant labour/time savings for the grower.

Opportunities to support increased adoption of biodegradable mulch options could include the establishment of demonstration sites to confirm the economics, logistics and risks of the certified soil biodegradable mulch option, and introducing rebates and/or loans to minimise the upfront costs for growers transitioning to certified soil biodegradable mulch.

Photo: istock/EuToch

Photo: istock/fernnas

CASE STUDY 4: Plastic use in fisheries and aquaculture

There is a wide range of gear and plastics used in fisheries and aquaculture, including fishing nets, buoys, boxes and ropes.

At the end-of-life, these materials are often considered low value by recyclers, as they are mixed with other materials such as timber and metal, contaminated by organic material and/or worn by use. In addition, the distance to recycling facilities and associated transportation costs presents another challenge for recycling.

This case study describes a process to identify potential solutions for the management of different types of plastic waste, including six key steps (see following page).

1 **IDENTIFY MATERIALS & LOCATIONS**

Identify and map plastic materials used and locations generated

2 **CONSIDER MATERIAL CHARACTERISTICS**

Consider requirements for material characteristics, including pre-treatment and aggregation needs

3 **ASSESS POTENTIAL OPTIONS**

Identify and assess potential recovery options

4 **DEVELOP A BUSINESS CASE**

Develop a business case to progress options

5 **PILOT OPTION/S**

Pilot and refine preferred options

6 **IMPLEMENT SOLUTION**

Implement the preferred solution

FIGURE 11 Six key steps to identifying potential solutions to plastic waste in fisheries and aquaculture

The case study considered the options for the recovery of plastic waste in the fisheries and aquaculture industries, undertaking an assessment of:

Step 1: Identify materials and locations, including

- Analysis of fisheries aquaculture production and locations of ports
- Assessment of types and compositions of plastic materials, including the polymer type, form, volume and material characteristics which have implications for possible and viable recycling options
- Understanding of the use of plastic materials by the fisheries sector

Step 2: Consider material characteristics involving

- Consideration of material characteristics (quality, physical, volumes, seasonality), including pre-treatment and aggregation requirements

Step 3: Assess potential options concerning

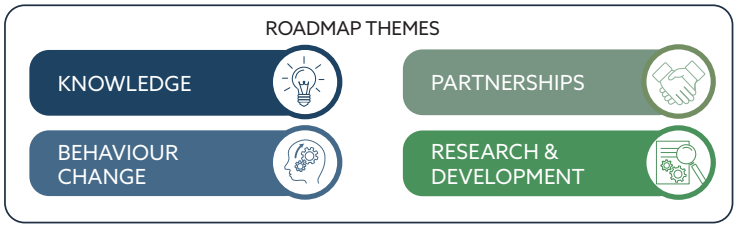
- Assessment of the infrastructure, market and processing capacity
- Consideration of cost, infrastructure needs (aggregation, pre-treatment, mechanical handling), logistics, contamination and standards, labour, circular economy and extended producer responsibility (EPR)
- Appropriateness of recovery and recycling technology and alignment with the waste hierarchy

The next steps would require the development of a business case (**Step 4**) and/or piloting (**Step 5**) of preferred options, which may include:

- Developing a business case for an extended producer responsibility (EPR) scheme
- Investigating and promoting plastic circular design options
- Assessing technology used for recycling fisheries and aquaculture plastics
- Trialling processing with existing recyclers to determine material presentation requirements and the most suitable destinations

4.5 WASTE AND RESOURCE RECOVERY ROADMAP

Aligned with the identified priority themes, there are several key activities to occur by 2030 to facilitate progress against the goal of moving up the waste hierarchy. These activities are highlighted with the following summary roadmap.



DEFINING THE PROBLEM

- Develop a strategy for agriculture, fisheries and forestry
- Identify current options for implementation
- Establish guidelines for monitoring and reporting

BASELINE & STANDARD INDICATORS

AWARENESS

ACTIVITIES & PARTNERS

OPTIONS FOR MOVING UP THE WASTE HIERARCHY

2022

INDUSTRY RESPONSE

- Develop industry action plans
- Confirm industry commitment
- Establish targets for moving up the hierarchy

MAKING THE CHANGE

- Incorporate waste management into industry strategy/ business as usual
- Assess progress towards targets
- Determine performance of agriculture, fisheries and forestry

INFORMATION SHARING & ADAPTIVE MANAGEMENT

IMPLEMENTATION & ADOPTION

INDUSTRY AND STAKEHOLDER COLLABORATION

INDUSTRY ADOPTION

2030

EXPLORING THE SOLUTIONS

- Foster collaborative partnerships
- Implement research and development programs

MONITORING

EDUCATION & SKILLS DEVELOPMENT

INDUSTRY INVOLVEMENT

PRACTICES & TECHNOLOGIES

Appendices

Appendix i

Alignment with 2018 National Waste Policy

TARGET	WHY
Target 1: Ban on export of waste plastic, paper, glass and tyres, commencing in the second half of 2020	Drawing on the best available science, research and commercial experience, we will work together to maximise the capability of our waste management and recycling sector to collect, recycle, reuse, convert and recover waste.
Target 2: Reduce total waste generated in Australia by 10% per person by 2030	We've already made many of the easy reductions and we now need to tackle the harder wastes, including through targeted waste avoidance action, better design and using knowledge sharing, education and behaviour change to drive new ways to reduce waste.
Target 3: 80% average resource recovery rate from all waste streams following the waste hierarchy by 2030	If we increase Australia's resource recovery rate to 80%, an extra 15 million tonnes of material will be recovered every year. Commitments made by governments across Australia are increasing resource recovery rates. But more needs to be done. The use of product stewardship, so manufacturers are responsible for the entire lifecycle of products, adopting common approaches to policy and regulation nationally, improving access to services for regional Australians and increasing industry capacity will all help achieve this target.
Target 4: Significantly increase the use of recycled content by governments and industry	Improving the quality of our recyclable materials is important; equally important is finding ways to use that material productively. If we don't increase demand for recyclables, the industry is not sustainable. Sustainable procurement by governments, businesses and individuals is needed to make the recycling sector thrive.
Target 5: Phase out problematic and unnecessary plastics by 2025	Plastic litter is one of the most insidious forms of pollution. About 80% of marine litter is plastic. It is estimated that by 2050, there will be more plastic in the ocean than fish by weight. We need to act now to identify and stop using the plastics that we can't manage effectively. The sound management of chemicals and hazardous wastes throughout their lifecycle is also intrinsic to this approach, to minimise the materials that could harm us and the environment.
Target 6: Halve the amount of organic waste sent to landfill for disposal by 2030	Organics like food and garden waste are valuable resources that can be harnessed and returned to productive use, turned into compost to improve and fertilise soil, or rescued to provide food for people and animals.
Target 7: Make comprehensive, economy-wide and timely data publicly available to support better consumer, investment and policy decisions	Australia has improved the availability of high-quality waste and recycling information but more current and detailed information, shared by governments and industry, would support better decision-making. Data collection and reporting on the flow of materials through the waste system, including disposal and recycling rates, can be enhanced by bringing together existing data, producing more detailed analysis and reducing the amount of time before data is released.

MEASURING WASTE

PLASTICS

AGRICULTURE

MATERIAL TYPE	UNIT ASKED FOR	UNIT REPORTED
Silo bags	Tonnes of wheat stored in silo bags	Tonnes
Polytunnel/protective housing	m^2 covered	Tonnes
Crop covering film (e.g. grapes, fruit)	m^2 covered	Tonnes
Mulch/fumigation films	m^2 covered	Tonnes
Mushroom grow bags	No. of bags	Tonnes
Coir plastic packaging film	m^3	Tonnes
Silage wrap	No. of bales covered with plastic wrap	Tonnes
Silage pit covers	m^2 covered	Tonnes
Shrink wrap/film	m^2	Tonnes
Soft robust non-woven plastic bags (e.g. fertiliser, fungicide bags)	No. of 20-litre bags	Tonnes
Seedling cells	No. of plants used	Tonnes
Picking bin liners	Litres of vessel, No. of liners	Tonnes
Irrigation drip tape	Kilometres	Tonnes
Irrigation drip tube	Kilometres	Tonnes
Irrigation poly pipe	Kilometres	Tonnes
Irrigation PVC pipe	Metres	Tonnes
Drainage pipes – agricultural pipes	Metres	Tonnes
Silage/hay mesh	No. of bales	Tonnes
Protective netting	Hectares covered	Tonnes
Shade cloth/mesh	Hectares covered, m^2 covered	Tonnes

AGRICULTURE

MATERIAL TYPE	UNIT ASKED FOR	UNIT REPORTED
Weed matting	m^2 covered	Tonnes
Woven bags (e.g. fertiliser/ seed/feed/Bulka bags)	No. of 1000-litre bags, No. of 20-litre bags	Tonnes
Horticultural twine	Metres	Tonnes
Strap/ropes	Metres	Tonnes
Hay baling twine	Metres	Tonnes
Tarps	m^2, No. of tarps	Tonnes
Produce crates/boxes	Volume (litres) of crate/box, No. of vessels	Tonnes
Polystyrene boxes	Volume (litres) of box No. of boxes	Tonnes
Seedling pots	Diameter (cm) of pot No. of pots	Tonnes
Seedling trays	No. of seedlings in a tray, No. of trays	Tonnes
Seedling protectors/guards (i.e. core flute or net sock)	No. of netted sock short (30-50cm), or No. of corflute short (30-50cm), or No. of corflute long (70-110cm)	Tonnes
Clips	No. of clips	Tonnes
Agricultural containers (e.g. chemical/oil/liquid fertiliser drums)	No. of containers 1-5 litres, No. of containers 10-20 litres, No. of containers 50-100 litres, No. of containers 100+ litres	Tonnes
Large containers and tanks	Litres of vessel, No. of vessels	Tonnes
Flagging tape	Metres	Tonnes
Rigid PVC plastic film cores (e.g. from cotton wrap)	No. of items	Tonnes

MEASURING WASTE
PLASTICS

FISHERIES

MATERIAL TYPE	UNIT ASKED FOR	UNIT REPORTED
Tank and pond liners	Litres of capacity, No. of liners	Tonnes
Shatter pack plastic film	m^3	Tonnes
Shrink wrap/film	m^3	Tonnes
Covers	m^2	Tonnes
Tarps	m^2	Tonnes
Shade cloth	m^2	Tonnes
Algae bags	Litres/kg, No. of bags	Tonnes
Feed pipe	Linear metres/km	Tonnes
Water pipes	Linear metres/km	Tonnes
Air lines	Linear metres/km	Tonnes
Fishing nets	m^2	Tonnes
Pots (crab, lobster)	No. of pots (approx. 800mm) No. of pots (approx. 900mm) No. of pots (approx. 1000mm) No. of pots (>1.2 metres)	Tonnes
Bird netting and rigging	m^2	Tonnes
Fish pens (netting)	Litres of capacity, No. of pens	Tonnes
Trawl nets	m^2	Tonnes
Gill nets	m^2	Tonnes
Pearl oyster panels	m^2, No. of panels	Tonnes
Catching slats	m^2, No. of slats	Tonnes
Mesh baskets (oysters)	m^2, No. of baskets	Tonnes
Mesh envelopes (oysters)	m^2, No. of envelopes	Tonnes
Fishing line	Linear metres/km	Tonnes
Bait box strapping	Linear metres	Tonnes
Culture ropes (mussels, oysters)	Linear metres/km	Tonnes

FISHERIES

MATERIAL TYPE	UNIT ASKED FOR	UNIT REPORTED
Bait bags	Litres/kg, No. of bags	Tonnes
Tuna bags	Litres/kg, No. of bags	Tonnes
Feed bags	Litres/kg, No. of bags	Tonnes
Other bags	Litres/kg, No. of bags	Tonnes
Ropes	Linear metres/km	Tonnes
Product bags	Litres/kg, No. of bags	Tonnes
Oyster baskets	m^2, No. of baskets	Tonnes
Storage tanks	Volume (litres) of tanks, No. of tanks	Tonnes
Culture tanks	Volume (litres) of tanks, No. of tanks	Tonnes
Tubs	Volume (litres) of tubs, No. of tubs	Tonnes
Boxes	Volume (litres) of boxes, No. of boxes	Tonnes
Buckets	Volume (litres) of buckets, No. of buckets	Tonnes
Tuna mats	m^2	Tonnes
Compliance tags	Length (cm), No. of tags	Tonnes
Drums/containers	No. of containers 1-5 litres, No. of containers 10-20 litres, No. of containers 50-100 litres, No. of containers 100+ litres	Tonnes
Buoys	No. of buoys less than 250mm, No. of buoys greater than 350mm, No. of buoys greater than 500mm	Tonnes
Floats	No. of floats (less than 250 mm), No. of floats (greater than 350mm), No. of floats (greater than 500mm)	Tonnes
Collars	No. of collars	Tonnes
Jigs	No. of jigs	Tonnes

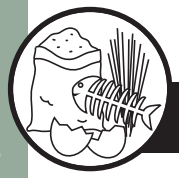
MEASURING WASTE
ORGANICS

ORGANIC MATERIAL	DESCRIPTION	UNIT ASKED FOR	UNIT REPORTED
Mortalities	Whole dead animals from livestock and fisheries	Tonnes/m^3	Tonnes
Manures/excrement	Animal excrement from livestock and fish	Tonnes/m^3	Tonnes
Animal bedding	Cleaned out hay or sawdust bedding, including animal manures from cattle, pigs, poultry	Tonnes/m^3	Tonnes
Egg waste and shell	Waste from egg and shell in all poultry production	Tonnes/m^3	Tonnes
Shell (from molluscs)	Shell waste from growing and grading of molluscs. Does **not** include processing (e.g. shucking)	Tonnes/m^3	Tonnes
Sludges from on-site effluent treatment	Sludges accumulated in wastewater treatment ponds or washdown processes in livestock and food processing processes	Tonnes/m^3	Tonnes
Sediment trap sludge and filtration bio material	Soil and vegetated material captured in filters	Tonnes/m^3	Tonnes
Prunings (woody clippings/trimmings from vines and trees)	Clippings/trimmings from woody plants such as vines and fruit trees	Tonnes/m^3	Tonnes
Used and discarded growing media (e.g. coir, potting mix)	Potting mix, coir or other growing media blend used in, for example, nurseries, hydroponics or other specialised plant production	Tonnes/m^3	Tonnes
Plant residues (whole/part plants)	Whole plants/trimmings/clippings from glasshouse vegetables or excess propagation material and plants not meeting quality (pest/disease/form)	Tonnes/m^3	Tonnes
Tree residues (e.g. orchard removal, tree felling)	Bulky tree residues from orchard upgrades or tree removal	Tonnes/m^3	Tonnes
Seaweed/algae removal	Residues from removal of seaweed and algae from aquaculture infrastucture	Tonnes/m^3	Tonnes
Packing shed loss (e.g. grading)	Loss of edible product in the fresh produce packaging shed and on-vessel fish grading – typically due to specification requirements and/or minor damage. Also includes retail-ready or wholesale packed produce returned by wholesalers or retailers after inspection	Tonnes/m^3/% of production	Tonnes
Crop loss – unharvested crop/part of crops	Edible portion of crop left in field because of a weather event or market-based decision (specification requirements and/or minor damage). Does **not** include harvest residues that are recycled to soil organic matter as part of a normal farming practices, such as potato vines, vegetable or fruit tree foliage or grain stubble	Tonnes/m^3/% of production	Tonnes
Harvesting residues (left in field after harvest)	Vegetated material left in field after harvest of broadacre crops	Tonnes/m^3/% of production	Tonnes
Forestry and logging residues (centralised)	The amount of forestry harvesting residues (wood, leaf) that is aggregated/centralised either for stockpiling, burning or transfer. This does **not** include the matter left in situ	Tonnes/m^3	Tonnes
Cotton and sugar harvest residues (left in field after harvest)	Vegetated crop matter left in field after harvest of broadacre crops	Tonnes/m^3	Tonnes

MEASURING WASTE

WORKSHOP WASTE

WASTE MATERIAL	UNIT ASKED FOR	UNIT REPORTED
Tyres	No. of small tyres (e.g. motor bike/buggy), No. of medium tyres (e.g. car), No. of large tyres (e.g. tractor)	No. of tyres
Oils	Litres	Litres
Batteries	No. of small batteries (e.g. car, motorbike), No. of large batteries (e.g. tractor, truck)	No. of batteries
Scrap metals	m^3	Tonnes
Electronics and e-waste waste	m^3	Tonnes
Vet waste (e.g. needle, packaging)	Litres/m^3	Tonnes
Treated timber posts (e.g. CCA-treated posts)	m^3, Tonnes, No. of six-foot posts, No. of eight-foot posts	Tonnes
Cardboard	Litres/m^3	Tonnes
Waxed cardboard	Litres/m^3	Tonnes
Glass (e.g. sheet/panes)	Litres/m^3	Tonnes
Asbestos	Litres/m^3	Tonnes
Machinery	Litres/m^3	Tonnes
Tools	Litres/m^3	Tonnes
Construction and demolition waste	Litres/m^3	Tonnes
Rubber	Litres/m^3	Tonnes
Industrial chemicals and substances	Litres/m^3	Tonnes
Ignitable corrosive liquids	Litres/m^3	Tonnes
Paints, resins, inks, organic sludges	Litres/m^3	Tonnes
Industrial chemicals and substances	Litres/m^3	Tonnes
Light bulbs	Small bulb/fluoro	No. of bulbs
Fish pens	Litres/m^3	Tonnes
Mooring systems	Litres/m^3	Tonnes
Stanchions	Litres/m^3	Tonnes
Light sticks	Litres/m^3	Tonnes
Safety equipment	Litres/m^3	Tonnes



PRE-FARM GATE WASTE

ORGANICS OPTIONS

AVOID
REDUCE
REUSE
RECYCLE
RECOVER

Appendix iii

Options for improved waste management

CASE STUDY

	INITIATIVE	DESCRIPTION
1	Whole crop purchasing	Refer to case study on page 28

SHORTLISTED OPTIONS FROM THE ASSESSMENT

	INITIATIVE	WASTE HIERARCHY POSITION	DESCRIPTION
2	Upcycling vegetable waste into powders	Reduce	Edible mushroom waste which is currently downgraded to landscaping can be transformed into powder. Demonstrated for broccoli waste and may be expanded to other vegetable types.
3	Transforming product loss into animal feed using heat treatment or black soldier fly technology	Reduce	Diverting product loss (from farms and packing sheds) and using black soldier flies to convert to protein and fertiliser. Protein outputs can be used as animal feed, displacing conventional feed.
4	Using a mobile laboratory to produce oil, protein and other products from raw fisheries waste	Reduce	Mobile laboratory with factory facilities to transform fresh, raw waste materials from the fisheries industry into marketable products such as oils, protein-rich fractions and other nutrients.
5	Producing clothing and textiles from agricultural waste	Reduce	Enable the collection and re-manufacture of agricultural waste (e.g. rice straw, banana plantation waste) to be upcycled to produce textiles.
6	Freezing and freeze-drying second-grade fruit to be sold in alternative markets instead of disposed	Reduce	Freezing (or freeze-drying) second hand fruit rather than disposal. Develop markets for products and show the commercial viability.
7	Utilising food waste on farms as feed for edible insects	Reduce	Upcycle food waste to be used by insect (e.g. cricket) breeders to produce edible products. Currently, insects for human consumption are not permitted to consume food waste as feed.
8	Creating compostable shopping bags from waste banana stalks/trees	Recycle	Using banana plantation stalk/tree waste to produce compostable and recyclable shopping bags.
9	Composting fish waste	Recycle	Diverting more marine by-products and fish waste to be turned into compost, potting mixes and other gardening products. Assumed this waste is currently going to landfill.

OTHER OPTIONS NOT SHORTLISTED

	INITIATIVE	WASTE HIERARCHY POSITION	DESCRIPTION
10	Using nanotechnology to improve the properties of compostable packaging made from sugar cane	Avoid	Sugarcane waste can be used to produce packaging and replace single-use plastics. This involves adding nanofibers to sugarcane pulp to improve its mechanical properties.
11	Regenerating reef ecosystems using seafood shells	Reuse	Collection and curing of used oyster, mussel and scallop shells from packing sheds. Deposit them in reef systems to restore the reefs.
12	Generating biogas from on-farm vegetable waste	Recover	Producing biogas (methane) on vegetable farms using on-farm vegetable waste via anaerobic digestion (AD). Facility could take waste from the farm and waste from other nearby farms if standards can be met. Biogas would be used to power farm operations.
13	Pelletising compost products	Recycle	Sending organic waste materials to a composter that pelletises the material and sells it as pelletised compost. This can be used during the sowing period to enhance growth.

14	Feeding product loss to animals	Reduce	Turning product loss (from farms and packing sheds) into low-risk, untreated animal feed.
15	Exploring upcycling of product loss into nutritious food options	Reduce	Upcycle food waste currently not meeting specifications or going to animal waste or compost (or left on site) by developing alternative markets (e.g. pomaces from apple food waste).
16	Producing hydrogen fuel and fertilisers from farm waste	Recover	Encourage collaboration between industry bodies to further develop hydrogen technology (e.g. via technology clusters) with the aim of utilising crop and product loss from farms, to produce hydrogen fuel and/or fertilisers.
17	Growing more resilient crop varieties to reduce inputs	Reduce	Making crops more resilient to disease, pests, climate factors and nutrient deficiencies. This aims to reduce the volume of inputs needed (e.g. reducing sprays and labour and machinery required to spray) to sustain healthy crops and reduce product loss on farm.
18	Promoting greater industrial symbiosis within the sector through planning	Avoid	Promote greater symbiosis in the agricultural sector. For example, co-locating farms and other services that can supply their by-products as feed to insect breeders (producers).
19	Recycling mushroom substrate into compost and casing	Recycle	Assumes substrate is recycled on farm. Either composted at the farm or transformed to new casing for use on farm (requires mixture with new products).
20	Using a rotary drum composter in the poultry industry	Recycle	Rotary drum composters that take in organic farm animal waste/mortalities (e.g. dead birds and eggs) to produce compost.
21	Certifying fisheries that prevent gear loss and operate sustainably	Avoid	Establishing a non-profit body that certifies fisheries against sustainability standards.
22	Upcycling prawn shells to prawn oil	Reduce	Upcycling waste from prawn fisheries (prawn shells) into prawn oil for cooking. Potential to expand and include other seafood waste such as lobster waste.
23	Turning forestry residues into marketable energy products	Recover	Producing marketable products from forestry harvesting residues such as plywood, Hardlam or wood pellets, to be used as biomass for energy production or co-generation, or to produce biofuels.
24	Recycling spent berry coir or using it in compost	Recycle	Using spent coir in compost mixtures, as a soil amendment, to be recycled by organic recyclers with the potential to reuse it as a substrate.
25	Using almond waste to produce power, compost and potassium-rich ash for orchards	Recover	Almond hull waste combusted to produce power in a co-generation power station. The ash, waste skins and other organic matter is used to produce compost.
26	Reducing crop wastage using machine learning-driven technology to assist with precision agriculture	Avoid	Example from 'The 77 Lab' : Technology driven by artificial intelligence and machine learning that measures ripeness of fruit, picks fruit carefully and can replace damaged billets of sugarcane with healthy billets. This serves to prevent crop wastage.
27	Establishing co-generation plants for sugarcane	Recover	Establish cogeneration plants for sugarcane farmers where they can take their bagasse to be used as fuel to produce energy. Energy may be used to power sugar mills, exported or for other purposes, offsetting fossil fuel consumption.
28	Implementing an auditable system requiring sound waste management to certify Australian products as sustainably made	N/A	Voluntary system that certifies saleable farmed products as being cultivated using sustainable methods. Include independent audits.

AVOID
REDUCE
REUSE
RECYCLE
RECOVER

PRE-FARM GATE WASTE
PLASTICS OPTIONS

AVOID
REDUCE
REUSE
RECYCLE
RECOVER

CASE STUDIES

	INITIATIVE	DESCRIPTION
29	Using certified soil biodegradable plastics	Refer to case study on page 29
30	Establishing reception facilities that accept unwanted fishing gear	Refer to case study on page 29

SHORTLISTED OPTIONS FROM THE ASSESSMENT

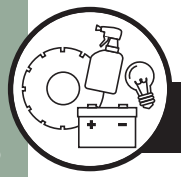
	INITIATIVE	WASTE HIERARCHY POSITION	DESCRIPTION
31	Using sisal, jute or hemp as plant twine, ties and nets instead of plastic counterparts	Reduce	Increase the use of compostable twine, ties and nets in place of polypropylene equivalents, by incentivising farmers to use them.
32	Closed-loop recycling of aquaculture plastics	Recycle	Expand closed-loop recycling of end-of-life aquaculture products to produce the same aquaculture products.

OTHER OPTIONS NOT SHORTLISTED

	INITIATIVE	WASTE HIERARCHY POSITION	DESCRIPTION
33	Establishing a database to report and find ghost nets	N/A	Central database to report ghost nets found.
34	Collecting and recycling banana bags	Recycle	Banana growers participating in an international plastic program whereby projects are issued credits if plastic is collected and recycled.
35	Exploiting enzymes that depolymerise plastic and enable recycling	Recycle	Technology that depolymerises plastics into the constituent monomers, which can then be reused to produce food-grade plastics. Reduces reliance on fossil fuels to produce virgin plastics and addresses existing plastic waste.
36	Leasing reusable pallets and containers	Avoid	Commonly used containers and pallets are leased to operations, preventing purchasing and subsequent waste.
37	Promoting sustainability in the marine industry to improve environmental outcomes and rehabilitate marine habitats	N/A	Setting up marine natural resource management organisations to promote sustainability practices, minimise environmental impact and improve marine ecosystem health.
38	Using reusable crates to replace EPS crates for fish	Reuse	Using crates that have smooth inner and outer surfaces and an insulating polyurethane centre to house fish, replacing conventional EPS crates. This reduces environmental issues caused by EPS use and the new crates can be cleaned and reused effectively.
39	Implementing greater standardisation of plastics to improve the viability of recycling	Recycle	Creating standards for common plastics. Work with suppliers to change manufacturing processes.
40	Implementing standards requiring minimum thickness of non-biodegradable mulch films	N/A	Improve ease of retrieving non-biodegradable plastic mulch films from soil (when they have reached their end-of-life), by requiring manufacturers to produce film with a minimum thickness.
41	Using hydroponics irrigation methods instead of irrigation tape	Avoid	Increasing the use of hydroponic irrigation methods in place of drip irrigation systems.

42	Using recycled-content field plastics in place of virgin plastic products	Recycle	Using recycled-content field plastics rather than newly manufactured products.
43	Using organic alternatives to polystyrene for produce packaging	Reduce	Replacing polystyrene packaging with plastic-free organic options.
44	Recycling plastic mulch into other products for use on farm	Recycle	Recycling plastic mulch film into stakes (e.g. for tomato growing) or other plastic products that can be used on farm.
45	Collecting and recycling plant pots	Recycle	Closed-loop recycling of plant pots into new plant pots. Fixed collection points to gather end-of-life pots.
46	Replacing plastic tree guards with compostable guards	Recycle	Using tree guards that are compostable rather than conventional plastic guards when planting new trees.
47	Using a mobile plastic baler to recycle plastics	Recycle	Mobile plastic baler system that can recycle agricultural plastics. A mobile cleaning system is recommended to accompany the baler to treat the highly contaminated plastics.
48	Establishing an IBC challenge on Twitter	Reuse	Social media challenge asking farmers to show how they have reused their old IBCs for other purposes instead of disposing to landfill.
49	Increasing traceability and accountability of plastic film	N/A	Producers include their logos onto every metre of film so these products can be traced more easily. Also increases accountability of the manufacturers.
50	Replacing plastic ear tagging of livestock with AI or injectable transponders	Avoid	Facilitating the implementation of new facial recognition technology to identify livestock, making plastic ear tags redundant. Similarly, injectable transponders may be a solution.
51	Implementing a plastic ear tag deposit return scheme to incentivise famers to collect the waste	Recycle	Developing a deposit scheme similar to the CDS to collect and recycle plastic ear tags used on farms and livestock.
52	Incentivising farmers to bring clean waste streams into transfer stations	Recycle	Initiative where farmers are incentivised to treat their waste prior to recycling (e.g. taking nozzles off piping) to make recycling more efficient and viable.
53	Using compostable pots or meshes instead of plastic tubes/cells for forestry seedlings	Avoid	Incentivise the use of compostable pots or meshes for forestry seedlings to replace plastic equivalents.
54	Requiring fishing gear to be designed to prevent ghost fishing	N/A	Modifications made to the design of fishing gear so they do not trap marine life when lost ('ghost equipment'). Include escape panels being fitted on traps and biodegradable fastenings.
55	Product labelling with expected effective working life of products	N/A	Labelling silage and greenhouse films with effective working life.

AVOID
REDUCE
REUSE
RECYCLE
RECOVER



PRE-FARM GATE WASTE
WORKSHOP OPTIONS

AVOID
REDUCE
REUSE
RECYCLE
RECOVER

CASE STUDY

	INITIATIVE	DESCRIPTION
56	Shifting to alternatives to treated timber posts	Refer to case study on page 28

OPTIONS NOT SHORTLISTED

	INITIATIVE	WASTE HIERARCHY POSITION	DESCRIPTION
57	Running campaigns about leasing farm equipment and tools	Avoid	Campaigns with agriculture machinery and tool leasers to promote increased leasing. Leasing equipment will reduce the accumulation of workshop waste.
58	Providing a steel post straightening service	Reuse	Mobile steel post straightening service. On-farm service prevents the purchase of new posts and discarding of bent posts.
59	Expanding pesticide spraying services to prevent chemicals being stored on farm	Avoid	Provide a pesticide spraying service so farmers do not have to keep pesticides on their properties. Create a registry of service providers and enable farmers to book in the service.
60	Increasing the durability of materials and reducing inputs through nanotechnology	Reduce	Investigate possible nanotechnology solutions for agriculture so there are less inputs (avoiding waste). For example, current research suggests nanotechnology may help improve the efficiency of pesticides (nano pesticides).
61	Promoting the use of integrated pest management to reduce pesticide use	Reduce	Promote increased use of integrated pest management (IPM) practices, which reduce the volumes of pesticides purchased and therefore waste generated.
62	Trading obsolete farm machinery and equipment to recover scrap metal	Recycle	Campaigns with scrap metal collectors to pick up redundant and old machinery and tools from farms.
63	Expanding and improving the product stewardship scheme for agricultural drums	Recycle	Expanding participation in the drumMUSTER program and improving accessibility for producers (improving access to drop-off sites, hours of operation).
64	Reversing logistics and takeback programs to prioritise reuse	Reuse	Additional price paid for new products which covers the cost of taking back the item at its end-of-life. Producer then reuses or recycles. Purchaser may also obtain a rebate when the item is returned. Suggest reverse logistics where the old item is taken from the farm and replaced with the new item.

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RM Consulting Group
Level 1 East, 1100-1102 Toorak Road
Camberwell VIC 3124

03 9882 2670
www.rmcg.com.au
ABN 73 613 135 24

AgriFutures Australia
Building 007, Tooma Way
Charles Sturt University
Locked Bag 588
Wagga Wagga NSW 2650

02 6923 6900
www.agrifutures.com.au
ABN 25 203 754 319