Innovative Ways to Address Waste Management on Vegetable Farms - Plastics

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Final Report VG13109

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Purpose of this report: This report presents the findings and recommendations from the cost effectiveness analysis of current and alternative approaches to plastic management on Australian vegetable farms. A number of recent projects have been undertaken to explore the feasibility of alternative waste management systems on Australian vegetable farms. Plastics are used in a variety of ways on vegetable farms due to their suitability and versatility. However, there are some challenges in the disposal and recycling at end of life.

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Purpose and drivers for project

Vegetable production can result in the creation of large amounts of unwanted materials or waste products. Waste can create problems for growers (related to disposal), the community and the environment. Whilst dealing with waste is often not of priority for an individual grower, there is concern at an industry level that waste products are not appropriately managed.

There are two main sources of waste including (1) organic waste, generated through the production and processing of vegetables and (2) waste related to the input products used in vegetable production systems (e.g. plastics, chemicals).

The Australian vegetable industry is currently looking at the feasibility of alternative use of vegetable waste on-farm, and processing and reuse of waste. Plastics are primarily persistent waste materials, but degradable alternatives are used to a limited extent. Plastics represent the greatest volume of persistent input products and are used in a variety of ways on vegetable farms due to their suitability and versatility. However, there are some challenges in the disposal and recycling of plastics at end of life.

This project engaged with the industry, growers, plastic providers and plastic processors to:

- Determine the key sources, management, volume and cost of on-farm plastic by state and growing region
- Identify different plastic processing opportunities, financial costs and benefits and associated logistics of each option
- Assess the feasibility of available and emerging processing opportunities for on-farm plastic waste.

The following plastic products were the focus of the project:

- Irrigation pipe
- Plastic mulch sheeting
- Polytunnels and protective housing
- Trays e.g. seedlings, bed trays
- Chemical containers.

The aim of the project was to enable the Australian vegetable industry to consider alternatives to plastic use and recycling contributing to continuous improvement in farm management practices, efficiency and sustainability.

Main findings

It is clear from our discussions with growers and plastics industry participants that on-farm plastics management is not a major concern for all growers, but is an issue that affects all growers to varying degrees. Those growers using a larger share of plastics, especially plastic mulch, will be particularly interested in a low cost solution to their plastic management problems.

While not a pressing concern to all vegetable growers, a solution to the plastic management challenge is not straightforward:

- Disposal of on-farm plastics by burning or burying is illegal but essentially costless to those who are willing to do so regardless of laws, which are difficult to enforce in regional areas.
- Supply chains exist for some plastics processing in some areas, particularly larger horticultural areas that are closer to processing plants and ports. The cost-effectiveness of recycling is determined by these factors and others, such as the international price of plastic and plastic recyclate. These elements are not easily influenced by Government or HIA.
- Technological barriers also exist in the processing of some key plastics, particularly plastic mulch. The cost of decontamination is currently seen as the main barrier to cost-effective reprocessing, however a number of technological advancements are being developed to address this.
- Another technological solution – the development of a photodegradable plastic mulch product – has practical limitations and questions over environmental performance, which require further analysis.
- Lack of information held by processors about on-farm plastic availability, and by growers about plastics collectors operating in their area, is another barrier to better supply chains for on-farm plastic waste. The recently developed FARM MUSTER program may help overcome this barrier.

Future scenarios

A number of factors will influence the future of plastic management on vegetable farms:

- Monitoring and compliance: burning and burying are typically considered the most attractive alternatives to best practice management of on-farm plastics. However, these practices are typically prohibited by law. While these practices are well understood to be illegal, anecdotal evidence suggests they are not unusual across the industry. Enforcement action by environmental protection agencies is historically rare, but an increase in enforcement activity could significantly influence future activities in this area.
- International price of plastic: the future cost of plastic and recycled plastic is uncertain. Prices are volatile and are influenced by petroleum prices and global economic growth. A significant increase in plastic prices over time can be expected to drive up the price of plastic recyclate and improve the cost-effectiveness of on-farm plastic recycling.
- Technological development: the main on-farm plastic for which a current solution does not yet exist is plastic mulch, which has proven prohibitively costly to decontaminate for processing.
  - However, several companies are progressing technology to increase the cost-effectiveness of reprocessing and it is likely that one or more of these may significantly change reprocessing rates if successful.
  - Alternatively, biodegradable or photodegradable plastics may replace traditional methods of removal and disposal of plastic mulch over time.
- Grower attitudes: in the absence of strict monitoring and compliance of illegal activities, grower attitudes towards these activities may be a strong factor in future on-farm plastics management.
- Supply chain/logistical developments: the geographic spread of on-farm plastic and the voluminous nature of the product have made the collection and transport of plastic waste a challenge. However, improvement in logistics (tracking and collection points) and processes to reduce the volume of the plastic may improve the feasibility of recycling.

These issues suggest a range of specific recommendations, which are outlined below.

Recommendations

The following recommendations are made based on the findings, analysis and discussion from this project. These are grouped into the following themes:

- Extension and practice change
- Supply chain collaboration
- Research and development.

Table 1-1: Recommendations

#	Recommendation	Description	Who	Priority
Extension and practice change				
1	Increase awareness of appropriateness and efficacy of different plastic products	Many different products exist on the market and the description of their benefits can be both confusing and in some cases misleading. It is important that the industry plays a role in clearly describing the appropriateness and efficacy of different products including their costs and benefits. Publication of extension materials through existing AUSVEG channels would assist.	HIA, AUSVEG	High
2	Link EnviroVeg program to state-based environmental organisations	There is an opportunity to promote EnviroVeg as the flagship program of the vegetable industry that encourages growers to adopt better practice and move up the waste hierarchy. In addition, there are reasonable policies and strategies in place to deal with waste through state environment organisations (EHP/EPA) and NRM groups. These groups are generally interested in exploring options to progress plastic recycling with the industry.	HIA, AUSVEG to facilitate, state-based environmental organisations	Medium
Supply chain collaboration				
3	Participate in FARM MUSTER	FARM MUSTER is a program that could possibly address the logistical challenges associated with the collection and management of plastic waste and provide a solution to broader waste problems. HIA could potentially participate as an industry partner to encourage member uptake. We suggest that the involvement and opportunities with AgStewardship Australia for management of waste (including plastics) be investigated further.	HIA, AgStewardship Australia	High
4	Ensure fit-for-purpose plastic products	The horticulture industry has specific needs when considering the type of plastic that is appropriate. This differs for individual commodities and regions and includes	HIA, plastic producers	Medium

#	Recommendation	Description	Who	Priority
		specifications such as strength, duration and efficacy. The agronomy of the particular commodity will also drive specific requirements. It is important that the industry work with plastic processors during the development of biodegradable and photodegradable plastics to ensure that their needs are met.		
Research and development				
5	Undertake further research on impact of photodegradable plastics on the environment	One of the particular concerns highlighted in this study was the potential impact of photodegradable plastics on the environment. There is little known about the longer-term environmental effects, which could significantly influence their appropriateness for the vegetable industry (particularly in environmentally sensitive regions). This issue is one that is relevant to all agricultural industries and may lend itself to collaboration with CSIRO or universities.	HIA, research providers	High
6	Consider investing in recycling technology	Additional technology is currently being developed that could make the reprocessing of plastic mulch a more feasible option. This technology includes the pre-processing of plastic using new advances associated with decontamination and compression technology. Whilst companies are currently exploring these technologies, state environment associations (e.g. Sustainability Victoria) also have a keen interest in their broader uptake. HIA may be able to invest in research and development of these technologies.	HIA, plastic processors	Medium

Keywords

Biodegradable plastics	Biodegradable plastics are degraded by naturally occurring microorganisms (bacteria and fungi), which feed on the product and mineralise it completely, leaving no toxic residues. They are biopolymers made primarily from corn starch plus proprietary biodegradable complexing agents.
Capital costs	Costs that are fixed, one-time expenses incurred on the purchase of land, buildings, construction, and equipment used in the production of goods or in the rendering of services.
Consultation	Discussion with identified groups to determine their views on a particular issue. Different methods can be used to undertake consultation including surveys, interviews and group discussions.
Degradable plastics	Degradable plastics disintegrate on exposure to certain triggers such as sunlight (UV radiation), heat, oxygen, moisture, chemicals and microorganisms. On exposure to one or more of these triggers, the chemical structure of the plastic will be changed, resulting in fragmentation and loss of some of its properties, with a residue left behind. Depending on the chemical properties of the plastic, the material will degrade up to a certain extent, under a set of conditions, within a certain time frame. Degradable plastic can then be classified into two categories: biodegradable or photodegradable.
Feasibility assessment	Evaluation and analysis of the potential of a proposed option or series of options. It is based on extensive investigation and research to support the process of decision-making.
Operating costs	Expenses that are related to the operation of a business, or to the operation of a device, component, piece of equipment or facility.
Photodegradable plastics	Photodegradable plastic, also known as oxo-degradable (OXO) plastic, is polyolefin plastic (such as polyethylene [PE] and polypropylene [PP]) which has been amended with metal salts; a photo- or oxo-degradable additive. These speed up the natural degradation process so that the photodegradable plastic breaks down into micro-fragments of plastic and metals which remain in the environment but are not seen as a visual contaminant. Sunlight is the main trigger for photodegradable products to disintegrate. These products don't break down effectively when buried due to lack of light and oxygen.
Recyclate	Raw material sent to, and processed in, a waste recycling plant or materials recovery facility.
Waste management hierarchy	Hierarchy of management practices relating to waste on the basis of resource conservation and environmental performance principles.

Abbreviations

ABS	Australian Bureau of Statistics
AS	Australian Standard
AWT	Alternative Waste Technology
EPA	Environmental Protection Authority (Department of Environment and Heritage Protection in QLD)
EPR	Extended Producer Responsibility
EPS	Expandable Polystyrene
GBR	Great Barrier Reef
HIA	Horticulture Innovation Australia Limited
HDPE	High Density Polyethylene
IBC	Intermediate Bulk Containers
L/LLDPE	Low Density Polyethylene and Linear Low Density Polyethylene
NRM	Natural Resource Management
OXO	Oxo-degradable
PACIA	Plastics and Chemicals Industries Association
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
UV	Ultra Violet

1 Introduction

1.1 Project background and context

Vegetable production can result in the creation of large amounts of unwanted materials or waste products. Waste can create problems for growers (related to disposal), the community and the environment. Whilst dealing with waste is often not of priority for an individual grower, there is concern at an industry level that waste products are not appropriately managed.

The primary aim associated with good waste management is that waste products are avoided, minimised, reduced, reused or recycled wherever feasible or are disposed in a manner in line with community expectations and legislation.[1]

There are two main sources of waste including (1) organic waste, generated through the production and processing of vegetables and (2) waste related to the input products used in vegetable production systems (e.g. plastics, chemicals) (Table 1-1).

Table 1-1: Sources of waste and their impacts[2]

Sources of waste	Impacts of waste	Description
Organic waste	▪ Contributes to landfill ▪ Can produce greenhouse gas emissions ▪ Can contribute to pollution of groundwater	Organic waste can include the non-harvested parts of plants, off-cuts and by-products, product which does not meet retailer specifications and product that is abandoned before harvest due to low market prices[3]. It is estimated that over 277,000 tonnes of the major vegetable lines[4], representing around 25% of production, is 'lost' each year, at a cost to growers of $155million annually[3]. This waste is usually put into landfills/tips, which is poor use of valuable space and can result in other environmental impacts such as creation of greenhouse gases and pollution of groundwater (e.g. chemicals and nutrients).
Input products	▪ Contribute to landfill ▪ Can cause air pollution ▪ Can contribute to groundwater pollution	Waste products include: ▪ Inert materials (e.g. metal (car bodies etc.), rubble, glass (building materials, bottles) ▪ Persistent materials (e.g. timber (wooden bins, pallets, crates), packaging (waxed or unwaxed cartons, polystyrene boxes, plastic film, net wrap), plastic (seedling trays, fertiliser and seed bags, mulch, irrigation drip tape and pipes) and tyres). ▪ Biodegradable materials (e.g. paper and cardboard (office paper waste, packaging), substrate (any growing medium used in place of soil for example potting mix, peat), spent hydroponic solutions) ▪ Toxic materials (waste oil, batteries, waste pesticide/chemical liquids (dip solution, rinsates) and treated timber.

[1] Horticulture Australia Limited (2014) Guidelines for Environmental Assurance in Australian Horticulture, Chapter 3 Chemical Management, Horticulture Australia Limited, Sydney
[2] AUSVEG (2011) EnviroVeg Manual Edition 3, AUSVEG, Camberwell
[3] Rogers, G.; Eckman, J; & Titley, M. (2013) Identifying new products, uses and markets for Australian vegetables - a desktop study Project Number VG12049, Horticulture Australia, Sydney
[4] Key vegetable lines: Carrots, capsicums, cauliflower, sweet corn, cabbage, baby leaf – transplant (TP), lettuce, broccoli, beans, beetroot, and baby leaf – direct seed (DS).

Poor management of these waste products includes inappropriate storage, generation of excessive amounts of waste through poor use of resources and irresponsible disposal including on-farm disposal and burning of waste products.

The Australian vegetable industry is currently looking at the feasibility of alternative use of vegetable waste on-farm (such as electricity generation), alternative use of vegetable waste for human consumption (such as extraction of volatile compounds and food flavours), alternative use of vegetable waste for animal feed (such as fish food), and/or processing and reuse of waste as soil amendment (such as biochar). A number of recent projects have been undertaken to explore the feasibility of alternative waste management systems on Australian vegetable farms, including biogas generation feasibility (VG13049) and another exploring the creation of fish food for aquaculture (VG13050) – both using organic vegetable waste.

A need has been identified to consider the management of waste generated from input products including:

- Inert materials
- Persistent materials
- Biodegradable materials
- Toxic materials.

Plastics are primarily persistent waste materials, but degradable alternatives are used to a limited extent (Figure 1-1). Plastics represent the greatest volume of these input products and are used in a variety of ways on vegetable farms due to their suitability and versatility. However, there are some challenges in the disposal and recycling of plastics at end of life.

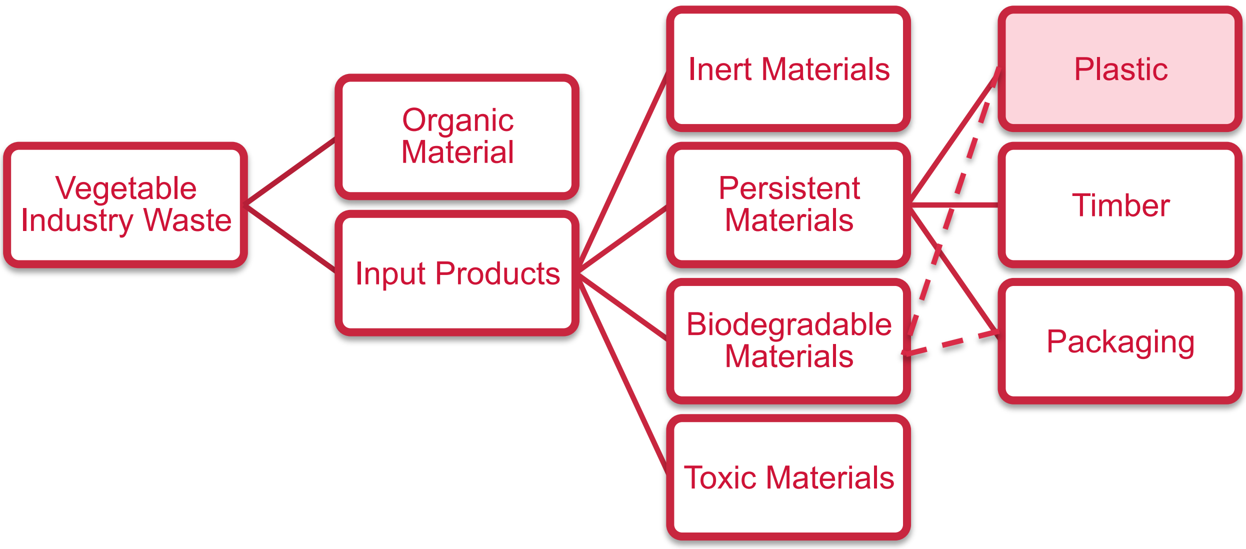

Figure 1-1: Plastic is primarily a persistent input product within vegetable industry waste

1.2 Project purpose

This project engaged with the industry, growers, plastic providers and plastic processors to:

- Determine the key sources, management, volume and cost of on-farm plastic by state and growing region
- Identify different plastic processing opportunities, financial costs and benefits and associated logistics of each option
- Assess the feasibility of available and emerging processing opportunities for on-farm plastic waste.

The following plastic products were the focus of the project:

- Irrigation pipe
- Plastic mulch sheeting
- Polytunnels and protective housing
- Trays e.g. seedlings, bed trays
- Chemical containers.

The aim of the project was to enable the Australian vegetable industry to consider alternatives to plastic use and recycling contributing to continuous improvement in farm management practices, efficiency and sustainability.

1.3 Purpose and structure of this report

The purpose of this report is to document the findings and recommendations from the cost effectiveness analysis of current and alternative approaches to plastic management on Australian vegetable farms.

The structure of this report has seven main sections, these are:

1. Provides project background and context
2. Outlines the project methodology
3. Lists the project outputs
4. Details the project outcomes including industry context, plastics in the Australian vegetable industry and feasibility assessment of current and alternative approaches to on-farm plastic management
5. Discusses future opportunities and industry structures and includes evaluation of the project
6. Provides recommendations.

2 Methodology

2.1 Overview

The approach for this study involved three key aspects:

1. Defining the problem: desktop review of plastics information and consultation with the vegetable industry
2. Engagement with plastic providers, processors and recyclers
3. Feasibility assessment of current and alternative plastics disposal options.

These are described in further detail below.

2.2 Defining the problem

Desktop review of plastics data

A desktop review of available information was undertaken on the main types of plastic waste generated on Australian vegetables farms. After an initial review, the types of plastic waste types generated were classified into six (6) main categories:

- Expandable Polystyrene (EPS) plastics
- Polypropylene (PP) plastics
- Polyvinyl Chloride (PVC) plastics
- Polyethylene (PE) plastics
- High Density Polyethylene (HDPE) plastics
- Low Density Polyethylene and Linear Low Density Polyethylene (L/LLDPE).

The review then concentrated on these six waste plastic categories generated on vegetable farms.

A key document used in the review to estimate the tonnage of plastic waste generated was the *2012-13 National Plastics Recycling Survey.*[5] The report, commissioned by the Plastics and Chemicals Industries Association (PACIA), provides the only key reference document on the total volume generation and recycling rates for plastics across Australia. The review also assessed previous Horticulture Innovation Australia (HIA) reports and other information sourced from Universities and State Government Departments across Australia.

Consultation with the vegetable industry

Extensive consultation with the vegetable industry and growers was undertaken as part of this project. A total of 16 interviews were undertaken with industry and growers. Interviews were semi-structured and a mix of face-to-face and phone depending on location. This allowed the project team to determine:

- Main plastic types and volumes for vegetable farms, including timing, cost and relative importance

[5] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

- Current plastic management practices and associated costs
- Identification of difference in approaches by state and growing region
- Grower perspectives in recycling and using different plastic products on-farm.

The findings from this consultation are provided in section 4.1.2. The industry and grower representatives consulted with as part of this project are provided in Appendix 1.

2.3 Engagement with plastic providers, processors and recyclers

A total of 30 interviews were undertaken with plastic providers, processors and recyclers from across Australia. Again, interviews were semi-structured and a mix of face-to-face and phone depending on location. This allowed the exploration of key themes and issues, including:

- Key features of each plastic type
- Different processing and recycling options available in the Australian market by processing type and state
- Financial costs and benefits (potential revenue) associated with each option
- Associated logistics of each processing option, varying by location
- Alternative and emerging products.

The details of engagement with plastic providers, processors and recyclers are provided in Appendix 1.

2.4 Feasibility assessment of current and alternative plastics management options

Consultation and desktop review of relevant literature revealed two relevant alternatives to current plastic management approaches on Australian vegetable farms:

1. Use of biodegradable and photodegradable alternatives to current plastics used on-farm; and
2. Greater recycling of plastics used on-farm.

Analysis undertaken for this project suggest that biodegradable alternatives are limited in practice to plastic mulch, for which a number of photodegradable alternatives have been developed and are available commercially. As such, we considered both the effectiveness of use and the cost-effectiveness of these options with traditional plastic mulch. The cost-effectiveness analysis included the cost of collection, transport and disposal of plastic mulch, as well as considering illegal disposal which consultation suggests remains a practice undertaken by some in the industry.

The feasibility of recycling is dependent upon many factors that will differ by farm, and does not lend itself to a similar analysis methodology. As such, we have explored the supply chain of the plastics recycling sector before recommending options to improve these for different plastics.

3 Outputs

The outputs from this project were:

- Communications summary for industry (Appendix 2)
- Engagement and consultation with the vegetable industry and plastic processors
- Final report (this report) containing:
  - Full description of the processing options, including technological processes and associated capital requirements
  - Financial feasibility elements of the processing option (capital and operating costs or financial charge if through a service provision arrangement, and benefits – revenue or energy creation)
  - Identification of associated elements such as logistical or contamination barriers
  - Discussion of emerging technologies that are not yet widely available but may be in future
  - Discussion of factors that will influence their adoption within the vegetable industry
  - Outline of other important factors identified over the course of the project, particularly from consultation
- Establishment of a network of plastic processors and potential for these to liaise with the horticulture industry
- Participation in the Bundaberg Agricultural Plastics Collaborative Workshop, 27 May 2015, Bundaberg, QLD run by Australian Institute for Commercialisation.

4 Outcomes

4.1 Industry context

4.1.1 Industry approaches to waste management

The vegetable industry's Strategic Investment Plan[6] has a vision:

> *'To be a cohesive, financially and environmentally sustainable, and highly efficient industry focused on growing demand profitably.'*

As such, the vegetable industry has been concerned about being on the 'front foot' and demonstrating their environmental credentials to markets, government and consumers. Management of waste is a key issue that industry is aiming to be proactive on. The horticulture industry more broadly has developed environmental assurance guidelines, which include waste management.[7] The EnviroVeg Manual focuses on opportunities for vegetable growers to improve their waste management with the objective being:

> *'Waste products are avoided, minimised, reduced, reused or recycled wherever feasible or are disposed in a manner in line with community expectations and legislation.'*[8]

The waste management hierarchy from the *Environment Protection Act 1970* governs the waste management approach in the vegetable industry (Figure 4-1). This means that:

- Waste is stored correctly
- Waste is minimised by avoiding, reducing, reusing or recycling wherever possible
- Where it cannot be reused or recycled, waste is disposed of responsibly
- On-farm dumping is avoided
- Waste is managed to meet legal requirements for health, safety and environmental purposes and to meet community expectations.[9]

[6] AUSVEG (2012) Australian Vegetable Industry Strategic Investment Plan 2012-2015, http://cms2live.horticulture.com.au/admin/assets/library/strategic_plans/pdfs/PDF_File_56.pdf accessed November 2014
[7] Horticulture for Tomorrow (2014) About us, http://horticulturefortomorrow.com.au/about-us/horticulture-for-tomorrow/, accessed November 2014
[8] Horticulture Australia Limited (2014) Guidelines for Environmental Assurance in Australian Horticulture Second Edition, http://hoho3216.staging-cloud.netregistry.net/environmental-assurance-guidelines/introduction/, accessed November 2014
[9] AUSVEG (2011) EnviroVeg Manual Edition 3, Camberwell

Figure 4-1: Waste management hierarchy

Waste avoidance is the most preferred option because it has the least impact on the environment. It is also the best value for money because no waste means no cost involved in its management.

Waste reduction is the next best option. If it is impossible to avoid waste generation, we can try to minimise the amount through the choices we make.

Waste reuse follows avoidance and reduction as a preferred option. It involves reusing products in their original form - refillable drink containers for instance - or for another purpose altogether, such as planting seedlings in empty milk containers.

Waste recycling is an option when reuse is no longer practical. Resources contained in waste items are recovered and reprocessed to make similar materials or provide feedstock for another process. Making new products from recycled materials uses less energy and fewer resources and has less impact on the environment than using raw materials.

Waste recovery uses the energy embodied in waste, generally after waste reduction, reuse and recycling options have been fully explored. The energy may be recovered through burning or gassifying the waste or using a bioreactor landfill to extract methane gas for use as a fuel.

Waste disposal is considered the last resort in waste management, as all the resources and energy embodied in the waste are lost when it is disposed of. The most common form of waste disposal is landfilling where waste is buried in specially engineered areas.

The priority waste management approaches for the vegetable industry are storage, minimisation and responsible disposal. Action plan templates, checklists and suggested practices are provided to assist industry and growers sustainably manage their waste (Table 4-1).

Table 4-1: Priority waste management approaches for the vegetable industry

Approach	Overview
Waste storage	▪ Separate waste streams ready to reuse, recycle or dispose of responsibly ▪ Keep waste clean that will be reused or recycled ▪ Eliminate litter and offensive odour ▪ Control pests ▪ Eliminate run-off from stored waste so waterways and groundwater are not polluted ▪ Ensure waste is not unsightly
Minimising waste	▪ Avoid or reduce waste when purchasing supplies and equipment ▪ Avoid or reduce waste produced on-farm (e.g. crop production, packing and transport) ▪ Reuse or recycle supplies or equipment on-farm ▪ Arrange for collection of waste for reuse or recycling
Responsible disposal	▪ Deposit waste at registered landfills ▪ Use licensed waste contractors ▪ Avoid burning of waste ▪ Avoid on-farm disposal

4.1.2 Industry and grower perspectives

Based on consultation conducted during this project it is unlikely that the driver for improved management of plastic waste will come from growers themselves. This is due to a number of factors, including:

- Plastic waste disposal currently constitutes a small component of a vegetable growers total operating costs (less than 5%).
- A number of growers utilise opportunistic, localised disposal options (such as landfill at a local gun club)
- drumMUSTER is available for the disposal of plastic drums
- Growers are currently using photodegradable plastic products despite the unknown environmental impacts
- Illegal disposal (such as burning or burying of plastic) is difficult to monitor.

Despite an inherent will by the vegetable industry to manage waste sustainably, as demonstrated by the current environmental policies, is it unlikely that growers will lead the implementation of alternative strategies until there is increased pressure on their businesses to do so. This is likely to come from increasing waste disposal costs, increased regulation and/or a greater consumer demand for environmentally sustainable vegetable products.

4.1.3 Plastic processor perspectives

The project team consulted with several businesses involved in on-farm plastic collection and processing, all of who pointed to economic barriers preventing increased plastic recycling, rather than specific regulatory barriers. These economic barriers relate to the profitability of plastic recycling in a highly competitive international market, in which the cost of collection, decontamination, transportation and either processing onshore or export for overseas processing must be cheaper than the international price for recyclate or competing virgin plastics.

As an industrial process, the regulations governing plastics reprocessing are accepted across the industry. Regulations governing the appropriate management of on-farm waste plastic are typically managed by state and territory EPAs and prohibit burning or burying of plastic. This is to ensure the protection of human and environmental health. No discussions undertaken for the project raised the expectation that these regulations should be reduced.

4.2 Plastics in the Australian vegetable industry

4.2.1 Overview

A variety of plastic types are used on Australian vegetable farms for different uses. In this section, we explain the various types of plastics used on farm, how they differ from each other, and their associated quantity and management.

While the different plastic types and management can be defined for the vegetable industry, data availability on the volume of plastic used on farm is limited.

4.2.2 Plastic types

There is a range of plastic types used on Australian vegetable farms. These can be classified into the following six categories:

1. Expandable Polystyrene (EPS) plastics identification code 6
2. Polypropylene (PP) plastics identification code 5
3. Polyvinyl Chloride (PVC) plastics identification code 3
4. Polyethylene (PE) plastics identification code 2
5. High Density Polyethylene (HDPE) plastics identification code 2
6. Low Density Polyethylene and Linear Low Density Polyethylene (L/LLDPE).

A summary of the main plastic types, features, products and uses is outlined in Table 4-2 below.

Table 4-2: Plastic types used on vegetable farms

Plastic type	Main features	Types of products and uses
Expandable Polystyrene (EPS)	Lightweight and good temperature control	Produce boxes for vegetables including broccoli, asparagus, corn, beans & zucchini and seeding trays
Polypropylene (PP)	Rigid and lightweight	Seeding trays, pots, clips, racks and labels
Polyvinyl Chloride (PVC)	Rigid, lightweight and durable	Rigid irrigation pipe and fittings
Polyethylene (PE)	Flexible, lightweight and durable	Flexible irrigation pipe and fittings
High Density Polyethylene (HDPE)	Lightweight and durable	Chemical containers
Low Density Polyethylene and Linear Low Density Polyethylene (L/LLDPE)	Flexible	Mulch sheeting, polytunnel and protective housing, flooring and horticultural twine

There are alternatives to the standard plastic polymers used in the vegetable industry, which includes degradable products.

Degradable plastics disintegrate on exposure to certain triggers such as sunlight (UV radiation), heat, oxygen, moisture, chemicals and microorganisms. On exposure to one or more of these triggers, the chemical structure of the plastic will be changed, resulting in fragmentation and loss of some of its properties, with a residue left behind. Depending on the chemical properties of the plastic, the material will degrade up to a certain extent, under a set of conditions, within a certain time frame. Degradable plastic can then be classified into two categories: biodegradable or photodegradable.

Biodegradable plastics are degraded by naturally occurring microorganisms (bacteria and fungi), which feed on the product and mineralise it completely, leaving no toxic residues. They are biopolymers made primarily from corn starch plus proprietary biodegradable complexing agents.

Photodegradable plastic, also known as oxo-degradable (OXO) plastic, is polyolefin plastic (such as polyethylene [PE] and polypropylene [PP]) which has been amended with metal salts; a photo- or oxo-degradable additive. These speed up the natural degradation process so that the photodegradable plastic breaks down into micro-fragments of plastic and metals which remain in the environment but are not seen as a visual contaminant. Sunlight is the main trigger for photodegradable products to disintegrate. These products don’t break down effectively when buried due to lack of light and oxygen.

4.2.3 Plastic quantities: scale of the problem

By sector

The quantity of plastic used in the agricultural sector is a small component of overall plastics consumed nationally. In 2012-13 a total of 1,477,800 tonnes of plastics were consumed in Australia. Of this total tonnage the agricultural sector consumed 4%, or 59,112 tonnes, as outlined in Figure 4-2. This is the lowest plastic use by sector following transport (5%) and electrical and electronic (7%).

A total of 307,300 tonnes, or 20.8%, of the total plastics consumed were recycled, 145,600 tonnes of which was recycled in Australia. Of the plastics recycled within Australia the agricultural sector generated 3,800 tonnes or 2.6%.

Plastic use within horticulture represents a subset of the total agricultural sector use. The vegetable industry uses an even smaller proportion of this. The National Plastics Recycling Survey is the best available data set on plastic use in Australia.[10] However, there is limited data available at the horticulture and vegetable industry level. Consequently, the limited available data was complemented with the extensive consultation and modelling undertaken as part of this project to calculate plastic quantities used on vegetable farms. The following sections provide plastic quantities by plastic type and crop.

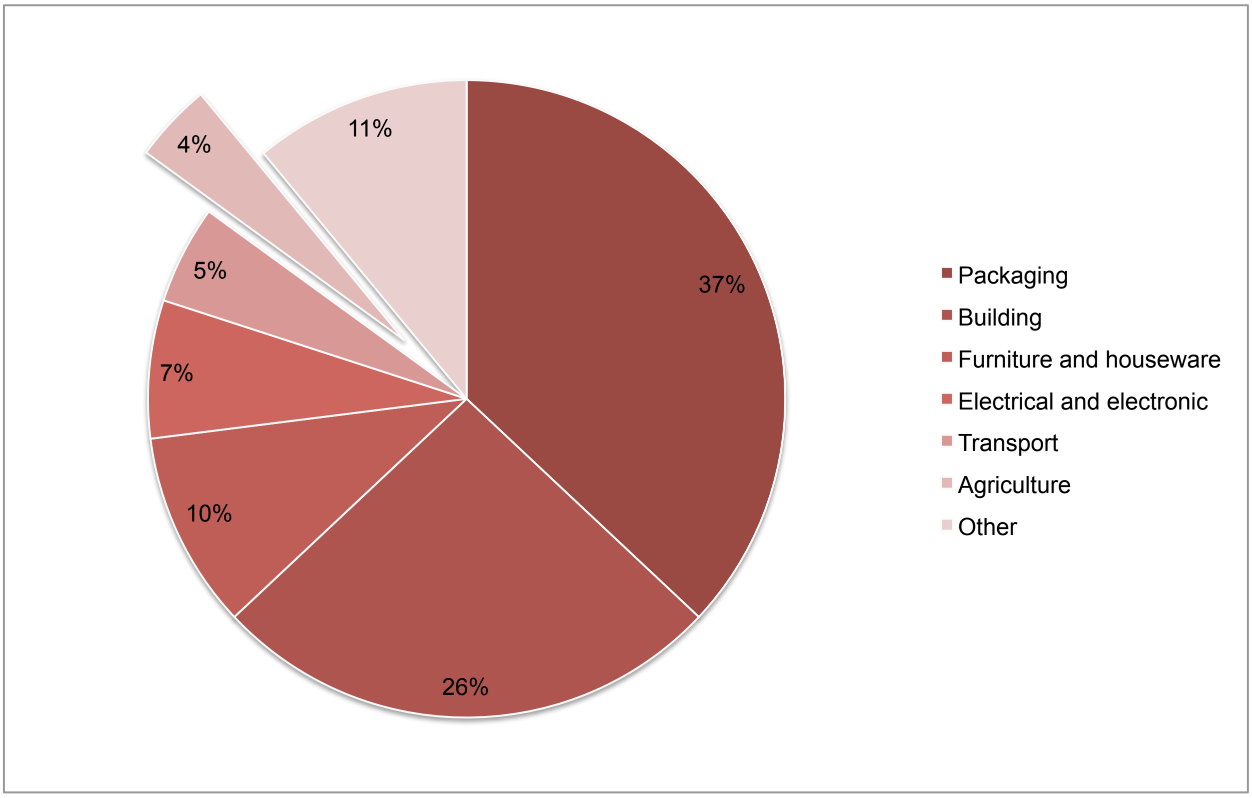

Figure 4-2: Plastic use by sector[11]

[10] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

[11] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

By plastic type

A summary of the total quantity of plastic used in Australia compared to the estimated use within the horticulture sector by plastic type is outlined in Table 4-3. This information was sourced from the National Plastics Recycling Survey and is the best available data set on plastic use in Australia.[12]

Data availability was limited at the vegetable farm scale, and as such an estimate for the whole horticulture sector is provided. This provides an upper limiting figure on which to model plastic use by crop on vegetable farms, which is presented in the latter part of this section. This was also complemented by extensive consultation undertaken as part of this project.

Table 4-3: Summary of plastic quantity by type

<table>
<tr><th>Plastic type</th><th>Total consumption (tonnes)[13]</th><th>Total recycling (tonnes)</th><th>Total recycling rate (%)</th><th>Estimated quantity for horticulture sector (tonnes/year)[14]</th><th>Main product on vegetable farms</th><th>Lifespan</th></tr>
<tr><td>1. Expandable Polystyrene (EPS)</td><td>43,800</td><td>4,300</td><td>9.9%</td><td>5,000</td><td>Seedling trays</td><td>Up to 30 years</td></tr>
<tr><td>2. Polypropylene (PP)</td><td>218,600</td><td>45,800</td><td>21.0%</td><td>9,000</td><td>Seedling trays, bed trays</td><td>Long (varies)</td></tr>
<tr><td>3. Polyvinyl Chloride (PVC)</td><td>194,100</td><td>6,900</td><td>3.6%</td><td>5,000-7,000</td><td>Permanent irrigation pipe</td><td>Up to 50 years</td></tr>
<tr><td>4. Polyethylene (PE)</td><td rowspan="2">400,100</td><td rowspan="2">93,200</td><td rowspan="2">23.3%</td><td>5,000-10,000</td><td>Drip/trickle irrigation pipe</td><td>1-10 years</td></tr>
<tr><td>5. High Density Polyethylene (HDPE)</td><td>Vegetable farms account for 2-5% of the total HDPE chemical container use in Australia. In 2011-12 a total of 2.2 million chemical containers were collected and recycled by drumMUSTER</td><td>Chemical containers</td><td>drumMUSTER program exists to recycle chemical containers</td></tr>
<tr><td>6. Low Density Polyethylene and Linear Low Density Polyethylene (L/LLDPE)</td><td>213,200</td><td>66,700</td><td>31.3%</td><td>5,500</td><td>Mulch sheeting, polytunnel and protective housing and flooring</td><td>1-10 years</td></tr>
<tr><td>Total</td><td>1,477,800</td><td>216,900</td><td>-</td><td>36,500</td><td></td><td></td></tr>
</table>

[12] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne
[13] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne
[14] Based on extensive consultation with industry, growers, plastic providers and plastic processors as part of this project

Expandable Polystyrene (EPS)

The total EPS used in Australia in 2012-13 was 43,800 tonnes, of which 4,300 tonnes was recycled at a rate of 9.9%.[15]

The key EPS product used in the vegetable industry is the white foam produce boxes used to store and transport vegetables requiring constant temperature such as broccoli. There is no data on the actual tonnage of boxes used by the vegetable industry within Australia. The best estimate provided by Expanded Polystyrene Australia*,* the peak national industry body for manufacture and distribution of EPS products across Australia, was approximately 5,000 tonnes of EPS vegetable boxes manufactured in Australia each year.

However, the overall volume of EPS seeding trays used on-farm is negligible compared to EPS produce boxes transported off-farm. Since EPS use on vegetable farms is not significant this plastic type was not a focus of this study.

Polypropylene (PP)

The total PP use in Australian in 2012-13 was 218,600 tonnes, of which 21% was recycled (45,800 tonnes).[16]

A desk audit report in 1999 for Horticultural Research and Development Corporation (precursor to HIA) and Nursery Industry Association of Australia (precursor to NGIA) estimated that 13,000 tonnes of seedling trays of varying polymers were sold to and used by the nursery industry each year.[17]

Consultation with industry identified the current quantity of seedling trays, clips and labels for all types of plants is approximately 10,000 tonnes, of which ~9,000 tonnes is recycled PP. Approximately 80% of the total quantity is used in nurseries (wholesale and retail) and landscaping, with 20% making it on farm. It is estimated that 8-10% of all PP seedling trays and other miscellaneous polymers, or 1,000 tonnes, is used on vegetable farms. Again, due to the relatively small quantity used on-farm seedling trays were not a focus of this study, nor were they identified as being a significant issue during consultation.

Polyvinyl Chloride (PVC)

A total of 194,100 tonnes of PVC was used in Australia in 2012-13, of which 6,900 tonnes were recycled at a rate of 3.6%.[18]

PVC appears on vegetable farms in limited quantities in common products such as electrical cable, plumbing pipe, plumbing fittings and garden hose. There are two forms for PVC. The first is PPVC, which is plasticised and flexible for products such as hose and electrical cables, and secondly, UPVC which is un-plasticised and rigid, and appears in irrigation pipes and fittings.

It is estimated that 5,000-7,000 tonnes of PVC pipe is used in the horticultural sector, and only a small fraction of that is used on vegetable farms (~1,750 tonnes).

[15] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne
[16] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne
[17] Horticulture Australia (1999) Desk audit of waste plastic within the nursery industry, 1999, Project Number NY98028, report prepared by Peter Goodwin University of Sydney, Sydney
[18] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

Almost all PVC pipe is locally made with some fittings imported. Australian PVC manufacturing is regarded amongst the most advanced in the world due to innovations in production and high quality given almost all domestic manufacturers are signatories to the Vinyl Council of Australia Product Stewardship.

Polyethylene (PE) and High Density Polyethylene (HDPE)

Total PE/HDPE consumption in Australia in 2012-13 was 400,100 tonnes, and 93,200 tonnes (23.3%) was recycled.[19]

PE pipe is widely used on farms for irrigation, particularly intensive horticulture such as vegetable production. PE irrigation pipe is more flexible and less brittle than PVC, and can bend around corners and is more elastic to impact. Hence, it is used for applications where greater bending is required. PE is generally used for smaller diameter pipes, connectors and small irrigation fittings i.e. drip line irrigation. These pipes are generally coloured black or brown, with carbon black added as a sun UV stabiliser. The lifespan for most PE irrigation pipe is 1-10 years however some can last up to 50 years. Thin walled drip/trickle tape is replaced every year, and a large proportion of this product is used in the vegetable industry. Buried pipe lasts longer than exposed pipe due to the impact of the sun, sharp objects and compression. It is estimated that 50% of PE product into the horticulture sector is made locally.

It is estimated there may be between 5,000-10,000 tonnes of PE pipe sold in the horticulture sector each year, of which vegetable farms are a moderate component (~2,500 tonnes). There are no comprehensive national programs for recovery of PE pipes or fittings from farms.[20]

HDPE containers are used to transport most chemicals, such as fertilisers and pesticides. There is a range of chemical packaging options with the 20 litre HDPE container the most common. There are also some growers moving to larger deliveries in intermediate bulk containers (IBCs), which are 1m^3 HDPE containers in a metal reinforcing cage.

It is estimated that the vegetable farms account for 2-5% of the total HDPE chemical container use in Australia. In 2011-12 a total of 2.2 million chemical containers were collected and recycled by drumMUSTER.[21]

drumMUSTER is a well-established national recovery program for eligible empty rigid agricultural and veterinary chemical containers, mainly made with HDPE (1 – 200 litre containers). Only those rigid containers that display the drumMUSTER logo are eligible (both hazardous and non-hazardous chemicals), and no other plastics or packaging materials are currently accepted. There are 789 collection sites around Australia.

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[19] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

[20] Netafim operates their own product stewardship program called Recoil for thin walled drip/trickle tape. However, this only applies to products supplied by Netafim.

[21] AgSafe (2012) Annual Review 2012, Canberra

Low Density Polyethylene and Linear Low Density Polyethylene (L/LLDPE)

A total of 213,200 tonnes of L/LLDPE was consumed in Australia in 2012-13, of which 66,700 tonnes (31.3%) was recycled.[22]

L/LLDPE is used in the manufacture of sheeting and film and includes:

- **Mulch sheeting:** estimated 2,500 tonnes/year for the Australian market. Features black and white colours, generally 23-40 micron with some manufacturers achieving 20um thickness with lifespan of 1-2 years. Innovations include different properties that enable quicker laying on beds. Low use of recycled material in order to deliver best quality consistent product. Unable to estimate what proportion goes to vegetable farms as a proportion of the whole horticultural industry.
- **Polytunnel and protective housing:** estimated 2,000 tonnes/year of clear and white LLDPE film which is mostly imported. Ranges from 100 to 250um thickness. Key features are tensile strength, flexibility across frame structures and lightweight. Life span of product up to 5 years and many growers extend this to 5-10 years if there is no damage. Major competitor materials are glass for fixed structure greenhouses.
- **Flooring film:** estimated 200-300 tonnes/year for the Australian market. Features white and black colours with lifespan typically 1 year. Product is mainly used in greenhouses as a ground barrier. Australian manufacturers is strong in this market. Unable to estimate what proportion goes to vegetable farms as a proportion of the whole horticultural industry.
- **Cloche film:** estimated 200 tonnes/year into the Australian market. Features clear LLDPE with life span of 2-3 months. Used to support early field planting for frost protection and warmth.
- **Horticultural twine:** estimated 300-500 tonnes/year into the Australian market. Features black, blue, white colours with long life span, but tends to be used for 1-5 years. All now woven and imported from overseas due to labour costs. Mainly used in nurseries, orchards, cut flowers, greenhouses, bananas and tomatoes.

There is an unknown quantity of wind breaks and shade cloth imported for the horticulture sector, and therefore on vegetable farms.

[22] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

By crop type, region and farm size

In addition to discussing the influence of property scale on plastic management, this section analyses the main plastics used by crop type and region.

The influence of farm scale on plastic management does not appear to be as significant as other factors that influence plastic recycling supply chains (the size of the agricultural region itself and hence the overall plastic volume produced, its distance from plastics processing plants and ports).[23] However, individual farm scale does influence a farm's access to and willingness to engage with reprocessing supply chains:

- Larger farms produce larger volumes of plastic at particular times, which may attract collection companies that are trying to maximise plastic collection for time spent and distance travelled
- Farms of a sufficient scale produce too much waste plastic to allow it to stockpile on-site, and may be more willing to manage it immediately as standard farm practice
- Reputation as a best practice operator may also feature in plastics management for the larger firms, although plastics management currently does not appear to feature explicitly in contracts with major supermarket chains.

Otherwise, farm scale does not appear to significantly affect plastic purchase price or waste plastic management costs. Plastic collection costs at end of life do not vary significantly with scale, and landfill costs do not change by volume or weight.

Potential access to a recycling scheme may be influenced by size of the property and volume of waste produced. It may be possible for the larger farms to enter into long term contracts with plastic processors who are eager to secure access to plastic for processing. Processors who were consulted for this project found that large farms were so far unwilling to engage in long term contracts for plastic waste management, possibly due to a preference for flexibility.

In terms of the relationship between plastic use, crop type and region, an overview of the plastic products used on vegetable farms by commodity group and representative crop type is outlined in Table 4-4.

[23] Plastic reprocessing supply chains tend to be located in areas of larger consistent volumes of waste plastic, that are located nearer to reprocessing facilities (domestic processing) and ports (international export), thus minimizing collection and transportation costs.

Table 4-4: Main plastics used by crop type

Commodity group	Includes	Representative crop	Plastic products used
Leafy	Some Asian vegetables, lettuce types, spinach, silverbeet, rocket	Lettuce	Drip/trickle and permanent irrigation pipe, poly tunnels/protective housing, chemical containers
Root and tuber	Carrot, parsnip, beetroot	Carrot	Permanent irrigation pipe, chemical containers
Legumes	Beans, peas	Beans	Drip/trickle and permanent irrigation pipe, chemical containers
Protected cropping	Solanaceous vegetables such as tomatoes, capsicums, eggplant	Capsicum	Drip/trickle irrigation pipe, mulch sheeting, chemical containers, poly tunnels/protective housing, seedling trays, bed trays
Brassica	Broccoli, cabbage, cauliflower, brussel sprouts, kohlrabi, swedes, turnips, and some Asian vegetables	Broccoli	Drip/trickle and permanent irrigation pipe, chemical containers
Other vegetables	N/A	Sweet corn	Drip/trickle and permanent irrigation pipe, chemical containers, seedling trays
Cucurbit	Pumpkin, cucumber, zucchini	Pumpkin	Drip/trickle and permanent irrigation pipe, mulch sheeting, chemical containers, seedling trays
Specialty leafy	Celery, parsley etc.	Celery	Drip/trickle and permanent irrigation pipe, mulch sheeting, chemical containers, poly tunnels/protective housing, seedling trays, bed trays

An analysis of the main plastic products on vegetable farms by crop type and region was undertaken using the Australian Bureau of Statistics (ABS) Agricultural Census data 2010-11.[24] This data set was used due to its reliability and coverage of levy paying vegetable crops. Plastic use was modelled based on:

- Product utilisation factor by crop type
- Lifespan of the product
- Annual use (t/ha/yr) and
- Total levy paying crop area by natural resource management (NRM) region.

The modelling used a number of assumptions outlined in Table 4-5, which were informed by the desktop review and consultation.

The plastics investigated were mulch sheeting, drip irrigation, permanent irrigation and miscellaneous other. It is estimated that a total of 5,500 tonnes/year of these plastics are used on vegetable farms. This represents 9.5% of total annual plastic use in the agricultural sector, and an estimated 15% of total horticultural use.

Table 4-5: Assumptions for plastic use modelling

Plastic product	Lifespan (yrs)	Annual use (t/ha/yr)	Other assumptions
Mulch sheeting	1	0.154	Based on 25 µm (depth) x 1.2 m (width) x 1,000 m (length) per roll at 5.55 rolls/ha
Drip irrigation	1	0.120	Based on 18 g/m for thin-walled dripper line, 6,667 m/ha of irrigation pipe, weighing 0.000018 t/m
Permanent irrigation	20	0.021	Based on 2,044 m/ha of irrigation pipe, average 32 mm diameter pipe, weighing 0.00021 t/m
Miscellaneous other	10	0.006	Based on 5% of drip irrigation waste

The analysis demonstrated that (Figure 4-3):

- Drip irrigation is the largest component of plastic use with a total of approximately 2,600 tonnes/year (48%)
- Mulch sheeting comprises 28% of total plastic use on-farm (approximately 1,550 tonnes/year)
- Permanent irrigation is a small component of plastic use with 945 tonnes/year (17%).

The remaining 7% (403 tonnes/year) is comprised of miscellaneous other plastic such as protective/flooring sheeting, labels and clips.

[24] Australian Bureau of Statistics (2012) 2011 Agricultural Census; Agricultural Commodities, Australia, 2010-11, cat. no. 7121.0, Australian Government, Canberra

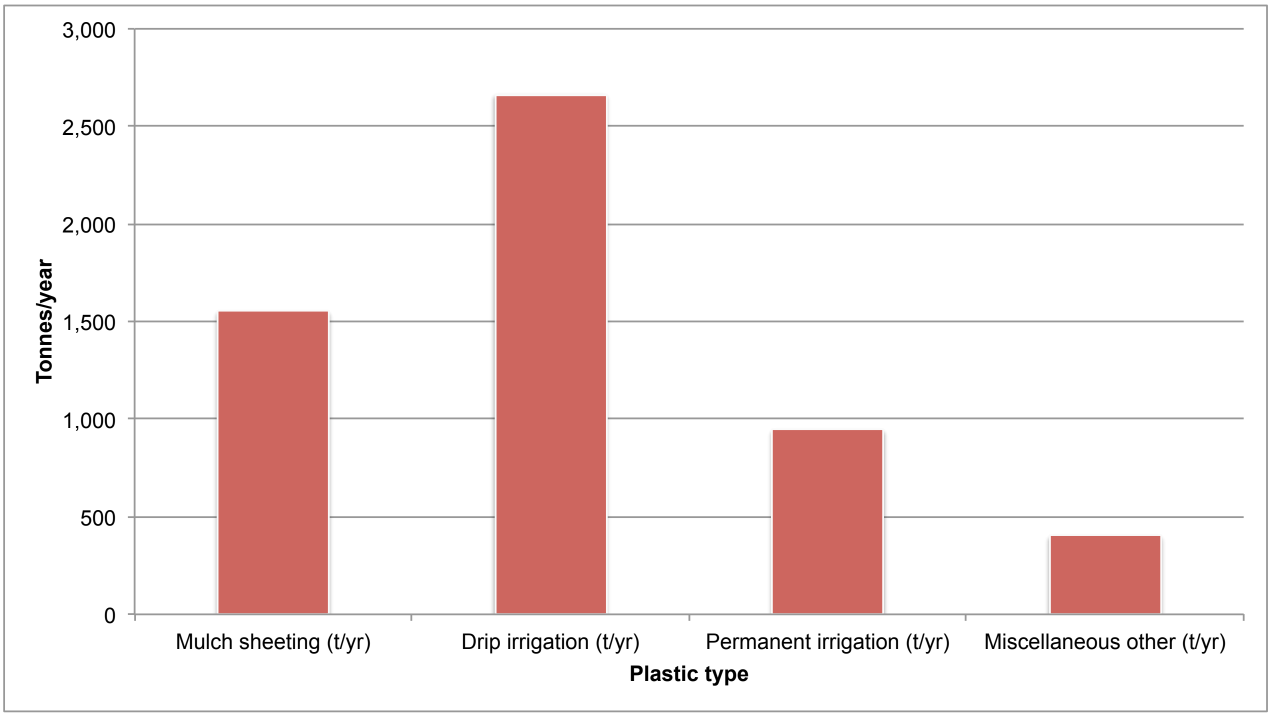

Figure 4-3: Quantity of plastic by type on vegetable farms

The largest plastic use by vegetable crop is 'other' with 1,900 tonnes/year (35%). This 'other' category includes celery, cucumber, zucchini, brussel sprouts, swedes, turnips, eggplant, parsnip, beetroot, some Asian vegetables, spinach and silverbeet. This use is followed by pumpkin (19%), capsicums (12%) and sweet corn (9%) with 1,100 tonnes/year, 650 tonnes/year and 500 tonnes/year respectively (Figure 4-4).

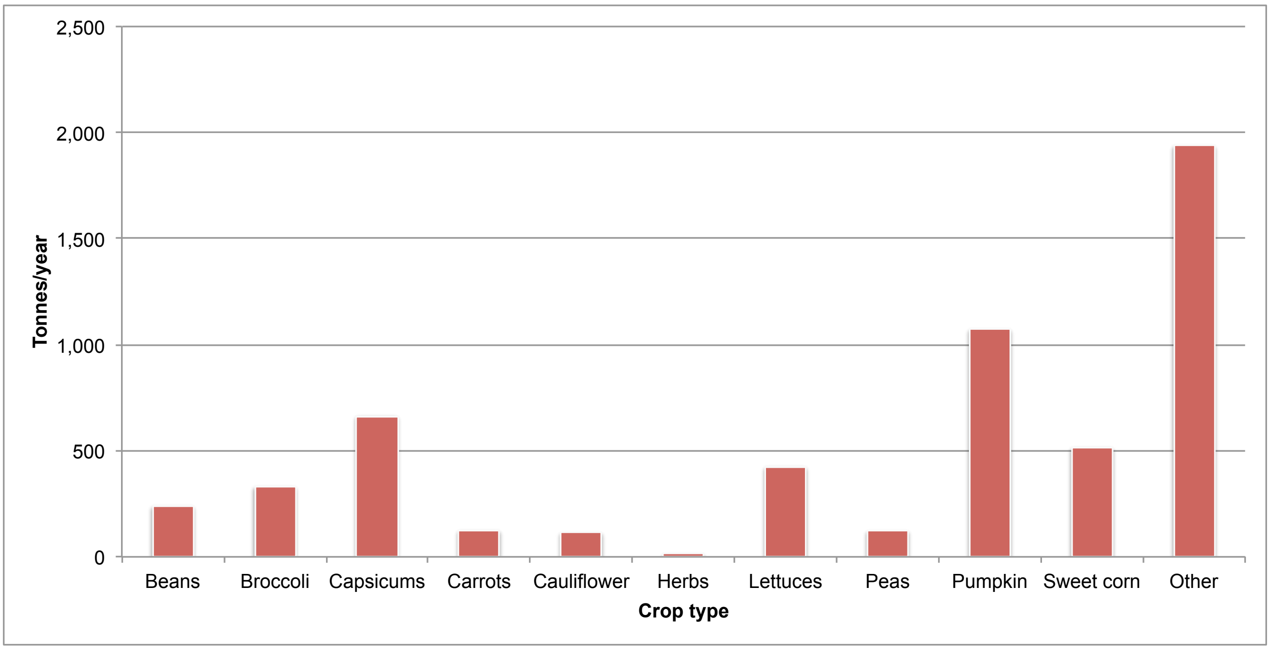

Figure 4-4: Quantity of plastic by levying paying crop type

The analysis of plastic use by region demonstrated that almost half (47%) of total plastic use on-farm was generated from four main growing regions, three of which are located in Queensland (Figure 4-6 and Figure 4-6). They are:

- South East QLD (16%) 900 tonnes/year
- Burnett Mary QLD (11%) 600 tonnes/year
- Burdekin QLD (10%) 575 tonnes/year
- Port Phillip and Westernport VIC (10%) 560 tonnes/year.

Figure 4-5 provides a heat map of total plastic use by NRM region on vegetable farms for Australia. This map represents the 'intensity' of plastic use by region, and the darker the colour the higher the use by region (t/yr). Vice-versa the lighter the colour on the map the lower the use by region (t/yr). NRM regions were chosen as the analytical unit by the project team due to the availability of robust ABS Agricultural Census data at a scale that could be represented in a useful way at a national level.

The next three largest regions include West Gippsland VIC (5%), Hawkesbury-Nepean NSW (5%) and Murrumbidgee NSW (4%) with 280 tonnes/year, 250 tonnes/year and 215 tonnes/year respectively. Additional maps of plastic quantities by product and region are provided in Appendix 3.

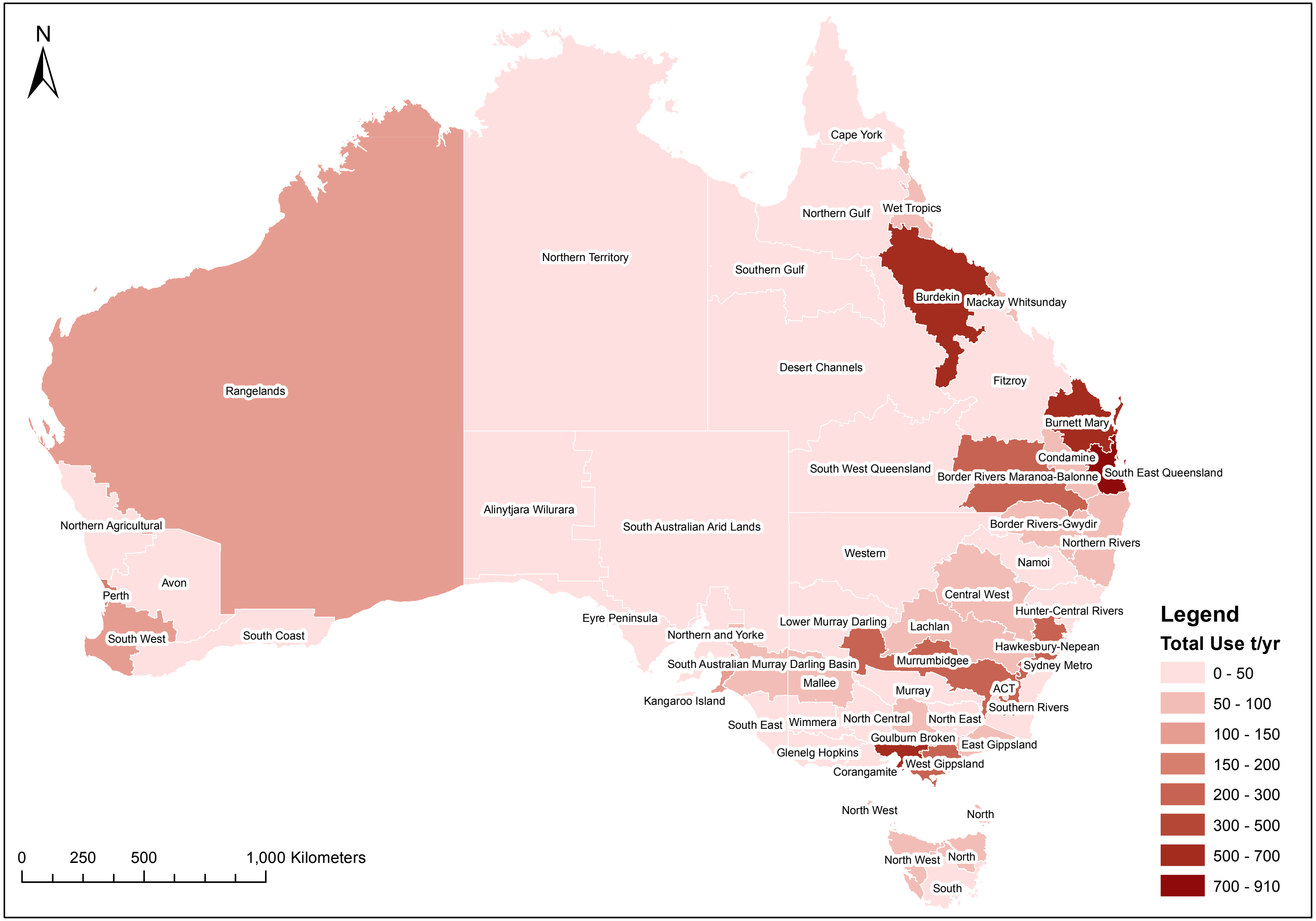

Figure 4-5: Heat map of total plastic use by NRM region on vegetable farms

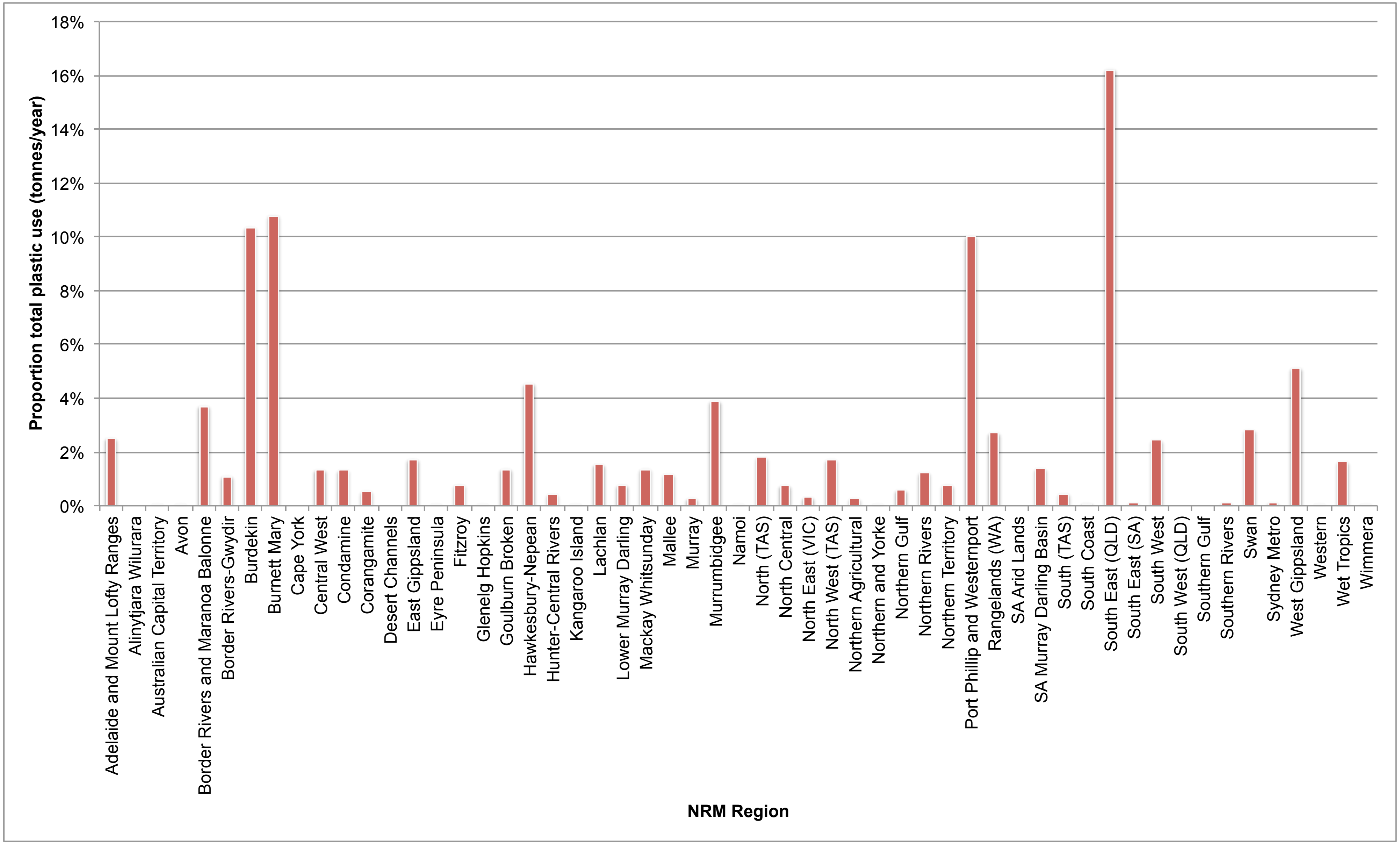

Figure 4-6: Graph of total plastic use by NRM region on vegetable farms

4.2.4 Plastics management and disposal

Overview

Given the number of different plastic types and uses on Australian horticulture farms, there are several different plastics disposal approaches currently used:

- Disposal to landfill at end of life
- Recycling
- Illegal burning or burying on-site
- Abandonment in-situ.

These approaches are discussed further below and were informed by consultation with the vegetable industry and plastic processors.

Landfill

Disposal to landfill at end of life involves collection and stockpiling, then transportation to landfill and payment of a gate fee. The landfill arrangements in each jurisdiction, including the gate fee and landfill levy is outlined below (Table 4-6).

Table 4-6: Landfill costs (gate fee and landfill levy) by jurisdiction[1]

State	Regional Landfill Levy	Landfill Rate/Tonne
Victoria	$51.80/t (Rural/Industrial)	$219.00/t incl. levy and GST (Wangaratta Landfill[2])
New South Wales	$120.90/t (Regional Levy)	$308.40/t incl. levy and GST (Spring Farm, Camden[3])
Queensland	$0.00 ($35.00/t removed 1/7/2012)	$107.00/t incl. GST (Toowoomba Council Landfill[4])
South Australia	$12.00/t (Inert Rate)	$112.20/t and levy including GST (Adelaide Hills Region Waste Management Authority[5])
Western Australia	$50.00/t (Inert Rate)	$135.00/t incl. levy and GST (Henderson Waste Recovery Park[6])
Tasmania	$2.00-$5.00/t	$79.00/t incl. levy and GST (Launceston Landfill[7])
Northern Territory	N/A	$116/t incl. levy and GST (Alice Springs Landfill[8])
Australian Capital Territory	N/A	$135.14/t (Mugga Lane Resource Management Centre[9])

[1] Note: while landfill levies are fixed across a jurisdiction (they often differ between urban and rural areas), the actual cost of landfill will differ for each landfill site. No useful 'average' exists for each jurisdiction
[2] http://www.wangaratta.vic.gov.au/services/waste-recycling/bowserlandfill.asp
[3] http://www.sita.com.au/media/publications/Waste_Charges_200x210_July_14.pdf
[4] http://www.toowoombarc.qld.gov.au/environment-and-waste/waste-and-recycling/rubbish-dumps/7422-waste-disposal-fees-and-charges
[5] http://website.ahrwma.com/Web%20Docs/BLF%20Public%20Fee%20Schedule%202014_15%20Web.pdf
[6] http://www.cockburn.wa.gov.au/Council_Services/Waste/Henderson_Waste_Recovery_Park/Gate_Fees/default.asp
[7] http://www.launceston.tas.gov.au/upfiles/lcc/cont/_facilities/major_council_facilities/launceston_waster_centres_and_transfer_station/lwc_disposal_fees__information.pdf
[8] http://www.alicesprings.nt.gov.au/council/fees
[9] http://www.tams.act.gov.au/__data/assets/pdf_file/0019/356041/Fees-and-charges-brochure.pdf

Recycling

Recycling involves collection and stockpiling, and either transportation to recycling centres or payment to an intermediary or end recycler who will collect plastic waste for a fee.

drumMUSTER is a well-established recovery program for eligible empty rigid agricultural and veterinary chemical containers, mainly made with HDPE (1 – 200litre containers). At the moment it does not accept any other plastics or packaging materials, and only those rigid containers that display the drumMUSTER logo (both hazardous and non-hazardous chemicals) are able to be collected. There are 789 collection sites around Australia.

Established in 1998, this voluntary product stewardship scheme brings together farmers, farming associations, 112 manufacturers and importers representing 95% of product (by weight) sold into Australia. There are also 365 local governments and 109 other collection agencies, including retailers. Funds raised from the $0.04 cent per litre/kilogram levy are administered by AgStewardship Australia through agreements with participating manufacturers and importers for the drumMUSTER and ChemClear programs.

The recovery and recycling of other plastics from vegetable farming operations would be challenging for a number of reasons including contamination (plastic recycling companies recycle the plastic feedstock to be provided in a clean format especially and distance and logistics. These issues are further explored in section 5.

Illegal burning and burying

Illegal burning on-site involves collection and stockpiling and burning with other non-plastic flammable wastes (such as fallen trees) on-farm. Burying can be undertaken on non-productive areas of the farm.

In the absence of data collection, it is impossible to quantify the extent of illegal burning and burying of plastics that take place on Australian vegetable farms. However, as an essentially zero cost disposal option, it must be accepted that these options may occur.

Consultation with the vegetable industry, plastics providers and recyclers for this project revealed that illegal disposal is a real and ongoing issue for the agricultural sector, including the vegetable sector. On-farm burning of plastics is an offence in every Australian jurisdiction, as described in the following summary of relevant regulatory arrangements (Table 4-7).

Abandonment in-situ

For some long-lived plastics that have been buried on-farm (such as irrigation networks), these may be left in-situ at end of life. Their exact whereabouts may be difficult to identify and the cost of unearthing may be prohibitive to growers. It is likely that significant volumes of PVC and PE related to irrigation are left in-situ.

Table 4-7: Regulatory arrangements relating to burning of plastic waste

State	Overview of regulatory arrangements
Victoria	*No waste, other than tree branches, should be burnt on a farm. Waste such as tyres, hay bands, silage wrap and domestic waste must not be burnt* (What to do with farm wastes, EPA Victoria Publication 1049.1 May 2008)
New South Wales	Under the *Protection of the Environment Operations (Clean Air) Regulation 2010*
Queensland	Under the *Environmental Protection Act 1994* and *Environmental Protection Regulation 2008*
South Australia	*Burning in the open for agricultural purposes is permitted in non-domestic premises for agricultural purposes occurring outside metropolitan Adelaide including the disposal of dead stock, crop stubble or diseased crop, and clearing of land for farming* (EPA Guidelines – Burning in the open on domestic and non-domestic premises EPA South Australia Sept 2003)
Western Australia	The Environment Protection Agency has introduced regulations that prevent open air burning of plastic.[10]
Tasmania	Under the Environmental Management and Pollution Control Act 1994 - *As a farmer/landowner, you have responsibility to – only burn dry vegetative material and in accordance with the conditions of a permit during fire permit season* (Q&A Sheet 10a Waste Management and Pollution Legislation)
Northern Territory	Under the *Waste Management and Pollution Control Act 2007* states that waste should not be burnt under the best practice scenario *'controlled burns are held at the landfill site as necessary to control amount of putrescible and windblown waste. Plastics, construction materials, whitegoods etc are all kept out of the controlled burn site.'* (Local Government Association NT (2009) Waste Management Guidelines for Small Communities in the Northern Territory Working Towards Best Practice 2009, Northern Territory Government, Darwin)
Australian Capital Territory	*The substances which may not be burnt are: synthetic plastics or other synthetic polymers* (Air Environment Protection Policy – ACT Government 1999 pg. 13)

4.2.5 Priority plastics on vegetable farms

The priority plastics in the vegetable industry have been determined by a combination of the main plastic types, scale (by crop and region) and current management performance (Table 4-8). This analysis demonstrated that the highest priority plastics on vegetable farms were:

- Mulch sheeting (L/LLDPE)
- Drip/trickle irrigation pipe (PE)
- Permanent irrigation pipe (PE/PVC).

Plastics such polypropylene (PP) clips, labels and other plastics must also be accounted for in a miscellaneous category. Chemical containers (HDPE) are adequately being managed on-farm under the drumMUSTER scheme. While seedling trays (PP) are collected, cleaned and reused multiple times by nurseries.

[10] http://archive.agric.wa.gov.au/objtwr/imported_assets/content/aap/dc/8_wastemanagement.pdf

Table 4-8: Priority plastics on vegetable farms

Plastic type	Main product	Scale	Current management performance	Priority
1. Expandable Polystyrene (EPS)	Produce boxes	Low	Adequate	Low
2. Polypropylene (PP)	Seedling trays	Low	Adequate	Low
3. Polyvinyl Chloride (PVC)	Permanent irrigation pipe	Medium	Limited / non-existent	Moderate
4. Polyethylene (PE)	Flexible irrigation pipe	High	Limited	High
5. High Density Polyethylene (HDPE)	Chemical containers	Medium	Excellent	Low
6. Low Density Polyethylene and Linear Low Density Polyethylene (L/LLDPE)	Mulch sheeting	High	Limited / non-existent	High

4.3 Feasibility assessment of on-farm plastic management: current approach and alternatives

4.3.1 Overview

As described in the previous analysis, the plastics of greatest concern to the vegetable industry are plastic mulch, for which recycling is extremely limited or non-existent, drip irrigation and to a lesser extent permanent irrigation. A number of other plastic types affect farms to varying degrees (such as seedling pots and greenhouse plastic).[11]

In the context of on-farm plastic waste in the vegetable industry, a hierarchy of better practice on-farm plastic management may be observed, reflecting the opportunities available and the realities of current practice. Management options include:

1. Minimising the amount of plastic used in production
2. Replacement with biodegradable or photodegradable plastics, requiring no disposal
3. Recycling of on-farm plastics into other products
4. Landfill of plastics in an appropriately managed landfill, to minimise environmental impacts of waste
5. Burning or burying on-farm plastics.

We assume that plastics are only being used when needed and to the extent needed on-farm, and that efficiencies in plastic use are constantly being sought as with all other farm inputs.

Replacement of plastics with biodegradable alternatives are only really relevant in the context of plastic mulch, for which a biodegradable alternative currently exists. However, we note that a biodegradable drip irrigation is currently under commercial development.[12] This option is not without its challenges, as we will discuss further below.

Recycling of on-farm plastic is the next best available option, as is being widely undertaken with chemical drums under the drumMUSTER program. For a number of reasons recycling of other on-farm plastics is not widely undertaken in the vegetable sector.

Where these options are unavailable or not cost-effective, the option of landfill exists. This at least ensures that plastics are appropriately managed within an official landfill. Importantly, however, this option is not always available. The sheer volume of some plastics lead to them being refused access to landfills in some locations.

A situation such as this can lead to the least favoured option for plastic waste management – burning or burying plastic on-farm. These options are illegal across Australia, but it must be acknowledged that they occur to some extent. Of course, no rigorous data is collected on the proportion of plastic managed in this way, but anecdotal evidence and some survey data suggests that a significant proportion of plastic continues to be treated this way across the agricultural sector.

For example, a survey of 400 Victorian farmers in 2011 produced the results presented in Figure 4-7. Of the 400 respondents, a combined six per cent reported burning or burying their plastic waste on-farm. However, a further 50 per cent responded to the broader survey but elected not to answer the question about plastics disposal.

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[11] Chemical drums are also a significant source of plastic, but are already addressed with the drumMUSTER program and are not discussed here.
[12] http://www.greenprophet.com/2012/05/biodegradable-plastic-drip-irrigation/

Figure 4-7: Results of a plastics management survey of 400 Victorian farmers in 2011[13]

In exploring the feasibility of alternative plastic waste management options for vegetable farmers, we propose considering the options in our waste hierarchy – of replacement with photodegradable and/or biodegradable plastics, and consideration of recycling opportunities.

4.3.2 Plastic as a share of total farm cost

It is worth considering the share of total farm costs comprised by key plastics. While average data can disguise some important considerations, it is possible to compare the cost per hectare of plastic mulch with industry averages for variable and total costs per hectare.

Drawing on data produced by ABARES on vegetable farm production costs, Table 4-9 compares the purchase cost per hectare of plastic mulch with an average variable cost per hectare and a total cost per hectare for Australian vegetable farms. Plastic mulch represents 6.2 per cent of the average variable cost per hectare, and 3.5 per cent of total farm cost per hectare.

Importantly, not every type of vegetable farm uses plastic mulch – they are typically used on higher cost crops. As such, it is useful to compare the cost of plastic mulch with the costs of a farm that is more likely to use plastic mulch. Table 4-9 also shows the cost of plastic mulch as a share of variable costs for a capsicum farm in the North Queensland Dry Tropics area. Clearly, variable costs per hectare are significantly higher than the average Australian vegetable farm. Plastic mulch cost represents only 1.3% of variable farm costs – a relatively small component.

[13] Plasback (2011) Farm Plastics Waste Disposal in Victoria; Key survey findings, Melbourne

Table 4-9: Plastic mulch as a share of variable and total farm costs[14]

	Variable cost ($/ha)	Plastic mulch as %	Total cost ($/ha)	Plastic mulch as %
Average Australian vegetable farm	$11,000	6.2%	$19,403	3.5%
Capsicum farm North Queensland	$50,440	1.3%	Data unavailable	-

4.3.3 Feasibility of photodegradable and biodegradable plastic

We limit our analysis of the feasibility of photodegradable and biodegradable plastics to the area of plastic mulch used most often in the production of capsicum, chillis, eggplant, squash, and zucchinis.[15]

Effectiveness of alternative plastic mulch

Biodegradable plastic mulches have been under development and use in Australia for around the past decade. Photodegradable mulches have arrived in the Australian horticultural market more recently, from around 2012. No data exists to confirm market share, however consultation for this project confirmed that combined market share was limited – in the order of 10 per cent of the total plastic mulch market.

The clear advantage of biodegradable and photodegradable mulches is that they avoid costs associated with retrieval (machinery and labour) and disposal (transport and landfill costs). These costs can be significant, and if biodegradable and photodegradable mulch options are equally effective compared to standard plastic mulch, they could produce cost savings to users.

A number of trials of various biodegradable and photodegradable mulches have produced results suggesting that these products are not yet perfectly suited to Australian horticultural conditions. A 2014 trial in the Northern Territory found that:

> *No commercial degradable mulch can be confidently recommended at this stage. None of the mulches we have tested so far have been able to meet all the desired requirements i.e. being strong enough to withstand varied conditions at laying, remain intact over the course of the growing season and breakdown rapidly when cultivated at the end. Manufacturer activity in this area is highly competitive and several companies are developing degradable mulches based on a number of technologies. It is expected that with further research and development, adequate degradable mulches will be found for NT conditions.[16]*

Discussions with users of biodegradable and photodegradable mulch, retailers and manufacturers reveal that effectiveness of these options is not yet equal to traditional plastic mulch. Shortcomings relate to:

- **Timing of degradation**: producing mulch to degrade over the right time period appears to be the most significant challenge, given unpredictable weather and varying soil conditions across Australia. A specific challenge exists for mulch that sits underneath the soil, which may not degrade unless exposed to sunlight. Further questions remain about the impact of pesticide and herbicide use on

[14] Source: Australian data sourced from ABARES surveys of Australian vegetable growers conducted on behalf of HAL during the six-year period from 2005-06 to 2010-11. Capsicum data: 2013 data sent by personal communication, TJ Mullins, Queensland Department of Agriculture and Fisheries
[15] As noted previously, no formal data exists on crops and regions which use plastic mulch. This list of crops comes from interviews held in the course of this project.
[16] Smith, S. & Wallace, H. (2014) Degradable Mulch Trials. Northern Territory Government. Agnote, No: D45, May

plastic degradation timing. Discussions with manufacturers suggest these issues may be resolved within the next two years.

- **Robustness of plastic**: standard plastic mulch has a thickness of 25 microns, while biodegradable and photodegradable options can be as thin as 15 microns to allow them to degrade over desired time periods. This renders them more susceptible to tearing and makes them more difficult to handle than standard options.
- **Environmental performance**: no compulsory Australian certification has been developed for biodegradable plastic, and researchers have raised questions in consultation about the environmental performance of petroleum-based photodegradable plastics, in relation to long term impacts on soils and waterways. Very little research appears in the literature about the long-term impacts of photodegradable mulch on soils and waterways. Further research into this topic may be valuable to the horticulture industry.
- **Local amenity impacts**: as plastic breaks down, wind may pick up degrading pieces and deposit them in nearby areas.

On the whole, it would appear that the effectiveness of biodegradable and photodegradable plastics is not yet equal to traditional plastic mulch, but continuing innovation may see many of these issues resolved in the short to medium term. The issue of environmental performance is one that is largely unknown at this stage.

Cost-effectiveness of alternative plastic mulch

Detailed analysis of the cost-effectiveness of biodegradable mulch compared to standard plastic mulch was undertaken in 2012 as part of a broader analysis of biodegradable mulch for HIA.[17] We draw on this work, updating for data collected in the course of this study. We also expand the analysis scope to consider other plastics and disposal options.

A cost-effectiveness assessment needs to consider all relevant costs of each option considered in the analysis. To appropriately address all options available and currently used by growers, we consider the feasibility of the following options:

- **Plastic mulch:** these are standard plastic polymer mulches used across the horticulture industry, which require collection (machinery plus labour), and disposal (landfill or illegal disposal by burning or burying)
- **Biodegradable plastic mulch**: these are typically biopolymers made primarily from corn starch plus proprietary biodegradable complexing agents. They are certified internationally as biodegradable products, and do not require collection and disposal
- **Photodegradable plastic mulch**: these are based on ordinary plastic polymers that degrade but do not biodegrade as per biodegradable plastic. They typically have an oxo-degradable additive which allows the material to break down over time, however they do not break down effectively when buried due to lack of oxygen and light. As with biodegradable products, they do not require collection and disposal.

All options involve the same costs for placement in field, which is therefore excluded from the comparative analysis. Relevant cost items that are considered for each option are:

- **Retail cost**: the purchase cost of all three types of plastic mulch, collected from providers and retailers in the course of this analysis. For our comparative analysis we use the following costs:

[17] Horticulture Australia Limited (2012) Comparison of biodegradable mulch products to polyethylene in irrigated vegetable, tomato and melon crops, Project Number MT09068, report prepared by Sarah Limpus DAFF QLD, Sydney

- Standard plastic at $280.5 for a 2,300m roll, or $678 per hectare (1.2m wide, 25 microns)[18]
- Biodegradable plastic at $260 for a 1,000m roll, or $1,444 per hectare (1.2m wide, 15 microns)[19]
- Photodegradable plastic at $375 for a 2,300m roll or $907 per hectare (1.2m wide, 20 microns)[20]

- **Retrieval cost**: the labour and machinery operation cost for retrieval of non-degradable plastic mulch, drawing on Limpus 2012 which estimated eight hours labour per hectare (at $20/hour) and eight hours of machinery cost (at $15/hour)
- **Transportation cost**: this will differ by farm, reflecting the distance from farm to landfill or other disposal option. For a central estimate, we again draw on Limpus 2012 which estimated the cost of transporting 34 rolls of plastic per truck load, costing $750/load, or $22 per roll
- **Disposal cost**: this is a function of waste tonnage and landfill gate fees (comprising landfill costs and state-based levies where they exist - in all states but Queensland). To estimate this, we calculate the waste tonnage per hectare (28kg per 1,000m length of roll[21]), plus an estimate of contaminant load. Discussions revealed understandable uncertainty about the proportion of contaminant load that can be added to plastic mulch at retrieval, extending as high as 60%. We conservatively assume 30% additional contamination load upon retrieval, producing total tonnage of 200kg/hectare. Landfill costs are as per Table 4-6, and we provide a sensitivity based on data from each jurisdiction.

For the purposes of comparison, we provide the costs of standard plastic with illegal disposal (burning or burying), reflecting a known if illegal practice. It is important for feasibility assessment to acknowledge a real if unpleasant practice, as the current least cost option undertaken in the industry. As we will see in the results, this produces some interesting results.

Cost-effectiveness of alternative plastic mulch results

The results of the cost-effectiveness assessment are provided in Table 4-10 comparing:

- Standard plastic mulch with landfill disposal
- Plastic mulch with illegal disposal and
- Biodegradable and photodegradable mulch.

Table 4-10: Cost-effectiveness of plastic mulch, biodegradable and photodegradable mulch ($/ha)

	Plastic with landfill disposal	Plastic with illegal disposal	Biodegradable mulch	Photodegradable mulch
Retail cost	$678	$678	$1,444	$907
Retrieval cost	$280	$280		
Transport cost	$123			
Landfill cost (average)	$32			
Total cost	**$1,114**	**$958**	**$1,444**	**$907**

As can be seen in the analysis, there are a few key differences between options:

[18] Source: pers. comm. Landmark and Elders retail outlets, Bowen Queensland, 8 December 2014
[19] Source: pers. comm. J. Gagliardi, Australian Bio-Plastics (producers of Mater-Bi biodegradable plastic mulch)
[20] Source: pers. comm. D. McGrath, DC Enviroplas (producers of OneCrop degradable plastic mulch). These costs were confirmed by discussions with retailers in Bowen.
[21] 1.2m wide, 1000m long, 25 microns thickness

- Plastic mulch with landfill disposal has the cheapest purchase cost, but bears costs for transport and disposal that is not incurred by the other options
- Plastic mulch with illegal disposal has the cheapest purchase cost, bears costs for retrieval but not disposal
- Biodegradable and photodegradable mulch bear higher purchase cost, but do not bear any costs for retrieval and disposal.

Considering purchase, retrieval, transport and landfill costs of all four options, in pure cost terms the photodegradable mulch is the most cost-effective option, followed by standard plastic use with illegal disposal, standard plastic with landfill disposal, and biodegradable mulch.

When we consider the landfill costs in different jurisdictions, these results are confirmed. **Table 4-11** shows the total costs per hectare for plastic mulch with landfill disposal, distinguishing between landfill costs in each jurisdiction.

Costs of standard plastic including landfill disposal range from as low as $1,095/ha for Tasmania to as high as $1,146/ha for New South Wales. These are all more expensive than the full costs of photodegradable mulch, and less expensive than the costs of biodegradable mulch.[22]

Table 4-11: Jurisdictional comparison of plastic mulch options ($/ha)

	Plastic with landfill disposal	Plastic illegal disposal	Biodegradable mulch	Photodegradable mulch
Victoria	$1,124			
New South Wales	$1,146			
Queensland	$1,102			
South Australia[23]	$1,108			
Western Australia	$1,107			
Tasmania	$1,095			
Northern Territory	$1,103			
All jurisdictions		$958	$1,444	$907

These results have significant implications for the users of plastic mulch in the future. The most important of these is that if the identified shortcomings of photodegradable mulch can be overcome, it will become the most cost-effective option for plastic mulch users. This option will be even more cost-effective than illegal disposal. Consultation undertaken suggests that it may be 1-2 years before a photodegradable product is commercially available that performs to the standards required by the horticultural industry.

The implication for the vegetable industry is that when a photodegradable product of sufficient performance arrives, it can be expected that a significant proportion of mulch users will begin using the product. This highlights the one outstanding issue for photodegradable mulch – that of environmental performance. This issue is further discussed in section 4.5.

[22] NSW costs are on a par with biodegradable mulch
[23] In the absence of available data on landfill costs, we use the average of other jurisdictions for this figure

4.3.4 Feasibility of plastic recycling

While no formal data is collected on plastic recycling within the vegetable industry, our discussions across the vegetable and plastics industry undertaken for this project suggest that a very small proportion of on-farm plastics is recycled. With the exception of the recycling of plastic chemical drums through the national drumMUSTER program, no comprehensive[24] national scheme exists for on-farm plastics in Australia.

As identified in our analysis of the scale of the problem and confirmed in consultation with growers, plastic producers and recyclers, the two main plastic items of significant volume affecting Australian vegetable farms are plastic mulch and drip irrigation. In addition to these, a number of other plastics exist on-farm that could also be recycled.

This section describes the supply chain of plastics recycling from the Australian agricultural industry, outlines options for recycling that exist in certain areas, and considers opportunities for more recycling in the future.

Plastic is typically collected, transported, sorted, and either processed domestically or transported overseas for recycling with the majority collected in Australia ultimately going overseas for processing.[25] As such, the value of plastics recyclate in Australia is largely defined by the international price for plastics recyclate, which is in turn influenced by the price of oil. As per all internationally traded commodities, this produces an inherent uncertainty into the market, as future prices are unpredictable.

The cost-effectiveness of plastics recycling is determined by the cost of collecting, cleaning, bundling and transporting plastic items to market (either domestic recycling centres located in major Australian cities, or ports for export). Where this can be done more cheaply than the going market price, recycling can be described as financially viable (Figure 4-8).

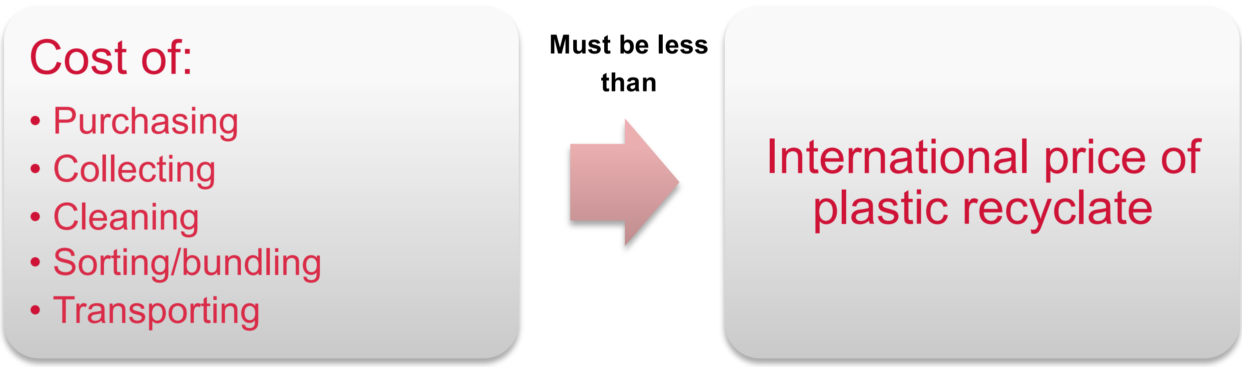

Figure 4-8: Determinants of plastics recycling feasibility

Collection is often undertaken by intermediaries specialising in the collection of recyclates, with the product then on-sold to recyclers domestically or internationally.

The most cost-effective plastics for recycling are therefore:

- Easily collected in large volumes

[24] drumMUSTER is a voluntary scheme, and some chemical companies do not participate, so we use the term 'comprehensive' loosely here.
[25] Sustainable Resource Use (2012) 2011–12 National Plastics Recycling Survey, Final Report, prepared for the Plastics and Chemicals Industries Association, Melbourne

- Clean of contaminants or inexpensive to clean
- Located close to either recycling plants or ports.

For the vegetable industry, there are several challenges that arise from this market structure:

- Plastics used in the vegetable industry are geographically spread out across different regions
- They become available for recycling at different times and in different quantities depending on farm location, size and crop
- They can often be heavily contaminated by soil, especially plastic mulch
- They are often located significant distances from major centres or ports
- Information linking potential suppliers and collectors of recyclates is often missing.

Discussions with recyclers and intermediaries in the course of this project confirm that these challenges significantly inhibit the cost-effectiveness of plastics recycling in the vegetable industry, as in the broader agricultural industry. Where recycling does occur, it either overcomes these barriers or benefits from some form of financial assistance:

- **drumMUSTER** is a national scheme for chemical drum recycling, in which farmers can deposit drums at landfills and transfer stations across Australia. As such, collection costs are partly borne by farmers in transporting drums to these areas. The scheme is funded by a product stewardship scheme where four cents per litre is added to cost of chemicals by participating chemical companies - the value of the plastics does not exceed the cost of the scheme. The program is run by AgStewardship Australia.
- **Recoil** is a service offered by Netafim for users of their drip line irrigation product, in which machinery is loaned to growers with which to recoil the product at end of use, and stacks of coiled product are removed free of charge to the grower. Despite being zero cost to growers, discussions with Netafim suggest that take-up has been insufficient for recyclate sales to exceed project costs.
- **Localised recycling** of drip line irrigation takes place in some growing regions of Australia. For example, discussions with growers in Bowen revealed that a contractor collects drip line irrigation free of charge, suggesting that sufficient scale and ease of collection for drip irrigation exists in some growing regions.

All discussions with growers, plastics producers and recyclers agreed that while drip line irrigation can be cost-effective to recycle under the right conditions, the same is not currently true for plastic mulch:

- **Drip line irrigation** is relatively free of soil contamination, is often already bundled by growers when collected, and is widely used by a range of crops in different growing regions. It can be coiled and stacked, ready for removal by recyclers or intermediaries.
- **Plastic mulch**, in contrast to drip line irrigation, typically has high and variable contamination (up to 60% of collected mulch by weight), and is difficult to decontaminate (no commercial method is currently being used in Australia); it is voluminous, requiring large areas to stockpile (that are also unsightly), and transportation costs are therefore high.

  Many recyclers consulted with in the course of this study suggested that plastic mulch had limited product value as a recyclate, but only one had tested the price by manually decontaminating and on-selling it; they found that it had significant product value, with the challenge resting on decontamination and transportation costs.
- **Other on-farm plastics** are relatively small in volume on average, suffering from diseconomies of scale (too small a volume to make a supply chain cost-effective).

4.4 Emerging technologies

4.4.1 Overview

As landfill and incineration become more expensive and less accepted, the recycling of plastic wastes is gaining increasing importance. Greater emphasis is being given to new disposal options, which have high energy recovery values and are more environmentally attractive. Increases in the cost of landfilling and community pressure to avoid landfilling and increase in resource recovery are the driving forces behind innovation in waste management in some parts of Australia and overseas, and new technology is the main way this is being achieved.

When assessing the applicability of technologies to the local context, consideration must be given not only to the particular local situation for marketing the outputs, but also the affordability and suitability of associated collection and disposal systems.

In regional areas, there is a clear trend towards collecting and processing source separated materials using simple technologies, while in the larger population areas, collection of mixed wastes with limited source separation, and processing them at more complex facilities that use a combination of technologies is a more common approach.

The different pathways for transforming waste products into forms of energy are outlined in Figure 4-9. The transformation of plastic waste into energy primarily occurs through thermal processing, which is discussed in further detail below.

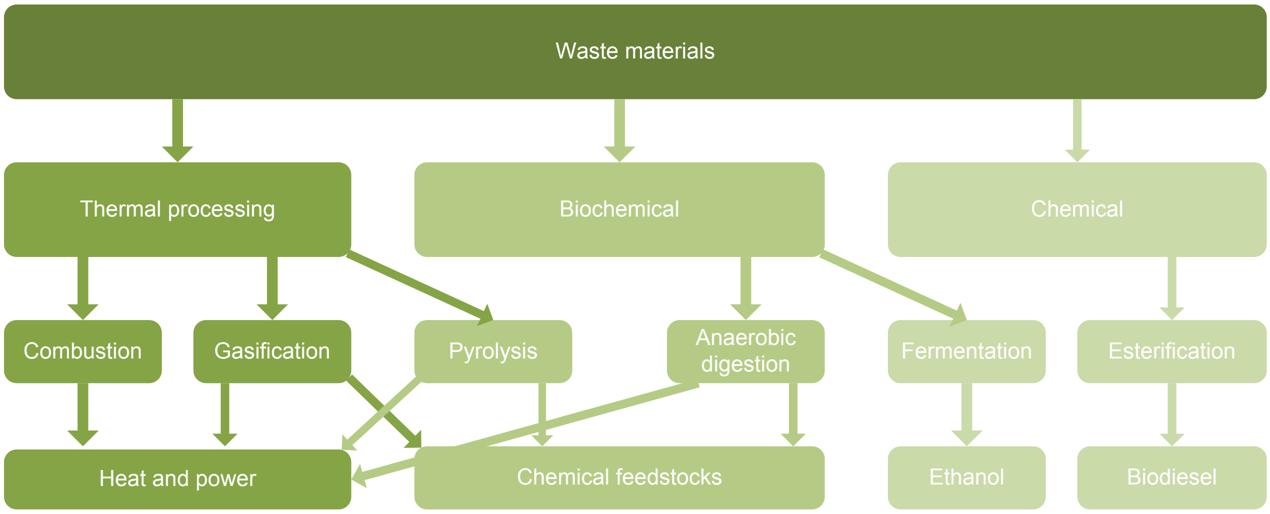

Figure 4-9: Overview of process flow for energy from waste technologies[26]

[26] Australian Business Council for Sustainable Energy (2005)

4.4.2 Traditional thermal technologies – incineration/combustion

Thermal waste treatment technologies are well established in Europe and North America, with incineration/combustion being the most widely used process. Energy is usually recovered in the form of heat and electricity.

These mature technologies recover the calorific energy contained in residual waste streams. Conventional ‘mass burn’ incinerators use reciprocating grates to move waste through the combustion chamber, usually at about 200–400 tonnes per day. The stages of combustion are usually: drying and preheating the solid waste, emission and combustion, and burnout and removal. Solid incombustible material is removed as a slag, and is usually landfilled. Flue gas from combustion contains water, combustion gases, oxygen and nitrogen. Air pollution is a critical consideration in incineration because particulates and dust, NO_x acid gases and dioxins, furans, polyaromatic hydrocarbons and heavy metals may be generated depending on the process, combustion temperatures and feedstocks.

In Australia the last solid waste incinerator, the Waverley Woollahra facility in south Sydney closed in 1997. At the time, community and government concern over stack emissions and the availability of relatively low cost landfilling made continuation of waste incineration a politically unpalatable option. Since then, acceptance of other forms of alternative waste technology (AWT) has all but eliminated mass burn incineration as a viable waste processing option.

4.4.3 New thermal processes

Several new thermal processes including gasification, pyrolysis and combinations of these have recently been adapted to handle municipal solid waste. These technologies require a uniform consistent input stream to ensure reliable operation. For mixed municipal wastes, some form of sorting/separation pre-treatment is required to remove unsuitable materials and ensure consistency. Some of these technologies are still considered to be commercially risky at a large scale and their widespread adoption in Australia is likely to be delayed until they are proven overseas by a number of years of continuous operation.

Pyrolysis

Pyrolysis involves indirect heating of carbon rich material with the aim of achieving thermal degradation of the material at temperatures of approximately 500°C in the absence of oxygen and under pressure. Useable energy of some 200–400 kilowatt hour per tonne of waste is generated. Energy production and greenhouse gas production are lowered in the absence of oxygen. Heavy metals that are less volatile remain as char, while volatile species need to be captured by gas cleaning systems and treated as hazardous materials. A liquid fraction is produced which may be used, with additional processing, as a synthetic fuel oil. The number of pyrolysis plants in operation in Australia mainly process reliable and consistent waste streams such as plastics or biosolids.

Cynar, a UK company, has recently signed an agreement with SITA UK to build the UK’s first fully operational plants to convert ‘end of life plastic’ into diesel fuel. The plant will use the pyrolysis process to create a solid fraction (char), gas and liquid (raw diesel). The raw diesel can be further refined into three products (road diesel, kerosene and light oil). Cynar claims that the plant will be able to process agricultural plastics such as those used for plastic mulch.

Gasification

Gasification is similar to pyrolysis but uses a small amount of air in the heating process. Hydrocarbons are broken down into a syngas by carefully controlling the amount of oxygen present. Gasification technology appears to be subject to significant research and commercial effort and investment, perhaps due to the possible synergies with sequestration of clean char in soil.

The advantages gasification has over incineration include:

- Flue gas cleaning can be performed on the syngas instead of flue gasses after combustion of which there are much larger volumes;
- Electric power can be generated in engines and gas turbines, which are cheaper and more efficient than the steam cycle used in incineration.

A significant amount of energy is required to process the waste and clean the gas and this offsets to a significant extent the high efficiency of converting syngas to electric power. Although several waste gasification processes have been proposed, the few that have been built and tested processing real waste are doing so using fossil fuels. As an example, a plant in Chiba, Japan, has been operating since 2000, but has yet to produce any documented positive net energy.

4.4.4 Issues

There are a number of barriers to the uptake of alternative waste technology (AWT) and in particular the use of these new technologies in managing plastic waste from vegetable farms. These include:

The relatively low cost of landfill in many areas

The highest barrier for the uptake of AWT is cost. In order for the pyrolysis process to be commercially viable, the plastic waste needs to be obtained for free, or a gate-fee charged. Pyrolysis plants also require a consistent 'un-mixed' feedstock in order to create suitable energy products. However the nature of waste streams mean that feedstocks are often scattered and not homogenous, incurring significant expenditure in collection, transportation and separation of materials. When compared to the current costs of landfill, AWT such as pyrolysis is not a cost effective option despite the environmental benefits.

Lack of cooperation between councils

The high cost of AWT processing means that AWT facilities operate more efficiently and with lower costs per tonne if certain quantities of waste are processed through them. Individual councils cannot often provide these quantities so AWT facilities usually must accept waste from more than one council. This is particularly true in regional areas where individual councils are unable to generate the large quantities of waste required for economies of scale. Signing a joint processing contract for significant sums of money over a long time frame requires a considerable commitment from councils to work together.

Distrust of alternative waste technologies

The largely unproven nature of these technologies presents one of the greatest risks and many decision makers remain unconvinced that the solutions proposed are significant enough to warrant taking on the extra risk. These waste management systems come at a higher cost and long-term financial commitments are generally needed to cover the capital and operating costs.

Other barriers include community concerns and environmental regulation. Communities are typically concerned about the environmental performance of technologies, particularly thermal treatments and their emissions. Regulation is also often complex, with a number of different government authorities responsible for development approval and regulation.

4.4.5 Facilitating the uptake of alternative waste technology

To improve the commercial viability of AWT the costs associated with collecting and sorting waste streams needs to be reduced. Tapping into the resources of the community to assist in collecting, transporting and sorting wastes offers huge potential to recover resources. Options could include:

- Providing financial incentives in the form of cash or credit vouchers to private individuals or businesses that transport materials from generation points to the likely location of high technology plants (large regional centres or cities).
- National product stewardship and extended producer responsibility schemes, such as drumMUSTER, which require manufacturers of certain products and by extension their distributors and retailers to take responsibility for the recovery of these products after use. Future product stewardship schemes could operate outside the normal waste collection chain or as part of it. Municipal and commercial transfer stations, AWT facilities and other waste disposal facilities are obvious and easy collection points for items subject to Extended Producer Responsibility (EPR) schemes, negating the need for separate purpose-built receiving centres.

4.5 Environmental impacts of photodegradable plastic

4.5.1 Overview

The implication of the cost-effectiveness assessment of plastic mulch options is that degradable mulch may significantly increase in use by the horticultural industry in the next few years if shortcomings associated with its use are overcome. One clear gap in information highlighted by this report relates to the environmental performance of degradable plastics.

4.5.2 Degradable plastic products

Degradable plastics disintegrate on exposure to certain triggers such as sunlight (UV radiation), heat, oxygen, moisture, chemicals and microorganisms. Depending on the chemical properties of the plastic, the material will degrade up to a certain extent, under a set of conditions, within a certain time frame. Degradable plastic can then be classified into two categories: biodegradable or photodegradable.

Biodegradable plastics are degraded by naturally occurring microorganisms (bacteria and fungi), which feed on the product and mineralise it completely, leaving no toxic residues.

Photodegradable plastic differs from biodegradable plastic in that the breakdown of the product is a fragmentation process resulting from a chemical reaction. Subsequent biodegradation of photodegradable plastic (after fragmentation) is disputed with very few positive results obtained (and those results which were positive could not be repeated under the same conditions by the same author or others).[27,28] A recent article in Vegetables Australia highlights the lack of information on the environmental impact of these products on soil health, the time taken for the product to disintegrate and the lack of clarity in labelling.[29] Until further information is known on these factors it is likely that confusion within the industry on the best way to manage photodegradable plastic will continue.

The primary benefit of degradable plastic to growers is the ability to leave it in-situ after production on the assumption that it will break down. Thus removing the cost associated with removal and disposal. However as discussed above the level to which this product degrades and its potential impact on soil health is unclear. Photodegradable plastic also presents a number of challenges for traditional disposal options as discussed below.

Landfill Issues

Disposal to landfill is not recommended for photodegradable plastic as it will not fragment below a depth of approximately 15 cm due to insufficient oxygen for the chemical reaction to occur.

In addition to additives that trigger the fragmentation process, photodegradable plastic also contain stabilisers, which are added to limit the unwanted fragmentation of the polymer chains whilst the plastic is being used. However, the stabilising effect of the additives is limited. Research studies have concluded that "even with some content of stabilising additives, PE film (with 'oxo-biodegradable' additives) loses its

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[27] Project Gutenberg (no date) Oxo-Biodegradable, World Heritage Encyclopedia (contributers) licensed under CC-BY-SA, http://self.gutenberg.org/articles/oxo-biodegradable, accessed 16 April 2015
[28] Deconinck, S. and De Wilde, B (2013) Benefits and Challenges of Bio- and Oxo-Degradable Plastics. A comparative Literature Study
[29] Sangwan, P. (2015) Weeding out the issues in weed mat plastics, Vegetables Australia, March/April 2015

mechanical properties rather fast, especially when exposed to sun-light.[30] For this reason, different storage conditions are required in order to prevent premature ageing and loss of mechanical properties.

Recycling Issues

Photodegradable plastic pose an additional disposal problem due to potential contamination of the recycling process. In practice the oxo-biodegradable plastics are considered the same as traditional plastics, the only difference being the incorporation of additives that affect their chemical stability. Thus, they are identified and classified according to their chemical structure and finish together with the other plastic waste in the recycling streams. In this way, they bring their degradation additives to the recyclate feedstock. As a consequence the recyclates may be destabilised, which will hinder acceptance and lead to reduced value.[31]

4.5.3 Environmental Impact

As noted, no compulsory certification exists for biodegradability in Australia, although a voluntary standard does exist (AS 4736–2006)[32]. Research undertaken for this report produced some work in Australia on the impacts of petroleum-based plastics on the marine environment, but there are significant unknowns about the contamination impacts of photodegradable plastics on the environment. It is particularly important that this information be determined for the sensitive waterways of the Great Barrier Reef.

The ability of photodegradable plastic to completely degrade in the soil has yet to be demonstrated. As a result there is substantial risk of accumulation of persistent substances in the environment.

The environmental impact of photodegradable plastic on the environment, particularly in relation to its effect on soil properties, has not been well studied. More is known on the impact of plastic fragments in the marine environment, where it has been shown that through the impact of wind or precipitation the plastic fragments can drift into aquatic or marine habitat where they negatively affect organisms and pose the risk of bioaccumulation. Of particular concern are micro plastics that are generally between 1 and 5mm in size.

Studies conducted by James Cook University researchers have demonstrated that coral, turtles and sea birds that ingested micro plastics suffered blockages to their digestive tracts and had their feeding patterns affected.[33] Other studies have shown that degraded plastics can accumulate toxic chemicals such as polychlorinated biphenyls (PCB), dichlorodiphenyldichloroethylene (DDE) and others from the environment and act as transport medium in marine environments.[34] Such persistent organic pollutants in the marine environment were found to have negative effects on marine resources.[35]

Vegetable production in the Port Phillip and Westernport region (VIC), Burdekin and Burnett Mary region of Queensland pose a significant risk to the marine habitat due to their proximity to the ocean. In particular management practices in the latter areas can have a direct impact on the Great Barrier Reef (GBR) due to the potential for high levels of run-off. The Caring for our Country Reef Rescue program has

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focused on reducing the amount of nutrients, chemicals and sediments entering the GBR by supporting land managers to adopt practices that improve the quality of water leaving their properties. While a reduction in sediment is likely to assist in reducing the movement of plastic fragments in waterways, there is little information available on the mobility of fragmented plastic and the extent to which transfer from vegetable producing areas into the ocean is an issue.

Agricultural studies conducted in Africa and Europe have identified some of the effects of plastic fragments on soil properties and subsequent crop development. These include observations that the addition of plastic granules to soil decreases soil porosity, leading to reduced water infiltration into the soil, reduced aeration and poor root penetration. In combination with a potentially negative effect on nutrient exchange, the growth of plants grown in soil containing plastic fragments is likely to be reduced.[36,37,38] The addition of plastic fragments is similar to increasing the bulk density of the soil. Plants grown in soil with a high bulk density can become stunted and drought stressed during dry years due to decreased root growth. Vegetable production in soils of high bulk density will require producers to employ practices such as continuous no-till, cover crops, compost application and diverse rotations in an effort to improve organic matter and reduce compaction.

A study of soil and water quality at a dumpsite in India revealed that chemical components like heavy metals, chloride and phthalates migrate from plastic waste into the surrounding medium because these plastic additives are not chemically bound to the polymeric chain remaining freely mobile and leachable. These additives can migrate from soft plastic into the environment due to physio-chemical exertion and microbial degradation. The leachate can cause considerable pollution problems by contaminating the surrounding soil, ground or surface waters.[39]

Although initial research indicates that fragmentation of plastic within the soil is likely to impede plant development and increase chemical contamination, these studies are rudimentary and limited. Further research is required to confirm these early results (on a range of soil properties) and to establish:

- The relationship between the volume of plastic within the soil and subsequent impacts on plant growth i.e. what volume of plastic is required to impair plant development?
- Likely movement of plastic fragments i.e. if photodegradable plastic is left in the ground to breakdown what is the expected spread of resultant fragments?
- The rate and type of chemical pollution as a result of additives moving away from plastic fragments into the soil, and what affect this may have on plant development.

Given the issues with disposal of photodegradable plastic, and the potentially negative impact of photodegradable plastic fragments on the environment, it is recommended that its use in the production of horticultural crops is limited until further research has been conducted.

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5 Evaluation and Discussion

5.1 Lessons and relevance to the vegetable industry

5.1.1 Key findings

This analysis has explored the use of a variety of plastics used on-farm in the Australian vegetable industry, producing a number of key findings. These are discussed below.

Plastic waste

- The main plastics considered a problem to growers are plastic mulch and drip line irrigation, which are annual use plastics that occur in large volumes where they are used. Other plastics such as permanent irrigation plastic, chemical drums, and seedling trays represent either small annual volumes per farm or have their own reuse or recycling supply chain.
- While recycling supply chains exist for most plastic types, particularly drip line irrigation and plastic drums, a recycling supply chain for plastic mulch has not yet developed. This is because the current commercial cost of decontamination does not render this product cost-effective to reprocess.

Alternative products

- Plastic mulch has alternative products to the single use disposable plastic product that is the current industry standard. These alternatives do not require removal and disposal as they degrade on the crop area:
  - Biodegradable plastic mulch products are typically made from starch and other biodegradable inputs which if certified to the biodegradable plastic standard (AS 4736) will completely mineralise
  - Photodegradable plastic mulch products are formed from traditional petro-based polymers with the addition of a degrading agent and will also degrade on-site.
- Trials of biodegradable and photodegradable mulch products have produced mixed results, with the analysis suggesting that some biodegradable products are sufficiently effective for use, but that photodegradable products are not yet ready for widespread commercial application.
- When the full costs of plastic mulch collection and disposal are considered, photodegradable mulch products ($907/ha) appear to be significantly more cost effective than traditional plastic mulch ($1,114/ha landfill disposal and $958/ha illegal disposal), suggesting that when effectiveness of use is improved, photodegradable mulch use may increase significantly in Australian vegetable production. Biodegradable mulch products are currently more expensive than traditional plastic for most users ($1,444/ha).
- The environmental performance of photodegradable plastics on soils and receiving waters has to date received little attention from researchers in Australia. More attention to these impacts prior to significant uptake may be beneficial to the industry.

Recycling

- The cost-effectiveness of plastics recycling involves a comparison of the costs of collection, decontamination, sorting and transport with the international price of plastic recyclate. Low recyclate product value means that recycling is not always a feasible option.
- Plastics recycling in the vegetable sector is particularly challenged by the geographical spread of farms and their distance to ports or recycling centres, the timing of that plastic availability which may

differ by farm and by crop, the contamination load or cost of decontamination, and lack of information in the supply chain.[40]

- Most plastic recycling from the vegetable sector requires funding beyond the product value of the plastic, although some examples of self-funding supply chains do exist (particularly for drip line irrigation).
- Plastic mulch is a particularly challenging product to recycle due to high contamination load and its voluminous size when collected from farm (and subsequent impacts on unit transportation costs).

In the light of these points, a number of potential options exist to improve plastics management on Australian vegetable farms. These are discussed further.

5.1.2 Education and practice change

Support for increased recycling – product stewardship

The most successful large scale agricultural plastic recycling scheme in Australia appears to be drumMUSTER, which is a 'product stewardship' scheme that is funded by four cents per litre paid by farmers for chemicals to support the system of collection and recycling of those drums at end of use. A voluntary scheme for participating chemical companies, it is highly successful and could be seen as the benchmark for other product stewardship schemes. Similar product stewardship schemes for silage wrap exist in Ireland[41] and New Zealand.[42]

The obvious option for such a scheme would be drip line irrigation, which is produced by a small number of companies in Australia (one of which, Netafim, has its own product stewardship scheme), and is already economic to recycle in some areas. Such a scheme could involve an up-front cost added to drip line irrigation at purchase, which is used to fund the recycling of drip line irrigation at end of life.

Other plastics such as mulch may be more problematic options for product stewardship schemes, given that current costs of recycling are seen as prohibitive (discussed further below).

5.1.3 Connecting supply chain and information flow

Improved information sharing – FARM MUSTER

As noted above, one key challenge for plastics recycling supply chains is imperfect information about the volumes and locations of plastics that might be recycled, and about the supply chains of plastics recovery across Australia. Growers may be unaware of the recycling opportunities in their region, and plastics collectors may be unaware of available plastics on each farm in a region. This could impede the development of supply chains. FARM MUSTER is a national scheme which aims to improve the collection and sharing of information on different types of farm wastes include plastics.

Support plastic mulch recycling technology development

The aforementioned options will assist the development of recycling supply chains for some plastics, but may not overcome barriers to management of some of the more challenging plastics. Plastic mulch

[40] Growers may not have information about parties interested in retrieving plastics from their farm, and plastics collectors may be unaware of each farm's plastic waste on a supply route.
[41] http://new.farmplastics.ie/
[42] http://www.plasback.co.nz/ Plasback has also been launched in Australia, however the larger transport distances have impeded its cost-effectiveness

appears to be the most significant problem for the vegetable industry, given that recycling is extremely limited or non-existent. Continued research into biodegradable and photodegradable mulch should be supported.

5.2 Effectiveness and impact

5.2.1 Within the project

It is difficult to determine the effectiveness of a project of this type given that it was focused on assessing the feasibility of plastic waste management. In this scoping phase, the project team have undertaken work which positions the industry to determine what next steps it should take.

The project has resulted in:

- Determination of the scale of the plastic waste problem
- Identification of a range of current and alternative solutions to deal with plastic waste and some of the possible risks
- Analysis of the likelihood of uptake of plastic recycling based on economic assessment.

Importantly, the project has enabled the connection of networks from both the horticulture and waste processing industries. It is important that both sectors have a better understanding of the key drivers and barriers for the use of plastics, alternative options and their potential for recycling.

5.2.2 Beyond the project

The focus on networks and relationships has facilitated discussions that will be enduring following the completion of the project. These activities include:

- Connections have been made between plastic processors, Recycling Design and Technologies (RDT) in QLD, and the Victorian Strawberry Industry Development Committee to advance the issues with plastic mulch particularly clustered in the Yarra Valley region of VIC
- Participation in the Bundaberg Agricultural Plastics Collaborative Workshop, 27 May 2015, Bundaberg, QLD run by Australian Institute for Commercialisation to further develop the potential for plastic recycling in Queensland horticulture regions
- Discussions with Sustainability Victoria (SV) to explore how they can implement policy objectives to improve the recycling of plastic (and more broadly encourage the adoption of the waste hierarchy) for horticulture producers in the peri-urban regions of Victoria.

5.3 Appropriateness and efficiency

The feasibility study brought together experts from both the vegetable and plastic processing industries. This was a strength of the team, enabling perspectives of the different sectors to be readily understood. In addition, the team included members with agronomic, environmental and economic skills. These combined skills ensured that we could determine the benefits and challenges of current plastic uses, and assess the potential feasibility of new technologies and/or changes to practices.

We consider that this skills mix ensured that the project was delivered efficiently and focused on the important issues.

6 Conclusions and recommendations

6.1 Conclusions

This project

It is clear from our discussions with growers and plastics industry participants that on-farm plastics management is not a major concern for all growers, but is an issue that affects all growers to varying degrees. Those growers using a larger share of plastics, especially plastic mulch, will be particularly interested in a low cost solution to their plastic management problems.

While not a pressing concern to all vegetable growers, a solution to the plastic management challenge is not straightforward:

- Disposal of on-farm plastics by burning or burying is illegal but essentially costless to those who are willing to do so regardless of laws, which are difficult to enforce in regional areas.
- Supply chains exist for some plastics processing in some areas, particularly larger horticultural areas that are closer to processing plants and ports. The cost-effectiveness of recycling is determined by these factors and others, such as the international price of plastic and plastic recyclate. These elements are not easily influenced by Government or HIA.
- Technological barriers also exist in the processing of some key plastics, particularly plastic mulch. The cost of decontamination is currently seen as the main barrier to cost-effective reprocessing, however a number of technological advancements are being developed to address this.
- Another technological solution – the development of a photodegradable plastic mulch product – has practical limitations and questions over environmental performance, which require further analysis.
- Lack of information held by processors about on-farm plastic availability, and by growers about plastics collectors operating in their area, is another barrier to better supply chains for on-farm plastic waste. The recently developed FARM MUSTER program may help overcome this barrier.

Future scenarios

A number of factors will influence the future of plastic management on vegetable farms:

- Monitoring and compliance: burning and burying are typically considered the most attractive alternatives to best practice management of on-farm plastics. However, these practices are typically prohibited by law. While these practices are well understood to be illegal, anecdotal evidence suggests they are not unusual across the industry. Enforcement action by environmental protection agencies is historically rare, but an increase in enforcement activity could significantly influence future activities in this area.
- International price of plastic: the future cost of plastic and recycled plastic is uncertain. Prices are volatile and are influenced by petroleum prices and global economic growth. A significant increase in plastic prices over time can be expected to drive up the price of plastic recyclate and improve the cost-effectiveness of on-farm plastic recycling.
- Technological development: the main on-farm plastic for which a current solution does not yet exist is plastic mulch, which has proven prohibitively costly to decontaminate for processing.
  - However, several companies are progressing technology to increase the cost-effectiveness of reprocessing and it is likely that one or more of these may significantly change reprocessing rates if successful.

  – Alternatively, biodegradable or photodegradable plastics may replace traditional methods of removal and disposal of plastic mulch over time.

- Grower attitudes: in the absence of strict monitoring and compliance of illegal activities, grower attitudes towards these activities may be a strong factor in future on-farm plastics management.
- Supply chain/logistical developments: the geographic spread of on-farm plastic and the voluminous nature of the product have made the collection and transport of plastic waste a challenge. However, improvement in logistics (tracking and collection points) and processes to reduce the volume of the plastic may improve the feasibility of recycling.

These issues suggest a range of specific recommendations, which are outlined below.

6.2 Recommendations

The following recommendations are made based on the findings, analysis and discussion from this project. These are grouped into the following themes:

- Extension and practice change
- Supply chain collaboration
- Research and development.

Table 6-1: Recommendations

#	Recommendation	Description	Who	Priority
Extension and practice change				
1	Increase awareness of appropriateness and efficacy of different plastic products	Many different products exist on the market and the description of their benefits can be both confusing and in some cases misleading. It is important that the industry plays a role in clearly describing the appropriateness and efficacy of different products including their costs and benefits. Publication of extension materials through existing AUSVEG channels would assist.	HIA, AUSVEG	High
2	Link EnviroVeg program to state-based environmental organisations	There is an opportunity to promote EnviroVeg as the flagship program of the vegetable industry that encourages growers to adopt better practice and move up the waste hierarchy. In addition, there are reasonable policies and strategies in place to deal with waste through state environment organisations (EHP/EPA) and NRM groups. These groups are generally interested in exploring options to progress plastic recycling with the industry.	HIA, AUSVEG to facilitate, state-based environmental organisations	Medium
Supply chain collaboration				
3	Participate in FARM MUSTER	FARM MUSTER is a program that could possibly address the logistical challenges associated with the collection and	HIA, AgStewardship Australia	High

#	Recommendation	Description	Who	Priority
		management of plastic waste and provide a solution to broader waste problems. HIA could potentially participate as an industry partner to encourage member uptake. We suggest that the involvement and opportunities with AgStewardship Australia for management of waste (including plastics) be investigated further.		
4	Ensure fit-for-purpose plastic products	The horticulture industry has specific needs when considering the type of plastic that is appropriate. This differs for individual commodities and regions and includes specifications such as strength, duration and efficacy. The agronomy of the particular commodity will also drive specific requirements. It is important that the industry work with plastic processors during the development of biodegradable and photodegradable plastics to ensure that their needs are met.	HIA, plastic producers	Medium
Research and development				
5	Undertake further research on impact of photodegradable plastics on the environment	One of the particular concerns highlighted in this study was the potential impact of photodegradable plastics on the environment. There is little known about the longer-term environmental effects, which could significantly influence their appropriateness for the vegetable industry (particularly in environmentally sensitive regions). This issue is one that is relevant to all agricultural industries and may lend itself to collaboration with CSIRO or universities.	HIA, research providers	High
6	Consider investing in recycling technology	Additional technology is currently being developed that could make the reprocessing of plastic mulch a more feasible option. This technology includes the pre-processing of plastic using new advances associated with decontamination and compression technology. Whilst companies are currently exploring these technologies, state environment associations (e.g. Sustainability Victoria) also have a keen interest in their broader uptake. HIA may be able to invest in research and development of these technologies.	HIA, plastic processors	Medium

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Appendix 1: Consultation details

Type	Position	Organisation	Date
Industry	Portfolio Manager	Horticulture Innovation Australia	Sep-14
Industry	Industry Services Manager Vegetables	Horticulture Innovation Australia	Sep-14
Industry	Consultant	Plastics and Chemical Industries Association	Sep-14
Industry	Training Manager	Irrigation Australia Limited	Dec-14
Industry	Board Member	Irrigation Australia Limited	Dec-14
Industry	Agronomist	Applied Horticultural Research, NSW	Nov-14
Industry	Director	D3 Consulting Group	Dec-14
Industry	Operations Manager, Greenlife	Boomaroo Nurseries	Dec-14
Government	Economist	Department of Agriculture, Fisheries and Forestry, QLD	Oct-14
Government	Officer	Department of Agriculture, Fisheries and Forestry, QLD	Oct-14
Government	Senior Horticulturalist	Department of Agriculture, Fisheries and Forestry, QLD	Oct-14
Government	Officer	Department of Environment and Heritage Protection, QLD	Dec-14
Grower	Owner/Operator	Jurgens Produce, QLD (capsicum, chilli)	Nov-14
Grower	Manager	Mulgowie Farms, QLD (sweet corn, beans, capsicum, brassica)	Nov-14
Grower	Manager	Center West, WA (carrots)	Oct-14
Grower	Owner/Operator	Corrigan's Produce Farms, VIC (lettuce, celery, pak choy, leeks, silverbeet, kale)	Nov-14
Plastic provider	Business Development Manager AUS/NZ	Netafim	Nov-14
Plastic provider	Agronomist	Netafim	Nov-14
Plastic provider	Manager Environmental Division	TAPEX / Plasback	Nov-14
Plastic provider	Dealer Development Manger	John Deere Water	Dec-14
Plastic processor	Officer	Polytrade, VIC	Nov-14
Plastic processor	Officer	BDM / GT Recycling, VIC	Nov-14
Plastic processor	Officer	Replas, VIC	Nov-14
Plastic processor	Officer	SKM Recycling, VIC	Nov-14
Plastic processor	Officer	Plastic Forests, VIC	Nov-14

Type	Position	Organisation	Date
Plastic processor	Officer	Drums Go Round, NSW	Nov-14
Plastic processor	Officer	ASTRON, VIC	Nov-14
Plastic processor	Officer	Tamworth Recycling, QLD	Nov-14
Plastic processor	Regional Consultant	drumMUSTER, VIC	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	VIP Packaging, VIC / NSW / SA / QLD	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	Challenge Recycling, NSW	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	NT Recycling Solutions, NT	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	Anuha Services, QLD	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	Hassle Free Recycling, QLD	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	CLaW Environmental, WA	Nov-14
Plastic processor	Officer, drumMUSTER approved processor	Plastic Recyclers International, SA	Nov-14
Plastic processor	Officer	Vanden Recycling, VIC	Nov-14
Plastic processor	Officer	IR Composite, VIC	Nov-14
Plastic processor	Engineer	Recycling Design Technologies (RDT), QLD	Nov-14
Plastic processor	CEO	AgStewardship Australia / FARM MUSTER, ACT	Dec-14
Plastic processor	Officer	PLASREC, VIC	Dec-14
Alternative products	Officer	Australian Institute for Commercialisation, QLD	Dec-14
Alternative products	Regional Market Development Manager	BASF, VIC	Dec-14
Alternative products	Manager	Australian Bio-Plastics, VIC	Dec-14
Alternative products	Officer	DC Enviroplas, SA	Dec-14
Alternative products	President	Australasian Bioplastic Association, VIC	Dec-14
Total	**46**		

Appendix 2: Communications summary

RMCG
Environment | Water | Agriculture
Policy | Economics | Communities

Innovative Ways to Address Waste Management on Vegetable Farms

Communication Summary

Horticulture Australia Limited

September 2014

A number of recent projects have been undertaken to explore the feasibility of alternative waste management systems on Australian vegetable farms, including biogas generation feasibility (VG13049) and another exploring the creation of fish food for aquaculture (VG13050) – both using organic vegetable waste.

Plastics are used in a variety of ways on vegetable farms due to their suitability and versatility. However, there are some challenges in the disposal and recycling at end of life.

This project, being delivered by RMCG and DJR Environmental, aims to engage with the industry, growers and plastic processing providers to:

- Determine the key sources, management, volume and cost of on-farm plastic by state and growing region
- Identify different plastic processing opportunities, financial costs and benefits and associated logistics of each option
- Assess the feasibility of available and emerging processing opportunities for on-farm plastic waste.

The following plastic products will be the focus of the project:

- Seedling trays, bed trays and produce boxes (expandable polystyrene [EPS])
- Plastic mulch sheeting, poly tunnels, protective housing, netting and shade cloth (polyethylene [PE])
- Irrigation pipe and chemical drums (polypropylene [PP]).

This project will enable the Australian vegetable industry to consider plastic use and recycling through a streamlined whole-farm approach, contributing to continuous improvement in farm management practices, efficiency and sustainability.

For further information please contact Kym Whiteoak on (03) 9882 2670 or kymw@rmcg.com.au.

Appendix 3: Maps of plastic quantities by product and region on vegetable farms

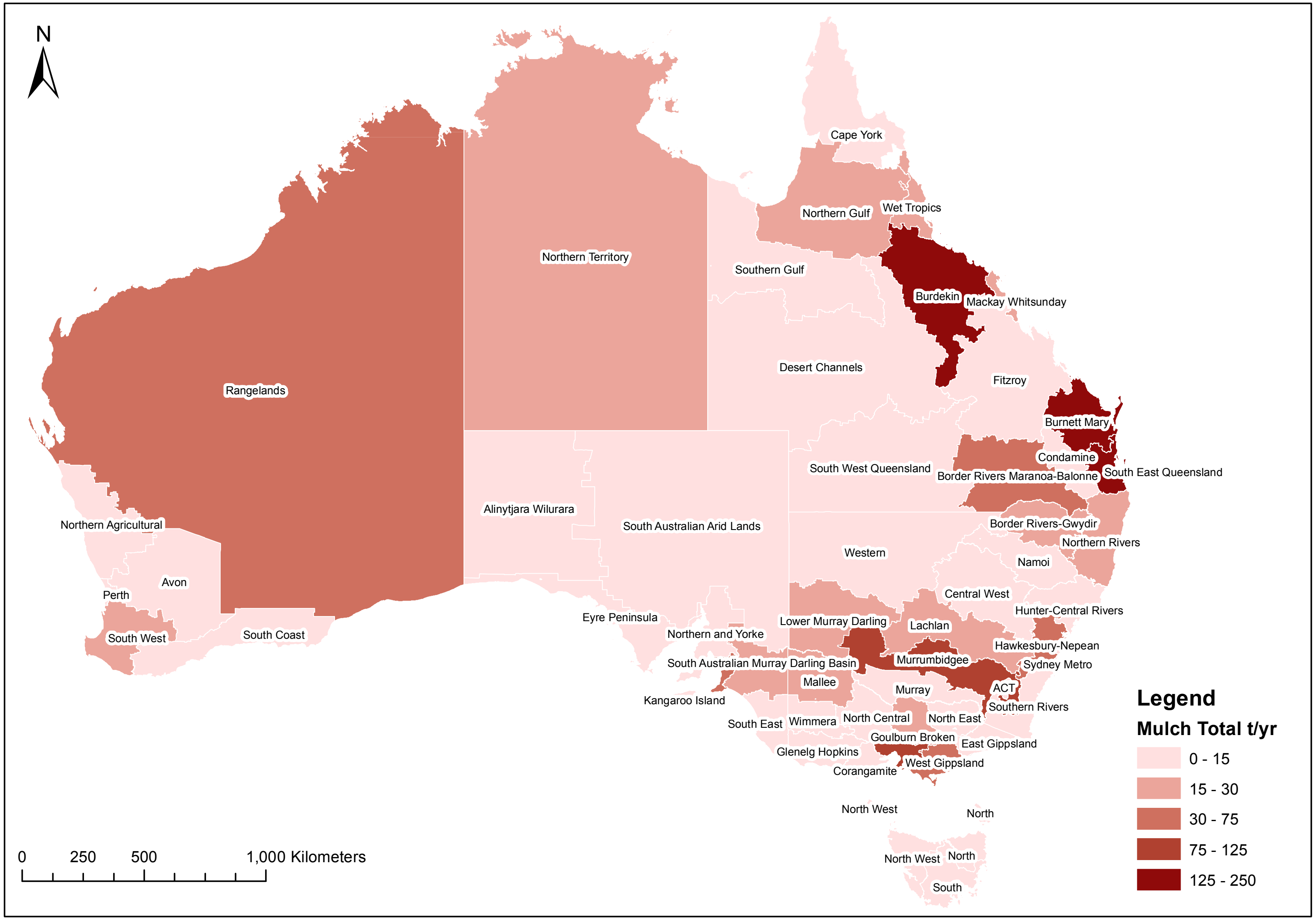

Figure A3-1: Heat map of plastic mulch sheeting use by NRM region on vegetable farms

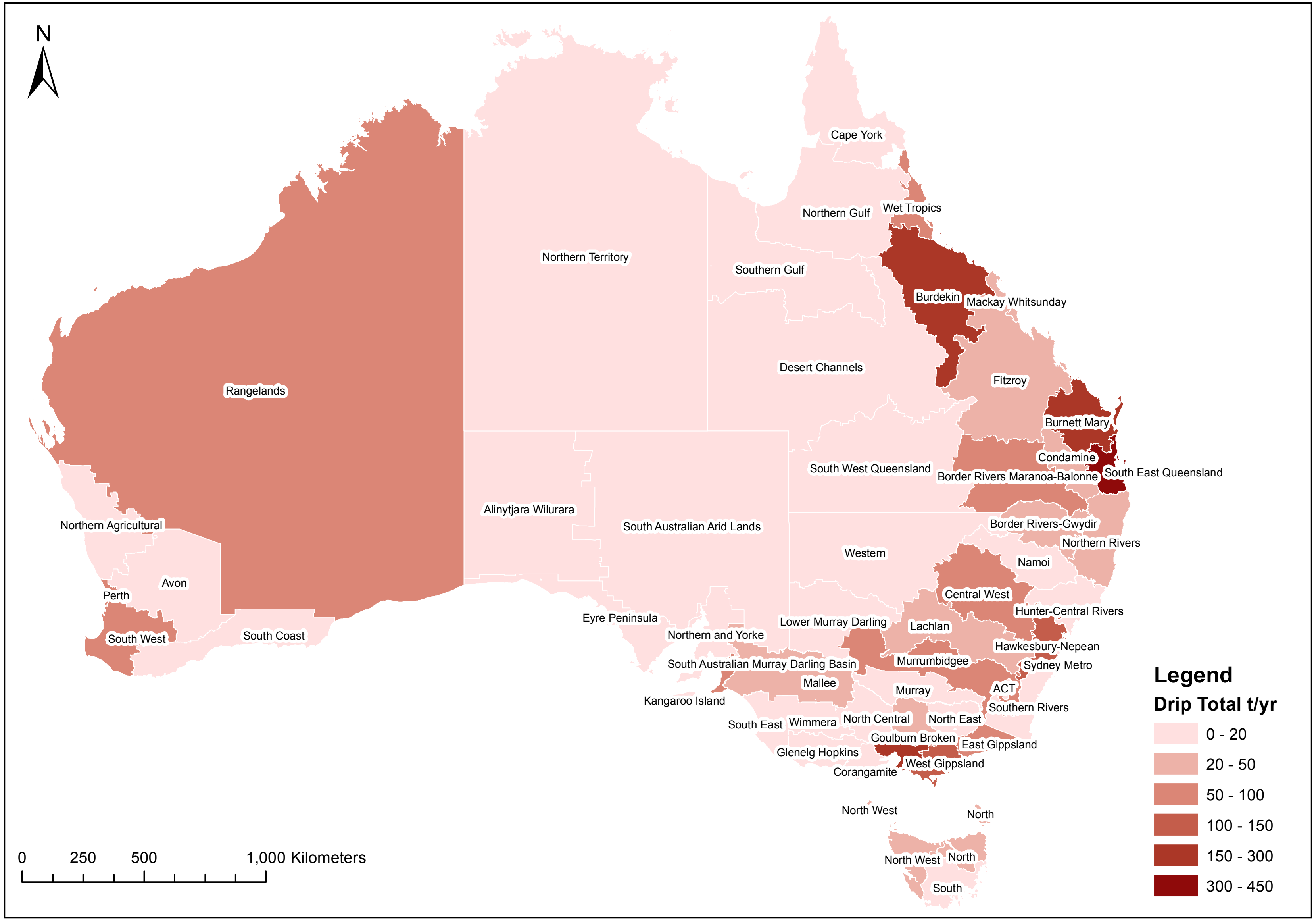

Figure A3-2: Heat map of plastic drip irrigation use by NRM region on vegetable farms

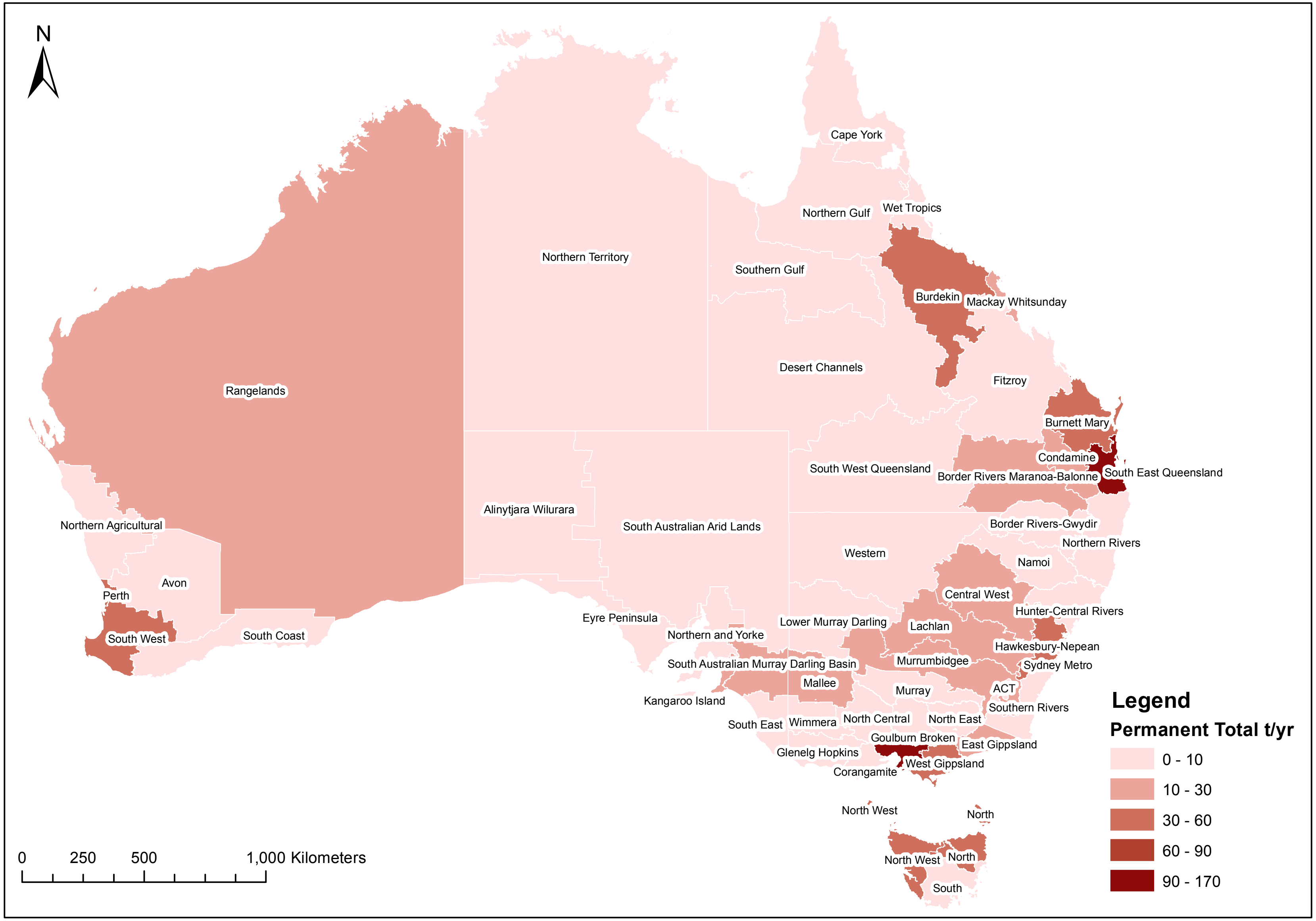

Figure A3-3: Heat map of plastic permanent irrigation use by NRM region on vegetable farms

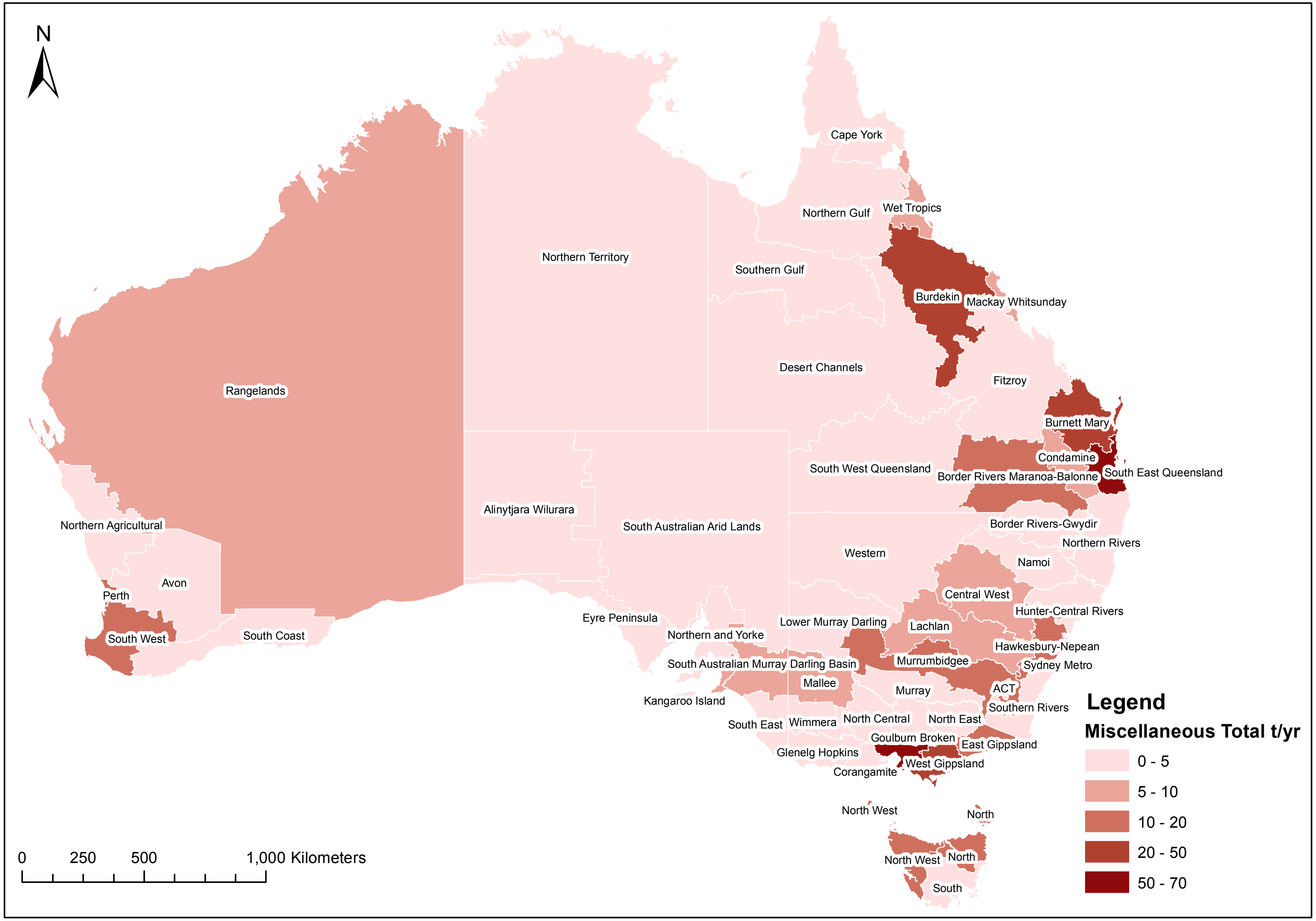

Figure A3-4: Heat map of miscellaneous other plastic use by NRM region on vegetable farms