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Sustainable and Secure Food Systems for Victoria

What do we know? What do we need to know? (Summary)

VEIL Research Report: No. 1 | April 2008

The Victorian Eco-Innovation Lab is a Victorian Government Initiative through *Our Environment Our Future - Victoria's Sustainability Statement 2006*

Sustainable and Secure Food Systems for Victoria: What do we know? What do we need to know?

VEIL Research Report No.1
(Summary)

April 2008

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The Victorian Eco-Innovation Lab (VEIL)

The Victorian Eco-Innovation Lab (VEIL) seeks to identify and promote emerging technical and social innovations that could form part of future sustainable systems. VEIL also creates conditions to explore emerging ideas and stimulate new ones.

VEIL was established through *Our Environment Our Future – Victorian Sustainability Statement 2006* and is funded through the Victorian Government's Sustainability Fund. The project is a partnership between the University of Melbourne, Monash University and the Royal Melbourne Institute of Technology (RMIT), and is led by Professor Chris Ryan. The VEIL project is part of the Australian Centre for Science, Innovation and Society, in the Faculty of Land and Food Resources, University of Melbourne.

Workshops involving policy officers from across the Victorian Government were held in early 2007 to identify priority areas for eco-innovation in Victoria. A key theme arising from these workshops was concern about the sustainability (and security) of the food system in Victoria and consequent possibilities for innovation. The need to understand the environmental impacts of food and the risks that these present to food security set the directions for the first 'policy challenges' research project for VEIL.

This report forms part of a larger work program envisaging sustainable systems for Victoria – see www.ecoinnovationlab.com and www.sustainablemelbourne.com for more information.

Both this summary document and the full report are available online at:
www.ecoinnovationlab.com/pages/library.php

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1. Overview

This report provides an overview of our food production and consumption system, its impacts on the environment, and its vulnerability to environmental problems and resource constraints. The aim of the report is to identify any significant challenges to the future security of the food system in Victoria, that arise from environmental and resource issues, and the risks, constraints and social or political responses to these. The report also considers a range of response strategies being developed and explored at various points across the food system.

Upon completion, this work will be circulated as a discussion paper to researchers, government policy officers, and other stakeholders. This is intended to inform and stimulate:

- Clarification (confirm or modify) the set of expected policy challenges;
- Policy responses and program development where sufficient evidence exists;
- More detailed studies (further research) where evidence or further investigation is needed; and
- Collaboration across complex issues in the food system.

The *'food system'* includes the interdependent parts of the system that provides food for local consumption and for export. It includes all the components and processes by which food is produced (grown and/or processed), stored and distributed, delivered to end-consumers and consumed (including further processing and storage) – as well as all the processes that deal with waste along the 'food chain'.[1]

'Food security' has been described as "the state in which all persons obtain nutritionally adequate, culturally acceptable, safe foods regularly through local non-emergency sources."[2] The Victorian Government's investment in food security focuses on regular access to healthy eating, noting that access is fundamentally dependent on secure food supplies.[3] The policy objective of food security requires attention to potential risks and challenges to the ongoing security of food supplies for all Victorians, where 'security' refers both to 'provision' and to 'access'.

As highlighted in Cribbs' discussion paper, which attracted wide publicity in Melbourne in January 2008, food security is being increasingly challenged by resource constraints (eg. water, energy, land, oil, agricultural inputs) and environmental risks such as climate change.[4] Significant concern about food security and supply in the UK has stimulated numerous investigations, including scoping papers such as *UK Food Supply: Storm Clouds on the Horizon?*[5] and the Prime Minister's Strategy Unit investigation into food.[6] The possible impacts of resource constraints and environmental risks on the Victorian food system, and food security, are examined throughout this report, guided by reference to research and policy development occurring in other comparable economies.

Policy responses to environmental risks, and the need to reduce the environmental impacts of the food system, will also present challenges. For example, the impacts of climate change are already (and will continue to be) a significant driver for change in production of food. But the

[1] Cornell University (2008), *Discovering the Food System - Glossary*, accessed 1 February 2008, http://foodsys.cce.cornell.edu/glossary.html.
[2] Community Food Security Coalition (1995), cited in VicHealth (2005), *Healthy Eating - Food Security: Investment Plan 2005 - 2010*, Victorian Health Promotion Foundation, accessed 1 February 2008, http://www.vichealth.vic.gov.au/assets/contentFiles/VicHealth%20Food%20Insecurity%20Investment%20paper.pdf.
[3] VicHealth (2005), *Healthy Eating - Food Security: Investment Plan 2005 - 2010*, Victorian Health Promotion Foundation, p2
[4] Cribb, J. (2007), *The Coming Famine: Constraints to Global Food Production in an Overpopulated, Affluent and Resource-Scarce World: The Scientific Challenge of the Era*, Julian Cribb & Associates Discussion Paper, October 2007, http://www.apo.org.au/linkboard/results.chtml?filename_num=190252.
[5] Chatham House (2008), *UK Food Supply: Storm Clouds on the Horizon?*, Chatham House UK, http://www.chathamhouse.org.uk/publications/papers/view/-/id/593/.
[6] To report to the Prime Minister in Spring 2008, see UK Cabinet Office (2008), *Food: An Analysis of the Issues*, The Strategy Unit, London, http://www.cabinetoffice.gov.uk/strategy/work_areas/food_policy.aspx

social and economic adjustments aimed at mitigating climate change (e.g. emissions trading) will themselves become pressures for the food system.

There are other non-environmental pressures on the existing food system for Victoria with possibly significant consequences such as the health and wellbeing of the community. The role of food production systems, consumption patterns and food-processing, on diet and nutrition, have been the subject of interdisciplinary research in Victoria and are under further investigation elsewhere. This area is addressed briefly in this document, but only to identify possible intersections of the health and environmental implications of the food system.

1.1. Scope and Status of this Report

This report is primarily a 'mapping' of information sources across the food system, to provide a sense of "what we know" and "what we need to know". Research has involved literature scans, selective interviews and correspondence with researchers and research groups, as well as some consultative workshops. It has also drawn on secondary sources including general media to map social concerns and awareness about food sustainability issues.

1.2. Structure

The report is structured with three main sections

Section 1 is an overview of the document. It provides an overview of the background to the report, its scope and structure, why the food system is the focus of study. It outlines the key challenges and possible directions identified in the course of doing this work.

Sections 1 also describes the current state of the food system in Victoria, summarising data and analysis already well understood and regularly reviewed in the course of government economic and agricultural research and analysis.

Section 2 discusses the most significant environmental challenges relating to the food system, both:

- The **impacts** of the food system on the environment; and
- The **risks** and **vulnerabilities** of the food system to environmental change, and associated technical, social and structural responses.

Section 2 provides an overview of issues relating to: direct impacts of climate change; energy, greenhouse emissions and responses to these; resource constraints such as water, land, oil and agricultural inputs and depleted stocks (eg. fish); biodiversity (ecological and agricultural); waste; and health and nutrition.

Section 3 presents an overview of strategies being developed or employed to manage environmental risks to the food system, and reduce impacts on the environment. It considers the extent of their potential contribution (identifying any empirical evidence that exists), and opportunities for further investigation or support.

This includes an overview of some emerging technologies, the result of well-funded and directed research and development programs in Governments and corporations worldwide. It summarises the possible contributions of information and communications technologies (ICT), biotechnology, nanotechnology and the convergence of these developments.

Section 3 also surveys strategies being adopted by individuals and small groups of food producers, distributors and consumers, as they seek to reduce their own risk or environmental impact, and examines the potential contributions of these innovations and movements. This

section includes strategies such as low-input production, farmers' markets, preference for local and seasonal food, and changing consumer preferences.

Each chapter in Sections 2 and 3 has a summary that outlines the key points, along with subject specific 'recommendations'

In these chapter summaries, three types of 'recommendation' have been identified:

!	*Significant policy challenges*
	*Lack of evidence or knowledge – further research or work suggested*
	*Innovation opportunity*

This summary document contains most of Section 1 (the overview) along with the chapter summaries of each section of the full report. It can be read as a standalone document with the more detailed analysis as a reference.

It is expected that this level of detail will be sufficient for many readers, however those who are interested in more detailed analysis and commentary should refer to the full report (accessible via www.ecoinnovationlab.com/pages/library.php).

1.3. Why Food?

Food production is a significant part of the Victorian economy, with a direct value of $8.9 billion in 2005-6. Even more economically significant are the flow-on benefits of this production – the food processing / manufacturing industry had a value of $21.4. billion in 2005/06, the food retailing sector turned over $20.9 billion in 2005/06, and exports of agricultural commodities and value-added food products were approximately $6.8 billion (2005/06) – 36% of Victoria's total exports.[7] Altogether the food sector generates approximately 20% of Victoria's gross state product.[8]

In 2004, approximately 15% of the total Victorian labour force were employed in the food sector: 3.2% in agriculture; 2.3% in food & beverage manufacturing; 5.4% in food retailing, and 4.3% in accommodation (eg. hotels), restaurants and cafes,[9] – about 370,000 people in total.[10] These figures have decreased recent years – in November 2007 only 2.7% of the population was employed in agriculture and 2.1% in processing.[11] Employment in the food sector is vital in regional areas, accounting for over 35% of jobs in Mallee, Western District, and the Wimmera regions, and over 20% in every other region except Barwon and Melbourne.[12]

The 'normal' dynamics of growth within this sector create challenges that are well recognised and understood by industry and government. Such challenges are essentially economic, social and technological, affecting decisions about land allocation and use, production processes and distribution, markets, labour, skills, demographics and so on. Many of those issues are essentially similar to other areas of production and consumption within the economy. However, this sector of the economy fundamentally depends on (and impacts on) the state of the environment and our

[7] VCEC (2007), *Simplifying the Menu: Food Regulation in Victoria*, Victorian Competition and Efficiency Commission, accessed 21 January 2008, http://www.vcec.vic.gov.au/CA256EAF001C7B21/0/9822EDC9789AB06CA2572AE001CEAA8?OpenDocument.
[8] This figure is a rough estimate, based on various figures from a range of sources as included in Figure 1.1
[9] ACIL Tasman (2004), cited in Ibid., p89
[10] VCEC (2007), *Simplifying the Menu: Food Regulation in Victoria*, Victorian Competition and Efficiency Commission,p65
[11] Taylor, M. (2008), *Victorian Agriculture, Forestry and Fishing Industries: At a Glance 2007 (Version 3.3)*, Victorian Department of Primary Industries, pp 6 &11
[12] ACIL Tasman (2004), cited in VCEC (2007), *Simplifying the Menu: Food Regulation in Victoria*, Victorian Competition and Efficiency Commission. p89

natural capital (water, soil, nitrogen, sunlight, biodiversity and so on). It also involves goods and services with immediate impacts on human health and wellbeing. This makes managing the impacts of and risks to this sector critical to our economy, environment and society.

The food sector is particularly vulnerable to environmental constraints and to social concern and action in response to environmental and resource constraints, a vulnerability that could undermine its future economic contribution to the State. Most commonly, this vulnerability is expressed as concerns over energy and water usage, pre and post farm-gate. These concerns have been further sharpened by flow-on effects of water shortages, potential carbon costs and projections of climate change and oil scarcity. Food and drink have been found to account for 20-30% of the various environmental impacts of private consumption when the full production and distribution chain 'from paddock to plate' is counted, and much more in some impact categories (eg. 59.7% of eutrophication).[13] Food production and consumption has been estimated to account for approximately 37% of Victoria's ecological footprint, compared to goods 23%, housing 19%, services 11%; and mobility10%.[14]

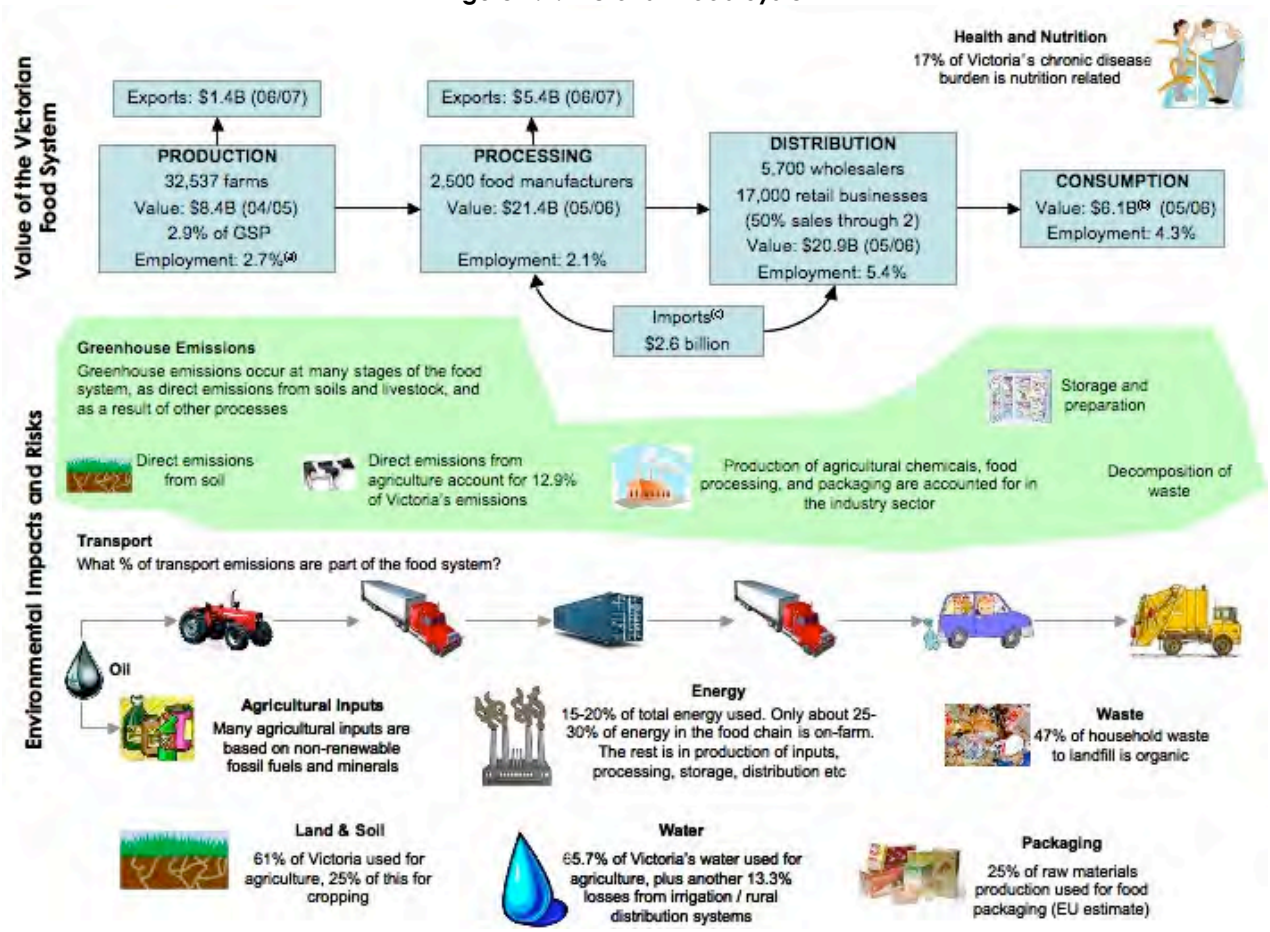
Food is essential, and will inevitably have an embedded environmental impact through its reliance on land, water and energy. However, a sustainable food system would have to be one that continues to supply the nutritional demands of the population without diminishing the stock of natural capital on which it relies. That will only be possible if there is relevant knowledge on the life-cycle impacts of the food system and if investment and policy is framed with sufficient foresight regarding environmental, technological and social trends.

Figure 1.1 maps some key statistics from throughout this report to provide an overview of the economic, social and environmental significance of the food system in Victoria. This report is intended as a contribution to maintaining a secure and sustainable food supply.

[13] European Science and Technology Observatory and Institute for Prospective Technological Studies (2006), *Environmental Impact of Products (EIPRO): Analysis of the Life Cycle Environmental Impacts Related to the Total Final Consumption of the EU25, Full Report*, http://ec.europa.eu/environment/ipp/identifying.htm, p106

[14] EPA (2005), *The Ecological Footprint of Victoria: Assessing Victoria's Demand on Nature*, Global Footprint Network & University of Sydney, October 2005 – note figures are approximate because of small differences in the methods used to calculate the eco-footprint; relativities do not change with any significance.

Figure 1.1: Victorian Food System



NB. Figures in this diagram come from throughout this report – they are drawn from a range of sources and cover different years (and different countries where Australian data is not available). Figures in the blue boxes are drawn mainly from Taylor 2008 and VCEC 2007. Values fluctuate from year to year and are intended as indicative only, not as exact proportions.

(a) Percentage of Victorian total employment, these averages are much higher in regional areas eg. employment in food production accounts for up to 22% of total employment in some areas

(b) Includes cafes, bars and restaurants, as well as turnover by hotels and clubs

(c) Reports in early 2008 state that imports have surged due to drought shortages, the strong dollar and subsidised international production - see *1.6.1 (Global Competition)*

1.4. Key Challenges for the Food System

There are four overarching challenges for the food system and food security in Victoria that have been identified; these are outlined below.

1.4.1. Reduce environmental impacts (and risks) while keeping food available and affordable.

The current food system is highly vulnerable to environmental change and resource constraints, and also has a significant impact on the environment.

Complex interactions of environmental effects and resource constraints can have significant and sometimes rapid impacts on food availability and price. Food production and prices are currently being directly affected by water shortages, climate change, oil prices, and competition for agricultural inputs and land – as well as international supply and demand.

While global food shortages and increasing international demand for food products benefit some producers and raise the value of exports, they are also making food more expensive. Access to

healthy and affordable food is already a problem for some disadvantaged groups and increasing food prices (along with housing and transport costs) will exacerbate this.

Increasing market internalisation of environmental costs will affect food prices as the food system has a significant impact on the environment. This will inevitably impact on some foods more than others, possibly reshaping the types of foods produced and consumed in Victoria. CSIRO analysis has suggested that "beef is undervalued in money terms by a factor of 5-10, if the value of the ecosystem goods embodied in its production chain are included."[15]

1.4.2. Continual adaptation to complex change

Uncertainty surrounds how, where and when the impacts of climate change, international or local emission control policies, resource constraints or ecological system breakdowns, will affect our food production and consumption capability. Environmental and resource challenges will impact on food systems in different ways and at different times, most likely with unexpected systemic impacts.

Ensuring a secure food supply, and viable food industries, under these circumstances will require attention to how the entire food system, and the productive eco-systems that underpin it, adapt to complex and often unpredictable change. Strategies to reduce risk need to encourage ongoing innovation and adaptation to new circumstances, and support *the development of flexible and resilient food systems.*

It is very difficult, but important, to consider multiple risks and uncertainties to the food system together. Separation of issues may lead to 'solutions' that are vulnerable to other risks. For example, increasing energy use to irrigate and manage water efficiently could increase energy costs and exposure to future carbon pricing. Systems that assume ongoing availability and access to cheap oil for inputs, on-farm energy, transport, packaging etc, or other non-renewable inputs, will remain vulnerable to changes in resource supply.

Individual food producers (farmers) are very adaptable – they are already responding to changing climate and resource constraints by changing what they produce and how they produce it. They are also moving out of food production altogether (a trend that may escalate if current global patterns of investment in bio-fuels continue). Many farmers are under high levels of stress from prolonged drought conditions.[16]

For all food production, there are tradeoffs between essential contributions to human diets, the energy and water demands of the product and the farm gate price.[17] Responding to new markets (eg. biofuels or almonds) can be good for individual farmers now, but could reduce the overall security of future food supply in the face of emerging risks.

1.4.3. Engaging innovation

To reduce the vulnerability of the food system to environmental (and other) challenges, all possible contributions should be explored. The scale of environmental impact reduction required (in energy, transport, emissions, water, packaging, biodiversity, land, soil etc) calls for careful consideration of every existing and emerging technology, technique and/or social and organisational innovation that might reduce risk and vulnerability, and contribute to a more sustainable food system.

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[15] Foran, B., Lenzen, M., and Dey, C. (2005), *Balancing Act - A Triple Bottom Line Analysis of the Australian Economy*, CSIRO Sustainable Ecosystems, accessed 10 October 2007, from http://www.cse.csiro.au/research/balancingact/

[16] BeyondBlue (21 March 2007), *Don't Beat About the Bush! Beyondblue and Rural Doctors Tackling Depression Together*, accessed 1 February 2008, from http://www.beyondblue.org.au/index.aspx?link_id=9.234&oid=906

[17] Foran, B., Lenzen, M., and Dey, C. (2005), *Balancing Act - A Triple Bottom Line Analysis of the Australian Economy*, CSIRO Sustainable Ecosystems, p54

There are new and emerging technological applications from the fields of ICT, biotechnology and nanotechnology and there is a convergence between these areas. These hold out promise for sustainable food and agriculture. However, we must maintain careful and measured scrutiny of the science even when there appear to be immediate benefits. The possibility of increased environmental or health risks, or side-effects leading consumers to reject other possible solutions, call for careful handling and governance of emerging technologies. The ongoing application of ICT will undoubtedly continue revolutionising all systems, however promising advances in some other areas may not be practically (or safely) useful for 10-15 years or more.

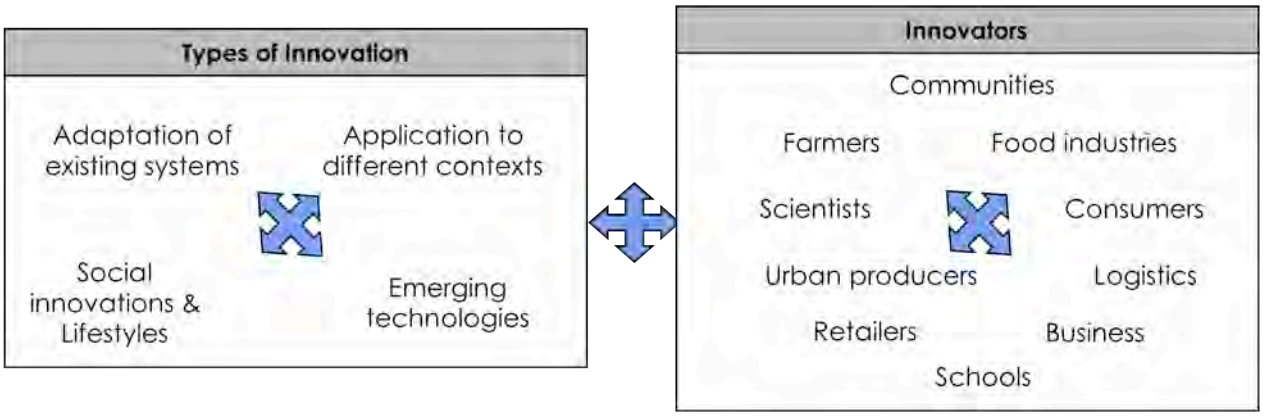
There are social, technological and organisational innovations emerging from individual and community efforts to reduce environmental impact and risk, such as diverse, low-input agriculture systems, re-designed distribution systems to reduce processing, storage and transport impacts and urban food production. Innovations in these areas also present new areas of opportunity for Victoria, with potential for broader application and further development.

There is great potential in 'evolutionary innovation' – the exponential increase in usefulness as each new scientific finding, commercialised technology, pattern of behaviour, and community or individual experiment is shared, applied and developed by other people in unforeseen ways. This can be facilitated by: building individual and community capability, supporting experimentation and collaboration, and developing effective systems for knowledge exchange.

Furthermore, much of what is needed already exists. For example, a lot is known about regenerative agricultural techniques (those that restore the natural resources – particularly soil – upon which production relies), but often this research and existing knowledge isn't considered innovative, or is difficult to access and doesn't reach farmers.

Development of future food systems should seek to make use of all possible participants and types of innovation – and to emphasise capability and knowledge exchange between them all.

Figure 1.2: What is innovation – who innovates?



1.4.4. Consumers driving change

The biggest impact that most individuals have on the environment is through the food we eat – food choices could make a much bigger difference to household sustainability than direct water and energy use. 50% of an Australian urban household's water use has been estimated to be through their food[18]; 28% of greenhouse emissions,[19] and 47% of municipal waste to landfill is organic (food and green waste).[20]

[18] Lenzen, M (2002), cited in Watermark Australia (2007), *Our Water Mark: Australian's Making a Difference in Water Reform*, The Victorian Women's Trust, Melbourne.
[19] ACF (2007), *Consuming Australia - Main Findings*, Australian Conservation Foundation, p5
[20] EcoRecycle Victoria (2005), *Information Sheet 2 - Waste Facts*, last modified March 2005, from http://www.sustainability.vic.gov.au/www/html/2039-waste-and-recycling-information-sheets.asp

There are emerging consumer trends in response to concern about the food system and environmental issues, for example interest in organic, locally produced and seasonal foods. In some countries, notably the UK, this consumer interest is being 'amplified' by the actions of retailers who are investing substantial funds in carbon labelling, local fresh food and origin labelling, systems to reduce or eliminate packaging, and so on. So whilst these consumer trends still comprise a relatively small market segment in Australia, they are increasing fast, and are likely to be bolstered by the changes in international markets.

There is a lack of information for Australian consumers wishing to make food choices to reduce their environmental impact. There are general (high-level) conclusions about the environmental benefits of organic / low-impact, local and seasonal foods, changing dietary composition, and reducing levels of processing and packaging. However, product and location specific factors mean few simple conclusions or recommendations can be made. Other considerations – like health, yield and wastage – also need to be taken into account to analyse overall food systems.

Australian / Victorian specific analysis and information is needed in a range of areas to underpin informed consumer choice and correctly guide producers and other food industry participants. Without robust information that is accessible, consumers will increasingly opt for simple - and even simplistic – indicators (such as 'food miles') to make their decisions.

1.5. Directions for Innovation in the Food System

There are six overarching messages about how and where innovation is occurring in relation to food that derive from the information in this report. These could form the basis for actions to accelerate the pursuit of sustainable and secure food systems in Victoria.

Broaden the perception of what 'innovations' are worth investing in.
New technologies will play an important part in developing more sustainable systems, but so will individual, social and cultural innovations. It is probable that systems innovation will be based on new configurations and new applications of existing knowledge and technologies. Broad experimentation has to be encouraged and supported.

Two tracks - parallel paths.
Incremental improvement to existing systems is essential to reduce their impacts and vulnerabilities and this approach will have to accelerate. However the extent of the change required (80% reduction in greenhouse emissions in 40 years) means that future food systems will be vastly different from today. So, incremental improvements and the exploration of significant systems redesign (including consideration of ideas that may seem unrealistic or radical) will need to happen in parallel.

Priority research areas
There is a lack of Victorian / Australian data in many areas of importance in the food system and these have been identified in the chapter summaries. There are three areas that could be considered as priorities to underpin policy design and action for the food system:

- Lifecycle analysis of key food products (particularly around greenhouse emissions and water): to enable measures to correct market failure, and support modeling of the impacts of policy interventions throughout the food system
- Measure the actual effectiveness of innovations and existing known agricultural techniques in Victoria: test claims of innovative (and existing) agricultural techniques; analyse their effectiveness in different conditions; and conduct controlled trials to determine the most beneficial techniques and systems
- Extend information on ecosystems, especially the quality and condition of soils

There's a lot we don't know, but a lot we do
Where information is available, ensure that producers, food industries and consumers can easily access and make sense of it. There is also a need to drive application and uptake of knowledge and systems that exist and are ready to use – as more people use them they will continue to evolve and improve.

Catalyse change and support the 'culture of innovation'
Innovation will come from many players in the system. There is value in looking to and supporting people and organisations that are already engaged in the process of redesigning systems and experimenting with new ideas. They can be supported through access to research, information systems and promotion; as well as the removal of policy barriers to experimental activity. The successes and failures of innovative experiments should be valued and shared to foster knowledge exchange and 'evolutionary innovation'.

The food system is a complex interaction of economic, social, health and environmental issues
Issues concerning the food system cross portfolios, communities and industries. They are wicked problems and will require coordinated responses. Identification and management of conflicting objectives in the food system will be necessary, along with consideration of roles and alignment between different players.

2. Environmental Risks and Impacts

The food system is vulnerable to environmental change and has a significant impact on the environment – these issues are summarised below.

2.1. Climate Change

2.1.1. Direct Impacts of Climate Change

The impacts of climate change include: higher temperatures, increased drought, extreme weather events, fires, and movement and outbreaks of disease, pests and weeds. Although there will be localised advantages and disadvantages, these impacts will present an overall challenge to food security.

Climate change is already affecting worldwide food availability and prices. Further impacts (such as higher degrees of warming) will exacerbate these effects, and reverberate through the system (eg. reduced grain yields are likely to affect availability of bread, cereals, meats, eggs and dairy products).

These impacts cannot be 'predicted' with any great certainty – fluctuations and unpredictability in weather conditions will be the new operating conditions. Farmers are adapting now by changing what they produce, when and where they produce it, or moving off the land. Ongoing adaptation will be required.

Climate change impacts, particularly extreme weather conditions, will also have impacts on food distribution and storage. For example, damage to transport infrastructure could prevent supplies reaching consumers. Heat waves could increase food spoilage directly or require more refrigeration – in turn adding pressure to stressed electricity systems (and greenhouse emissions). During the 2003 heat wave in France, 25-30% of food businesses were found to have inadequate cold storage capability.[21]

Food processing and storage industries will also need to adapt and be flexible to changing inputs from continually adjusting producers. Increasing energy costs will also already affecting these industries.

Increasing resilience of the food system to climate impacts will require flexibility, diverse solutions and continuous adaptation.

Social response to climate change generally – adaptation in other areas of the economy and mitigation efforts - will also cause problems for the food system. This is discussed in the following section.

!	*Climate change will interact with other challenges to drive up food prices*
!	*There is a need to develop improved data and information while building local capacity for ongoing adaptation*
!	*The loss of small / medium sized producers with diverse and local knowledge could reduce overall capacity for adaptation and the resilience of the food system overall.*
!	*Future food security may require balanced access to both locally grown and distant food supplies to reduce exposure to supply and storage system disruption, as well as to local production losses*

[21] Létard, V. et al. (2004) cited in IPCC (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Parry, M. et al, Cambridge University Press, Cambridge, UK.

🕮	*The IPCC has identified a number of research gaps regarding climate change impacts in Australia. These include:* ➢ *Impacts on agricultural pests, disease and weeds in Australia* ➢ *Interrelations of increased temperatures, carbon dioxide AND changing rainfall patterns on disease, weed and pest ranges (have mainly been studied separately – little is known about combined impacts)*
🕮	*The IPCC has also noted that global modelling of projected food security under climate change has tended to rely on assumptions about economics, trade and technology that are poorly tested against observed data. Further work is needed in this area.*[22]
🕮	*Expanded analysis of climate change adaptation in the food system beyond agricultural production*
🗲	*Increase diversity of food production to increase the likelihood of harvest even in unpredictable conditions*
🗲	*Changes to planting dates and varieties, more resilient crops and systems*
🗲	*Opportunities for low-input agricultural techniques (including organic systems), as they have been found to be particularly "resilient and productive" in climate adaptation strategies.*[23]
🗲	*Redundancy and flexibility in processing, logistics and distribution systems*
🗲	*Reduce the vulnerability of food distribution systems*

2.1.2. Energy, Greenhouse Emissions and Responses to Climate Change

Food production is a significant contributor to greenhouse gas emissions. Biological emissions from agriculture were directly responsible for 16.8% of Australia's greenhouse gas emissions in 2005, and 12.9% of Victoria's.[24] When emissions from energy, transport and waste are included, it has been estimated that at least 23% of Australian emissions come from the food system.[25]

Energy inputs to food production have increased with technological development. Chemical inputs, processing and storage facilities have greatly increased agricultural productivity and the economic value of our food resources, enabling us to exceed our domestic food requirements and export to global markets. While labour productivity has improved (the amount of food produced per person-hour), the energy intensity of the system has not. *Direct energy use in Australian agriculture* (on-farm, not including manufacture of inputs) has been estimated to represent only 25-30% of the energy consumed in the whole food supply chain.[26] The increasing energy intensity of agriculture and the rest of the food system increases risk as the cost of key energy inputs (eg. fertilisers) increase (due to oil scarcity and carbon pricing).

The full energy or greenhouse gas picture for food supply in Victoria is not well understood. Victoria has a substantial food-processing sector, but the emissions from this sector are generally attributed (in data sources such as ABS) to 'industry' rather than 'food', as is agricultural chemical production. Food related transport emissions are also accounted for elsewhere (under transport). The greenhouse emissions generated through raw material consumption for food packaging are

[22] IPCC (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Parry, M et al, Cambridge University Press, Cambridge, UK, chapter 5, p285
[23] International Trade Centre (2008), *Organic Farming and Climate Change*, International Trade Centre, Switzerland, http://www.intracen.org/Organics/publications.htm (NB: The ITC is the joint technical cooperation agency of the UN Conference on Trade and Development (UNCTAD) and WTO for business aspects of trade development)
[24] Victorian Greenhouse Gas Inventory (2007), *Victorian Greenhouse Gas Inventory: Information Sheet 2005*
[25] Hatfield-Dodds et al. (2007), cited in Garnaut Climate Change Review (2007), *Issues Paper 1 – Climate change: Land Use – Agriculture and Forestry*, Garnaut Climate Change Review, Melbourne
[26] Watt, M. (1979) and Organisation for Economic Co-operation and Development (1982), cited in Wood, R. et al. (2006), "A Comparative Study of Some Environmental Impacts of Conventional and Organic Farming in Australia." *Agricultural Systems*, vol. 89, no. 2-3: 324-48, p326. NB: These figures are from 1979 and 1982 – updated analysis would be very useful!

also a potentially significant contribution – in Europe it is estimated that 25% of raw material production in 2001 was used as food packaging.[27]

Introduction of a *carbon price* will affect foodstuffs very differently – meat from ruminants and dairy, highly processed foods, and foods that travel longer distances would be expected to rise in cost significantly. However, the survey of international studies undertaken for this report tells us that there are no generalisable answers, it depends on the specifics of the food system; some meat products are less energy-intensive than some vegetables (although overall greenhouse emissions are probably still higher); in some circumstances cooking of food has the most impact; emissions from processing and storage can be very significant for some foodstuffs; transport of food to retailers is significant in some circumstances, travel by consumers to retailers is more significant in others. How much these different aspects of the system will impact on food prices in a carbon constrained economy cannot be understood until there is detailed (life-cycle) data for different food products / plates.

International efforts to understand and manage the environmental impacts of the food system have produced significant analytical work, but findings are not directly applicable to Australia or Victoria. Australian analysis has identified the broad sectors within the food system that have the highest greenhouse intensity, but this analysis has not been refined to reflect Victorian conditions or to consider specific products in those sectors. Life-cycle data for different food products or plates does not currently exist in Victoria.

Carbon sequestration in agricultural soils (along with other changed techniques) has the potential to change the emissions profile of agriculture, as well as having other potential productivity benefits (such as improved water retention and fertility in soils).[28] There are difficulties in measuring soil carbon levels, but this should not prevent an accelerated roll-out of known techniques and investment in their improvement and further development.

Transport and long production chains have been shown to contribute significant energy (and greenhouse emissions) for some foods, but this is only one factor in the full lifecycle impacts of food. Distance does not directly indicate the level of total greenhouse or total environmental impact (as it doesn't take into account different transport modes or transport utilisation factors). Furthermore, it has been found (in the UK), that the 'car miles' (car-based shopping emissions) can be ***greater*** than transport emissions from the production and distribution phases,[29] and for some foods it could even be the most significant emissions contribution.[30] The impact of 'car miles' in Melbourne (and probably the rest of Victoria) would be likely to be higher again – a recent study has found that Melbourne's transport produces approximately 2.5 times as many greenhouse emissions (per person) as London's (road freight removed).[31]

Unless there are major changes in the mix of transport modes (towards very low carbon transport systems) and better life-cycle energy data for different foods then 'food miles' is likely to continue being accepted by consumers (and probably retailers) as a 'proxy' system indicator for environmental impact. Interest in food miles also reflects community concern about oil shortages (see 2.2.2. *Oil, Biofuels and Agricultural Inputs*), and a desire for reconnection with the producers of their food (2.3 *Distribution Strategies*).

! *The potential for emissions reductions within the agriculture sector and throughout the food*

[27] Jancovici, J. (2004), *How Much Greenhouse Gases in Our Plate?*, accessed 12 July 2007, from www.manicore.com/anglais/documentation_a/greenhouse/plate.htm
[28] Bellarby, J. et al. (2008), *Cool Farming*, Greenpeace International.
[29] Foster, C. et al. (2006), *Environmental Impacts of Food Production and Consumption: A Report to the Department for Environment, Food and Rural Affairs*, Manchester Business School, DEFRA, London, accessed December 2007, from www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf.
[30] Morgan, D. et al. (2006), *Seattle Food System Enhancement Project: Greenhouse Gas Emissions Study*, University of Washington, Program on the Environment, accessed 14 January 2008, from http://courses.washington.edu/emksp06/SeattleFoodSystem/Final_GHG_Report.pdf.
[31] BusVic (2008), *Transport Emissions 2006: Melbourne Vs London*, Bus Association of Victoria.

	supply chain is very significant and must be pursued – making use of current knowledge and technology and despite limitations to tracking and measurement
!	*Significant reductions in on-farm emissions will require changes to the way we farm livestock and use synthetic fertilizers*
!	*Other developed countries (eg. UK) are reducing their emissions by moving greenhouse intensive production offshore. This may create export opportunities in other markets, but it also shifts the pressure to actually reduce emissions to the exporter*
!	*Other emissions in the food chain, including energy to produce agricultural chemicals, processing, packaging, storage and transport, mean that food prices could rise with the introduction of emissions trading, even if agriculture is initially excluded*
!	*Demand for local foods is driven by a range of factors and is likely to continue increasing, even though the concept of 'food miles' does not convey full (or accurate) information about lifecycle energy or greenhouse impacts, unless detailed life cycle data becomes available for Australia/Victoria*
!	*Soil carbon sequestration could transform agriculture's emissions profile – with wide ranging ramifications for land use and production techniques.*
!	*Low-input agricultural techniques (including organic production) can make a significant contribution to emissions reduction and could be 'quick-win' policy options*[32]
🕮	*Update analysis of the energy and emissions of the full food chain (most recent Australian analysis is from 1982)*
🕮	*Conduct full lifecycle analysis (particularly on greenhouse emissions) on a range of essential foods in Victoria, to better understand how they will be affected by policy changes, and how emissions can most effectively be reduced. Victorian information on direct agricultural emissions (from conventional systems) is good. However, beyond the direct on-farm emissions very little information exists.*
🕮 !	*Measure and investigate the potential greenhouse benefits of non-conventional production and distribution systems (including techniques that reduce reliance on inputs)*
↗	*Shift to food production, processing and distribution systems that minimise greenhouse emissions will have competitive advantage under carbon pricing*
↗	*Market advantages where Victorian agricultural production is less emissions-intensive than international competitors*
↗	*Track and label emissions profiles to strengthen this advantage eg. inclusion of emissions data in new commodity tracking systems*
↗	*Drive development and extension (many are already known) of locally appropriate techniques for soil carbon sequestration*

2.2. *Resource Constraints*

Resource constraints present foreseeable threats to the agricultural sector, and the maintenance of affordable and accessible food supplies, as producers adapt to increasing scarcity of water, land, oil, and agricultural inputs (N-P-K fertilisers).

Resource constraints will also impact on Victoria's ability to continually increase production despite growing international demand. As resources become more expensive, producers may struggle to compete.

Increasing understanding of these threats can help us prepare for and reduce risks to producers and vulnerable consumer groups. Some environmental issues and resource constraints,

[32] International Trade Centre (2008), *Organic Farming and Climate Change*, International Trade Centre, Switzerland, http://www.intracen.org/Organics/publications.htm (NB: The ITC is the joint technical cooperation agency of the UN Conference on Trade and Development (UNCTAD) and WTO for business aspects of trade development)

particularly water and land, the widening gap between oil supply and demand, and competition for chemical inputs, are already impacting on food production, supply chains and therefore prices.

Some general recommendations for dealing with constrained resources are outlined below, and then four areas of resource constraint are considered in further detail (*2.2.1 Water, 2.2.2 Oil, Biofuels and Agricultural Inputs, 2.2.3 Land* and *2.2.4 Depleted Stocks (Fish)*).

!	*Impending resource shortages may be masked by economic fluctuations and other factors. Provision of information and analysis of trends and alternatives can ease transition and avoid resource 'shocks'*
!	*Some inputs are finite and will become unaffordable – food systems will need to adapt to significant input reductions and changes e.g. systems relying on oil and conventional agricultural inputs will continue to be vulnerable*
🕮	*Analysis of social and economic vulnerabilities to food price changes (linked to resource constraint) – possibly the development of scenarios*
↯	*Increase efficiency of input use*
↯	*Proactive investment in and development of renewable / sustainable resource alternatives*
↯	*Restore degraded land, soil and water resources so that production systems require fewer inputs*
↯	*Develop production and distribution systems that do not rely on scarce or contested non-renewable inputs (make use of what is available)*
↯	*Reuse 'waste' water and organic materials for food production – including in urban areas*

2.2.1. Water

Approximately 30% of Australia's water is used to grow food for domestic consumption. [33] Almost 50% of an Australian urban household's water use is through their food consumption, compared to 11% directly in showers, gardens and cleaning.[34] Water prices will grow significantly as demand grows and new supply systems are introduced (such as desalination). Food prices will rise correspondingly.

International demand for food (particularly meat and dairy) is continuing to increase, but water scarcity may restrict Victoria's ability to grow in response to this need. Approximately 40% of Victoria's harvested water is exported in food products – this constitutes about 25% of historic average streamflows (which are no longer being attained). Growth in exports will require a changed export mix, or would require all of our water by 2050.[35]

Some foods require much more water to produce than others. Victorian and Australian water production efficiencies are better than the international average, however we also have less water. Trade in water-intensive products between water rich and water scarce nations could improve global water efficiency, but would be complicated by oil and carbon constraints and the need to develop resilient systems.

Rain-fed agriculture is becoming increasingly difficult to manage, and there is little scope to increase irrigation – many irrigation areas have now reached the limit of their supply and are not receiving their full water allocations. There are still significant gains to be made through

[33] Lenzen, M. and Foran, B. (2001), "An Input–Output Analysis of Australian Water Usage " *Water Policy*, no. 3: 321–40.
[34] Lenzen, M. (2002), cited in Watermark Australia (2007), *Our Water Mark: Australian's Making a Difference in Water Reform*, The Victorian Women's Trust, Melbourne.
[35] Muntisov, M. (2007), "Thinking About Virtual Water," *Water: Journal of the Australian Water Association*, Sept 2007, p5

improvements to irrigation systems (reducing losses) though some gains will lead to associated energy / emission costs.

Competition for water means that it will be increasingly used for 'high value' products (eg. wine, almonds and dairy) often for export. As Australian and Victorian producers struggle with water scarcity and increasing costs, cheaper imports from international markets are filling market niches for basic food products such as fruit and vegetables. Under current conditions and excessive debt many producers are ceasing production, but reduced domestic production capability could undermine future food security.

!	*Water scarcity will continue to place pressure on Victorian producers and drive up the cost of food. Some foods will become more expensive than others and this could affect access to a healthy diet.*[36]
!	*Structural adjustment in response to water pricing (eg. replacement of local essential food production with high-value export crops) could increase vulnerability to other risks such as transport disruptions or carbon pricing*
!	*Importing water-intensive products ('virtual water' trade) has some advantages, but so does retaining local food production (eg. security)*
!	*Improving water access or efficiency through irrigation or technological investment often has an energy / greenhouse (or other) implication. Carbon pricing will then affect the ongoing viability of these systems*
!	*Strategies to improve efficiency of large irrigation systems (eg. maximise run-off and minimize evaporation and leakage) may conflict with strategies to prevent evaporation at the outset (eg. storage in soils and vegetation) and maximise production where this water is available*
🕮	*Explore the relationship between water pricing and nutritional value per litre - how can nutritional value from water and other scarce resources be maximised? Potential for analysis of L/$ to be extended to L per kj or other nutritional measure*
🕮	*Improve understanding of the affects of water scarcity on food production, prices and security. Investigate the changing volumes of Victorian production, how much of this is exported and how this is impacting on changes in local prices*
🕮	*Develop consumer information around embodied water in food choices through detailed lifecycle analysis of key food products (correct market failure and reduce reliance on cruder measures)*
🕮 🗲	*Investigate the water efficiency potential of active soil management in Victorian soils, in conjunction with soil carbon sequestration and other productivity benefits*
🕮 🗲	*Use of alternative water sources for food production – recycled water, greywater (research also required to ensure human and environmental safety). Increase production where these resources are most accessible*
🗲	*Transition to less water intensive foods or production systems – focus on making use of water where it is available (including storage where it falls and water in and around cities)*
🗲	*Accounting systems that can record water information for supply chain and consumer decision making – through global supply chains*

2.2.2. *Oil, Biofuels and Agricultural Inputs*

The implications of oil scarcity and price increases on Victorian food security are poorly understood. Oil underpins food security most obviously through transport through long supply

[36] Reidpath, D. et al. (2002) and Block, J.P., Scribner, R.A., and DeSalvo, K.B. (2004), cited in VicHealth (2005), *Healthy Eating - Food Security: Investment Plan 2005 - 2010*, Victorian Health Promotion Foundation, p6

chains, but also through agrochemical production and on-farm machinery in industrialised systems.

The international oil price increased by almost 400% between September 2003 and January 2008.[37] In Australia, this increase was moderated by a strong dollar but local prices are also increasing - petrol prices rose by 14.3% in 2007.[38] There are a number of contributing drivers to these price increases, but a slow-down in the growth of oil supply and concerns about 'peak oil' are part of increasing concern. Oil price increases have had repercussions throughout the food chain, and in combination with other costs (like water) and climate change impacts (like drought) are contributing to increased food prices – (sometimes referred to as 'agflation'). If the gap between supply and demand for oil outpaces mobilisation of new fuel sources, fuel scarcity could severely jeopardise food security.

Concern about oil shortages is driving development of possible substitutes, including biofuels. Biofuel production presents another risk to food supply. In many countries, the growth of the market for biofuels is driving deforestation Biofuels are also directly competing with food production for land, water and agricultural inputs – and therefore contributing to increasing prices.

Increasing global demand for food, and the rapid move from food to biofuel crops in the US, has led to surging demand for agricultural inputs such as fertilisers and pesticides. This demand is outpacing supply (some of which is dependent on oil), and prices are increasing fast – key fertiliser products in Australia increased by about $200/tonne or 30% between 2006 and 2007.

Melbourne's layout (with car-dependent outer suburbs) will compound the impacts of oil price increases for those that have to drive to collect it, on top of the upstream costs (which will be embedded in the price).

!	*On-going access to oil or affordable substitutes cannot be assumed, and it is likely that declining oil availability will continue to increase the costs of food, particularly foods which travel long distances. This complicates responses to the risks of climate change and water shortages*
!	*Increasing biofuel production can directly affect food production (and prices) through competition for land, water and agricultural inputs*
!	*Loss of peri-urban agricultural land to residential development is increasing transport distances and therefore reliance on oil for urban food supplies, affecting vulnerability and cost*
!	*The cost of driving to get food will increase food security concerns for vulnerable areas of Melbourne and regional / rural Victoria*
🕮	*Assessment of the Victorian food system's vulnerability to oil and input scarcity – how reliant is it? Where is substitution viable and where it is unlikely? Could significant production decreases or supply disruptions occur? Need to model possible price / adaptation scenarios*
↗	*Production methods and systems that are less reliant on oil, oil-based products (eg. chemical fertilisers and pesticides), and contested agricultural inputs*
↗	*Alternative biofuel production that is not reliant on conventional inputs or large amounts of productive land (possibility of genetically modified crops or algae systems)*
↗	*Developing markets / making use of potential biofuel feedstocks that are currently going to waste (eg. lignocellulosic (wood))*[39]

[37] BBC (2007), *Oil Reaches New Record above $99*, accessed 15 January 2008, from http://news.bbc.co.uk/2/hi/business/7105044.stm

[38] Colebatch, T. (2008), "Inflation Shock Puts Pressure on Rates", *The Age*, accessed 23 January 2008, from http://www.theage.com.au/news/national/rates-tipped-to-rise/2008/01/23/1201024993875.html

[39] Francis, P. (2008), personal communication from editor of the *Australian Farm Journal*, 13 March 2008.

- *Renewable / sustainable substitutes for petroleum-based agricultural inputs, including organic wastes*
- *Supply chains and distribution systems within cities – increasing production closer to consumption and/or innovations in food distribution and access*

2.2.3. *Land and Soil*

Land resources for food production are limited by the amount available (competing uses) and soil capability (how much it can produce). The amount of Victorian land used for agriculture is increasing, but this will be limited by changing water availability and competition with other uses – especially residential development and biofuels.

Housing availability and cost is currently an issue of great community concern, and this is likely to maintain pressure for conversion of peri-urban agricultural land; about 3% of Melbourne's new housing is on previously agricultural land on the urban fringe.[40] Since 1945, the expansion of Australian cities has removed more than one million hectares of rural land. If current trends continue, by 2021 Melbourne will have lost another 25,000 hectares of rural land to urban development.[41] In the context of oil and other resource constraints, and global pressures on food supply, protection of peri-urban land explicitly for food production (particularly horticulture) will be required.

The productive capacity of existing agricultural land depends on the distribution, nature and condition of the soil; continuing decline in soil condition globally and in Victoria presents a major risk to food security.

The need to protect remnant native vegetation makes further land clearing untenable – continued food production will require active restoration of existing land.

Some land quality issues (eg. salinity, erosion and acidification) have been widely recognised. Others; such as structural decline (soil compaction), contamination (from chemical fertilisers, pesticides etc) and loss of biological life in soils, are emerging concerns about which less is known and even less is being done.

There are known techniques that can reduce agricultural impacts on land and soil (eg. minimum tillage, grazing management, perennial pastures) but the take up of these techniques varies widely. Increased consumer interest (locally and in export markets), and the potential to reduce input costs, are increasingly making these practices beneficial to producers (rather than a cost) – see *3.2.1 Environmental Management*.

The long-term impacts of agricultural chemicals on soil quality are only starting to be understood. For example, some studies have demonstrated that reducing / removing synthetic fertilisers and pesticides can improve soil organic matter (and carbon retention) at least as much (or more) than reduced tillage. [42,43]

Soil quality is affected by physical, chemical and biological factors, and different soil types and management practices dispose soils to different problems. Management requires integrated consideration of all three elements, in the context of particular soil conditions.

[40] DSE (2002), *Melbourne 2030 - Planning for Sustainable Growth*, Department of Infrastructure, State of Victoria,
[41] Buxton, M. and Goodman, R. (2002), *Maintaining Melbourne's Green Wedges: Planning Policy and the Future of Melbourne's Green Belt*, School of Social Science and Planning, RMIT University, p76
[42] United States Department of Agriculture (2007), "Organic Farming Beats No-Till?" *ScienceDaily*, 24 July 2007, from http://www.sciencedaily.com/releases/2007/07/070722162434.htm
[43] Khan, S. et al. (2007), cited in Science Daily (2007), "Nitrogen Fertilizers Deplete Soil Organic Carbon", *Science Daily*, accessed 30 October 2007, from http://www.sciencedaily.com/releases/2007/10/071029172809.htm

!	*Land area is finite, and competition between food production and residential development on the urban fringe will intensify – there is a need to balance immediate development demands with longer-term food security (possible protection of horticultural zones)*
!	*Depleted soils that are heavily reliant on inputs for productivity will be less resilient to a changing climate and input shortages. Building healthy and resilient soils now can increase our ability to produce food in unpredictable conditions*
!	*The quality of land / soils is as important to food production as water supplies – attention to the root causes of land degradation, which includes some ongoing agricultural practices, will be necessary to reduce vulnerability to climate change and resource constraints*
!	*Many farmers recognise these issues and are improving / adapting where they can; communicating the outcomes of this experimentation will be critical to stimulating ongoing innovation*
!	*Innovations that overcome some land use problems can lead to other environmental impacts eg. raised-bed cropping making more land suitable has led to loss of some remnant grasslands*
! 🕮	*Improved land and soil management can have benefits for water use (greater retention in soils) and greenhouse emissions (carbon sequestration). Research specific to the Victorian context would help to fully capture the emerging opportunities.*
🕮	*There is a lack of statewide data on the actual state of soil health – little is known about the extent and spatial distribution of soil problems*
🕮	*Long-term monitoring of soil health, including impacts of physical, chemical and biological management in specific types of Victorian condition, network of sites to enable controlled comparison of management practices*
↯	*Active soil management techniques designed to reduce input costs and increase productivity while improving land and soil quality*
↯	*Create supportive conditions for diverse innovation and experimentation across many landscapes eg. different farming systems, crops, scales of production*
↯	*Design of residential developments that make use of productive capability of the land on which they are being built (urban agriculture built in from the start)*

2.2.4. *Depleted Stocks (eg. Fish)*

Fish are a renewable resource but when the rate of fishing exceeds the rate at which they reproduce, populations decline and can eventually collapse. 76% of the world's fisheries are fully or overexploited,[44] and catch records from 1950 to 2000 show that 366 out of 1,519 fisheries worldwide (approx. 25%) have collapsed.[45]

No Australian managed fisheries are currently classed as 'overfished', however at least 20% of the species that are fished in Australia are. It is also likely that fish imported to Australia is from depleted stocks.[46]

Fishing has other environmental impacts (such as damage to marine ecosystems), and is affected by other issues outlined above (eg. oil constraints).

[44] Worldwatch Institute (2008), *Oceans in Peril: Protecting Marine Biodiversity,* prepared by the Greenpeace Science Team, Exeter University, UK

[45] Greenpeace International (2007), *Worldwatch Report: Oceans in Peril*, from http://www.greenpeace.org/international/news/world-watch-report-190907

[46] Larcombe, J. and McLoughlin, K., eds, (2007), *Fishery Status Reports 2006: Status of Fish Stocks Managed by the Australian Government*, Bureau of Rural Sciences, Canberra, pp195–203

Aquaculture (fish farming) is increasingly providing an alternative source of fish, and could potentially alleviate pressure on wild stocks. However, it also has environmental impacts and some systems are much more sustainable than others.

Integration of aquaculture with horiculture (aquaponics) makes use of the nutrients fish excrete to grow food and can be a very efficient mixed production system

2.3. Biodiversity

'Biodiversity' – diversity of biological life within a system – increases resilience. Biodiversity is important in both the ecological systems that underpin food production, and in the agricultural systems themselves. Agriculture systems impact on the land and water on and around the farm - these impacts have repercussions for ecosystem function (native biodiversity) that can undermine productivity. Reduction of diversity within agricultural crops and livestock can increase their vulnerability to pests, changes in climate etc (agricultural biodiversity).

2.3.1. Native Biodiversity

Food production has a major impact on native biodiversity – Victoria's native biodiversity is still in an overall state of decline and the removal, decline in quality and fragmentation of native vegetation (usually related to agriculture) is the main cause. [47,48] Maintaining (improving) biodiversity also has many benefits for food production – the 'free' eco-system services biodiversity contributes to the maintenance of healthy and resilient food systems (such as pollination and pest management) are likely to become increasingly valuable to food security.

For Victoria, clearing of woody vegetation has slowed and ongoing native biodiversity loss is mainly due to changing use and poor soil management of existing agricultural land. This includes land being converted from pasture to crops, increase in irrigated crops (including vines), and intensive dryland pasture farming. Increasing intensification of land use has led to removal of remnant trees and patches of vegetation.[49]

The farming practices which have the greatest impacts on terrestrial (on-land) biodiversity include grazing, monoculture cropping, inadequate buffers between cropping and waterways and native habitats, and incremental loss of paddock trees. [50] Agricultural practices also impact on aquatic and marine biodiversity, primarily through competition for water (removal from rivers and streams), loss of streamside vegetation, and contamination of waterways with agricultural chemical and nutrient run-off.[51]

There are known strategies to improve biodiversity outcomes and increase productivity, such as rotational grazing, more cautious chemical use (with benefits to the soil and reduced run-off), protection of remnant trees, use of native vegetation for shelterbelt and, preventing grazing in riparian zones (by streams).[52] Specific interventions are occurring in these areas. There are also existing and emerging farming innovations that incorporate biodiversity improvement, such as integrated pest management, pasture cropping, phase cropping etc (see *3.2.1 Environmental Management*).

[47] VCEC (2007), *Simplifying the Menu: Food Regulation in Victoria*, Victorian Competition and Efficiency Commission, p23
[48] Dunlop, M. et al. (2004), *Environmental Sustainability Issues Analysis for Victoria: A Report Prepared for the Department of Sustainability and Environment, Victoria*, CSIRO Sustainable Ecosystems, Canberra.
[49] VCEC (2007), *Simplifying the Menu: Food Regulation in Victoria*, Victorian Competition and Efficiency Commission, p17
[50] Wilson, J. et al. (2004), *Land Use Impacts on Native Biodiversity - Background Report No. 1*, Drivers of Land Use Change Project (Driver Research Phase), Department of Sustainability and Environment, State of Victoria.
[51] Ibid.
[52] Ibid.

Comparatively little is known about soil biodiversity, either the causes or impacts of its loss, the management techniques for improvement or the potential productivity benefits.[53] This lack of knowledge is reflected in the lack of intervention.

!	*Current agricultural impacts on biodiversity are well known, as are some actions to reduce them. However, the costs of protecting biodiversity could increase with competition for land and changing land uses.*
!	*Techniques and systems that have been developed as 'alternatives' (such as polyculture systems and reduced chemical use) have been shown to have significant native biodiversity benefits – these may also have productivity and broader environmental benefits.*
!	*New challenges will be presented by genetically modified crops, the possibility of bee colony collapses, increasing competition for land and climate change.*
🕮	*Improve information about soil biodiversity – what's there, what's disappearing, what impact does that have on productivity and environmental services?*
↗	*Use of native species for food – may encourage preservation and improved knowledge while reducing impact on the environment*
↗	*Identifying and applying (in new contexts) techniques and systems that improve biodiversity and productivity (win-wins)*
↗	*Food products that incorporate and value native biodiversity eg. 'premium' for saltbush lamb*
↗	*Soil carbon sequestration potential of some native species or ecosystems may facilitate habitat preservation*

2.3.2. Agricultural Biodiversity

Declining diversity of crop and livestock varieties used for agricultural production (both fewer species, and less genetic diversity within species), will increase vulnerability to environmental change and resource constraints.[54]

!	*Declining diversity in agricultural products (and genetic variation) increases risk and vulnerabilty*
!	*The pace and extent of challenges to the food system will make 'keeping up' with emerging problems through problem-specific technical solutions increasingly difficult*
↗	*Diversification of species, products, mixed-farming systems etc – see 3.2.2 Diversification*

2.4. Waste

Large amounts of food are generated throughout the food system. This wasted (ie. not eaten) food represents significant wastage of water, energy, land, oil, chemicals, packaging and so on.

Increased processing and improvements in packaging reduce food spoilage and waste in long supply chains, but they also have environmental impacts.

The risk of spoiled and wasted food may increase along with other risks eg. extreme weather events, increasing energy prices or pest infestations.

[53] State of the Environment Advisory Committee (SoEAC) (1996), cited in Yencken, D. and Wilkinson, D. (2000), *Resetting the Compass- Australia's Journey Towards Sustainability*, CSIRO Publishing, Collingwood, p230
[54] UN FAO (2007), *Biological Diversity in Food and Agriculture - Crop Genetic Diversity*, United Nations Food and Agriculture Organisation, accessed 10 December 2007, from http://www.fao.org/biodiversity/crops_en.asp

In Victoria, 47% of municipal waste sent to landfill is food and green waste.[55] This has immediate environmental impacts (release of methane as it decomposes). It is also a wasted resource.

There has been little innovation or intervention in management of household food waste. There would appear to be many opportunities in this area.

!	*A lot of food waste is embedded in the system – long distances, storage times, aesthetic standards etc. The relationships between food waste and other system elements will need careful consideration*
!	*Food waste and food safety concerns may sometimes conflict. For example, consumer food waste could decrease as prices increase, with potential health impacts if information is not available*
🕮	*Analysis of waste throughout the food system in Victoria:* ➢ *Where does it occur (pre-harvest due to pests, through gluts, retailer logistics, spoilage, household, etc)* ➢ *Where can it be avoided, reused (as inputs to another process or redistributed), or recycled (potential resource?)*
🕮	*Analysis of the balance between the environmental impacts of food processing, storage & packaging, and the saved impacts of wasted food*
🕮	*Analysis of the productive potential of Melbourne / Victoria's food waste – including consideration of travel distances and available processing technologies*
🗲	*Food preservation technologies and systems eg. reduced reliance on refrigeration*
🗲	*Nutrients in food 'waste' as alternative fertiliser sources – organic waste recycling providing inputs to food production* ➢ *urban* ➢ *rural – innovation potential in logistics / distribution?*
🗲	*Effective, self-managing home composting systems or services*
🗲	*Biodegradable and recyclable food packaging*
🗲	*Adaptive food processing systems – able to adjust products and systems in response to scarcity and seasonal gluts*

2.5. Health and Nutrition

Disease related to nutrition is significant in Victoria; this includes obesity (8%), high cholesterol (6.1%) and inadequate fruit and vegetable intake (3.3%). Together, these conditions have a greater health impact than tobacco smoking (8.2% burden of disease); physical inactivity (4.1%) and alcohol (1.5%).[56]

The 2003 Joint Expert Panel of the World Health Organization and the Food and Agriculture Organization outlined basic recommendations for a dietary consumption pattern that "is not only healthier but more favourable to the environment and sustainable development."[57] A number of international studies have also suggested a strong correlation between recommendations for a healthy diet and lower-environmental impact diets.[58,59,60]

[55] EcoRecycle Victoria (2005), *Information Sheet 2 - Waste Facts*, last modified March 2005, from http://www.sustainability.vic.gov.au/www/html/2039-waste-and-recycling-information-sheets.asp
[56] DHS (2005), *Victorian Burden of Disease Study: Mortality and Morbidity in 2001*, Department of Human Services, State of Victoria
[57] WHO/FAO (2003), *Diet, Nutrition and the Prevention of Chronic Diseases: Report of the Joint WHO/FAO Expert Consultation* (No. 916), accessed 31 January 2008, from http://www.who.int/dietphysicalactivity/publications/trs916/summary/en/index.html.
[58] Gussow, J. and Clancy, K. (1986), "Dietary Guidelines for Sustainability." *Journal of Nutrition Education*, vol. 18, no. 1: 1-5.
[59] Collins, A. and Fairchild, R. (2007), "Sustainable Food Consumption at a Sub-National Level: An Ecological Footprint, Nutritional and Economic Analysis." *Journal of Environmental Policy and Planning*, vol. 9, no. 1: 5-30, p16

There is evidence that long storage periods can reduce the nutritional value of foods.[61] High 'energy-dense' foods (such as junk foods) with little nutritional value are more affordable than fresh fruit and vegetables[62] and therefore likely to make up a large part of the diet when money is scarce.

Attention is being given to increasing the concentrations of specific nutrients in foods via functional foods (to create high-value food products), although knowledge about how individual food constituents behave when isolated from whole foods remains limited.

There is increasing evidence of the nutritional benefits of foods produced with reduced chemical inputs (eg. organic).[63]

!	*Some disadvantaged groups already have difficulty accessing healthy and nutritious food, including fresh fruit and vegetables. Increasing food prices will increase the vulnerability of these groups.*
🕮	*Analysis of recommended 'healthy eating' in Victoria / Australia and the environmental implications of recommended changes to dietary composition (such as reduced sugar, increased fruit and vegetables, level of processing); are there areas where these conflict?*
🕮	*Analysis of the impacts of carbon pricing on access to healthy and nutritious foods (which foods will become more expensive and how will this affect food access?)*
🕮	*Analysis of potential improvement to nutritional densities of Victorian fruit and vegetable products through changed production methods – do methods that improve health outcomes have positive or negative environmental impacts? Which methods make a difference and for which foods?*
🕮	*Analysis of the potential for health and nutritional aspects of food to be improved through changes in processing, distribution and supply chains*
🕮	*Analysis of the potential to meet food needs through local, seasonal production in Melbourne / Victoria – what would diet include? Would it be nutritionally adequate?*
↗	*Identification of input / production factors that affect nutrition in food holds marketing / export potential*
↗	*Involvement in food production can increase knowledge of and access to healthy food, physical activity and/or community interaction*
↗	*Supply and distribution systems that minimise nutritional loss*

[60] Duchin, F. (2005), cited in Carlsson-Kanyama, A. et al. (2003), "Food and Life Cycle Energy Inputs: Consequences of Diet and Ways to Increase Efficiency." *Ecological Economics*, vol. 44: 293-307.
[61] Choice (2006), *Fresh Fruit and Veg?*, from www.choice.com.au
[62] Drewnowski, A. and Monsivais, P. (2007), "The Rising Cost of Low-Energy-Density Foods." *Journal of the American Dietetic Association* 107, no. 12: 2071-76., as discussed in Parker-Pope, T. (2007), *A High Price for Healthy Food*
[63] Benbrook, C. et al. (2008), *New Evidence Confirms the Nutritional Superiority of Plant-Based Organic Foods*, State of Science Review, March 2008

3. Response Strategies

The environmental and resource challenges outlined above will impact on food systems in different ways and at different times, most likely with unexpected systemic impacts. Under these circumstances, planning for and managing a secure food supply and viable food production industries will require attention to resilience in the face of complex and unpredictable change.

The resilience of a system refers to how effectively it can respond to shock and change whilst still delivering its critical functions (in this case providing food). Resilience will be required throughout the food system, and in the productive eco-systems that underpin it.

Resilient food systems will need to make the best use of available resources, respond to changing local conditions and adapt to ongoing environmental change. This will require:

- *Diversity:* in strategies and innovations, and in supplies, as well as production and distribution practices, *see 3.2.2 – Diversification*
- *Redundancy:* participants should build networks of suppliers and customers and ensure inputs (and food) can be obtained from a range of sources (networked distributed systems);
- *Research, experimentation and communication:* participants in the system need to be able to learn from each other's successes and failures, and have access to information for decision making.

The strategies and innovations that contribute to more resilient food systems will emerge from new technologies and new applications of existing technology, changed production and distribution systems, and changing consumer values and demands regarding food.

3.1. Emerging Technologies

The key technology groups influencing change in all systems of production and consumption are likely to be: information and communications technologies (ICT); biotechnology; nanotechnology; new materials – along with the convergence of these technologies. Rapid advance in these areas has the potential to increase the efficiency of existing technologies and systems, and could reduce the environmental impacts of food production and consumption. Change will also come from the continuing diffusion of technologies that already exist as they are used in new ways, particularly information technology and mobile communications. Development, convergence and widespread uptake of these technologies may also pose risks to the environment, and (particularly in food) to human health.

Information and Communications Technology (ICT) includes all technologies that enable communication and information processing. For the food system, increasing use of ICT will include technologies and techniques for gathering data (eg. using sensors and database systems to improve water efficiency), modelling eco-systems (and other systems such as consumption / production systems), and improving stock management and logistics, and tracking of environmental impacts (enabling accurate consumer information).

Biotechnologies are technologies that use and manipulate living organisms such as cells, bacteria and yeast, or parts of these ie. genes and enzymes. 'White biotechnology' refers to the use of biotechnologies in industrial processes (eg. enzymes and yeasts) and big benefits for food processing efficiency have been claimed for this area.[64] Agricultural biotechnology (adaptation or engineering of agricultural crops and livestock) is sometimes known as 'green biotechnology'. Genetic modification is a specific category of biotechnologies in which the genes of an organism are engineered to give desired characteristics to living organisms – the contentious genetic

[64] Jorgensen, M.S. et al. (2005), *Green Technology Foresight About Environmentally Friendly Products and Materials: Challenges from Nanotechnology, Biotechnology and ICT*, Institute for Product Development, Denmark, http://ec.europa.eu/information_society/istevent/2006/cf/document.cfm?doc_id=1671.

modification of released organisms (GMO's) is not the only type of biotechnology relevant to food systems.

Nanotechnology is the manipulation of atoms and molecules to create new materials, new structural characteristics and new products. Internationally, research funding for nanotechnologies is increasing rapidly and nanotechnologies have potential to vastly change many technologies and systems.

The **convergence** of ICT, biotechnology, and nanotechnology could revolutionise science and technology, and it is it has been claimed that "over the next two decades, the impacts of this convergence on farmers and will exceed that of farm mechanisation or of the Green Revolution."[65]

The urgent need to reduce the vulnerability of the food system to environmental challenges means that all possible solutions and areas of investigation should be explored. However, the precautionary principle should apply and a careful and measured scrutiny of the science must be maintained to avoid increasing environmental (or health) risks to the food system. This is a critical issue for future policy as the unintended side-effects of a premature technology release could lead consumers to reject other possible contributions from science and technology. Careful handling and governance is required.

For technological developments to become useful 'innovations', their social and cultural context as well as their commercial applicability need to be well understood as all these factors interact.. The relationship between emerging technologies and their social acceptance (rejection or endorsement) is particularly important in relation to food, where people are immediately and physically impacted if wrong judgements are made.

!	*Urgent need for major change means that all possible solutions and areas of investigation should be explored. These must encompass technological change, system change and behaviour / life-style change*
!	*The food system is very vulnerable and already exposed to many risks – increasing risk to the environment or human health should be avoided*
!	*Insufficient caution in early release of emerging technologies could lead to consumer backlash against later technologies*
!	*Potential for conflict between producers wishing to use GM crops and those who don't*
!	*The need for change is now – priority is uptake and transfer of existing, proven and safe, technologies and techniques that are already available*
🕮	*Governance of emerging technologies – particularly how to manage entry into the food system*
🕮	*Environmental impacts of genetically modified crops, including on soils and surrounding biodiversity*
🕮	*Potential environmental impacts of nanotechnology*
↯	*New applications and reconfiguration of existing technologies*

3.2. New Production Strategies

Many producers are already responding to these challenges and risks, finding new ways to increase the resilience of farming and food production and/or opening up new opportunities.

[65] ETC Group (2004), *Down on the Farm: The Impact of Nano-Scale Technologies on Food and Agriculture*, ETC Group, Ottawa from http://www.etcgroup.org/en/materials/publications.html?pub_id=80, p1

Three approaches to new production strategies have been identified: environmental management, diversification, and reduced reliance on inputs. These approaches intersect, with some producers embracing all three.

3.2.1. Environmental Management

The purpose of agriculture is to feed and clothe people. Two things will guarantee this happens with maximum efficiency. Firstly, farming must be prosperous and secondly, soil fertility must constantly improve.[66]

Improved environmental practices are now being applied more broadly within existing production systems. Farmers are working independently and in small groups to explore more sustainable, resilient and profitable farming methods that do not rely on great capital investment or increasing farm size.[67]

Increasing consumer interest and concern about how food is produced (from both an environmental and ethical perspective) have created opportunities to reward producers for doing things that were previously considered a cost (eg. fencing off creeks and remnant vegetation, reducing stock numbers, decreasing or eliminating synthetic fertilisers and pesticides, and so on). Gippsland beef producers who implement an (independently audited) Environmental Management System (EMS) and supply *Enviromeat*[68] can receive a 25% premium for their meat.[69] Some Australian farmers are also working with polycultures, perennial species (including native grasses), cover crops, reduced tillage, rotational / cell grazing, keyline techniques and mineral and trace element balancing to develop innovative systems suitable to their conditions. One example of such an innovation is pasture cropping,[70] which is claimed to be 27% more profitable than conventional agriculture, whilst also improving soil and regenerating landscapes.[71]

!	*Important innovations are emerging that do not require large capital investments, and depend more on knowledge and understanding of particular landscapes; these need to be systematically captured, evaluated and communicated*
!	*There are no simple answers – there is a need to encourage and support producers to experiment and share both successes and failures*
🕮	*Evaluate benefits of specific methods in Victorian conditions – which ones work best where and why? Measurement and evaluation through controlled trials*
↯	*Further development and application of existing methods above, underpinned by research*
↯	*Certifications / branding that can take new issues into account – improved soil health, water use, emissions generation, potentially carbon sequestration*

3.2.2. Diversification

One important aspect of environmental management and food security is diversification. Maintaining diverse crops and ground cover is a way to increase resilience in the face of unpredicted weather conditions and pests, with producers avoiding situations in which they lose their entire crop/ income because of extreme weather or pest infestation.

[66] P.A. Yeomans, cited www.permaculture.biz
[67] For an example, see Birchip Cropping Group – Agricultural Community Innovators, www.bcg.org.au
[68] Enviromeat is a premium beef brand that requires producers to implement an EMS covering: protection of biodiversity and water quality, management and protection of soil health and organic matter, and control of weeds and vermin.
[69] *Future Farming in Gippsland*, available via www.enviromeat.com.au
[70] Sowing crops directly into perennial pastures (usually native) – benefits of polycultures, cover crops, perennial plants etc
[71] Seis, C. (2006), "Pasture Cropping as a Means to Managing Land", *Australian Organic Journal,* Winter 2006.

Large farming systems and agribusiness has provided a path to continual productivity increases and the associated capital investments required to retain viable and internationally competitive operations. This has meant the consolidation of many small, family farms and the consequent movement of farmers off the land.

Changing conditions, including increasing environmental risks and vulnerabilities, may see another (complementary?) trend with a viable new role for smaller farms with diverse production systems. These farms may be more able to survive in a market that emphasises security and resilience in the total food supply, with different organisational systems linking producers and consumers. A network of smaller independent farms may be more likely to develop innovations that respond to local conditions, using information systems to communicate knowledge about management of intensive agricultural systems and new methods of sustainable food production. Diversification is also important in development and application of technologies; a concentrated focus on particular technology trajectories can reduce openness to imaginative innovation.[72]

The variety of products and methods being experimented on by small / medium farms could potentially support the security of food supplies in changing conditions. Diversification within single enterprises (including the productivity and environmental benefits of polycultures and mixed farms – integrated livestock / cropping systems) is likely to provide different types of solutions that can increase the overall resilience of Victorian food. Gippsland Natural (*EnviroMeat*) has demonstrated how effectively groups of smaller farmers can produce quality food with high market value.

There is a strong movement in the USA for smaller farms, partially for the social and environmental, as well as local economic benefits of keeping more people active in landscapes.[73] The potential importance to food security of maintaining diverse production systems and products (and increasing the contribution from small farms) is still to be systematically explored in Victoria. The support services needed for farmers with diverse smaller scale systems, or different types of farming enterprise may well differ from those developed for larger, export-oriented farmers.[74]

!	*Diverse small / medium sized farms could increase the resilience of the food system*
!	*The knowledge of local bio-regions and ecosystems that is held by small / medium farmers could be important in adaptation to climate change*
!	*Diversification in systems, products and technologies enables more widespread innovation and increases resilience*
🕮	*How important are diverse farms to Victorian food production / security? Key questions include:* ➢ *What types of products? How is it being distributed? How viable are these businesses?* ➢ *What production systems / methods are they using?* ➢ *What are their relative efficiencies and environmental impacts?* ➢ *What is the potential contribution to food security?*
🕮	*Analysis of the contribution of smaller farms and more farmers in the landscape to health and social objectives, and adaptation to climate change*
↯	*Extension services for entrepreneurial small farmers to develop new products and reach new markets*
↯	*Production and distribution systems more suited to smaller land areas and farming enterprises*
↯	*Adaptation of agricultural knowledge and services to smaller-scale, diverse production systems*

[72] Reeve, I. (1992), "Sustainable Agriculture: Problems, Prospects and Policies," *Agriculture, Environment and Society: Contemporary Issues for Australia*, edited by G. Lawrence, Vanclay, F. and Furze, B., MacMillan, Melbourne, Australia, p211
[73] Francis, J. (2002), *Recognising the Value and Potential of Small Farms: Learning from the USA*, Department of Primary Industries, State of Victoria, pviii
[74] HAWCAEP 2001, cited in Ibid., pix

3.2.3. Reducing Reliance on Inputs

Production systems that seek to minimise or eliminate the use of synthetic chemical inputs are experiencing rapid growth around the world. The major systems considered in this discussion paper are 'organic' and 'biological'. Organic systems have an absolute ban on synthetic fertilisers, pesticides and herbicides. Biological farming (similarly to 'natural farming' and 'regenerative farming') seeks to actively improve soil fertility and reduce use of synthetic chemicals, but allows use of microbe-friendly fertilisers and herbicides. Biological systems aim to actively regenerate soil biology and fertility, and are being used in conjunction with conventional farming. Biodynamic farming is a subset of organic farming, which additionally focuses on the farm as a closed, self-nourishing system[75],[76] where (ideally) everything needed for production should be provided from the farm (in current practice this is often not be the case as pre-prepared biodynamic formulations are now available).

In Australian retail sales, organic lines are growing fast.[77],[78] So is export market potential; the Asia-Pacific region's demand for organics is growing faster than any other market in the world, posting a 28% annual growth rate.[79] The Australian organics industry is currently on a 'recruitment drive' for farmers to help it keep up with its growth rate of 25 per cent a year.[80] Despite industry growth, both domestic and export market demand for certified organic produce still exceeds the Australian supply of organic produce.[81]

Adoption of biological, natural and regenerative farming methods is linked to the increasing costs of agricultural inputs. The techniques that have been developed through these systems over the last 20 years can be used to increase soil and plant resilience and therefore reduce dependence on fertilisers, pesticides and other inputs. Biodynamic, organic and biological practices are also being adopted in some industries (eg. viticulture) because they are believed to produce a higher quality product. [82]

There is ongoing vigorous debate about the environmental benefits of low or no synthetic input food production (including organics and biological farming). There are many international studies exploring the relative benefits of different systems, and results vary according to food type, production system and location. While insufficient evidence exists to say that all organic production is better for the environment than all conventional production, there are substantiated benefits (biodiversity, land and soil health, water efficiency)[83],[84],[85] for many food types. The extent to which these translate into overall lifecycle benefits is not clear. It is most likely that for many foods the overall environmental impacts of organic produce are lower than those conventionally

[75] Lorand, A. (1996), *Biodynamic Agriculture — a Paradigmatic Analysis*, Ph.D. Thesis, Pennsylvania State University.
[76] Diver, S. (1999), *Biodynamic Farming & Compost Preparation*, ATTRA - National Sustainable Agriculture Information Service, Publication #IP137
[77] Lea, E. (2005), cited in Cuthbertson, B. and Marks, N. (2007), *Beyond Credence? Emerging Consumer Trends in International Markets*, Department of Primary Industries, State of Victoria, p13
[78] Ibid, p14
[79] Prance, L. (2007), *Increased Health Awareness Drives Organic Food and Beverage Market*, accessed 15 November 2007, from http://www.foodnavigator.com/news/ng.asp?n=78397&m=1FNE723&c=opcaiaxodmazqrp
[80] Farm Online (2007), *Farmers Wanted to Meet Organic Boom*, accessed 1 May 2007, from http://theland.farmonline.com.au/news/nationalrural/agribusiness-and-general/general/farmers-wanted-to-meet-organic-boom/54910.aspx
[81] Kinnear, S. (2000), cited in Ashley, R. et al. (2007), *Intensive Organic Vegetable Production: Integrated Development,* Report Produced for the Australian Government Rural Industries, Research and Development Corporation, RIRDC Publication No 04/121
[82] de Bortoli now has some organic lines - http://debortoli.com.au/our-wines/press-reviews.html, a list (and discussion) of wineries moving to biodynamic can be found at http://redwhiteandgreen.com.au/
[83] Alfoeldi, T. et al. (2002), "Organic Agriculture and the Environment," I*Organic Agriculture, Environment and Food Security, Environment and Natural Resources - Series 4*, edited by N. El-Hage Scialabba and H. Caroline, Food and Agriculture Organisation of the United Nations (UN FAO), Rome.
[84] Zierhl, A. (2004), *Organics and Sustainability: Substantiating the Claim of 'Clean and Green'*, Department of Primary Industries, State of Victoria, p41
[85] Delate, K. (2007), "Fundamentals of Organic Agriculture,", *Organic Agriculture Series,* accessed 15 November 2007, from http://extension.agron.iastate.edu/organicag/pubs.html

farmed,[86] particularly when water use and off-site energy impacts are accounted for.[87] However, the relative benefits of different systems need to be assessed for particular products rather than in general, and a full system analysis is required which considers possible trade-offs eg: productivity per acre and the impacts of different tillage methods and fertilizers on the sequestration of soil carbon and soil structure.

The potential contribution of organic systems to greenhouse gas mitigation and to climate change adaptation is receiving increased attention. A 2008 study that conducted a comprehensive review of the relevant peer-reviewed scientific literature, found that organic farming could serve as a 'quick-win' policy option in carbon offsetting markets. The study concluded that:[88]

> *organic agriculture has much to offer in both mitigation of climate change through its emphasis on closed nutrient cycles and is a particularly resilient and productive system for adaptation strategies.*

There is substantial international evidence that low/no input agricultural production systems can sustain yields at or close to conventional agricultural levels for many products, and considerably more in some circumstances (up to 80% more in developing countries).[89] Long-term field trials in the USA and Europe have had varying conclusions for a range of products; systematic trials in Victorian / Australian conditions would be required for better understanding.

Many developments and discoveries in the fields of organic and biological farming also have benefits for conventional farming, particularly with the increasing need to reduce agricultural inputs and environmental impact. Many of these are already being picked up, developed and used (eg. crop rotation and cover cropping – see *3.2.1 Environmental Management*).

High tech (precision techniques) and agro-ecological or biological farming systems are not mutually exclusive; future farming systems can make use of nets of sensors to monitor soil condition, information technology systems to mange minimum input, and GIS/GPS to design landscape scale applications of low-input techniques – 'the best of both worlds.'

Controlled field trials are suggesting nutritional advantages to some foods produced with low-input methods, eg. organic fruit and vegetables containing up to 40% more antioxidants and organic milk up to 60% higher levels of beneficial minerals such as iron and zinc.[90] Possible health concerns (and how to reduce them) are also being investigated through this research program. Furthermore, an extensive review of controlled comparison studies (released in March 2008) found that "yes, organic plant-based foods are, on average, more nutritious."[91]

!	*Increasing consumer demand for organics (domestically and in international markets) creates opportunities for Victorian producers – inability to meet increasing demand in Victoria requires more imports*
!	*Reducing reliance on costly and potentially scarce inputs can increase the resilience and reduce the environmental impact of all agricultural systems – not just those labelled 'organic'*

[86] Foster, C. et al. (2006), *Environmental Impacts of Food Production and Consumption: A Report to the Department for Environment, Food and Rural Affairs*, Manchester Business School, DEFRA, London, accessed December 2007, from www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf, p14
[87] Ibid, p343
[88] International Trade Centre (2008), *Organic Farming and Climate Change*, International Trade Centre, Switzerland, http://www.intracen.org/Organics/publications.htm (NB: The ITC is the joint technical cooperation agency of the UN Conference on Trade and Development (UNCTAD) and WTO for business aspects of trade development)
[89] Badgley, C. et al. (2007), "Organic Agriculture and the Global Food Supply." *Renewable Agriculture and Food Systems*, vol. 22: 86-108.
[90] Cordis RTD-News (2007), "EU Research Finds Organic Food Healthier and Better", *Food Quality and Safety - Cordis EU*, 30 October 2007, from http://cordis.europa.eu/
[91] Benbrook, C et al. (2008), *New Evidence Confirms the Nutritional Superiority of Plant-Based Organic Foods*, State of Science Review.

!	*Low-input farming (including organics) has significant potential to affect emissions profiles through soil carbon sequestration, and is likely to increase resilience in the context of climate change*[92]
!	*In Victoria, the innovation potential of low input agricultural methods and innovations are being largely overlooked in institutional or research investment*
!	*Recognising and developing innovations that reduce input reliance may be resisted by some commercial interests*
!	*Conflicts between biological farming methods and potential for organic certification. For example, best-practice low-input grazing management requires flexible stocking rates (which means buying in cattle seasonally), but high demand for organics means that young 'organic' animals are likely to be sold straight to market rather than to other farmers. Therefore it is very difficult for many small farmers following biological or organic methods to certify their meat as organic, because they cannot source organic animals to bring onto their properties.*
🕮	*Long-term field trials of organic, biological and conventional methods, including:* ➢ *yield comparisons for different products* ➢ *overall efficiencies of inputs and yields*
🕮	*Further investigation of the environmental benefits of low/no-input farming methods in a Victorian / Australian context, with particular attention to:* ➢ *The most significant changes – which techniques / processes make the most difference to environmental impact (including soil, water and emissions) and what is the potential for their adaptation more broadly; and* ➢ *For which food types or production systems are the benefits greatest – focus attention on development of methods and systems with most potential impact*
🕮	*Investigate whether low-input production in Victoria is resulting in higher nutrient levels in fruit and vegetables – pursue opportunities for health **and** environmental gains*
🗲	*Improving low/no-input systems and techniques – significant domestic and export potential for knowledge and innovation in this area*
🗲	*Improvements to sustainability and resilience across all agricultural systems using knowledge / techniques developed in low/no input production systems*
🗲	*Product quality improvements through organic / biodynamic / biological methods eg. viticulture*
🗲	*Build consumer awareness of biological / low-input farming systems other than organic – possibly branding / labels – enabling purchase of products from low-impact farming methods*
🗲	*Integration of other technology development eg. use of ICT for precision farming, soil testing, GIS/GPS for low-input methods etc*[93]

3.3. New Distribution Strategies

Distribution can be taken to include all activities which involve the movement and value-adding of food – from farm to processor, processor to wholesaler / retailer etc. Technological developments have supported improvements in logistics and transport efficiencies, packaging materials and efficient storage, all of which help reduce the environmental impacts of food distribution. Attention to increasing efficiencies in food processing and retail will have benefits. Continual improvement throughout mainstream agri-business and food supply chains will be necessary, and the need to reduce risk and impact is increasingly understood.

[92] International Trade Centre (2008), *Organic Farming and Climate Change*, International Trade Centre, Switzerland, http://www.intracen.org/Organics/publications.htm (NB: The ITC is the joint technical cooperation agency of the UN Conference on Trade and Development (UNCTAD) and WTO for business aspects of trade development)

[93] As with all agriculture, energy / emissions and resource implications may need to be considered

Community-led distribution strategies are focusing on localisation – reducing the distance that food travels between the producer and consumer. This 'distance' can be conceived both directly in kilometres, and in stages of the food chain ie. reduced processing, packaging, storage. While remaining contentious, localisation movements have led to a number of innovations discussed further below.

3.3.1. Localisation

Food localisation aims to shorten the supply chain by producing food close to where it is consumed,[94] reducing the energy used and greenhouse gases released through food-related transportation[95] and the associated processing, packaging and storage. Food localisation movements are also being driven by concern about resilience of local food supplies, particularly in preparation for the dual challenges of climate change and peak oil.

International analyses have suggested that while there are general environmental advantages to local food production, this depends on the type of foods, how they are produced, processed, packaged and stored. For example, the lower embedded energy of lamb produced in NZ makes it a lower impact choice for UK consumers than lamb produced locally in the UK.[96]

It is most likely that for Victoria, which has relatively good production conditions for many food groups and substantial food production and processing capability, local foods will present environmental benefits.[97] But analysis appropriate to local conditions (taking into account water efficiency & scarcity, relative emissions in production etc) is advised before specific conclusions could be drawn.

As discussed in *2.1.2*, in the section on *Transport-Food Miles*, the greenhouse emissions from car based shopping may exceed the transport emissions from production and distribution, and if purchase of some local foods (from different outlets than the rest of the food) means extra car trips, this could outweigh benefits.

Climate change, emissions pricing and oil constraints will present new challenges to long food supply chains, and ensuring access to locally produced basic foods could help increase resilience and food security under these conditions. Local production of food is also likely to have health and regional development benefits.

!	*Ongoing access to food from interstate and overseas will continue to reduce vulnerability to disruption of local food production (such as extreme weather events)*
!	*Consumption of some locally produced some foods will have clear environmental benefits, but others may need careful balancing across water, emissions, land impact etc*
!	*In many cases, local food systems have nutritional and food security benefits, improved understanding and regulation of production practices, and benefits for local communities and economies.*
🕮	*Analysis of benefits of local food consumption in Victoria, with consideration given to:* ➢ *How much environmental impact is related to transport & storage vs production;* ➢ *Different production conditions for different foods; and*

[94] Cowell, S.J. and Parkinson, S. (2002), "Localisation of UK Food Production: An Analysis Using Land Area and Energy as Indicators." *Agriculture, Ecosystems and Environment,* vol. 94, p222

[95] Van Hauwermeiren, A. et al. (2007), "Energy Lifecycle Inputs in Food Systems: A Comparison of Local Versus Mainstream Cases." *Journal of Environmental Policy and Planning*, vol. 9, no. 1: 31-51.

[96] Saunders, C. et al. (2006), *Food Miles - Comparative Energy/Emissions Performance of New Zealand's Agriculture Industry*, AERU - Lincoln University

[97] Short transport distances and favourable local conditions led to this finding in a US study, Victoria's strengths in food production suggest that it might also be the case here - Morgan, D. et al. (2006), *Seattle Food System Enhancement Project: Greenhouse Gas Emissions Study*, University of Washington, Program on the Environment, accessed 14 January 2008, from http://courses.washington.edu/emksp06/SeattleFoodSystem/Final_GHG_Report.pdf.

	➢ *Relative environmental impacts of production / processing in Victoria vs elsewhere*
🕮	*Analysis of the potential to meet food needs through local, seasonal production in Melbourne / Victoria – what would it include? Would it be nutritionally adequate?*
↯	*Reducing environmental impacts and vulnerability of supply chains – logistics, packaging innovations, storage systems etc*
↯	*Collaboration with transport / retailer / health sectors to encourage change in how people access food ie. increase walking / cycling and ensure that increased local food purchase does not require extra car trips*

3.3.2. Farmers' Markets

and

3.3.3. Community Supported Agriculture

The emergence of farmers' markets and community supported agriculture (CSA) schemes has been driven by desire to: reconnect producers and consumers, provide new distribution avenues that give producers a higher proportion of the return, and improve consumer access to fresh and diverse produce.

Farmers' markets are increasingly popular in Australia – there are now over 40 regularly operating in Victoria and the economic and social advantages have been documented.[98] Likely environmental benefits include: reduced waste and packaging (as produce and packaging do not need to meet strict supermarket conformity standards); reduced travel distances for food; and opportunities to access more sustainably produced food. However it is possible that farmers travelling to more distant farmers' markets (ie. not just their local one) with small amounts of produce could cause an increase in transport emissions.

CSA's are very popular in the USA but less so in Australia and as of 2001 only one was operating in Victoria.[99] It is unclear why this innovation is so popular internationally but has not found a market niche in Australia. It may be due to a lower rural to urban proportion of population, the different distribution of people in the landscape (Australians are concentrated in a few big cities whereas Americans have more smaller cities surrounded by rural areas), or higher levels of awareness / concern in US communities.

Victoria / Australia's population densities may affect the overall environmental benefits, and vulnerability to oil prices, of farmers' markets and CSAs (if they require more car / small truck trips).

!	*Urban farmers' markets may be more concentrated in higher income areas (where producers can get good returns) limiting access to disadvantaged groups*
🕮	*An understanding of the full transport patterns of Victorian farmers' markets, and comparison with full transport cycles of conventional distribution systems*
↯	*Increased efficiencies and accessibility of food distribution – reducing reliance on separate car / small truck trips*

[98] Coster, M. and Kennon, N. (2005), *'New Generation' Farmers' Markets in Rural Communities* (No. 05/109), Rural Industries Research and Development Corporation (RIRDC).
[99] Parker, A. (2001), *Feasibility of Community Supported Agriculture in Australia*, Department of Natural Resources and Environment, State of Victoria.

3.3.4. *Urban Agriculture*

Over 50% of the world's population now live in cities, and there is increasing attention to the benefits of producing food close to these consumers in the cities themselves – urban food production now accounts for 15% of the world's food production.[100]

Large amounts of food can be grown in cities and by citizens when it is required – Cuban cities produce an average of 60% of their vegetables (a response to oil shortages), [101] and US Victory Gardens in World War II produced up to 40% of the national food supply.[102] Australians have a strong history of urban food supply, and from the most recent records (1992) Victoria already has the largest number of households growing fruit and vegetables.[103]

Urban agriculture can reduce environmental impacts and increase the resilience of urban food supplies by: reducing vulnerability to oil prices; reducing food miles (and greenhouse emissions); making use of alternative 'agricultural inputs' ie. stormwater, wastewater and food waste; and reducing land conflict between food production, biodiversity and biofuels.

Consumer transport emissions from cars to actually collect food may be the most significant transport component of food footprint,[104] and for some foods it could even be the most significant emissions contribution.[105] Producing some food in backyards and local neighbourhoods has potential to remove (or significantly reduce) this impact.

International efforts to increase urban food production are making use of both traditional as well as innovative technological developments.

!	*Access to affordable food may be greatly improved through urban production – at home, community or commercial levels. Flexible urban water policy should allow for (or even encourage) this*
!	*Increased interest in home food production without adequate consideration of water provision may lead to environmental and public health risks (particularly greywater use on vegetables)*
!	*The ability to produce food is particularly important for low-income families and other disadvantaged groups*
🕮	*Explore the economic and social implications of increased urban agriculture – how much could it affect access to and affordability of food (particularly fruit and vegetables)*
🕮	*Investigate how much food is currently, and could potentially be, produced within Melbourne[106] - how much land could be available, and what technologies / systems could contribute?*
🕮	*Analyse the resource / environmental costs and benefits of urban food production (specific to Melbourne and regional urban centres)* ➢ *Relative contributions of transport, energy, water use (including potential use of wastewater)* ➢ *Comparison of water / emissions / inputs of home vegetable garden & fruit trees to food from other sources[107]*

[100] Pearce, F. (2006), "Ecopolis Now: Forget the Rural Idyll. Urban Living May Be the Best Way to Save the Planet." *New Scientist* 190, no. 2556, p39

[101] Institute of Science in Society (2008), *Organic Cuba without Fossil Fuels*, accessed 23 January 2008, from http://www.cityfarmer.info/organic-cuba-without-fossil-fuels-the-urban-agricultural-miracle/#more-87

[102] Hopkins, R. (2006), "Designing Energy Descent Pathways: Unleashing Abundance as a Community Response to Peak Oil," *Transition Culture*, accessed 26 July 2007, from http://transitionculture.org/?p=266

[103] ABS (1992), *Home Production of Selected Foodstuffs, Australia*, Cat. No. 7110.0, Australian Bureau of Statistics, Canberra

[104] Foster, C. et al. (2006), *Environmental Impacts of Food Production and Consumption: A Report to the Department for Environment, Food and Rural Affairs*, Manchester Business School, DEFRA, London.

[105] Morgan, D. et al. (2006), *Seattle Food System Enhancement Project: Greenhouse Gas Emissions Study*, University of Washington, Program on the Environment, accessed 14 January 2008, from http://courses.washington.edu/emksp06/SeattleFoodSystem/Final_GHG_Report.pdf

[106] VEIL is investigating how much food is already being produced within urban Melbourne.

↯	*Cheap, simple and safe household greywater systems enabling use for food*
↯	*Small scale green / organic waste composting systems (and larger scale energy from waste facilities)*
↯	*Integrated urban water treatment / food production systems*
↯	*Improved production practices in urban systems – applying useful agricultural knowledge to small-scale (household and community) systems*
↯	*Knowledge and systems for urban food production have very significant export potential*

3.4. Consumer Choices

Consumer concerns and demand for different types of food, produced and distributed in different ways, can become expressed as new consumption preferences which change the marketplace. Even though they may be relatively small (compared to the mainstream market) they can have real economic impacts, either because of their purchasing power or because there are marketing companies or producers focused on 'trend-spotting', looking to find new niche markets to expand.

The behaviours discussed in this section require only a change in the consumer's purchasing choices to reflect their values, they can lead to but do not necessarily require changes to production or distribution systems.

3.4.1. Fair Trade

Fair Trade aims to improve conditions for producers in the developing world by providing a fair price for produce – consumers in the developed world pay a premium for Fair Trade products on the basis of social benefits (ie. no claim to or guarantee of quality or environmental benefits).

Markets for Fair Trade produce are increasing: worldwide sales increased 42% in 2006,[108] and Australian and New Zealand sales were $12 million in 2006/07 (making up almost half of the total sales of $25 million since September 2003).[109]

!	*Some consumers are willing to pay more for fair prices and conditions in developing countries. It is not yet clear whether consumers are / would be willing to pay more to ensure more sustainable operating margins for local producers*
🕮	*Are Victorian producers receiving 'fair' prices for their produce?*

3.4.2. Reducing Waste

Reducing food waste at the household level can save money and reduce environmental impacts of food.

Food waste can be reduced through changed eating habits, improved storage and revival of food, and more information about how to cook and make use of ageing food.[110] The environmental impacts of food waste can be ameliorated by reusing / recycling (ie. composting)

[107] Rough calculations suggest that between $5.7 and $29.4 million of fruit and vegetables could be produced in the City of Melbourne, using 10% of the mains water currently used for open space irrigation and 25% of that used for private gardens – see full report for calculation (*3.3.4 Urban Agriculture*),
[108] Fairtrade Labelling Organizations International. (2007), *Figures*, accessed 18 March 2008, www.fairtrade.net/figures.html
[109] Fair Trade Association of Australia and New Zealand (2007), *Fairtrade Retail Sales Set to Top AU$12 Million in Australia and New Zealand*, accessed 12 November 2007, from http://www.fta.org.au/node/1761/view
[110] see "Love Food Hate Waste" – www.lovefoodhatewaste.com

the food waste – ABS data has suggested that an increasing number of households are composting food / kitchen waste,[111] perhaps almost 50%.[112]

Food that is discarded by retailers and wholesalers is sometimes salvaged by 'urban gleaners' or 'freegans', who aim to live off the waste generated by the mainstream food system.[113,114] Salvaged food waste is either consumed personally or redistributed to the homeless or other groups.[115,116]

!	*Understanding and reducing food waste at the household level may be an effective way to both build resilience to rising food prices and reduce environmental impacts*
🕮	*How much food is wasted, and where in the system could it be reduced, salvaged, redistributed or recycled (see 2.4 Waste)*
↯	*Reducing, reusing and recycling food that is currently wasted at the consumer end of the system (ie. retailer and household)*
↯	*Potential for processing innovations to reduce waste from seasonal 'gluts'*

3.4.3. *Eating in Season*

Seasonality may simplify analysis of distribution systems, and enable more general statements to be made about the sustainability of local foods. If foods are grown locally and in season, this is more likely to mean that they have not required greenhouses or other climate control for production, and may have also undergone less processing, packaging and storage. Production conditions in some areas may still be more sustainable than others, but seasonality removes one layer of complexity!

!	*A changing climate is likely to change the concept of 'seasonality' – knowledge about what is seasonal in particular locations will probably need to continually adapt*
🕮	*Explore seasonality in Victoria (and/or different regions in Victoria) – is it changing?*
🕮 (R)	*Analysis of the potential to meet food needs through local, seasonal production in Melbourne / Victoria – what would diet include? Would it be nutritionally adequate?*
↯	*Information and access to seasonal produce*[117,118]
↯ (R)	*Processing and marketing of seasonal gluts*

[111] ABS (1998), *Australian Social Trends 1998 - Waste Management: Household Waste Management*, Cat. No. 4102.0, Australian Bureau of Statistics
[112] ABS (2007), *Australian Social Trends 2007 - Article: Household Waste*, Cat. No. 4102.0, Australian Bureau of Statistics, Canberra, p3
[113] see Freegan Info at http://freegan.info/
[114] Singer, P. and Mason, J. (2007), *The Ethics of What We Eat: Why Our Food Choices Matter*, Text Publishing, Melbourne
[115] See http://www.foodnotbombs.net/story.html
[116] Port Philip Leader (2007), cited in Edwards, F. and Mercer, D. (2007), "Gleaning from Gluttony: An Australian Youth Subculture Confronts the Ethics of Waste." *Australian Geographer*, vol. 38, no. 3: 279-96, p281
[117] A US example can be found at http://www.nrdc.org/health/foodmiles/, search by State and time of year for a list of locally seasonal products.
[118] Seasonal fruit and vegetable guides for Victoria were published by the Melbourne Market Authority in 2002 and are available from: www.marketfresh.com.au/images/download/fruitguide.pdf and www.marketfresh.com.au/images/download/vegetableguide.pdf

3.4.4. Choosing a Sustainable Diet

Some people are attempting to reduce the environmental impacts of their food by making personal choices about the types of food they will actually eat. Concern about health has and will continue to shift eating habits, and concern about the environment may well shape the average Australian diet into the future. As some people attempt to adjust their diets to reduce their environmental impact, it is important that they do not jeopardise their health and nutrition in the process, or make decisions based on misguided information.

Swedish researcher Anika Carlsson-Kanyama has found that "food products with similar functions and nutritional qualities can differ widely in terms of life cycle energy inputs, so meals and diets can be more or less energy efficient while providing households with adequate nutrition,"[119] and that meals similar in calorie content can vary by 2-9 times in greenhouse gas emissions.[120] She found that, in Sweden, some meat products are much more energy intensive than others, as are some vegetable products – product specific analysis is necessary for recommendations.

A number of international studies, including the 2003 Joint Expert Panel of the World Health Organisation and the Food and Agriculture Organisation, have suggested that healthier diets (lower in salt, sugar and saturated fats, with more fruit, vegetables and legumes, and a higher proportion of foods of plant or marine origin), are also better for the environment.[121,122] Carlsson-Kanyama's work also highlighted the potential to reduce both environmental impacts and health concerns through a reduction in snacks, sweets and drinks.[123]

A Welsh study analysed the economic, environmental and nutritional impacts of a number of dietary changes. They found that substantial reductions in the ecological footprint of diets can be achieved through food substitution (with equivalent nutritional value), and can often represent a financial saving to the consumer.[124]

The high environmental impacts of meat (particularly from ruminants) and dairy consumption are under increasing international and domestic scrutiny.[125,126,127]

!	*There is a strong correlation between the dietary changes recommended for improved health, particularly reduction in non-communicable diseases, and reduced environmental impact.*
!	*The personal choice to reduce red meat consumption (particularly from ruminants) and dairy consumption is very likely to reduce the environmental impact of an individual's diet.*
!	*Livestock play an important part in mixed farming systems and provide essential inputs (manure) that will increase in importance as conventional agricultural input costs increase. Efforts to reduce the environmental impacts, particularly methane emissions, from livestock*

[119] Carlsson-Kanyama, A., Pipping Ekstrom, M., and Shanahan, H. (2003), "Food and Life Cycle Energy Inputs: Consequences of Diet and Ways to Increase Efficiency." *Ecological Economics*, vol. 44: 293-307, p300
[120] Carlsson-Kanayma, A. (1998), "Climate Change and Dietary Choices: How Can Emissions of Greenhouse Gases from Food Consumption Be Reduced." *Food Policy*, vol. 23, no. 3-4: 277-93.
[121] WHO/FAO (2003), *Diet, Nutrition and the Prevention of Chronic Diseases: Report of the Joint WHO/FAO Expert Consultation* (No. 916), accessed 31 January 2008, from http://www.who.int/dietphysicalactivity/publications/trs916/summary/en/index.html.
[122] Duchin, F. (2005), cited in Carlsson-Kanyama, A. et al. (2003), "Food and Life Cycle Energy Inputs: Consequences of Diet and Ways to Increase Efficiency." *Ecological Economics*, vol. 44: 293-307.
[123] Carlsson-Kanyama, A. et al. (2003), "Food and Life Cycle Energy Inputs: Consequences of Diet and Ways to Increase Efficiency." *Ecological Economics*, vol. 44: 293-307, p306
[124] Collins, A. and Fairchild, R. (2007), "Sustainable Food Consumption at a Sub-National Level: An Ecological Footprint, Nutritional and Economic Analysis." *Journal of Environmental Policy and Planning*, vol. 9, no. 1: 5-30.
[125] FAO (2006), *Building Resilience for an Unpredictable Future: How Organic Agriculture Can Help Farmers Adapt to Climate Change*, Food and Agriculture Organisation of the United Nations
[126] Diesendorf, M. (2007), *Paths to a Low Carbon Future: Reducing Australia's Greenhouse Gas Emissions by 30 Per Cent by 2020*, Sustainability Centre, Epping, Australia, p16
[127] McMichael, A.J., Powles, J.W., Butler, C.D., and Uauy, R. (2007), "Food, Livestock Production, Energy, Climate Change and Health." *The Lancet*, vol. 370, no. 5: 1253-63.

	are vitally important as worldwide demand for meat and dairy continues to increase.
!	*Ultimately though, a continuing global expansion of meat (from ruminants) and dairy consumption is likely to be undermined by the need to reduce greenhouse gas emissions and constrained land and water supplies*[128]
🕮 *(R)*	*Analysis of recommended 'healthy eating' in Victoria / Australia and the environmental implications of recommended changes to dietary composition (such as reduced sugar, increased fruit and vegetables, level of processing); are there areas where these conflict?*
🕮	*Analysis of the most effective ways to reduce the environmental impact of diets through food substitution in a Victorian context – which foods to reduce, avoid, replace etc*
🕮	*Adaptation of knowledge about behaviour change in other fields (health, water, drink-driving etc) – how can food programs be developed, or integrated into existing programs*
↯	*Alternative sources of meat protein and other foods – native species?*
↯	***Systems and information enabling informed consumer choices***

[128] McMichael, A.J., Powles, J.W., Butler, C.D., and Uauy, R. (2007), "Food, Livestock Production, Energy, Climate Change and Health." *The Lancet*, vol. 370, no. 5: 1253-63.

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ABS (1998), *Australian Social Trends 1998 - Waste Management: Household Waste Management*, Cat. No. 4102.0, Australian Bureau of Statistics, accessed 29 January 2008, http://www.abs.gov.au/ausstats/abs@.nsf/2f762f95845417aeca25706c00834efa/e47f22f69c7ac1b1ca2570ec0019ebad!OpenDocument.

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