Australian Government

Australia and Food Security in a Changing World

PMSEIC

It is true that the tide of the battle against hunger has changed for the better during the past three years. But tides have a way of flowing and then ebbing again. We may be at high tide now, but ebb tide could soon set in if we become complacent and relax our efforts. For we are dealing with two opposing forces, the scientific power of food production and the biologic power of human reproduction. Man has made amazing progress recently in his potential mastery of these two contending powers. Science, invention and technology have given him materials and methods for increasing his food supplies substantially.

Extract from Nobel Peace Prize acceptance speech by Norman Borlaug (1970).

Australia and Food Security in a Changing World

Can we feed ourselves and help feed the world in the future?

Report of the PMSEIC Expert Working Group

October 2010

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A report for the Prime Minister's Science, Engineering and Innovation Council .

This report has been prepared by the independent PMSEIC Expert Working Group on Food Security. The views expressed in this report are those of the Expert Working Group and not necessarily those of the Australian Government.

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Foreword from the Chair

Food is a fundamental requirement for survival. When it becomes scarce, people will fight for it, yet when it is abundant, we waste it. The transition from abundance to scarcity can happen rapidly. A major drought, a natural disaster or war, can suddenly plunge a community into famine. While the transition to hunger can be rapid, escape from hunger can be slow, painful and difficult.

In Australia, we have had an abundance of food. We can produce more food than we need and we have the resources to import food if necessary. However, we have faced crises for specific foods, such as the banana shortage after Tropical Cyclone Larry in 2006. Further, our food transport, distribution and storage systems are vulnerable to disruption. For example, a major epidemic could restrict movement of people and materials resulting in food shortages in some urban centres. Perhaps Australia's most serious food security issue relates to the ways in which we consume and use food. Poor nutritional choices made by many in our community are developing into an increasingly important public health issue.

Global food security will demand the development and delivery of new technologies to increase food production on limited arable land and without relying on increased water and fertiliser use. In addition, the frequency and severity of climate 'shocks' are expected to increase due to the effects of climate change. Australia can make a significant contribution to addressing this challenge. We have extensive experience in dealing with difficult and low input food production systems. This technical and scientific expertise is valuable and well-regarded internationally. However, success in technology development and delivery requires community support. Although agriculture is one of our most productive and efficient industries, it struggles to garner community support. The decline in knowledge and interest in food production has probably resulted from the urbanisation of the Australian population. This shift risks limiting our ability to deliver innovation to the Australian and international food industries.

Innovation is required to meet the challenge of ensuring food security. There are two broad tasks ahead. The first is to define the framework for the future food production environment. Greater climatic variability now seems very likely and we know that future production increases will occur in a resource-constrained environment. The future costs of energy, water, fertilisers and carbon will determine the production framework. Australia has the expertise and skills needed to devise the food production models and develop an effective framework for producing food.

Once a production framework is established, the second task is to adapt our agricultural and food industries to the new production environment. The key advances are expected to come from new breeding technologies, improved resource management systems and a greater understanding of the relationship between food composition, consumption and health. Significant technical advances will help ensure efficient production in Australia and in countries where food security is of critical concern. Of course, technology will provide only one component of the solution. Many other factors are important, such as population, infrastructure and political stability.

In this report, we explain the nature of the food security challenges and outline opportunities and possible solutions to the problems. In developing this report, we were very conscious of the breadth of the task and the seriousness of the challenge. We also became increasingly confident that Australia can play an active and highly productive role in tackling this challenge.

Professor Peter Langridge

Chair, PMSEIC Expert Working Group on Australia and Food Security in a Changing World

Executive Summary and Recommendations

Food security is achieved when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life.

(based on the Food and Agriculture Organisation (FAO) 1996 definition)

Food security is an issue for Australia

Australians recognise that food security is a major global issue. The food price crisis of 2008 elevated food security to a high priority on the international policy agenda. While several factors precipitated this crisis, the FAO ominously highlighted the fragility of the global food system as a critical factor. Globally, the number of undernourished people is unacceptably high and stands close to one billion or around 16 per cent of the world population (FAO, 2009). This situation is likely to deteriorate given the projected global population growth to 9.2 billion by 2050, existing and emerging food production constraints, changing consumption patterns and the anticipated impact of climate change.

For Australia, food security is inextricably linked to the political stability of our region and has the potential to affect our national security. Food security also affects our status as a premier food exporting nation and the health and wellbeing of our population. The likelihood of a food crisis directly affecting the Australian population may appear remote given that we have enjoyed cheap, safe and high quality food for many decades and we produce enough food today to feed 60 million people. However, if our population grows to 35-40 million and climate change constrains food production, we can expect to see years where we will import more food than we export. We are now facing a complex array of intersecting challenges which threaten the stability of our food production, consumption and trade. It is imperative that we continue to develop food-related science and technology to fuel a future food revolution that must exceed the achievements of the Green Revolution. Australia is uniquely positioned to help build a resilient food value chain and support programs aimed at addressing existing and emerging food security challenges, such as:

- Vulnerability to climate change and climate variability.
- Slowing productivity growth in primary industries observed over the last decade.
- Increasing land degradation and soil fertility decline coupled with loss of productive land in peri-urban regions due to urban encroachment.
- Increasing reliance on imports of food and food production inputs (such as fertilisers) and the susceptibility of these supplies to pressures outside our control.
- A finely tuned and 'just in time' food transport and distribution system that presents risks of rapid spread of contaminated food and is vulnerable to events such as pandemics.
- Poor nutritional intake leading to an increasing burden of diet-related diseases in the population.
- Conflict in our region and elsewhere.

What role can Australia play in global food security?

Although Australia accounts for less than three per cent of global food trade, we are among the net food exporting nations of the world. While the challenges around food security are considerable, there are significant opportunities for Australia to contribute to global solutions.

Australia's strengths

Australia has key strengths that are highly relevant to building food security:

- Australian agriculture has maintained its leading position by producing food on the driest inhabited continent, on low quality soils and in the face of continual climate variability.
- We have built strong links and capabilities in delivering technological development to developing countries in our region.
- We have a strong research and development (R&D) base and our agricultural R&D capability ranks among the best in the world.
- We have developed a strong capability in climate change research including studies on impacts, adaptation and mitigation.
- We have expertise in human health and nutrition research.

These strengths provide a solid foundation to catalyse transformation in the food value chain required to address food security issues. Advances can be made through a national and coordinated approach to food; by building human capacity; by investing in R&D and by inspiring awareness of the nutritional value of food at both the production and consumption levels.

Main messages

A national approach to food

Food production and processing is a fundamental part of Australia's economy and the health and wellbeing of its citizens. Food, however, is not currently dealt with in a way which brings together food related policy, regulatory agencies and research organisations.

As food security continues to emerge as a challenge globally and domestically, there will be increasing demand for:

- Efficiency in food production, processing and distribution and responsibility in purchasing and consumption to reduce wastage and minimise costs.
- R&D and the delivery of innovations to underpin productivity growth in the food sector, to meet human health needs and bring improvements in food processing.
- Flexibility and responsiveness in regulation to ensure rapid delivery of innovations to the food value chain.

Different policy, regulatory and program areas related to food should be brought together to ensure that government takes a consistent approach to food and food security.

A national approach would bring a high level of coordination, build a strategy for a resilient food value chain and emphasise the link between food and population health.

Investing in R&D to reverse declining agricultural productivity growth

Agriculture has an excellent record of productivity growth over the last fifty years. This has allowed global production to meet the large population increase and, for countries like Australia, these gains have kept food prices low while helping farmers stay in business. However, the rate of productivity growth has slowed dramatically over the past decade and there is international consensus that the current productivity gains are not sufficient to meet future global food demands.

Scientific advances have underpinned productivity growth through yield improvements in crop production. The key challenges are clear:

- To improve water use and management in agriculture.
- To tackle the problem of soil nutrition and reduce the reliance on high energy requirements for fertiliser production.
- To ensure sustainable management of the natural resource base.
- To accelerate advances through new plant, livestock and fish breeding strategies.

While the role of scientific advances in dealing with problems of food supply are well recognised, global investment in agricultural R&D has decreased over the past 20 years (Royal Society, 2009). The drop in investment has been linked to a decline in agricultural productivity (Alston et al, 2009).

A similar trend has been observed in Australia where R&D investment has progressively fallen from a peak of five per cent of gross value of agricultural production in the 1970s to just above three per cent in 2007. Consequently, international debate on the global approach to food security has focused on global underinvestment in food production research.

The decrease in real investment in R&D has led to the substantive decline in underlying productivity growth in the Australian agricultural sector. Increased investment will boost agricultural productivity and provide a key strategy to reduce the impacts of climate change, as well as reduce the greenhouse gas emissions footprint of the agricultural sector.

Building human capacity to meet the challenges and opportunities

Technological advance is critical to productivity gains. It is dependent upon people who can develop the new technologies, deliver them where they are needed and apply the advances to food production systems. The number of agricultural graduates produced nationally falls far short of the estimated needs. Similar declines in other areas of science are increasing the competition for graduates. There are too few graduates taking up the opportunity to study for a higher degree by research and develop a career in agricultural and food sciences. The proportion of graduates in the agricultural industry is lower than that of the broader economy. The age structure across the sector is also of concern. Agriculture has Australia's oldest workforce with a median age of 48 years. Importantly, the effective delivery of technological advances will depend upon a highly skilled, receptive and dynamic food sector workforce.

Raising the importance and awareness of food in the public consciousness

Food is often treated as a bulk commodity which is cheaply and readily available. However, food is strongly linked to the health of the nation. High quality food should be available to all groups within the population. Although information on food and health is readily available in our society and many take advantage of this information, there appears to be a society-wide lack of appreciation of the fundamental role of food in health. Further, authoritative sources of information can be lost in the sheer volume of general information. As a nation there is great potential to apply new technologies in food production and processing systems to benefit our health.

Management of the food supply should be improved to ensure all Australians, including at-risk populations, have access to food that promotes health and wellbeing. At the same time, to reduce the high levels of food waste in the community, food should be regarded as a valuable resource.

Recommendations

Addressing food security challenges requires a suite of actions to accelerate the transformation of food production and processing systems in Australia. Action is needed to meet food security challenges that will be increasingly important for Australia as we deal with major resource constraints and climate variability and change. Action is also required for Australia to play its part in achieving global food security.

The Expert Working Group puts forward a number of recommendations ranging from the establishment of a National Food Security Agency to encouraging greater community awareness of food production and the relationship between food and health.

Recommendation 1

To provide the basis for a national approach to addressing food security challenges:

The Expert Working Group recommends the establishment of the Australian Food Security Agency.

The Australian Food Security Agency will coordinate the development and implementation of policies and programs targeted to improving Australia's food security. The Agency would report to an appropriate minister and liaise with states and territories through existing processes such as the Primary Industries Ministerial Council.

In collaboration with relevant agencies, the Australian Food Security Agency would ensure that the following issues are tackled:

1. Availability of nutritious food in Australia through coordination of government policy and programs across the food production, processing and supply sectors.

2. Data collection on the environment, food production, food processing and distribution, and food consumption patterns, to support effective policy and program development.
3. A Food Security Research Strategy to provide a framework and research targets for future food production and processing environment. The Strategy would build on the outcomes of current reviews such as the Productivity Commission's review of the Rural Development Corporations and the Rural R&D Investment Plan being developed by the Rural R&D Council.
4. A National Land Use Planning Framework based on a landscape perspective, developed in conjunction with state and territory governments to secure future food production.
5. Streamlining and harmonisation of regulatory procedures to support technology development, evaluation and delivery across the food value chain.

Recommendation 2

There is a direct and quantifiable link between the decline in agricultural productivity growth and the decline in R&D investment. Urgent investment is required to rebuild R&D capability and regain momentum in productivity growth.

The Expert Working Group recommends that Australia increases investment in agricultural R&D to harness national expertise and take a leading role in national and international programs targeted to improving low input farming systems.

The aim of this recommendation is to enable sustainable levels of food production in low input environments nationally and internationally by leveraging the world-leading R&D capabilities in Australia.

This would be achieved by:

1. Increasing aggregate agricultural R&D spending to at least the peak levels of the 1970s to accelerate agricultural productivity growth.
2. Launching new national and international research programs targeted to:
    - Dryland agricultural production under increasing resource constraints.
    - Developing and managing food production systems under a variable and changing climate.
    - Integrated land management strategies with a particular focus on efficient water and nutrient use and reduced greenhouse gas emissions footprint for agriculture.
3. Substantial research programs should be selected and supported through the Australian Food Security Agency in collaboration with existing research agencies, research-funding and aid bodies and linked to advanced international research organisations. They should target outcomes to food production systems in Australia and the developing world.

Recommendation 3

There is a looming human capacity gap in almost all areas of agriculture and food production and research. This trend threatens the long term viability of the local industry and will limit the role we will be able to play in international initiatives.

The Expert Working Group recommends the development of incentives to recruit and nurture future generations of innovative and adaptive farmers, researchers and associated professionals for the Australian food production and processing sectors.

A skilled workforce made up of innovative farmers and talented researchers is required to build our research and delivery capacity to meet food security challenges.

Specific approaches to building human capacity that need to be taken are as follows:

1. Include studies on food production and nutrition in the national school curricula with an emphasis on the sophisticated science that underpins modern agricultural and food industries and the value of food in promoting health. This would include the provision of resource material and support programs to primary and secondary schools.
2. Develop and support nationally coordinated tertiary programs in agricultural sciences built on core capabilities. The programs would encourage student movement across Australia and allow particular areas of specialty to be built by individual tertiary institutions. The inclusion of agriculture and human nutrition in the priority Higher Education Contribution Scheme (HECS) band would encourage student uptake.

3. Enhance career paths in agriculture and food processing sectors for students trained in science and related areas. This can be achieved by building strong training programs into international research activities (*Recommendation 2*) and through the provision of PhD scholarships and fellowships.
4. Provide cadetships and secondments to develop linkage and collaborative programs between school teachers, researchers and farmers to help understanding, adoption and adaptation of research outcomes. This activity would also include provision of resources to regional farmer groups that provide agricultural extension services.

Recommendation 4

Food is subjected to both supply and demand pressures. Improving food and nutrition awareness strengthens the demand for nutritious food and results in population health benefits. An appreciation of the value of food and its quality will support innovation in food industries for the public good and reduce waste across the food value chain.

The Expert Working Group recommends better engaging the community and partner organisations to elevate the status of food in Australia and build cooperative commitment to an improved food value chain.

Implementation of this recommendation will build on the findings of the National Preventative Health Taskforce and current and upcoming reviews, including the Review of Food Labelling Law and Policy and the Review of Australian Dietary Guidelines. Consideration will also be given to market and non-market mechanisms for translating community food awareness to better food choices and to changes in the food processing industries. For example, full costs of embodied energy, water and, potentially, net greenhouse gas emissions would need to be reflected in food production.

Specific considerations are as follows:

1. The Australian Food Security Agency would work with existing funding structures in state, territory and local governments to establish nutrition education programs that build knowledge and capabilities across the food value chain.
2. Projects to support community driven developments in food production, such as school and community gardens. These would be co-funded and supported through the Australian Food Security Agency in partnership with local governments and state and territory education departments.
3. Community projects to encourage local groups to develop infrastructure that drives the supply of healthy food would be co-funded and supported through the Australian Food Security Agency.
4. The Australian Food Security Agency would support the development of nutrition guidelines and standards in community food outlets, institutional food service systems and school canteens. These would be linked with existing nutrition education programs for at-risk populations.
5. The Australian Food Security Agency would work with existing and expanded granting systems to engage and support the food processing industry in developing innovative and healthy food products.

Implementation plan

Immediate activities (initiated within the first 12 months):

- Establish the Australian Food Security Agency (*Recommendation 1*). The Agency would then take responsibility for the phased introduction and oversight of the remaining recommendations.
- Invest in research capability (*Recommendation 2*). This is seen as an urgent task given the long lead times from research to industry uptake and the realisation of productivity gains.
- Commence development of the Food Security Research Strategy and enhancement of data collection related to food (*Recommendation 1*) by building on existing initiatives.
- Change HECS band (*Recommendation 3*) through existing structures and mechanisms.

Medium term activities (initiated within the second year):

- Identify suitable funding sources and launch scholarship and fellowship programs (*Recommendation 3*) linked to the new research priorities (*Recommendation 2*).
- Commence consultation to identify opportunities for secondment and appropriate farmer group support programs (*Recommendation 3*).
- Initiate process to improve the regulatory framework (*Recommendation 1*). This will involve:
  – Detailed mapping of the existing regulatory structures.
  – Developing proposals for streamlining processes.
  – Consultation with industry, research and community groups.

Long term activities (initiated within the third year):

- Initiate consultation processes to coordinate and restructure tertiary training in agriculture and food and introduce food production and nutrition studies into the national school curricula (*Recommendation 3*). The National Association of Agriculture Educators and the Council of Deans of Agriculture will be important partners in this process.
- Build on existing programs and the recommendations of the National Preventative Health Taskforce and current and upcoming reviews, including the Review of Food Labelling Law and Policy and the Review of Australian Dietary Guidelines, to implement the various programs outlined in *Recommendation 4*.
- Initiate consultation with relevant stakeholders on the development of the National Land Use Planning Framework. The recommendations of the Expert Working Group on *Carbon, Energy and Water* regarding landscape considerations, pricing structures around water and energy and establishing Resilient Rural and Urban Environments, will be critical for this process.

1. Introduction

Preamble to the Terms of Reference

Food security[1] is affected by the availability of arable land, energy and water, nutrients, farming and trade practices, transport and storage. Climate change is expected to have a significant impact on all of these. Current projections indicate we can expect changes in the patterns of spatial and temporal distribution of water available for agriculture, temperature patterns and frequency of adverse weather conditions and geographical distribution of pests and diseases. This will make the production of some crops and livestock at some locations unsustainable and geographical adaptation will be required to address these challenges.

In addition, global demand for food will increase due to population growth and increasing demand from developing nations. Global food supply will need to increase to avoid another food crisis. This provides an opportunity and a moral obligation for Australia to make a significant contribution to global food stocks which are likely to remain low in relation to global demand. To maintain the ability of Australia's agricultural sector to compete internationally and benefit from a profitable and sustainable export business, agricultural productivity must continue to improve while using land and water more sustainably and reducing greenhouse gas emissions.

The Expert Working Group will prepare two documents, a complete technical report and a summary suited to policy makers. The latter document should detail the key findings of the report in a way that makes clear the connections between these findings and individual governmental portfolios. In addition, the Expert Working Group will prepare a presentation for the 22nd PMSEIC meeting.

Terms of Reference

With a planning horizon of at least 20 years, from a national perspective within an international context:

1. Identify the main food security risks and opportunities for Australia posed by global climate change including projected:

   a. temperature rises within this century of 2°C and 4°C.

   b. changes in rainfall and water storage.

   c. increased frequency of adverse weather conditions.

   d. changes in availability of arable land.

2. Determine the biophysical challenges to food security, including:

   a. the science for increasing the nutritional value of food.

   b. supply of key nutrients inherent in the soil or through trade.

   c. nutritional requirement of humans.

3. Identify challenges and opportunities for increasing productivity to match the expected increased demand for food and nutrition, whilst supporting sustainability, through the reduction of inefficiencies in current agricultural and fisheries practices and introduction of appropriate science and technology-led innovation.

4. Outline current research to mitigate the impact of these challenges, or support these opportunities, as well as the availability of current projection tools.

5. Determine gaps in the research and research capacity (including the necessary tools to make reliable projections), suggesting ways these gaps can be closed.

1 Defined as sustained physical availability of, and access to, affordable food

6. Sketch the possible environmental and social impact of adopting new agricultural practices and technologies including those related to storage, transport and distribution.
7. Formulate options for government consideration that could have a positive and transformational impact on the long term food security in Australia within a global context.

Approach

The Expert Working Group included members with expertise in:

- Plant genomics and crop breeding technologies.
- Agribusiness.
- Pest management.
- Advanced animal breeding technologies.
- Soil chemistry.
- Climate change and adaptation of primary industries.
- Natural resource management.
- Agricultural R&D.
- Human nutrition and functional foods.

A list of members of the Expert Working Group is provided in *Appendix A*.

Concurrent activities

In Australia, there are a number of other activities that are examining issues of food security and are relevant to this report. These include:

- The development of a rural sector R&D investment plan by the Rural R&D Council.
- The Productivity Commission's inquiry into the Rural R&D Corporations.
- The development of a National Primary Industries R&D and Extension Framework by the Primary Industries Ministerial Council.
- The recently concluded inquiry entitled *Food production in Australia* by the Senate Select Committee on Agricultural and Related Industries.

Additionally, there is the PMSEIC Expert Working Group dealing with issues related to energy, water and carbon. There is obvious complementarity between the two PMSEIC groups. *Figure 1.1* is a diagramatic representation of the links.

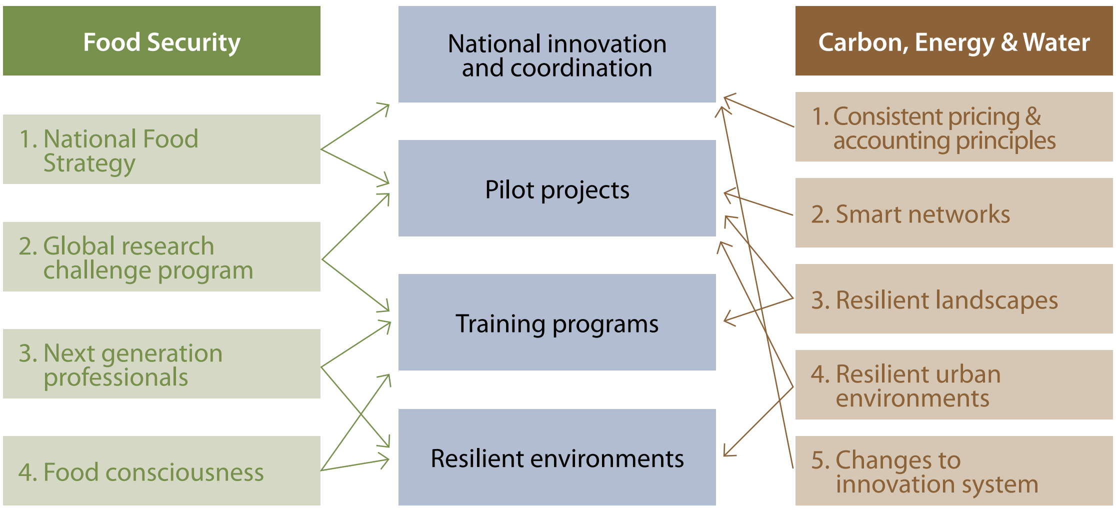

Figure 1.1 Relationship between recommendations of the PMSEIC Expert Working Groups on 'Food Security' and 'Energy, Water and Carbon'.

2. Setting the scene

Food is an essential part of our everyday lives. Not only does food nourish our bodies, it also creates jobs and substantially contributes to the Australian economy. However, we presently face significant challenges to provide all Australians with sufficient, affordable, safe and nutritious foods.

We are at a critical point in our history where we will need to produce more food of high nutritional quality using production systems under increasing resource constraints, while maintaining the integrity of our natural environment. We must help feed more people globally than ever before. At the same time, we must tackle the increasing obesity epidemic facing Australia which will have a significant impact not only on the health of our population but also on the economy. All of these tasks must be pursued against the backdrop of global climate change which will increase average temperatures, change rainfall distribution and create more adverse weather events.

Due to our geographical position, Australia is particularly vulnerable to the effects of climate change. This has placed pressure on us as a nation to be flexible, adaptive and creative in finding solutions to the new challenges which we face. This pressure also presents a great opportunity for Australia to become a world leader in food security.

In today's inter-connected and trade-liberalised world, food security for Australia is inextricably linked to regional and global food security. We need to help our neighbours and those beyond our region to also reach their food security goals to ensure our own food security.

2.1. Definition of food security

Food security is achieved when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life.

(based on FAO 1996 definition)

The definition is based on the following five key pillars which are also outlined in *Table 2.1*:

Availability sufficient supply of food for all people at all times.

Accessibility physical and economic access to food at all times. This has also been taken to describe equality of access to food.

Acceptability access to culturally acceptable food which is produced and obtained in ways that do not compromise people's dignity, self-respect or human rights.

Adequacy access to food that is nutritious, safe and produced in environmentally sustainable ways.

Stability reliability of food supply.

Five components of food security	Explanation	Issues for Developed Countries	Issues for Developing Countries	Addressed in Report section
Availability	Sufficient supply of food for all people at all times	■ Supply to remote communities ■ Rising dependence on imported foods	■ Rapid population growth ■ Serious crop failures ■ Depleted food reserves	■ 2.2C; 2.3 ■ 3.3G
Accessibility	Physical and economic access to food at all times. This has also been taken to describe equality of access to food	■ Disadvantaged groups – some Indigenous populations and some people in institutions ■ Poverty ■ Cost and promotion of nutritious food relative to 'junk food'	■ Cost of food imports ■ Endemic poverty ■ Food transport and storage infrastructure	■ 2.2D ■ 3.3; 3.4
Acceptability	Access to culturally acceptable food which is produced and obtained in ways that do not compromise people's dignity, self-respect or human rights	■ Concerns about sources of some imported foods ■ Perceptions of risk and lack of understanding of food production and associated technology ■ Cultural and family issues (migration, need for special foods, food and nutrition literacy, group attitudes and work/life balance)	■ Animal production methods ■ Reliance on aid programs and food imports ■ Cultural restrictions on particular foods	■ 2.3E ■ 3.3; 3.4C ■ 4.3G
Adequacy	Access to food that is nutritious, safe and produced in environmentally sustainable ways	■ Fresh fruit and vegetables can be seasonal and import dependent ■ Ability to meet nutrient needs ■ Ready access to cheap food of poor nutritional quality	■ Poor dietary balance ■ Reliance on imbalanced diets ■ Nutritional deficiencies	■ 2.2D ■ 3.3; 3.4M,N
Stability	Reliability of food supply	■ Impact of urbanisation and loss of horticultural land ■ Supply of fertilisers and agricultural and veterinary chemicals ■ Impact of severe and more frequent droughts and heatwaves ■ Major weed, disease and pest incursions	■ Scarcity of water and arable land ■ Adverse climate events ■ Conflict and post-conflict ■ Variation in global food reserves ■ Reliance on aid programs ■ Food transport and storage infrastructure	■ 2.2A,B; 2.3H,I,J ■ 3.2; 3.3A,D ■ 4.3G

Table 2.1 Food security issues for developed countries such as Australia and for developing countries.

2.2. National context

A. Food and the environment

Food production in Australia is challenging due to our generally ancient and infertile soils, variable and in many cases harsh climates and significant degradation such as soil erosion, acidification and salinisation. However, effective R&D, low levels of government subsidy, a culture of innovation and dense social networks to communicate innovation have resulted in highly efficient production systems and increasing attention to management of impacts on the environment.

More than half of Australia's land area is committed to agricultural activities such as grazing, cropping and horticulture (*Figure 2.1*). The largest proportion (46 per cent) of land used for agriculture is accounted for by extensive grazing of mainly natural vegetation. However, most of the farm profit arises from the more intensive cropping and horticultural activities, especially when irrigated.

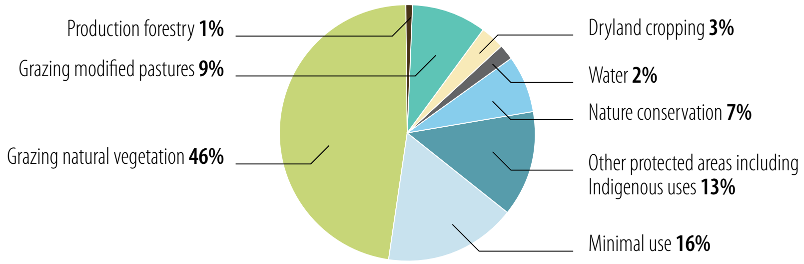

Figure 2.1 Land use in Australia (ABARE–BRS (2010) – Version 4, 2005-06 dataset).
A more detailed breakdown of land use in Australia is provided in Table 1 in Appendix D.

Land degradation

The area of productive land in Australia is diminishing due to increasing urbanisation and various degradation processes. For example, the National Land and Water Resources Audit's risk assessment (NLWRA, 2000) identified approximately 5.7 million hectares of land to be within regions at risk of or affected by dryland salinity, with this area increasing over time. Dryland salinisation occurs when water inputs and extraction are out of balance, resulting in movement of salt stores closer to the soil surface. Soil acidification is also a major issue with some 50 million hectares of land with a surface soil pH (measure of acidity or alkalinity) less than 5.5, the level at which most commercial agricultural plants suffer yield losses. A further 23 million hectares of land is estimated to have acidification in subsurface layers. Again, this problem is increasing, with estimates of doubling of the area affected on a decadal time scale. Lime applications can increase pH but this is not economically viable in many cases (particularly grazed lands) and it is associated with substantial greenhouse gas emissions. Soil erosion is common in lands used for food production, with a tendency for erosion rates to be higher in the north and lower in the south west of the continent. This erosion is caused by both water and wind. The extent of erosion depends on rainfall intensity, wind strength and the nature of the soil.

Invasive weeds, both exotic and native, are also a major issue costing agriculture approximately $4 billion annually through losses in production, control costs and reduction of farm management options, as well as impacting on health, recreation and conservation values (Natural Resource Management Ministerial Council, 2006). Pests (eg. cattle ticks) and diseases (eg. wheat rust) also affect Australian food production with an on-going 'arms-race' of technical and managerial solutions needed to stay ahead of these challenges without compromising food quality or environmental values (eg. via stringent chemical residue limits).

Water

Food production in Australia is often limited by water availability. For example, a drought year can reduce national wheat production by 60 per cent or more when compared with a good year. Consequently, to reduce this risk and to ensure stability of water availability for other uses, Australia has invested in large scale water storage and distribution systems. These systems plus groundwater extraction allow Australians to consume more than 24 000 gigalitres of water a year (ABS, 2006). More than 70 per cent of this is used for irrigation for food production, a further 21 per cent going to urban and industrial uses and the rest used in additional rural activities such as stock watering (ABS, 2006). There is recognition of the need to provide water for the environment, cultural and recreational uses amongst others. Past over-allocation of water from many rivers in southern Australia along with a significant recent period of low flow and water stress, at least in part attributed to climate change, have triggered significant water reform processes. These processes have lead to water markets, buybacks and efficiency programs being implemented or planned. In contrast, recent trends have been towards higher rainfall and greater river flows in northern Australia.

Greenhouse gas emissions

Australian agriculture is a significant contributor to the national greenhouse gas emissions profile with about 16 per cent of the national emissions arising directly from livestock, cropping and savanna burning with another nine per cent from net deforestation likely to be largely associated with food production activities (*Figure 2.2*; Department of Climate Change and Energy Efficiency, 2010). Further, but less significant, emissions occur from the on-farm use of diesel fuel (tractors, fishing boats, irrigation pumps) and electricity usage and also along the food value chain—the emissions of which are accounted for in non-agricultural parts of the greenhouse emissions inventory. The direct emissions from agriculture have changed little since 1990 whereas those from deforestation have dropped sharply (62 per cent) in that period. There is ongoing research into the establishment of cost-effective, sustainable and measurable emission-reduction options.

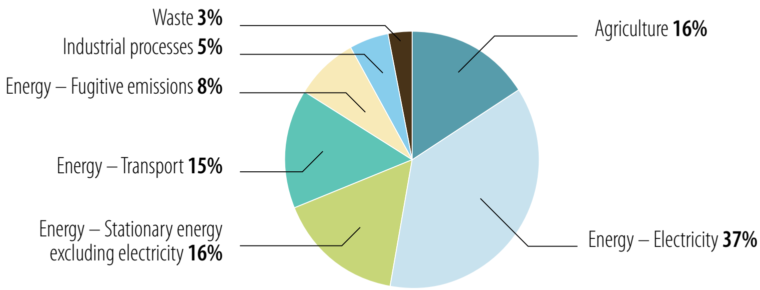

Figure 2.2 Australia's greenhouse gas emissions by sector, for the year to December 2009 (Department of Climate Change and Energy Efficiency, 2010).

B. Climate change

Australian agriculture is highly dependent on the climate and its variability: Australia is indeed 'a land of droughts and flooding rains'. Climate affects almost every aspect of food production: the plants and animals used, average production and production variability, product quality, what areas are farmed, what soil types are preferred, the management systems and technologies used, input costs, product prices and natural resource management. It, therefore, follows that if the climate changes, many aspects of food production will change too.

The atmospheric concentrations of greenhouse gases such as carbon dioxide (CO_2), methane and nitrous oxide are increasing as a result of human activity (Intergovernmental Panel on Climate Change, 2007). These greenhouse gases affect the radiative balance of the earth, keeping it warmer than it would otherwise be. The atmospheric concentration of CO_2, the main anthropogenic greenhouse gas, is now 392 parts per million (ppm) 40 per cent above the pre-industrial concentration of 280ppm. Furthermore, the rate of increase of CO_2 concentration is itself increasing, being larger during the last 10 years (1.9 ppm per year), than it has been since measurements began in 1960 (1.4 ppm per year). This is in response to accelerated growth in CO_2 emissions and a reduction of the proportion of these emissions absorbed by the oceans (Canadell et al, 2008). There is strong evidence that these changes in atmospheric composition are affecting the climate at both global and continental levels, including in Australia. The changes in Australian climate are summarised below as reported by Hennessy et al (2007).

Temperatures have increased across the food production areas of Australia, with average maximum (day-time) temperature rising by 0.7°C and the minimum (night-time) temperature by 1.1°C since 1910, with much of this change occurring since 1950. These increases are highly likely to have been influenced by increasing atmospheric greenhouse gas concentrations. These temperature rises have made droughts more severe because temperatures are higher for a given rainfall level. Temperature extremes have also changed with an increased number of hot days (*Figure 2.3*) and hot nights and a decrease in cold days and nights. Exceptionally hot years are now occurring over 10–12 per cent of the area of Australia, about twice the expected long term average.

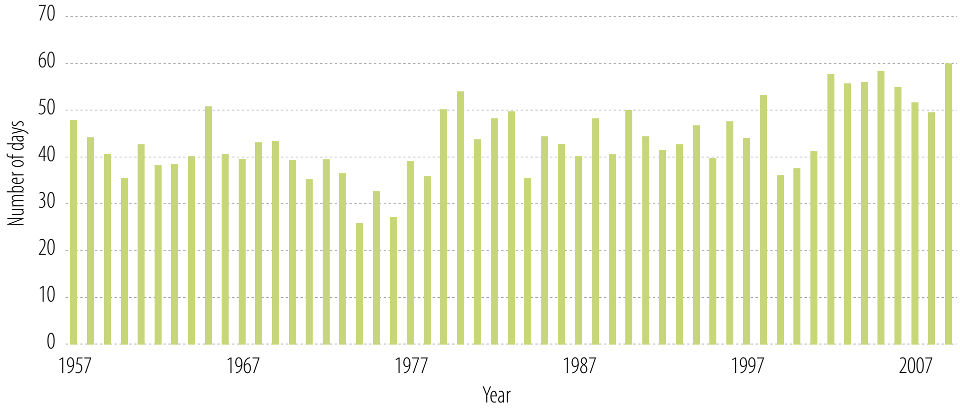

Figure 2.3 Average number of hot days (above 35°C) each year for Australia since 1957 (Bureau of Meteorology, 2010).

Rainfall has also changed, with southern and eastern Australia becoming drier. These changes are likely due to a combination of altered synoptic pressure patterns such as the location of the sub-tropical ridge, natural climate variability and perhaps land use change. The reductions in rainfall and increases in temperature in south-eastern and south-western Australia have resulted in record low river flows. Extreme rainfall events have also changed in some cropping regions with heavy rainfall increasing over the western tablelands of New South Wales but decreasing in the southeast, southwest and central east coast.

Farming in the Australian environment, therefore, involves significant challenges in juggling these climate risks as well as price risk. One response to this has been to establish effective networks of farmers such as Landcare groups to share information, technologies and experiences. This has enabled more effective and innovative approaches for sustainable production across the food value chain.

Case Study 1

Impact of Tropical Cyclone Larry

In March 2006, the far north Queensland coast was declared a natural disaster zone after experiencing the impact of Tropical Cyclone Larry.

Cyclone Larry was classified as a category five cyclone and created winds of up to 290 km/h.

It destroyed banana plantations within a 40 to 50 kilometre radius of the cyclone path and caused damage to sugarcane crops in the area.

The total estimated bill for the damage was $1.5 billion.

Extreme weather events, like cyclones, can adversely affect the availability and cost of fresh food. In 2005, poor weather and higher fuel costs increased the prices of potatoes, broccoli, onions, tomatoes and other varieties of fruit.

Furthermore, scientists have warned that more cyclones like Larry will form if no action is taken against climate change. Cyclones obtain their energy from warm tropical seas. The warmer the ocean is the greater the intensity of the cyclone. Climate change has been shown to increase sea temperatures.

Sources: http://www.ga.gov.au/ausgeonews/ausgeonews200609/larry.jsp, http://www.cultureandrecreation.gov.au/articles/naturaldisasters/ http://www.abc.net.au/am/content/2007/s1876516.htm

Image: NASA - Jeff Schmaltz, MODIS Rapid Response Team, Goddard Space Flight Center. Available online at: http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=16268

C. Food production

Australia has efficient, low input food production systems which have historically provided significant surplus for export. This has provided food security not only in Australia but supported food security in other nations. Food production also provides the basis for a significant processing sector as well as supporting rural communities. The efficiencies and innovation in food production systems have been supported by a significant but declining R&D base.

The food value chain in Australia is a major part of the economy. It has a combined worth of approximately $230 billion which comprises $38 billion in farm and fish production, $80 billion in food processing and $112 billion in retail food sales (DAFF, 2009). Food exports have a value of around $23 billion and food imports about $9 billion (DAFF, 2009). The food and beverages sector is considered as Australia's largest manufacturing industry and employs around 210 000 people. In excess of 40 per cent of food processing occurs in rural and regional areas. Recent jobs growth in the food and beverages industries has been predominantly in non-metropolitan areas and this trend is likely to continue (DAFF, 2009). This is especially important for the social fabric of Australia across regional and rural communities due to the long-standing trend towards farm aggregation and, hence, fewer farmers. For example, in the period 1982-83 to 2002-03 average farm size increased by 23 per cent. The key driving factor behind this is a long term decline in the terms of trade for agricultural production (*Figure 2.4*) and that large farms tend to be able to provide better return on investment (*Figure 2.5*). At the same time, there has been increasing fragmentation of farms in the peri-urban areas, often resulting in reductions in productivity.

Figure 2.4 Productivity growth for agricultural industries (ABS (2007a); Bureau of Rural Sciences (2008); Nossal and Gooday (2009)).

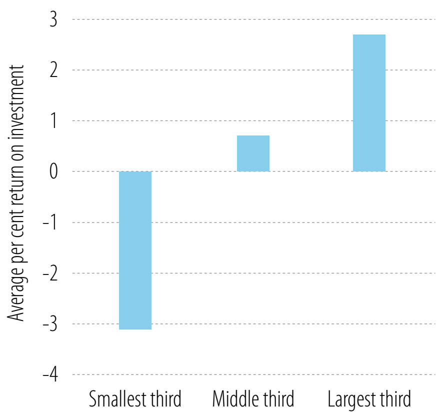

Figure 2.5 Average percentage rate of return related to farm size for 2001-2003 (Productivity Commission (2005); ABARE (2005)).

At present, Australian farmers produce almost 93 per cent of Australia's daily domestic food supply and export 60 per cent (in volume) of total agricultural production. Australian production represents one per cent of all food consumed in the world feeding some 40 million people each day outside Australia. The challenge of producing the increasing volumes of food and fibre required by domestic and international markets is likely to continue to grow as a result of population growth and per capita consumption growth (DAFF, 2009).

Fisheries and aquaculture

In addition to terrestrial-based food production, Australia has significant fishing industries based on both wild-caught and farmed elements. The Australian Fishing Zone is the third largest in the world, covering nearly nine million square kilometres. It extends to 200 nautical miles from the Australian coastline and also includes the waters surrounding our external territories, such as Christmas Island in the Indian Ocean and Heard and McDonald Islands in the Antarctic (Wilson et al, 2009).

Australian fisheries are the fifth largest food producing industry, worth more than $2.1 billion annually. Fish are also a healthy source of food with Australians consuming around 16 kilograms (kg) of seafood per person each year. However, the wild catches of almost all fish species have declined with some species, such as prawns, now at only half the level of ten years ago (*Figure 2.6*). Importantly, we have now moved from a net exporter of fish to a net importer (*Figure 2.7*).

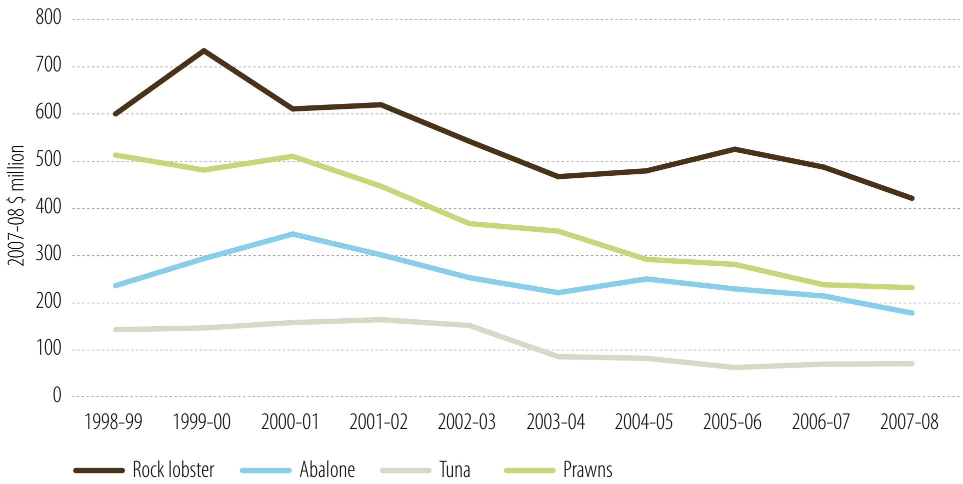

Figure 2.6 Gross value of production of key species (ABARE, 2009).

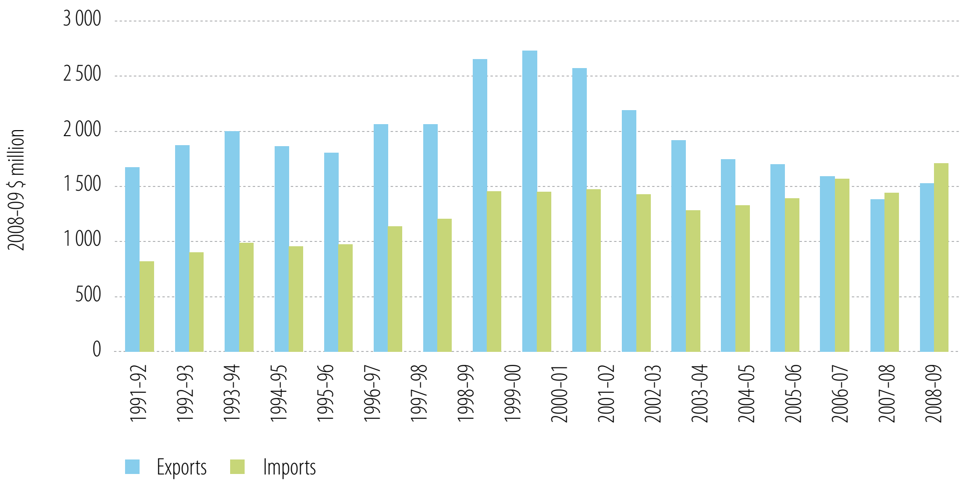

Figure 2.7 Export and import values of fish products (ABARE, 2009).

There has, however, been a large growth in aquaculture of mainly salmonid (ie. salmon and trout species) which now account for 41 per cent of Australian aquaculture production. This represents a growth of 55 per cent over the ten years to 2007-08. The second most important aquaculture species is southern bluefin tuna (ABARE, 2009). In 2007-08, the total value of commercial seafood production was $2.19 billion with exports at $1.3 billion. However, recreational fishing is also very important in Australia with 3.4 million Australian fishermen and women and an estimated value of $2.5 billion to regional economies (ABARE, 2009).

Case study 2

The perfect prawn for aquaculture?

CSIRO's Food Futures Flagship in collaboration with its industry partners have developed a new prawn that is producing record farm yields. This has contributed to increased supplies of top quality, sustainably produced seafood. This has been achieved through a decade of arduous research on the popular Black Tiger prawn.

The science underpinning the development of the new prawn includes:

- Selective breeding.
- Novel genetic and viral health screening.
- Mating allocation systems.
- Use of genetic markers.

According to the CSIRO, positive features of the newly developed prawn include:

- Developed and bred in Australia – the new breed is providing a real boost for the prawn farming industry in Australia and local consumers.
- Tastier – the new Black Tiger breed has won five gold medals at the Sydney Royal Easter Show for Gold Coast Marine Aquaculture in the last two years, including the highest award possible: 'Champion of Show'.
- Sustainable and renewable – the new breed is grown and farmed in drought-proof salt water ponds, which eases pressure on ocean/estuary stocks.
- More productive – the new breeds have improved growth and survival rates, boosting pond yields by more than 50 per cent.
- Securing food supply – the sustainable and high yielding new prawn breed could play an important role in helping secure food supplies around the world through the production of a more sustainable and higher yielding source of healthy protein.

Imports account for approximately half of Australia's prawn consumption. The development of an Australian prawn that breeds better and can be sustainably farmed is a boost for both the local prawn industry and for consumers wanting Australian seafood.

Source: Commonwealth Scientific and Industrial Research Organisation – http://www.csiro.au/science/tiger-prawn-farming.html

Image: CSIRO

R&D and productivity

Over the last 30 recorded years (1977-78 to 2007-08), Australian farms have achieved average multifactor productivity growth of 1.4 per cent per annum (*Figure 2.8*), which is higher than most industries except telecommunications and information technology. R&D has underpinned this growth with evaluations showing that $1.00 invested in rural R&D returned $10.51 over the course of 25 years (Council of Rural Research and Development Corporations, 2010). A key element of this success has been the partnership approach taken by industry and government in prioritising and designing relevant research programs to address the challenges of sustainable production systems. However, this long term positive view needs to recognise that the first 20 years of this period had annual growth averaging 1.8 per cent whereas the last 10 years has this reversing with shrinkage of 1.3 per cent per year. A significant part of this decline is attributed to reductions in R&D investment (Nossal and Gooday, 2009).

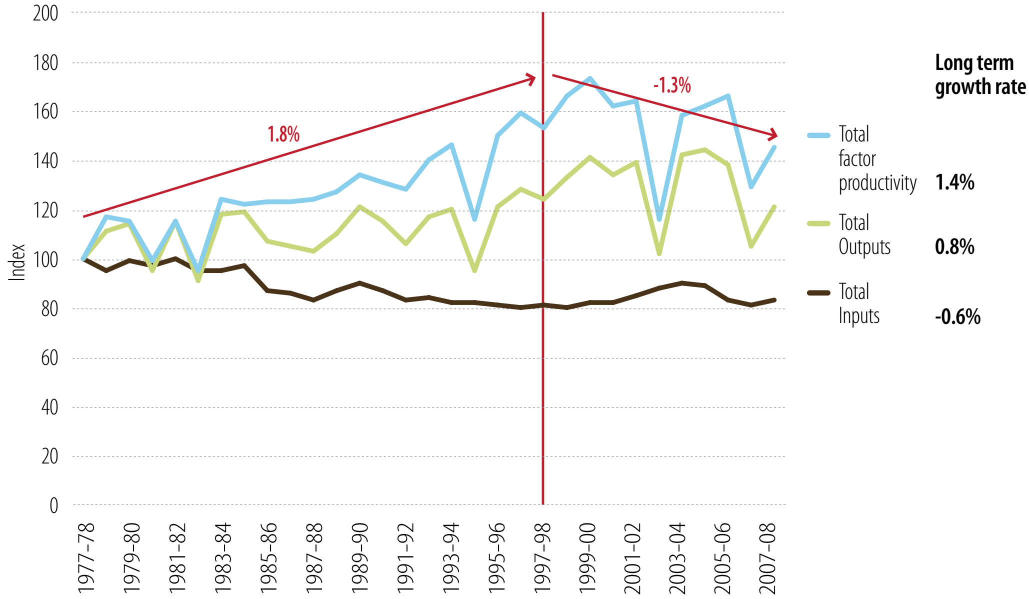

Figure 2.8 Long term rate of productivity growth in broadacre production (DAFF, 2010).

Australia's growing population, estimated to be 35 million in 2050, and growing per capita consumption (eg. wheat consumption per capita has increased 55 per cent since the 1970s) will also present a challenge for domestic food security given the potential for increasing climate shocks and dwindling international stockpiles of commodities.

D. Food and health

The inter-relationship between food and health is complex and goes beyond the simple view of food delivering nutrients and energy to sustain the human body. There is now a greater awareness of balancing the need to feed a growing population and maintaining environmental integrity. It is also necessary to consider the health and disease profiles of the population and consider social aspects of how people interact with food.

Population trends

National population issues centre on population growth rate. This reflects fertility in women, the aging population at home and in institutions, increasing urbanisation and immigration rates. The population of Australia is projected to increase to between 30.9 and 42.5 million people by 2056 and to between 33.7 and 62.2 million people by 2101 (*Figure 2.9*). This growth will be dependent upon fertility rates (1–2 babies/woman), life expectancy of around 85 years and a stable rate of net migration (about 180 000/year) (ABS, 2009a).

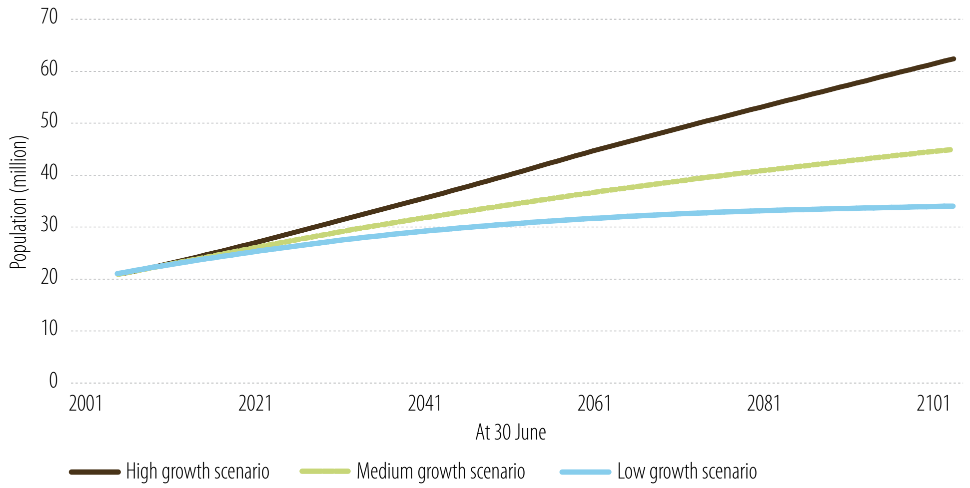

Figure 2.9 Projected population growth in Australia from 2001-101 (ABS, 2009a).

ABS data shows that for each older person in 2007 there were five working aged people (15–64 years), but in 2056 there will be fewer than three working people for each older person. The number of people aged 85 years and over is also projected to increase rapidly from 344 000 in 2007 to 1.7 million in 2056. Aged care provision is increasing in both residential aged care places and in the community (AIHW, 2009a). To prevent diet-related disease in the aging population, food security strategies need to prevent malnutrition in the institutionalised aged care sector.

Providing adequate nutrition is a central tenet of food security. It means delivering a food supply that contains all the nutritional requirements to all the sub-groups within the population. Adequate nutrition is defined as meeting energy requirements (calories) for growth and development throughout the lifecycle, in addition to vitamins and minerals in amounts defined by nutrient reference values for the population (NHMRC, 2006).

Diet-related diseases are connected through inherent metabolic dysfunction. For example, obese individuals were four times more likely to develop type 2 diabetes than those who were normal weight (Barr et al, 2005). A greater proportion of people with type 2 diabetes have heart disease and 67 per cent of cardiovascular deaths have type 2 diabetes reported as an underlying condition. The recently released *Australia's Health 2010* report states that the burden of type 2 diabetes is increasing and is expected to surpass cancer as the leading cause of disease burden in Australia by 2023 (AIHW, 2010).

The prevalence of overweight and obese individuals has increased across all age groups from 1995 to 2004-05 (*Figure 2.10*). The most marked increases were among the age groups 25–44 years and 75 years and over. More than 20 per cent of Australian children aged 5–17 years were estimated to be overweight or obese in 2007 (*Figure 2.11*). Most recent data indicates that one in four (25 per cent) of Australian children aged 5–17 years were overweight or obese in 2007-08 (AIHW, 2010). Children who are socially, economically and geographically disadvantaged are at an increased risk of being overweight or obese. These children generally have reduced access to basic necessities such as fresh fruit and vegetables due to lack of availability and affordability—and are less likely to be physically active (AIHW, 2008).

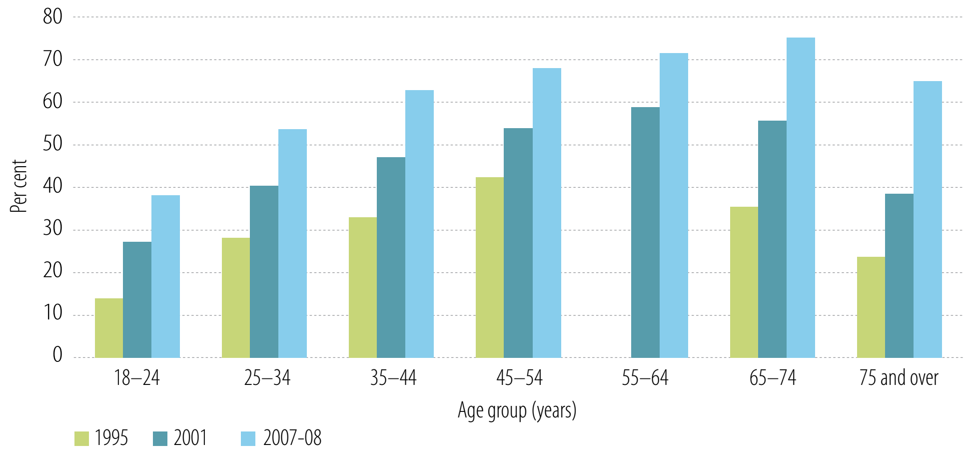

Figure 2.10 Proportion of the Australian population overweight or obese by age group (AIHW, 2008).

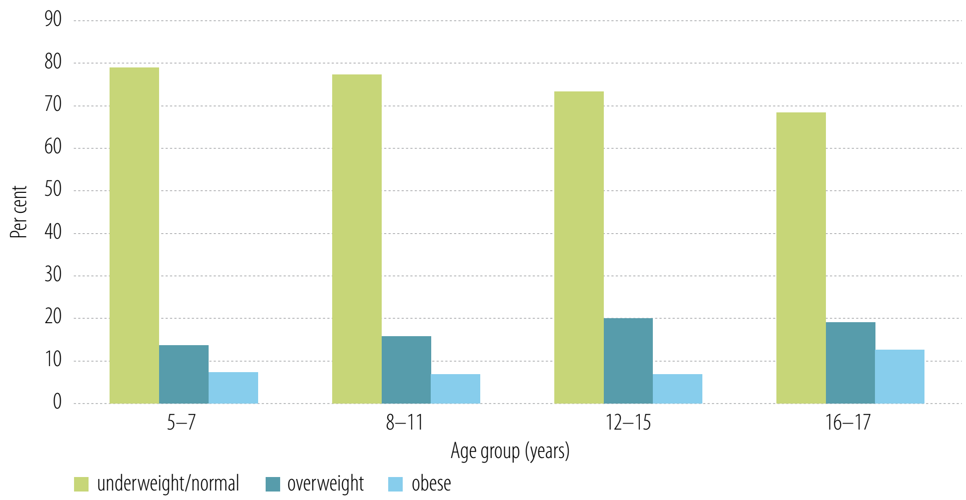

Figure 2.11 Proportion of children aged 5–17 years who were underweight/normal, overweight or obese 2007 (ABS, 2009b).

Groups at risk of under- or over-nutrition include infants and young children, pregnant and lactating women, older Australians and, in particular, those in institutions and migrants in transition (Wahlquist, 2002). Indigenous Australians, particularly those in rural and remote communities, are also at risk. The lower average life expectancy for Indigenous Australians co-exists with higher rates of obesity and type 2 diabetes, conditions that are intricately linked to dietary patterns (AIHW, 2009b). The National Health and Medical Research Council recently released draft models for dietary patterns that would meet dietary requirements for most age groups within the population (NHMRC, 2010). Further, the development of functional foods should help meet nutritional requirements in the population (Tapsell, 2008; CSIRO Food Futures Flagship).

Societal attitudes to food production

With increased urbanisation and diversification of Australia's economy, there has been anecdotal evidence of a weakening in cultural links between urban and rural Australia and a loss of understanding of the importance and operation of the food sector. Outdated public perceptions of agriculture belie the technological sophistication and the extent of knowledge management relied upon to deliver agricultural produce to the Australian community. However, a recent poll conducted by the Australian National University (2009) indicated that the Australian public generally has a very positive view of food production in Australia. The rising level of public interest in food is also reflected in the popularity of food shows, such as *Masterchef*, on television.

E. Key messages

- Food production in Australia is challenging due to our generally ancient and low fertility soils, variable and harsh climates and significant degradation such as soil erosion, acidification and salinisation.
- Productivity growth in the agriculture sector has been well above the average for the Australian economy. However, productivity growth has been declining over the past decade.
- Evaluation of return on investment has indicated that $1.00 invested in rural R&D returned $10.51 over the course of 25 years.
- The food value chain in Australia is a major part of the Australian economy.
- To remain profitable, farms have been getting larger.
- Food and food choices play a major role in human health but many Australians are currently making poor choices about what they eat, resulting in an increase in obesity, type 2 diabetes and cardiovascular diseases.

2.3. Global context

F. Global population growth

Current projections suggest the world population will grow to around 9.2 billion by 2050. This growth is expected to occur almost entirely in developing countries, with Asia continuing to account for over half of the world's population (*Figure 2.12*; FAOSTAT, 2010).

Figure 2.12 Predicted world population growth over the next 40 years (FAOSTAT, 2010).

The vast majority of hungry people also live in developing countries but there are also many starving people in the industrialised world (*Table 2.2*). Asia is home to the largest number of hungry people while Sub-Saharan Africa has the highest prevalence of hungry people, with more than one in three people being undernourished.

Region	Number of hungry people
Asia and the Pacific	642 million
Sub-Saharan Africa	265 million
Latin America and the Caribbean	53 million
Near East and North Africa	42 million
Developed countries	15 million

Table 2.2 Estimated numbers of hungry people by region (FAO, 2010).

The numbers of under-nourished people grew in absolute terms in 2007 to over 900 million. Data from the FAO suggests that this number has now grown to 963 million while other estimates suggest the one billion mark has already been exceeded (Worldometer, 2010). This actually represents a decline in the total percentage of under-nourished people over the past two decades from 20 per cent of the world population in the early 1990s to around 16 per cent mainly due to large food production increases in Asia (FAOSTAT, 2010).

G. Food production trends

The agricultural industries have shown spectacular improvements over the past 50 years. Food production is still dominated by the cereals which make up around 50 per cent of global food production. Altogether crops make up around 80 per cent of human food (FAOSTAT, 2010). Since the introduction of the Green Revolution crops in the early 1960s, there has been a linear increase in crop production from 1.84 billion tonnes to 4.38 billion tonnes in 2007. This represents an increase of 138 per cent but on a total area of agricultural land that grew by only 11 per cent. This growth occurred over a period where the human population grew from three to 6.7 billion. The major improvements in food production occurred in Asia. For example, food production in China increased five-fold over this period. In Asia and Latin America, per capita food production increased by 98 per cent and 61 per cent, respectively. Africa, however, has fared less well, with food production per person falling from the 1970s and only just recovering to the 1960 level in 2005.

Three factors have underpinned the rapid improvements in crop production:

1. Improved varieties through development and adoption of new breeding technologies.
2. Expansion in area under irrigation.
3. Widespread use of fertilisers, particularly those based on nitrogen and phosphorus.

Of these, only the first can be regarded as sustainable. The problems associated with water and fertiliser use are addressed in sections that follow.

With the predicted growth in the world population to around 9 billion, the World Food Summit on Food Security in 2009 set a target of 70 per cent increased food production by 2050 which would require an annual rate of increase of 44 million tonnes. The implications of this target on cereal production are shown by the green line in *Figure 2.13,* with the blue line representing the current rate of production increase. This is an ambitious target for several reasons. Firstly, there are some serious concerns about the viability of existing production systems and the sustainability of the current growth rates. Secondly, the predicted environmental changes associated with climate change are expected to have an overall negative effect on agricultural production with serious crop declines in some countries. The red and black lines in *Figure 2.13* indicate two scenarios associated with the impact of climate change on global cereal production. The red line is based on an optimistic prediction of only a five per cent decline over the next 40 years while the black line shows the effect of a 15 per cent decline. It should be noted that a 15 to 30 per cent decline in food production is predicted for Australia.

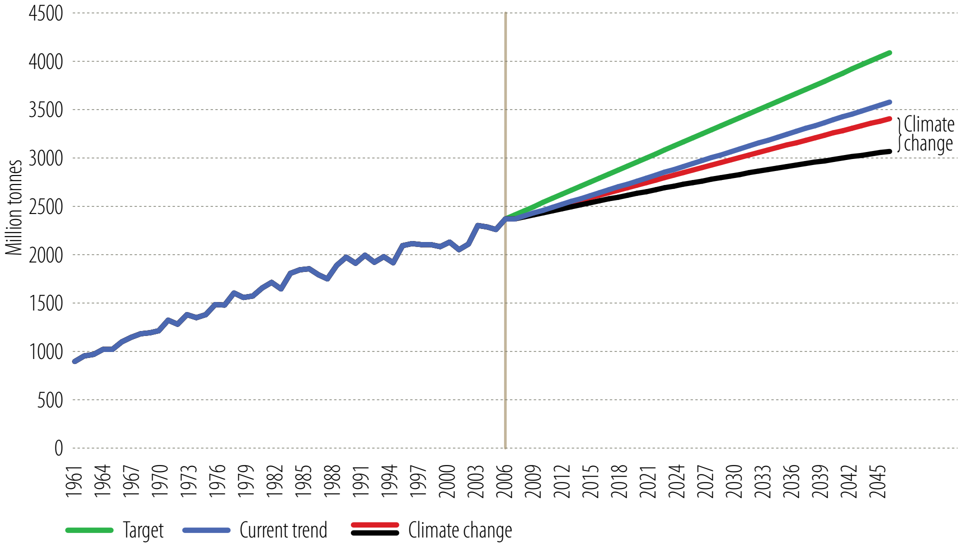

Figure 2.13 Global cereal production – past and future. The trend lines represent the World Food Summit target (green), an extrapolation of the current rate of productivity increase (blue) and two possible scenarios resulting from climate change – a five per cent decline (red) or 15 per cent decline (black) over the next 40 years (Based on data from FAOSTAT, 2010).

The large increases in crop production have also been reflected by substantial growth in livestock production (*Table 2.3*). Chickens are the most efficient sources of animal protein offering feed conversion rates of 2–4 kg of feed needed to produce 1kg meat, followed by pigs (conversion rates of 3–6) and finally ruminants (sheep, goats, cattle and camels have feed conversion rates at around eight). Increased meat consumption is closely linked to increases in living standards. In China, the annual per capita consumption of meat rose from 4 kg to 54 kg over the past 50 years (FAOSTAT, 2010).

Millions of live animals	1961	2008	Fold increase
Chickens	3884	18398	4.7
Pigs	406	941	2.3
Cattle and buffalo	1030	1528	1.5
Sheep and goats	1343	1940	1.4

Table 2.3 Changes in global livestock numbers since 1961 (FAOSTAT, 2010).

An important aspect of the rise in animal production has been the large diversion of grain from human consumption to animal feed. Globally, around one third of total grain production goes to animal feed. In the developed economies, almost 70 per cent of production goes to feed animals.

Fisheries and aquaculture

The global fisheries and aquaculture situation is very similar to the Australian position. Wild fish stocks are seriously depleted. Harvests are declining but the effort required is increasing. It is inevitable that the wild catch will continue to decline and this will have a significant effect on many poor communities in Africa and Asia that rely on fish as their major protein source. Currently, around two billion people rely on fish for over 20 per cent of their annual protein intake. Growth in fish production is now almost entirely from aquaculture, with production increasing by 20 per cent in the period 2002-06 (*Figure 2.14*). Predicted rise in sea level through climate change is expected to create many problems for the coastal aquaculture industry. Climate change studies also suggest that fish catches in tropical waters will decline by as much as 50 per cent with some of the most severe effects in South East Asia and the Pacific (FAOSTAT, 2010).

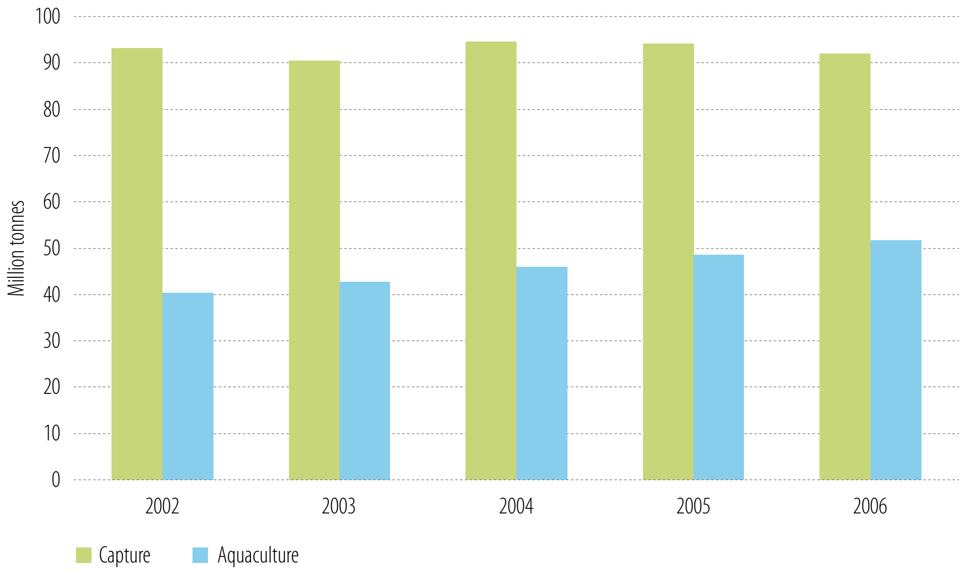

Figure 2.14 World fisheries and aquaculture production (FAOSTAT, 2010).

H. Factors limiting food production

Water availability

Water is probably the most critical factor affecting food production. Any viable strategy for increasing food production from the limited area of arable land must address the problems of ensuring sustainable access to water for irrigation and human consumption. However, the current trends are far from favourable. In 1990, chronic water stress or scarcity affected 28 countries with a combined population of three million. This is predicted to grow to 52 countries and over three billion people by 2030. The most severe effects are in the Near East and North Africa where water availability per person is now 60 per cent less than in 1960. This situation will deteriorate since Jordan and Yemen are now removing water at a rate 30 per cent higher than the rate of replenishment (Watkins et al, 2006).

Global water withdrawals are now at over 10 per cent of the total resource, with agriculture accounting for around 85 per cent of the use (Foley et al, 2005). This has resulted in seriously reduced flows in several major rivers, particularly in semi-arid regions. Tapping into the other source of fresh water, groundwater, is generally regarded as unsustainable in most regions and has led to declining water tables (Foley et al, 2005). Therefore, available water for agricultural uses is likely to decline and the costs of water can be expected to increase.

About 20 per cent of the arable land is under irrigation and this accounts for about 40 per cent of global food production. An increase in area under irrigation has underpinned the large yield increases in both India and China. For example, in India the area of crop production under irrigation has grown from less than 20 per cent to over 40 per cent between 1961 and 2004. Over the same period, cereal production in India rose from 87 to 230 million tonnes (FAOSTAT, 2010). The dependence of India and China on irrigation water derived from the Himalayas is a great concern given predicted changes in rainfall patterns in this region.

It is also important to note that water pollution has exacerbated water shortages in many regions. In China, for example, most of the major rivers have suffered from serious pollution. Although action has been taken in many countries to address pollution problems, remediation has been slow and patchy and will take many years to restore river systems.

Fertiliser and energy availability

Fertiliser use has grown dramatically since the early 1900s and has been responsible for substantial increases in crop yields. However, fertilisers have become a major direct cost in agricultural production and have indirect costs associated with contamination of waterways, freshwater and marine environments.

The two most widely used fertilisers are those based on nitrogen and phosphorus from rock phosphate. Until around 1960, phosphate (phosphorous fertiliser) was the most widely used fertiliser but now over 2.5 times more nitrogen is applied than phosphate, although use of both has grown. Indeed, over the last 40 years fertiliser use has increased by around 700 per cent (Foley et al, 2005).

In 2007, over 100 million tonnes of nitrogenous fertiliser and over 40 million tonnes of phosphate were used. Most energy consumption in fertiliser production is associated with the production of nitrogenous fertilisers from natural gas. Over 1000m^3 natural gas is required to produce one tonne of anhydrous ammonia. In 1999, it was estimated that three per cent of total USA natural gas consumption went to the production of nitrogenous fertiliser. The rising cost of natural gas has driven up production costs for nitrogenous fertiliser and production facilities have tended to shift to regions where natural gas is readily available (Gelling and Parmenter, 2004).

The major concern with phosphate supplies is that mining of rock phosphate is restricted to just a few countries: Morocco (including Western Sahara has 34 per cent of reserves), the USA (six per cent of reserves and already severely depleted) and China (39 per cent of reserves protected by export tariff) (International Institute of Sustainable Development, 2009). Consequently, Europe, India and Australia are almost completely dependent on imports from a small number of sources. Further, exports from Morocco are restricted due to territorial disputes over Western Sahara (Smit et al, 2009). It is predicted that use of rock phosphate will peak in around 2030 then enter a rapid decline as available reserves are depleted and costs rise even more rapidly (Cordell et al, 2009).

The ready availability of nitrogenous and phosphorous fertilisers for the past fifty years has meant that there was little incentive for growers to reduce inputs and for breeders to select for nitrogen efficient germplasm. However, there have been rising environmental concerns due to pollution of waterways from agricultural runoff and the high energy costs of nitrogenous fertilisers. These factors have led to restrictions, penalties or levies imposed on fertiliser use. In addition, the rapidly rising cost of both nitrogenous and phosphorous fertilisers has encouraged intensive breeding and research on improving efficiency of fertiliser use by crop plants. Importantly, there is now clear evidence that significant improvements in efficiency of fertiliser use can be achieved.

Climate change

Estimating the impact of climate change on agricultural production is complex. Some aspects of climate change will actually be positive. Rising CO_2 levels increases photosynthetic efficiency for crops such as wheat and rice and this could translate to small increases in yield. However, there are also likely to be decreases in nutritional content of crops (Gleadow et al, 2009a; see *Case Study 3*). Increases in temperatures can also be expected to open up more land for cereal production in North America, Northern Europe and the Russian Federation. Rising temperature will also reduce low temperature inhibition of plant growth and this again can translate to yield increases. However, these benefits are only expected to apply for temperature increases of below 2°C and will be largely offset by deleterious changes, including an increased frequency of high temperature events and changed patterns of drought. It is also probable that there will be new pest and disease incursions in most cropping regions as the climate shifts.

The changing weather patterns can be expected to require major changes in agricultural practices in many regions and to place strain on infrastructure, notably transport and water storage and distribution systems. Some of these effects will be highly significant.

The impact of climate change will vary greatly between regions. For some areas, crop substitution may help sustain food supply. For example, in East Africa, cowpea production is expected to decline by as much as 20 per cent but increases in barley yields may help compensate. For some regions, such as Southern Africa, there is a greater than 95 per cent probability of severe declines in maize and wheat yields and no viable substitute crops are currently available (Lobell et al, 2008).

Case Study 3

Cassava and cyanide under elevated atmospheric CO_2

As atmospheric CO_2 increases, it has been demonstrated that the nutrition levels of many plants decrease and for some the levels of toxins increase. This may present serious problems when trying to feed an increasing population under conditions of climate change.

Cassava is a staple crop for more than 750 million people worldwide. Both the tuber and the leaves are edible. The tubers are the main food product and are toxic unless carefully processed. All parts of the plant contain cyanogenic glycosides. These serve as a defence mechanism against pests by breaking down to poisonous cyanide gas if the leaves are crushed or chewed. Leaves must be carefully prepared to liberate the gas or those who consume it risk developing a lifelong paralysis, known as Konzo.

Under elevated atmospheric CO_2, cassava plants allocate more resources to defence so the cyanogenic glycosides in leaves increase and protein content decreases. Further, the increased defence comes at the cost of decreased tuber yields.

By 2050, it is estimated that nearly 1 billion people will rely on cassava. In the next 20 to 30 years, scientists will need to develop cultivars that will show different responses to increased CO_2 concentrations.

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Catalyst, Toxic crops, ABC1 Broadcast 6 May 2010. Available online at: http://www.abc.net.au/catalyst/stories/2891924.htm.

Image: Dr Ros Gleadow, Monash University.

I. Competition for arable land

Most of the growth in crop production will be a result of higher yields and increased cropping intensity in developing nations (Bruinsma, 2009). Deployment of new land into production will account for a relatively small portion of this growth.

It is estimated that around two billion hectares of land could potentially be under cultivation. This would mean that there could be a maximum growth in arable land by around 30 per cent (FAOSTAT, 2010). However, most of this unused land is marginal with poor soils or low rainfall or both.

The rapid population growth in developing countries has placed considerable pressure on available arable land. For example, in 1961, an average of 0.5 hectare arable land was available per person in the developing world. This dropped to 0.2 hectare by 1992 and is predicted to further decrease to 0.1 hectare by 2050 (UNFPA, 2007).

Despite the clear pressures on global food production, there is only limited scope to increase the area under cultivation. As noted previously, climate change may allow new land in Northern Europe, Asia and America to come into production. Land from these regions may provide partial compensation for land with declining productivity or lost to agriculture altogether. However, there are also regions where substantial improvements in yield can still be achieved. The primary impact of the Green Revolution was in Asia with relatively little improvement in Africa. There is still an opportunity for significant yield increases in parts of Africa, particularly Southern Africa. Selective breeding programs, improvements in agronomic practices and accelerated technology delivery offer opportunities for yield increases.

Another part of the world where increases are possible in both yield and area under production is in Central Asia. Agricultural production in this region collapsed along with the Soviet Union. Cereal production halved from 34 million tonnes to less than 15 million tonnes over the period from 1990 to 1998. However, improvements in nearly all aspects of production from breeding to farm machinery have resulted in rapid restoration of yields to levels equal to or better than in the Soviet era and a large expansion in production areas is now underway.

For countries with the financial resources, food security can be supported by production of food in other countries on leased land. For oil rich countries, this has been an important strategy (*Table 2.4*). More recently, Asian countries with a strong industrial base have also leased land, particularly in Africa.

Country	Leased Area (hectares)
South Korea	2 million
China	1.5 million
United Arab Emirates	710 thousand
Saudi Arabia	620 thousand
Japan	320 thousand
Libya	250 thousand
Malaysia	40 thousand
India	10 thousand

Table 2.4 Countries leasing land abroad to sustain and secure their food supply (Nellemann et al, 2009).

Land degradation

Land degradation has been widespread in agricultural systems and there has been a direct correlation between population density and land degradation in the developing world (Bot et al, 2000). Therefore, there is a danger that degradation will become more severe in major regions of population growth. It has been estimated that around 40 per cent of all arable land has been exposed to erosion, nutrient depletion or over-grazing. The global loss of productive land has been estimated at between five and seven million hectares annually from both degradation and urbanisation (Bot et al, 2000). In irrigated areas, salinity and boron toxicity have become serious issues. Around 1.5 million hectares of arable land is being lost annually to salinisation (Foley et al, 2005). Water and wind erosion remain major problems in many parts of the world with an estimated 25 billion tonnes of topsoil lost each year.

Table 2.5 summarises the three major soil constraints by region. The table also shows the small proportion of the world where there are no significant soil constraints (note the potential of Central Asia mentioned previously).

	Area (million km^2)	Aluminium toxicity	Salinity and sodicity	Erosion hazard	Soils without major constraints
Sub-Saharan Africa	24	18%	4%	15%	18%
North Africa and Near East	12	0%	6%	10%	9%
Asia and Pacific	29	14%	11%	16%	23%
North and Central Asia	21	4%	10%	16%	40%
South America	20	39%	5%	19%	19%
North America	21	10%	1%	18%	27%
Europe	7	8%	3%	20%	31%
World	135	15%	6%	16%	24%

Table 2.5 Area of major soil constraints (Bot et al, 2000).

Urbanisation

The land area actually occupied by cities is not large. Although cities contain half the world's population, they account for only 2.8 per cent of the land area (UNFPA, 2007). However, cities tend to occupy prime agricultural land. Food production is influenced by the encroachment of urban development onto productive land and also by the loss of farmers and farm labour through population movement to cities. The development of cities in the developing world tends to be 'dynamic, diverse and disordered – and increasingly space-intensive' (UNFPA, 2007). Peri-urban areas often lack regulations and infrastructure and can be severely affected by the adverse consequences of urban growth, such as pollution, poverty and degradation of natural resources. This amplifies and disperses the worst effects of urbanisation into the surrounding countryside. These problems could be addressed by effective urban and peri-urban planning and regulation.

Impact of biofuels on food production

A large increase has occurred in the production of biofuels in several countries as a result of a range of subsidy schemes including direct subsidies, tax exemptions, consumption mandates and import tariffs. This has led to an increased demand for cereals and oilseeds, particularly in the USA and the European Union, and is believed to have contributed to increases in food prices (Sheales and Gunning-Trant, 2009). Large scale production of ethanol is occurring in Brazil (from sugarcane) and USA (from grain). The biofuel growth in Europe has been mainly through biodiesel. There are various estimates of the impact of biofuels on food prices but most analyses indicate that the effect is significant. Increases in biofuel production between 2000 and 2007 are estimated to have contributed up to 30 per cent of the increase in cereal prices at the time (IFPRI, 2008).

A modelling study of the potential impact of setting a biofuels target of 10 per cent of global transport fuel concluded that this would result in a 15 per cent increase in the number of people at risk of hunger and would only give significant savings in greenhouse gas emissions after 30 to 50 years (Fischer et al, 2009). Sugarcane produced under sustainable rainfed production systems offers the best option. Ultimately, only second-generation biofuels produced on land that is unsuitable for food or feed production provides a viable option for biofuel production (Fischer et al, 2009).

In the absence of government support, biofuels production is not regarded as economically viable. Consequently, current biofuel policies have had a negative impact on livestock producers and consumers due to increased grain prices (Sheales and Gunning-Trant, 2009).

Cereals, sugar, soybeans and vegetable oils previously used to feed humans and animals are being used for biofuel production. This is likely to lead to a scenario where biofuels and food/feed crops will be forced to compete for the same land and resources (Sheales and Gunning-Trant, 2009).

J. International conflict zones and peace efforts today

Conflicts can cause major risks to stability of food supply. Indeed human-induced food security emergencies are as frequent as natural emergencies (*Table 2.6*). In countries undergoing conflict or post-conflict period, food insecurity can affect over 20 per cent of the population (Nellemann et al, 2009). These countries frequently struggle to meet their basic needs and are heavily dependent on food imports. Countries in conflict or at war struggle to maintain a labour force able to produce food and work arable land, and crops are frequently damaged during conflict. In addition, infrastructure is usually damaged and transport can be difficult and hazardous.

Dominant variable	**Africa**	**Asia**	**Latin America**	**Europe**	**Total**
Human	10	3	1	1	15
Natural	8	7	1	0	16
Combined	7	1	0	0	8
Total	**25**	**11**	**2**	**1**	**39**

Table 2.6 Food emergencies 2005 (FAO, 2006).

It is important to note that food insecurity resulting from conflict does not end with the conflict. It takes many years for food production to recover from periods of conflict (Teodosijevic, 2003).

K. Key messages for Australia

- Countries in our region will be particularly threatened by food insecurity due to population growth and reliance on irrigation for food production.
- Climate change is predicted to reduce food production in Australia by over 15 per cent.
- Depletion of phosphate reserves is potentially a serious threat to food production. Major sources are China where exports are levied to secure Chinese supplies and Morocco where deposits are in the disputed territory of Western Sahara.
- Nitrogen production is moving to regions with abundant supplies of natural gas.
- Several countries are endeavouring to secure food supplies by leasing cropping land in other countries, including Australia. This applies particularly to China, South Korea and oil rich countries in the Middle East.
- Human-induced food emergencies, such as armed conflicts, are a major contributor to food insecurity in Africa and Asia. Food insecurity also triggers conflict leading to a spiralling problem. Our region will be particularly vulnerable to rising conflict as food security issues increase.

3. What are the key challenges and opportunities?

3.1. Introduction

While the formula for achieving global food security may appear simple enough, the task of actually achieving food security is fraught with challenges. Put simply, we need to produce more food from the same or reduced land area without damaging the environment and by reducing waste along the food value chain. Increases in food production must be achieved while reducing inputs, particularly fertilisers, and coping with the effects of climate change. Australia's role will not be as a major provider of food for the world but Australia can, and should, be a major provider of technological capacity to support the global challenge.

Australia's ability to provide a coherent strategy to tackle the global food security challenge will be built around actions and capabilities within Australia. The Australian challenges traverse the entire food value chain and go beyond agricultural and fisheries production to include food transport, processing and, ultimately, consumption.

This chapter defines key challenges and opportunities associated with food security. The first section of this chapter deals with food production and the environment, a relationship which has often lead to environmental degradation. The second section of this chapter deals with food as a commodity and Australia's position as a net food exporting nation. The final section provides an analysis of the inextricable relationship between food and health by highlighting how informed food choices can lead to positive population health outcomes and reduced food waste.

3.2. Food and the environment

A. Land use planning and availability of arable land

Climate, soil quality and rainfall are the key determinants of where and what agricultural activities occur. A recent report on farming in Northern Australia highlighted the significance of effective rainfall and soil type on the suitability of land for agricultural purposes (Northern Australia Land and Water Taskforce, 2010).

Climate change will considerably alter the productivity of arable land. As rainfall retreats to the coast and inland temperatures rise, the effective rainfall in currently productive areas will be lowered quickly. Areas currently cropped to produce grain will become increasingly marginal and be turned over to extensive grazing. Such areas are often characterised by low soil nutrients and unable to sustain grazing systems without fertiliser input. Although climate change may increase the proportion of marginal arable land due to reduced effective rainfall, land degradation processes such as salinity and acidification may slow, as these are driven by profile water movement. The decreased biomass production, however, significantly increases erosion risks associated with reduced vegetative cover, resulting in dust storms and silted dams.

Land use conflicts are likely to become more acute in the future. Already population and development pressures in coastal peri-urban areas have resulted in the loss of arable land to housing and industry. The coastal peri-urban zone is predicted to become increasingly valuable as rainfall patterns retreat to the coast. As coastal cities expand into productive and arable areas, viable block sizes for potential horticultural production are reduced to high value parcels of land for housing. As development proceeds, neighbouring viable and productive parcels of land come under increasing pressure to cease traditional farming methods.

Furthermore, rising land prices, particularly in peri-urban areas, may cause a shift to using arable land for purposes other than food production. This situation has developed because the return on investment in arable land is dominated not by food production but by rising land value. Policies and economic drivers which increase the value of long term forestry production, or conversion of cropped areas to biofuel production may also create incentives to use arable land for non-food production purposes (see *Section 2.3I*).

Policy challenges involved in maintaining viable arable farming in both marginal inland areas and peri-urban coastal areas are, therefore, considerable. These constraints on the availability of arable land apply equally to other nations within our region, particularly China. The rate of loss of arable land is disturbing as it directly affects regional food security. Policy changes which maintain arable land for food production will have considerable socio-economic benefits.

B. Increasing productivity and impact on energy usage

R&D has underpinned productivity improvements in the Australian agricultural industries by providing new technologies, innovations and knowledge which improve production efficiency and increase production volumes. Trade changes, such as the ratio of output price to input price, have significant implications for profitability. Australian farmers are generally price-takers, with individual farmers unable to influence the prices of outputs or inputs. Growth in productivity has been the main driver of long term profitability growth in the agricultural industries because terms of trade are largely out of a farmer's control.

Despite consistent declines in their terms of trade over the past 40 years, productivity gains have enabled farmers to maintain their profitability. Examples of productivity gains include:

- Improved system management through the use of spatial information to optimise input use.
- Improved breeding through conventional plant and animal breeding programs and the use of biotechnology.

However, the productivity gains experienced have come during a period when energy was relatively cheap and the agricultural industries were reaping the benefits of significant advances from the Green Revolution.

The next 40 years will see new challenges which will need to be considered and addressed through agricultural research. Challenges to maintaining Australia's production base will be ongoing and will include:

- Maintaining the quality of our land, water and biological resources.
- Ensuring threats to biosecurity are addressed.
- Adapting to climate change.
- Dealing with increases in input costs.

These challenges will require numerous solutions, including a move to low energy input production systems. Such a move will not only mitigate greenhouse gas emissions from energy use but also reduce costs associated with the use of energy and other farm inputs.

C. Impact of energy policy changes domestically and globally

Changes in energy or carbon policy, either domestically or internationally, have significant implications for agricultural industries and the food system more broadly.

Implications for domestic food production

Agriculture makes a significant contribution to our national greenhouse gas emissions profile (see *Figure 2.2*). Several lines of evidence (Department of Climate Change, 2008; Productivity Commission, 2008; Garnaut, 2008), however, indicate that it is currently impractical for agriculture to be covered under a greenhouse gas emissions trading scheme. The reasons for this include:

- A lack of accurate, verifiable and cost effective reporting mechanisms for agriculture.
- A lack of demonstrable commercially viable abatement and sequestration options for agricultural sectors.

- The practicality of implementing such a scheme.
- Technical difficulties in the way the sector is treated under the current Kyoto Protocol accounting rules.

International consensus on these issues will influence Australian policy and the conditions under which food is produced in Australia and how Australian food is traded in the global market.

Research will be required in the agricultural sector to better understand these issues for agricultural systems and inform farm practices. Specifically, research is required in areas related to:

- Managing agricultural greenhouse gas emissions.
- Managing carbon in farm landscapes.
- Adapting farming systems.

Implications for food costs and global food production

On a broad scale, changes in energy policy will have significant implications for the cost of farm inputs (eg. fuel and fertiliser costs), but also on the cost of food once it has passed through the farm gate and into the food value chain. Off-farm processing, packaging, transporting, marketing, consumption and disposal of food and food-related items require a range of inputs and associated fuel costs which will be influenced by changes in energy prices. For example, agriculture only accounts for approximately one fifth of food system energy use in the USA (Heller and Keoleian, 2000). As a consequence, changes in the costs of these supporting sectors will have significant implications for the cost of food at the supermarket shelf or restaurant table.

The United Kingdom's Low Carbon Transition Plan outlines mitigation strategies for sectors including agriculture. In acknowledging a world population of more than nine billion by 2050, the United Kingdom (UK) Government recognised its role in ensuring safe, affordable food supplies, balanced by the need for the agricultural sector to adapt to the impacts of climate change and safeguard environmental resources such as biodiversity and water quality. However, the report also recognised that agricultural products are traded internationally and that solutions to reduce emissions in the UK need to be developed to ensure that the problem is not simply transferred to other countries. Australia may have a competitive advantage in that our production systems use relatively low levels of energy. However, it is unclear if or how this advantage will be recognised in international trade.

At present, it is not clear what the implications of changes in energy policy will be on food prices, food security or consumer behaviour. The way agriculture is treated by different countries under their respective energy policies will influence the cost of food. Similarly, how food processing sectors are treated may also have implications for the cost of food, which in turn may affect food consumption habits.

D. Biophysical constraints

Climate change scenarios are likely to accelerate soil degradation and loss of soil fertility. Australia's soil landscapes are characterised by unleached salts and low levels of carbon, nitrogen and phosphorus presenting a naturally low production benchmark and requiring innovative farming strategies.

Soil nutrition

Due to the poor quality of soils in Australia, food production in the Australian landscape relies heavily on fertiliser inputs. Hence, the price and availability of these inputs impacts directly on food security. The two key inputs to Australia's arable production systems are nitrogen and phosphorus. The availability of nitrogenous fertiliser sources in Australia is controlled by only a few fertiliser manufacturers. Production and manufacture of nitrogenous fertiliser is an energy intensive process with 1 kg of oil required to produce 1 kg of nitrogenous fertiliser (*Fertiliser Manual*, 1998). This intimate link between oil, energy and farm productivity cannot be underestimated. The volatility in energy prices and future availability of oil and gas directly affect the potential for farmers to respond to spikes in food prices.

Similarly, phosphorous fertiliser is a limited and valuable resource enabling food production in Australia. Australia relied historically on reserves from Nauru and Christmas Island prior to the development of Phosphate Hill in north Queensland. Currently, the majority of production from Phosphate Hill, a small reserve by global scales, is exported (85 per cent). The CSIRO has recently convened a group of experts in phosphorus supply and phosphorus use efficiency to develop a research strategy for Australia. This working group is in response to a paper by Cordell et al (2009) outlining the case for a peak phosphorus scenario within the next 20 years. Although the total amount of current economically viable phosphorus for extraction is reasonably clear, a comprehensive review of reserves is currently in preparation by the International Fertiliser Development Centre. Although estimates of reserves may move upwards, more than 85 per cent of current reserves are in the hands of only 4 or 5 countries (see *Section 2.3H*).

Optimising the management of phosphorus in Australia's production systems is critical because the key to decoupling food production from dependency on energy-intensive inputs, such as fertilisers and pesticides, involves use of rotation systems incorporating legumes (see *Case Study 4*). Unfortunately, the phosphorus requirements for legumes are significantly higher than for cereals. Hence, shifting to legume rotation systems places stress on soil phosphorus reserves. At present, the amount of phosphorus and nitrogen applied to most Australian production systems is less than the amount removed in produce.

Other constraints

Soil resources

Nutritional constraints present one of the key biophysical challenges that need to be addressed to increase the productive capacity of farms. Within farming systems in Australia, a number of other key biophysical constraints emerge on a region by region basis. One of the most important areas, yet least resourced, remains minimising losses of topsoil through erosion. History has demonstrated that civilisations that lose or mismanage soil resources often decline rapidly—Australia is no exception to this rule and the risks are high. Soil resources include available soil moisture capacity, effective rainfall, temperature, water vapour pressure, soil micronutrients, sodicity, salinity and acidicity.

Pests and diseases

Recent biological challenges include the emergence of new cereal rust strains, the development of nematode populations and the rise of herbicide and insecticide resistance. Many of these challenges are being addressed through both industry and public sector research. Researchers in Australia and overseas are identifying possible solutions through genetic modifications of important crop species, research into tillage and rotation systems that control pests and diseases, basic agronomy and soil science.

Case Study 4

Smart crop rotations

Having good soil is vital for growing good crops. Soil is a complex soup of living organisms, decaying organic matter and non-organic materials like sand, clay, silt and air. Good soil provides nutrients to plants which helps them to convert the sun's rays into energy (through photosynthesis) and grow into feed and crops for animals and people. We all rely on good soils.

Nitrogen and phosphorus are the two most important soil nutrients. Nitrogen needs to be 'fixed' (combined chemically with another element) or released from decaying matter by organisms before plants are able to use it. Bacteria that live in the root nodules of legumes (peas, soybeans, alfalfa) fix nitrogen gas turning it into a form which plants can use. Planting legumes in alternate years lifts available nitrogen levels and varies the demand on soil nutrients.

Human activity (eg. pollution, use of pesticides and irrigation) has had a negative impact on the quality of our soils. One producer near Inverell in New South Wales has developed an innovative farming system to help manage these problems. He does this by rotating his crops between lablab beans and wheat, oats or barley.

Since the lablab bean is a legume, it does not require any additional nitrogen. The lablab bean acts as food for grazing cattle over summer and helps to prevent soil erosion during the dominant summer rains. The lablab bean is then killed by the first frosts and cereals are planted in its place. The removal of the lablab bean and planting of the new crop at the time of the first frosts also helps to minimise weed spread and reduce herbicide use.

Smart crop rotations like this will help create the profitable, sustainable farming systems of the future.

Source: Dr Chris Guppy, University of New England
Image: Shutterstock Images

3.3. Food as a commodity

E. The food value chain

As mentioned in *section 2.2C*, food production, processing and sales constitute a large part of the Australian economy and are valued at around $230 billion annually. The relative value of each sector is 17 per cent for production, 34 per cent for processing and 49 per cent for retail (*Figure 3.1*).

Figure 3.1 illustrates the relationship between the three major sectors of the food industry and the value that is added as the produce moves from the farm to the retail stores. It also shows the importance of domestically grown and processed food to the Australian community with imported foods accounting for less than 10 per cent of food retail sales.

The food value chain is strongly driven by consumer demands. A study by Jacobs et al (2007) concluded that the following consumer trends and drivers will shape the future food value chain:

- Consumers are dissatisfied with their current shopping environments.
- Online shopping will grow rapidly.
- Sustainability and other environmental issues will increasingly influence shopping behaviour.
- Consumers want personalised food product offerings.
- Health and wellness is a growing factor in consumer buying decisions.

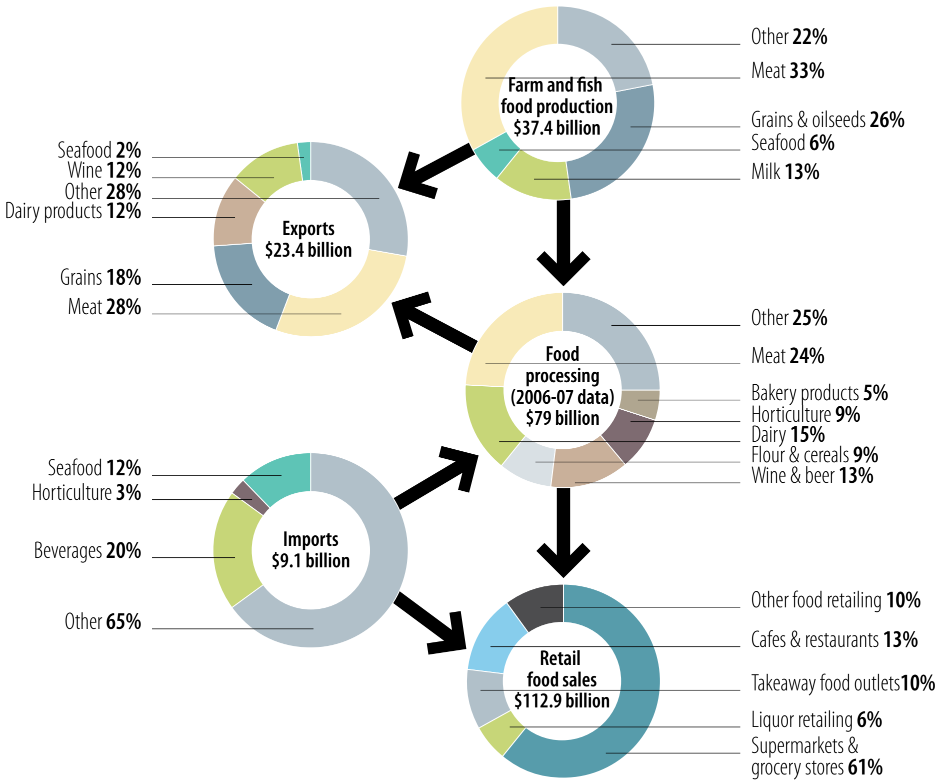

Figure 3.1 The food value chain in Australia for 2007-08 (DAFF, 2009).

F. Food production

The total value of Australia's farm and fisheries production was $38 billion in 2006-07 (*Figure 3.2*). The value does vary greatly from year to year with some particularly severe dips due to droughts in 2001-02 and 2006-07.

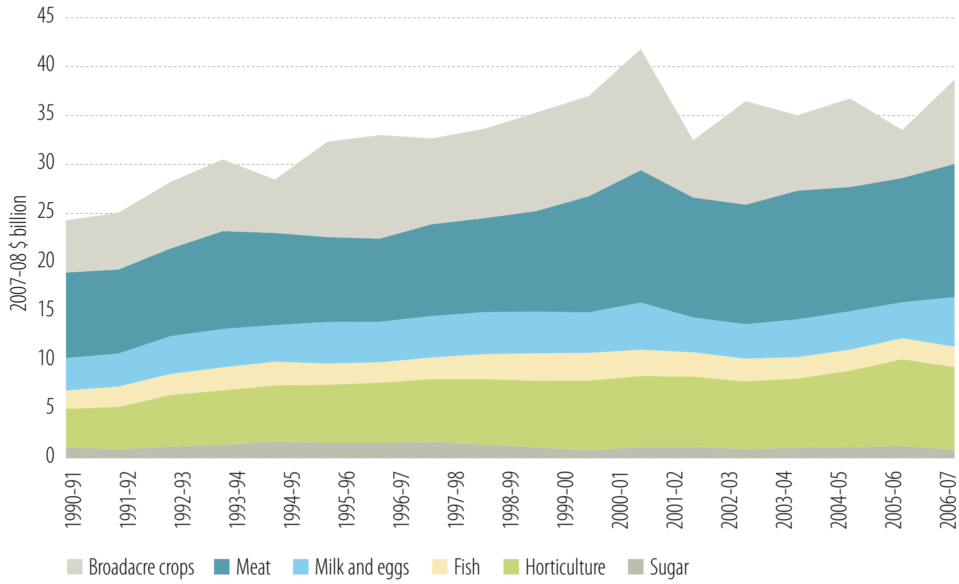

Figure 3.2 Value of Australian farming and fisheries production (DAFF, 2009).

G. Food imports

The *Australian Food Statistics 2008* (DAFF, 2009) indicates that Australia is a net exporter of food. Over the past five years, export earnings have averaged $18 billion a year in constant dollar terms. However, food imports have been steadily rising. Over the 18 year period up to 2008, this rise was an average of six per cent a year. In 2008, food imports were valued at $9 billion. Over the past decade, the rise in food imports has been accelerated by bad drought years which affected local food production. The increase in imports is not surprising as, in general, the world's largest food exporters are also the world's largest importers. These include the industrialised, developed countries of Northern Europe and North America. These high income countries typically import high value food products.

Major contributors to the growth in imports have been processed fruit and vegetables, bakery products, confectionary, beer and malt, wine and other processed food (*Figure 3.3*). Substantially and elaborately transformed products make up most of the imported goods, now accounting for around 95 per cent of the value of food imports. The import share of these goods has grown compared with less transformed food.

New Zealand remains the major source of Australia's food imports, accounting for $1.7 billion of total Australian food imports, up from $1.5 billion in 2006-07. New Zealand's share of food imports to Australia steadily increased from 14 per cent in the early 1990s to 19 per cent in 2007-08. Other countries to increase their share over the past 17 years were China, France, Italy, Ireland, Vietnam and India. Countries for which their shares fell over the period include Brazil, Canada, Indonesia, Malaysia, Singapore, Spain, the Netherlands, Papua New Guinea, the UK and the USA.

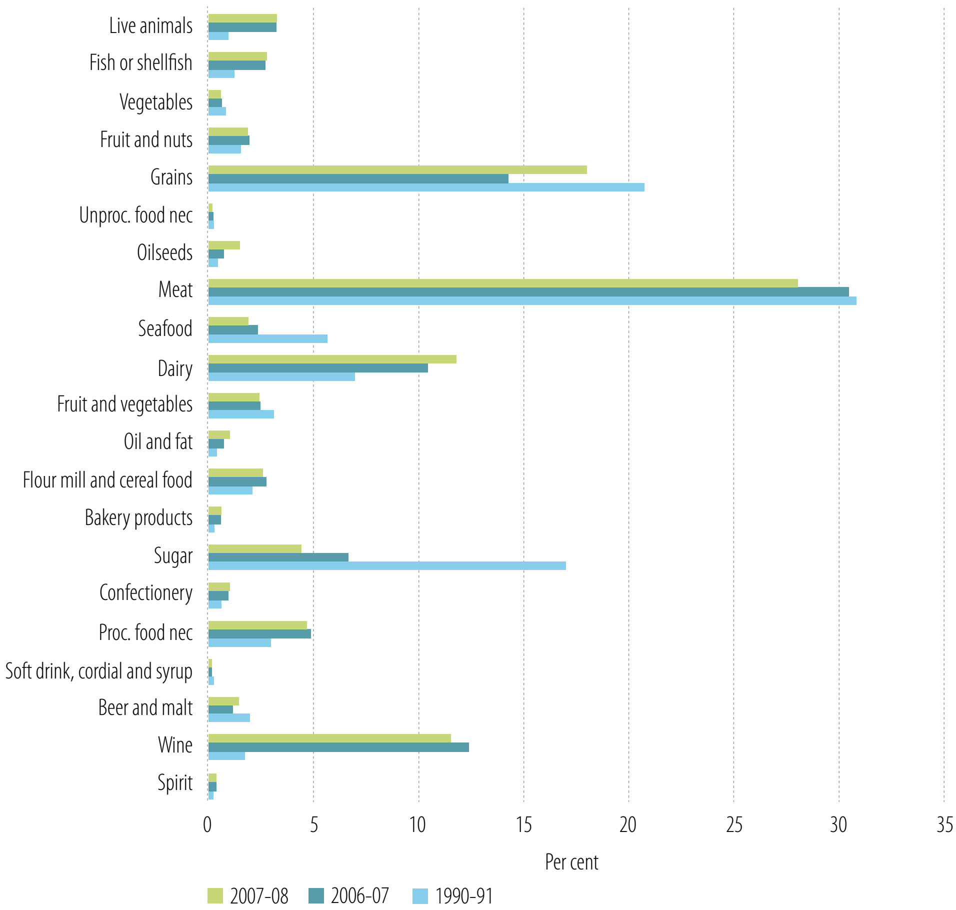

Figure 3.3 Composition of Australia's food imports (DAFF, 2009). nec – not elsewhere classified.

H. Food exports

Food exports were worth $23.4 billion to the Australian economy in 2007-08. This is lower than ten years ago and well below the peak of $31.8 billion (in 2007-08 dollars) of 2001-02 (*Figure 3.4*). The decline reflects the impact of drought, changes in import demand and the rising value of the Australian dollar relative to the US dollar. The likely impact of climate change will be an increase in the frequency and severity of adverse weather events, particularly droughts and heat waves. Consequently, the current downward trend in exports is expected to continue.

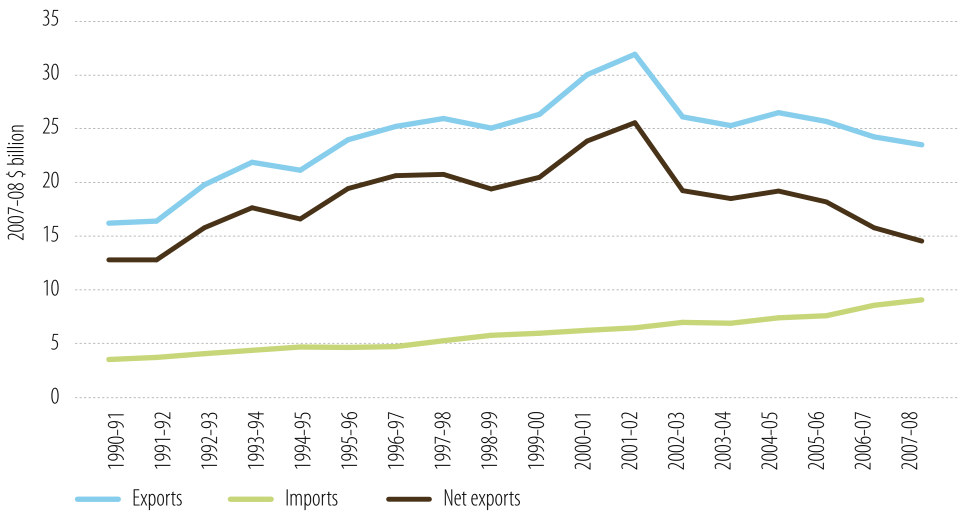

Figure 3.4 Trends in Australia food trade (DAFF, 2009).

Although agricultural production has been and will continue to be important for the Australian economy, Australia is only a small player in the total global trade for food (*Figure 3.5*). Total world food exports were estimated to be worth around US$836 billion in 2007 with substantially and elaborately transformed foods making up about 65 per cent. Australia's share in this trade was US$17.5 billion or a mere two per cent.

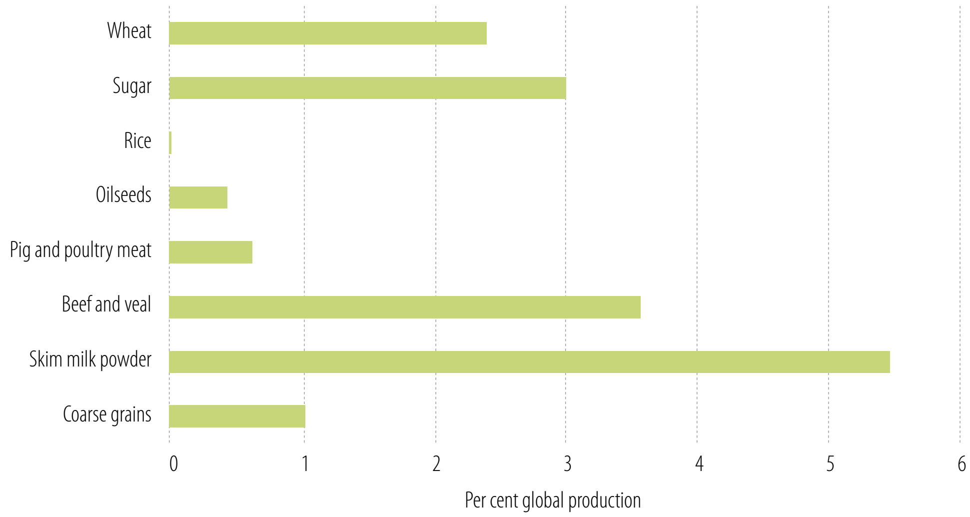

Figure 3.5 Australia's share of the world trade in key commodities (DAFF, 2009).

I. Food processing

The food and beverage sector plays a very significant role in the Australian economy. Total consumer expenditure on food continued to increase in 2007-08, reaching $112.9 billion, a growth of nearly six per cent over the previous year.

Overall, the food processing industry perceives itself as a manufacturing industry. Many food companies are based in regional Australia, primarily along Australia's eastern seaboard with more than 80 per cent of food industry production by turnover being located in Victoria, New South Wales or Queensland. The food processing sector is regarded as Australia's largest value added manufacturing industry at $20 billion (in 2004-05 dollars). This industry accounted for 19 per cent of industry value added and 21 per cent of the total sales and service industry of Australia.

The food processing industry worldwide is dominated by large, multinational firms. In Australia, the largest 50 food and beverage corporations accounted for around 75 per cent of the revenue for the domestic industry ($44 billion) in 2003. About half of the 50 major players are overseas owned and account for almost 50 per cent of the domestic revenue.

Importantly, the food and beverage sector employs around 18 per cent of the processing staff (DAFF, 2009). Meat processing is the largest employer with recent growth largely in the inner regional areas. Although over half the workers in the food and beverage industries are based in major cities, this industry is the major employer in rural and regional communities (*Figure 3.6*).

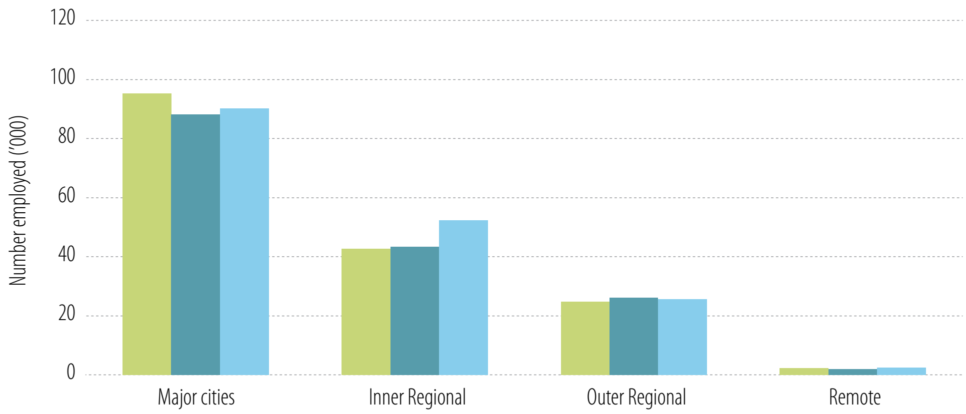

Figure 3.6 Food processing employment by region and census (DAFF, 2009).

J. Waste reduction

Whilst it is difficult to comprehend, food wastage, after purchase in Australia, is in the order of $5.2 billion annually (Baker et al, 2009). Major causes of this wastage include uneaten fruit and vegetables ($1.0 billion) and leftovers at restaurants and from takeaway ($1.0 billion combined). Wasted meat and fish account for around $600 million, dairy products around $500 million and the remainder is due to other sources of food wastage. In the USA, the annual cost of food wastage is around US$40 billion and each household wastes a similar amount (15 per cent of purchased food) as households in Australia (see *Table 3.1*). The food wastage in the USA has been called *America's Second Harvest*.

Recent reports show the average Australian household throws out an estimated $616 worth of food a year, which equates to $239 per person (Baker et al, 2009). The reported level of waste is substantial and is likely to be an underestimate.

	QLD	NSW	ACT	WA	VIC	TAS	SA	AUS
Waste/household	$678	$643	$641	$619	$560	$545	$517	$616
Waste/person	$262	$250	$249	$238	$214	$226	$213	$239

Table 3.1 Cost of food waste in Australia (Baker et al, 2009).

The *National Waste Report 2010* (Environment Protection and Heritage Council, 2010) noted that food waste constitutes 35 per cent of municipal waste (4.45 million tonnes) and 21 per cent of commercial and industrial waste (3.12 million tonnes). In 2006-07, 238 000 tonnes of organics were recovered from municipal waste streams and 91 000 tonnes of food waste from the commercial and industrial waste streams. Australians generate an estimated 361 kg of food waste per person per year or approximately 936 kg per household per year.

In developing countries, farmers have to contend with diseases and pests, poor infrastructure for transport and storage of food and unpredictable climatic conditions. Inefficient harvesting, transport, storage and packaging make a considerable contribution to food losses (*Figure 3.7*). Further losses and wastage occur in food processing, wholesale, retail and in households. As a result, around 25–30 per cent of food is wasted even in countries with high malnutrition and hunger. At the global level, estimated losses and wastage across the food value chain may be in the order of 50 per cent.

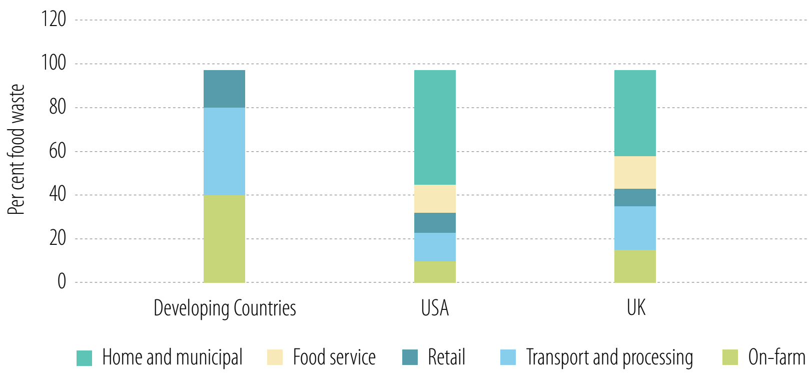

Figure 3.7 Components of food wastage in developed and developing countries (Adapted from: Godfray et al, 2010).

Both developed and developing countries would benefit greatly from R&D that reduced food wastage on-farm and at different points in the food value chain.

K. R&D investment, productivity and innovation

The food sector has a strong culture of innovation and development. The sector is exposed to international markets and has a history of adapting quickly to market forces, adopting new technology, altering product output and production methods in response to shifting demand and environmental factors. R&D is a major driver of this sector's innovative spirit and responsiveness.

The technology employed in the food sector covers a range of fields of science including gene technology, spatial imaging, microbiology, process engineering and materials handling. R&D has also been the major factor in maintaining strong productivity growth over several decades. The challenge is to maintain a stable, quality food supply with R&D providing the mechanism to reduce fluctuations in supply and cost that consumers would otherwise face across most food products.

Australia benefits enormously from food R&D conducted overseas particularly in areas such as biotechnology, pesticides, germplasm and veterinary medicines. It is estimated that these spillovers could be responsible for as much as 40 per cent of agricultural productivity gains in Australian broadacre agriculture (Mullen, 2007). In the context of international relations, this 'windfall' enables Australia not only to improve national productivity but also to disseminate knowledge on agricultural sciences more broadly to tackle food security issues worldwide. All nations, rich and poor, will need to contribute to this challenge and to grow the collective stock of knowledge on the environment, food and fibre production and to increase agricultural productivity.

There is clear evidence indicating consistently high returns from investment in agricultural R&D (Alston et al, 2000). Additional investment is expected to continue to yield high rates of return and substantial payoffs can be achieved through R&D. A recent report discusses the crucial role of R&D in underpinning agricultural productivity in Australia (Mallawaarachchi et al, 2009).

In spite of the high returns, there has been a decline in public R&D investment in Australia over the last three decades. Investment in R&D reached a peak of five per cent in the late 1970s, as a proportion of agricultural gross value of production, but this has steadily declined to just over three per cent in 2007 (Nossal and Sheng, 2010). The slowing in real investment in R&D has been linked to a substantial slowing in the underlying agricultural productivity growth (Sheng et al, 2010).

A further important feature of the interrelationship between R&D investment and productivity is the delay in measurable outcomes of productivity gains as a result of R&D investment. There is a lag effect from R&D investment to productivity gain, with the effects often continuing beyond 35 years (Alston et al. 2009; Mullen, 2007). The long term slowing of investment growth could, therefore, have a durable impact on productivity gains for many decades. A range of factors such as climate change, land degradation, urbanisation, greenhouse gas abatement and water availability will impact on food productivity in the future. Investing in R&D now can help identify solutions to these challenges before the most serious impacts occur. Lifting productivity back to at least the long term trend rate of improvement is necessary through substantial investment in food R&D.

L. Capacity constraints

Infrastructure

Infrastructure plays a valuable role in moving commodities in an efficient and cost-effective manner. Continued access to adequate infrastructure will remain a critical element for ensuring Australian agriculture remains internationally competitive and that Australians have access to cheap, nutritious food. These issues have been discussed in the recent review into the opportunities for intensive agricultural production in Northern Australia (Northern Australia Land and Water Taskforce, 2010). Competition for road, rail and port infrastructure leads to difficulties and delays in transport and increases costs, particularly where goods are perishable or live animals are involved.

Urban development and increased private transport also creates conflicts in infrastructure use, particularly around the transport of goods to and from ports. Research to understand future production from Australian agricultural regions has not been undertaken and there is no clear information on how changes in consumption may occur with increased populations.

It has been suggested that the majority of grain produced in eastern Australia may be domestically consumed and there could be the need to 'import' grain from Western Australia. This will have implications for the cost of basic food stuffs, as well as infrastructure requirements.

There is a need to develop scenarios for future food production in Australia and compare it with consumption patterns. This would have benefits in understanding where agricultural regions may need to be developed to underpin food supplies, as well as informing broader national decisions about infrastructure development and population policy.

The infrastructure associated with water use provides a growing problem in Australia and many other countries. Poorly designed and maintained irrigation systems and low levels of control of water use have been identified as significant problems in many regions. Climate change is expected to exacerbate these problems and efficient water use grows in priority due to changing rainfall patterns.

The agriculture industry is the largest consumer of water in Australia and accounts for more than 70 per cent of water consumption (ABS, 2006). Nearly all (90 per cent) of the water used for agriculture in 2007-08 was used for irrigation of crops and pasture (ABS, 2008).

Australia's irrigation industry faces ongoing pressures from water scarcity, increasing energy costs, climate variability and the need for sustainable use of natural resources. Impacts from climate change are likely to exacerbate this scenario. To address such issues, the National Program for Sustainable Irrigation (NPSI) and Irrigation Australia Limited (IAL) have jointly developed a framework for future irrigation R&D and extension in Australia (NPSI and IAL, 2010). The framework comprises a vision, priorities, implementation options and immediate actions. It identifies modernisation of irrigation infrastructure as an immediate opportunity for development and extension. The framework would address:

- Storage.
- Managing evaporation.
- Delivery (system efficiency, drainage).
- Reuse.
- Materials science eg. channel and storage lining systems.
- Use of remote sensing in forecasting demand.

Declining number and growing age of primary producers and farm advisors

Australia's rural workforce is becoming, on average, older (*Figure 3.8*). Agriculture and fishing are facing a worrying and unsustainable demographic situation characterised by:

- Highest median age workforce in Australia at 48 years.
- Particularly high proportion of workers aged over 55 years (35.8 per cent).
- Disproportionately low number of workers aged less than 35 years (23.6 per cent).

In addition to the changing age structure, changes in average farm size are impacting both positively and negatively on the availability of appropriately trained labour. Many individuals are moving from rural Australia to larger regional centres or cities in search of greater work options, better health and education services. This, in turn, has dramatic effects on the regional skills profile, its labour pool and the general health and vitality of the local community. The resurrection of the mining industry is viewed by many as a further drain on regionally based skilled labour. Many of the jobs in the agriculture and fishing sectors are not seen as attractive to a large proportion of the population.

Image: Shutterstock Images

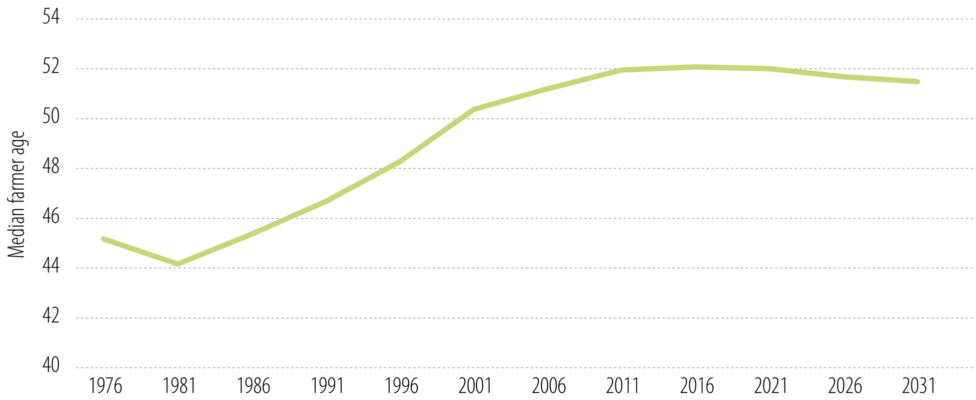

Figure 3.8 The median age of farmers based on observed data between 1976 and 2006 and predicted age 2011 to 2031 (Department of Primary Industries, Victoria, 2004).

These issues have all compounded the agricultural industries long term difficulties in attracting and retaining workers.

Projections on agricultural and food employment growth differ widely depending upon the source but no growth is predicted in the fisheries and agriculture sectors through to 2014. Modest growth of around five per cent is predicted in the food processing sector over the same period (Agrifood Skills, 2010). This is particularly concerning given the steady increase in the age of the farming community and the predicted average age of farmers (*Figures 3.8* and *3.9*).

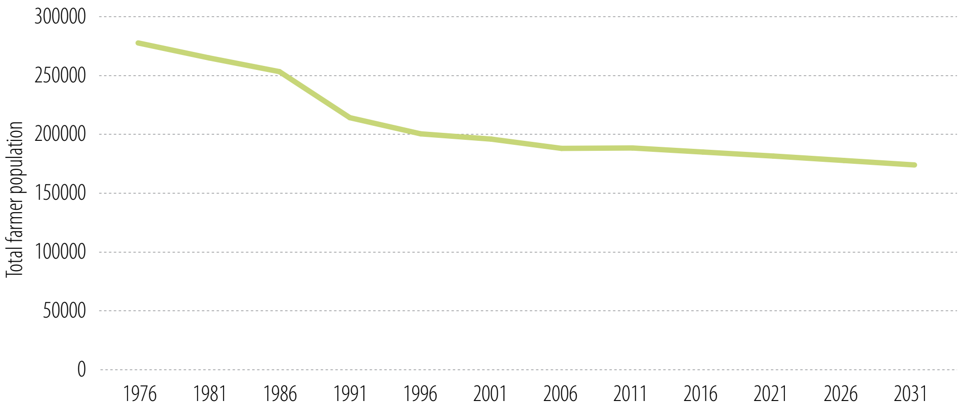

Figure 3.9 Declining population of farmers, based on observed data 1976 to 2006 and predicted data 2011 to 2031 (Department of Primary Industries, Victoria, 2004).

Skill sets in production and R&D

There is evidence to suggest formal training in the agriculture, farm and food sectors is in decline (Pratley and Copeland, 2008). In the tertiary sector, universities for a decade have been reporting declining enrolments in agricultural science courses raising concerns about the future availability of trained scientists and skilled farmers. There has also been a decline in students undertaking more generalist science courses not branded 'agriculture' but which include soil, plant and animal sciences.

For Australia to maintain an effective food R&D effort, government policy must have a clear long term commitment to sustaining the human and physical resources required for the task. There are real concerns that some scientific fields are reaching critically low numbers and facing real difficulties in recruiting new entrants. This will affect capability in the medium term.

The problem begins early in education and there is a danger that primary industries will be absent from the new Australian Curriculum from kindergarten through to secondary education. It will be very difficult for food security to become part of the national conscience if children have no training in food awareness in early formative years.

Urban and rural planning

The area of agricultural and arable land in Australia is finite and equates to 9.2 per cent and 3.4 per cent of global share, respectively. Significant areas of arable land are close to the coast and major population centres and are, therefore, subject to significant pressure from alternate uses, particularly urbanisation.

The creation of peri-urban fringes—ie. those small-hectare blocks on the edges of cities often used as 'hobby' farms or for small-scale conservation purposes—has had the effect of removing from production significant areas of arable land close to urban centres. This can create tensions between land for food production and land for residential uses. For example, rapid population growth in southeast Queensland has placed pressure on land that is one of the most intensively privately farmed regions of the state (Willis, 2005), responsible for the production of large amounts of Australia's fruit and vegetables.

Increasing population can create competition not only for potentially productive land but increases pressure on water resources and infrastructure. This is exacerbated by constraints on farming in peri-urban areas. Activities are also restricted in urban water catchment zones and land set aside for public use. Further competition for land is evident from other broadacre land use including forestry and biomass production. This challenge is not restricted to Australia with similar impacts of planning decisions being experienced elsewhere.

Given the juxtaposition of arable land and urban population centres, it would be prudent to integrate food production as part of metropolitan land and development strategies. Such strategies could be guided by the following principles:

- National recognition of productive agricultural land as a strategic asset and finite resource.
- Taking a landscape perspective and factoring 'food miles' into land use planning.
- Preserving peri-urban land for growing food as part of the land use and development strategies of cities.

3.4. Food and health

M. Nutrition and population health profile

From a nutrition perspective, food should supply adequate total energy (calories) but limit total fat (in particular, saturated and trans-fats) and added sugar and salt.

The recent development of functional foods can also be of use in providing health-promoting or disease-preventing benefits to the consumer.

Obesity, diabetes and cardiovascular disease

Any strategic development of the food supply needs to help prevent obesity, diabetes and cardiovascular disease. A recent analysis of dietary patterns in the USA showed that the oversupply of food calories accounted for the obesity epidemic there (Swinburn et al, 2009). Similar analyses have shown that reductions in the amount of salt in the food supply can have a significant impact on the prevalence of heart disease within populations (Bibbins-Domingo et al, 2010).

There are many areas in which actions have been taken to work with the community to improve the food supply. These include:

- Salt reduction in manufactured food[2].
- Helping consumers to choose healthier food[3].
- Health professional food and nutrition advice[4].

2 Through partnership between the Australian Division of World Action on Salt and Health and the National Health and Medical Research Council
3 Through the Heart Foundation Tick program
4 Through the Dietitians Association of Australia – www.daa.asn.au

Groups at risk of under- or over- nutrition

Due to particular circumstances, a number of groups within the Australian community are at greater risk of under- or over-nutrition:

- **Rural/remote/Indigenous communities**
  These communities may have insufficient access to quality affordable food (especially fresh fruit and vegetables).
- **Culturally diverse populations**
  Our multi-cultural population means that food needs to accommodate a variety of culturally diverse eating patterns (seen especially in recent migrants).
- **Women of child-bearing age**
  Women of child-bearing age are likely to need access to fortified foods.
- **Children**
  Childhood obesity demands a focus on better quality children's food and better promotion of healthier food to children. Children's nutrition education may also include an opportunity to learn about food production and preparation through school gardens and cooking classes.
- **Elderly patients**
  Elderly patients in hospitals and nursing homes need access to adequate food, including the development of supplemental foods for malnourished patients, high quality institutional foods and more effective food service systems.

National dietary guidance

Based on the National Nutrition Survey (ABS, 1995) data, it is likely that to meet nutritional recommendations, there will need to be a shift to increased demand for vegetables (particularly legumes), fruit, wholegrain cereals and nuts. Sustained supplies will be required of fish and seafood, poultry, eggs, red meat and of low fat dairy products. There are some indications that fruit availability may not meet requirements. From a nutritional perspective then, current Australian food supplies would seem to promote the health of Australians but horticultural food production may need to be monitored for stability of supply.

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Functional foods

Opportunities exist for foods to deliver functional properties to address diet-related disease risk factors (eg. lowering cholesterol).

The national Rural R&D priorities (Australian Government, 1994; 2007) include the need to add value through improved products and processes that focus on consumer needs and expectations such as healthier food. This could be followed by serious attempts to capture the market advantage of such foods. Stakeholders across the food value chain need to support the development of food products that enhance consumer health and wellbeing.

Food safety

The food supply in many parts of the world is unsafe and causes a large number of acute and life-long diseases ranging from diarrhoeal disease to a variety of cancers. Food and water borne diseases are estimated to cause around 2.2 million deaths annually, including 1.9 million children. Incidents of food poisoning through contamination can be severe in some cases. For example, the melamine contaminated infant formula in dairy products in China lead to the hospitalisation of 51 900 young children and several deaths (WHO, 2008).

There are many potential hazards that can appear in food (*Table 3.2*) but biological hazards present the greatest risk in Australia.

Biological hazards	Chemical hazards	Physical hazards
Infectious bacteria	Naturally occurring toxins	Metal, machine fillings
Toxin-producing organisms	Food additives	Glass
Moulds	Pesticide residues	Jewellery
Parasites	Veterinary drug residues	Stones
Viruses	Environmental contaminants	Bone chips
Prions	Chemical contaminants from packaging Allergens	

Table 3.2 Examples of hazards that may occur in foods (WHO, 2006).

Gastrointestinal illness affects over 20 000 people annually in Australia and results in over 300 deaths. However, only between 30 and 40 per cent of these cases are due to food-borne microbial contamination, the remainder coming from person to person contact.

Food poisoning through contamination is rare in Australia and when it does occur, it is usually from imported foods or food ingredients. There have, however, been two recent incidents of food contamination: the melamine contamination in China lead to the withdrawal of several products from sale in Australia (FSANZ, 2008) and early in 2010, very high iodine levels were found in a line of soy milk containing kombu seaweed which lead to 38 reported cases of thyroid dysfunction (FSANZ, 2010).

Overall, we enjoy particularly safe food in Australia due to the high processing standards and a tight regulatory framework.

N. Social aspects

Societal attitudes to food production

While it appears that Australians have a positive view of food production in their country, there are opportunities to keep the population abreast of new developments, particularly considering recent concerns about climate change. For example, the Public Health Association of Australia recently produced a document outlining the nutritional quality of the food supply, families at risk of food insecurity and an inadequate understanding in the community of the effect of food choice on the environment (Public Health Association of Australia, 2010). Building stronger links between the farming community, the school community, consumers and public health advocates would be a positive step toward greater understanding between key food stakeholders at the community level.

Contemporary urban food culture

Taking advantage of recent media trends on food preparation presents a major opportunity to influence community attitudes toward food. Currently aired popular television shows also provide an opportunity to bring in the farming community and build a layer of understanding on the source of food used in these shows.

Case study 5

Tasmanian backyard gardens

Historically, in times of hardship and change, householders have taken to their gardens and grown their own food to supplement commercial supplies. During World War II, for example, 40 per cent of fresh vegetables produced in the USA were from backyard gardens.

A resurgence in the popularity of backyard gardens is taking place in Tasmania. An increasing number of Tasmanians are growing their own food and sharing or bartering surplus produce within their communities.

There is evidence that the increased production of food in urban environments is in response to heightened awareness of the environmental impacts of food production, food transport costs and the costs of inputs such as energy and water. The urban production of food can have a range of social, environmental and health benefits that address issues of food security. These include increasing the consumption of fresh foods, developing and strengthening communities, providing culturally appropriate foods and increasing awareness of food production systems.

Encouraging and supporting the production of food by households through mechanisms such as education and planning can contribute to food security at a range of levels, from the individual through to the community.

References:

A Tasmanian revolution is growing across suburban backyards. ABC news, Hobart, 7 July 2010. Accessed online at http://www.abc.net.au/local/stories/2010/07/07/2947328.htm

Dixon, J.M., Donati, K.J., Pike, L.L. and Hattersley, L.(2009). Functional foods and urban agriculture: two responses to climate change-related food insecurity. *NSW Public Health Bulletin*, vol.20 (1-2), 14-18.

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4. How to meet the key challenges and opportunities

4.1. A national approach to food security

A. Framework for the food value chain

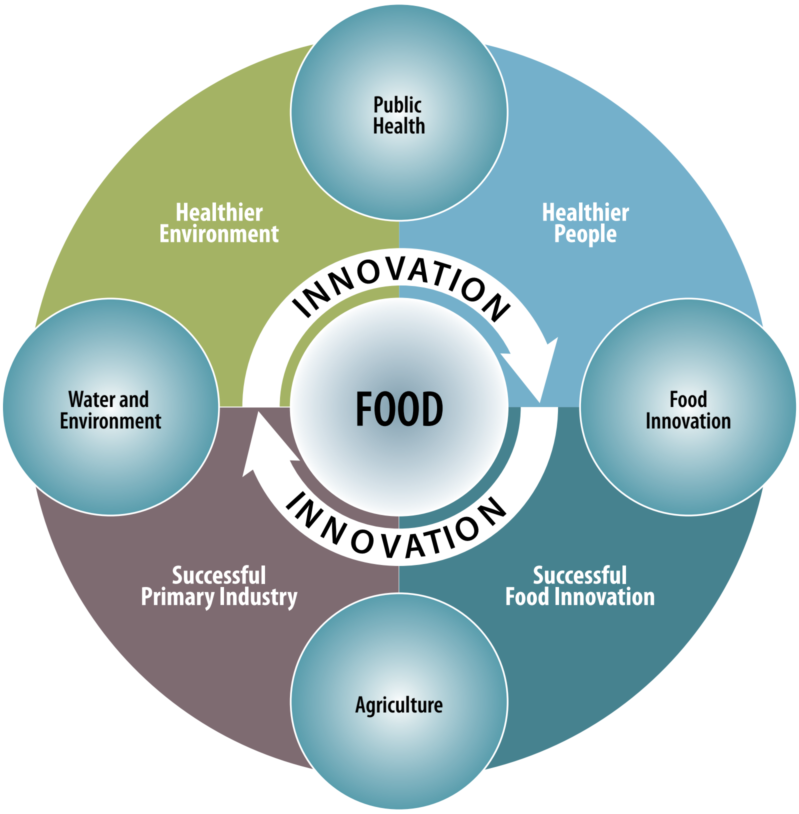


Figure 4.1 Food and food production is central to our health and the health of the environment.

Food production and processing is a fundamental part of Australia's economy and the health and wellbeing of its citizens (*Figure 4.1*). Despite this, food is not currently dealt with in an integrated way which brings together the policy and regulatory agencies involved with food. Actions taken in any one area can have widespread ramifications, ranging from the health of the environment to public health. As food security continues to emerge as a challenge globally and domestically, it seems likely that:

- There will be increasing demands for greater efficiency in food production, processing and distribution to reduce wastage and minimise costs.
  – For example, research to value-add in processing waste by extracting and recycling nutrients from food waste.
- There will be a demand for R&D and the delivery of innovations to underpin productivity of agriculture and also to meet human health needs and bring improvements in food processing.
  – For example, the development of intensive agricultural systems or research to deliver health-promoting attributes in fresh produce.

- There will be greater flexibility and responsiveness in regulation to ensure that innovations to underpin productivity and efficiency improvements are delivered effectively.
  – For example, flexibility in regulation to reduce the cost and time of bringing new technologies to market and increase the rate of innovation in agriculture.
- In Australia, there is a long list of policy, regulatory and program delivery agencies involved in areas related to food, inputs into food production and food distribution and trade. An illustrative list is provided in *Appendix D*.

The development of a consistent and whole-of-government approach to food will encourage understanding, communication and innovation in the food sector. Such an approach will be vital to respond to global and domestic food security challenges. A holistic approach to the food value chain could also result in the creation of new international markets for food and food technologies developed in Australia, as well as opportunities to export technologies and innovations to help address global food security issues.

B. Australia's position in the international food security scene

There is significant international debate on the most appropriate strategies to ensure global food security. This debate is going on in a range of international forums and has had a focus on global underinvestment in food production research. Globally, agricultural productivity improvement has been driven by R&D activities and there is broad awareness that the productivity gains currently seen are not sufficient to meet global population increases and food demands (Godfray et al, 2010). This gap in food production and population increase has implications for global food prices and global political stability (see *section 2.3*).

Australia invests significantly in overseas efforts to improve agricultural production. This is done through the Australian Agency for International Development (AusAID), the Australian Centre for International Agricultural Research (ACIAR) and through participation of Australian researchers in a wide range of international programs. This effort capitalises on the domestic agricultural R&D base and draws on funding through the Rural R&D Corporations and other agencies. Australia's success in addressing international food security issues is partly due to the leveraging of scientific resources to address agricultural problems in developing countries. Innovations that address food security are delivered through a variety of programs through AusAID and equivalent agencies.

Australia is well placed to support agricultural R&D in developing countries across a range of commodities. Australia is already experienced in dealing with many agricultural challenges due to the diversity of our agricultural environment and industries. Historically, this effort has been supported by investment in agricultural research in public institutions such as the CSIRO, universities and state departments of agriculture. To maintain delivery of food security solutions globally, it is important that Australia's international strategy on R&D is underpinned by and complements a national rural R&D effort.

C. Regulatory constraints to adoption of existing and new technologies

Differences in state regulation, such as moratoria on genetically modified (GM) crops, may also increase the uncertainty of doing business in Australia and have the potential to increase the costs of R&D. These moratoria are also making it difficult to develop GM technology further. For example, regulatory requirements on GM seed producers makes it difficult for them to transport GM seeds through South Australia from the eastern states to Western Australia and vice versa. Experience with the Australian veterinary and agricultural chemical industries also suggests that many large international companies are not prepared to pay for the efficacy testing of chemicals to register products in Australia through the Australian Pesticides and Veterinary Medicines Authority. This limits the range of opportunities for productivity improvement by Australian farmers.

As food security issues continue to emerge, the regulatory environment in Australia will need to be more flexible and responsive. This will ensure that innovations which underpin productivity and efficiency improvements are delivered effectively.

Use and importation of materials

The current regulatory framework for the use and importation of biological materials pose significant challenges for food security. The importation and use of biological materials are key requirements for plant, animal and fish breeding programs. However, imports of biological material present risks of disease and pest incursions and there is a need to maintain biosecurity for Australian primary industries and integrity of the Australian environment. Changes in the global spread of pests and diseases due to climate change will potentially increase complexities and risks related to the importation of biological materials. Australia also relies on its pest and disease-free status for competitive advantage in a number of key markets. The need to import biological materials must be carefully balanced by the need for effective quarantine mechanisms. Risk assessment associated with the importation of biological material and features of a quarantine system must be based on the best available science.

Therefore, the scientific expertise which Australia requires to underpin its system of quarantine needs to be consolidated and further developed. Where possible, more flexibility and responsiveness needs to be built into the system. Initiatives such as the Australian Biosecurity Intelligence Networks and the Atlas of Living Australia offer opportunities to strengthen the quarantine system and deliver greater responsiveness. At present the regulation governing this activity is the responsibility of Australian Quarantine & Inspection Service (AQIS) which is supported by science and policy advice from Biosecurity Australia.

Development of biotechnologies

Biotechnology, which includes the development of GM organisms (GMOs), is becoming increasingly widespread in agriculture. The use of GMOs in agricultural systems offer a range of opportunities, including increased plant and animal production, greater efficiency of plant and animal production, the potential to better manage environmental challenges such as drought and salinity. GM technology can also confer novel attributes in food which can assist in dealing with nutrition and other health challenges (see *Case Study 6*). At present, federal regulation governing this activity is the responsibility of the Office of the Gene Technology Regulator (OGTR). In addition, state and territory governments exercise various rights regarding the on-farm use of approved GMOs.

A recent survey of the impact of GM crops in 12 countries from both the developed and developing world showed substantial improvements in yield, particularly in developing countries (Carpenter, 2010). These results support the widely held view that the application of GM technologies will be a component of the suite of options required to meet global food security challenges.

The current regulatory framework and, in particular, the difference in state approaches to the use of approved GMOs, are creating significant uncertainty around research and investment in GM technologies. Whilst GM cotton and canola have been approved by the OGTR for commercial production, the process leading to these approvals has been slow and complex. The development of GMOs has been in place for a number of years and represents a maturing technology. Under these circumstances, it is appropriate for a review of the existing system of regulation to see where improvements may be made, including opportunities to shift risk assessment towards a greater emphasis on evaluation of food product safety.

Related to the debate around GMOs is a changing landscape around gene patenting. Australia will need to monitor international development in patenting to ensure our patent laws reflect world best practice and provide sufficient security and incentive to our research scientists, institutions and industry. The regulatory framework should also provide clarity of ownership of intellectual property between organisations.

Case Study 6

The potential of GM technology for crop improvement

In decades to come, increasingly sophisticated GM technology could be deployed to develop crops with multiple desirable traits. Unlike the relatively simple single gene manipulation involved in currently available GM crops, the future will see an emergence of combinations of traits (such as herbicide and pest resistance) or the introduction of new traits such as drought tolerance.

The table below outlines current and potential applications of GM technology for the genetic improvement of crops.

Time scale	Target crop trait	Target crops
Current	Tolerance to broad-spectrum herbicide	Maize, soybean, oilseed, brassica
	Resistance to chewing insect pests	Maize, cotton, oilseed, brassica
Short term	Nutritional bio-fortification	Staple cereal crops, sweet potato
(5–10 years)	Resistance to fungus and virus pathogens	Potato, wheat, rice, banana, fruits, vegetables
	Resistance to sucking insect pests	Rice, fruits, vegetables
	Improved processing and storage	Wheat, potato, fruits, vegetables
	Drought tolerance	Staple cereal and tuber crops
Medium term	Salinity tolerance	Staple cereal and tuber crops
(10–20 years)	Increased nitrogen use efficiency	
Long term	Higher temperature tolerance	Staple cereal and tuber crops
(>20 years)	Denitrification inhibitor production	
	Conversion to perennial habit	
	Increased photosynthetic efficiency	

Reference: Godray et al (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science,* 327, 812–817.

Use and registration of chemicals

Farm chemicals are a vital tool in agricultural production and assist in making food production systems secure. Farm chemicals are generally used to increase efficiency of production (including through the prevention of pests, diseases and weeds) and productivity (which includes the use of fertilisers). For Australia to have internationally competitive farming systems, the regulatory system should promote the development of innovative chemicals and provide certainty for private companies looking to invest in this area.

The current regulatory framework presents a number of challenges for the development and introduction of new technologies into the Australian market. Given the relatively small market for chemicals which exists in Australia, there is anecdotal evidence to suggest that high costs and long processing times for applications may be restricting access to new technologies, including bio-pesticides and potentially safer farm chemicals.

Development of nanotechnology

Nanotechnology is an emerging area which provides opportunities to improve the delivery of chemicals and nutrients in agricultural systems. The regulatory arrangement governing the use of nanotechnology applications and products remains an area under development. A clear framework and institutional arrangements would need to be in place to support the development of nanotechnology.

Health and label claims on food products

Regulation around food labelling and the claims made on food labels are critical to ensuring the safety of imported and domestically produced food. There are increasing demands for more information on food labels. This information relates to a variety of food attributes from impacts on consumer health to information about the agricultural systems used in the production of food, information on the water and energy used during production and transport and the origin of the food or its various ingredients. Such information and the supporting regulation ensure that food is safe, nutritious and appropriate for our health.

A Council of Australian Governments (COAG) review of food labelling law and policy is currently underway as part of regulatory reform to create a seamless national economy. This review process includes a preventative health component which aims to tackle the burden of chronic disease through the food regulatory system. Innovation in the food regulatory framework may provide opportunities to add value to food products and create markets for niche or newly developed products. There is also a need for regulation to plan for emerging trends in food which may require labelling.

At present, health claims on food products are largely limited to claims about the food content. One of the main requirements for higher level claims is the body of evidence supporting such claims (Jones et al, 2008). This is dependent on the alignment of food and nutrition science and substantiation of the claim. The complexity associated with data collection to support health claims is summarised in *Appendix D* (*Table 2*).

D. Access to international technologies

International linkages are vital to ensure access to emerging technologies and developments in food security. Although Australia currently contributes to international food security through a number of agencies, there remains an opportunity for Australia to be even more active in international forums and markets.

An example of the benefits of international linkages is Australia's participation in the Global Research Alliance on Agricultural Greenhouse Gases. This Alliance allows the outcomes and benefits of Australian agricultural research in areas related to soil carbon, methane emissions and nitrous oxide to be distributed to the partners of the Alliance. In turn, the Alliance allows Australia to access the knowledge and innovations developed by other members of the Alliance.

International engagement should be one of the pillars of our national rural R&D strategy. This would provide rural R&D with opportunities to:

- Address gaps in Australia's own research capacity.
- Assist Australian agricultural industries in accessing new technologies and information.
- Allow Australia to provide international leadership in rural R&D where Australia has internationally recognised expertise.

This approach may also provide opportunities to access public funds from international sources, as well as private investment from international agribusiness companies. However, to derive value from these activities, it is also important that the development of domestic research capacity is also a focus. This will ensure that Australia has the capability to integrate international developments into Australian food production systems.

4.2. International and national research agenda

E. Role of R&D in maintaining global food security

Spending on agricultural R&D has been closely linked to increases in crop yield (Pardey et al, 2006). Historically, scientific advances have continuously underpinned yield improvements in crop and livestock production. The major increases in crop yield that came with the Green Revolution were based on improvements in plant breeding. The Nobel Prize to Norman Borlaug in 1970 underscored the role of new breeding technologies in tackling food security. In his acceptance speech for the Nobel Prize, Borlaug highlighted the role of technological advances in helping to secure food supplies but warned of the dangers associated with failure to maintain the effort.

'It is true that the tide of the battle against hunger has changed for the better during the past three years. But tides have a way of flowing and then ebbing again. We may be at high tide now but ebb tide could soon set in if we become complacent and relax our efforts. For we are dealing with two opposing forces, the scientific power of food production and the biologic power of human reproduction. Man has made amazing progress recently in his potential mastery of these two contending powers. Science, invention and technology have given him materials and methods for increasing his food supplies substantially' (Borlaug, 1970).

While the role of scientific advances in dealing with problems associated with food supply are well recognised, investment in agricultural research has been declining over the past 20 years (Royal Society, 2009). *Figure 4.2* shows the large increases in spending by the USA aid organisation (USAID) that followed and facilitated the implementation of crop breeding and related technologies. These technologies were vital in fueling and sustaining the Green Revolution in the 1960s and 1970s. The rise in USA spending for agricultural R&D correlated strongly with rapid increases in crop yield across the world, particularly in Asia. Similarly, the large decline in spending during the 1990s is correlated with the stagnation of yield improvements over that period (Alston et al, 2009). Indeed, since the mid-1990s the rate of improvement in crop yields has slowed dramatically. The USA trend has been reflected by many other aid donors.

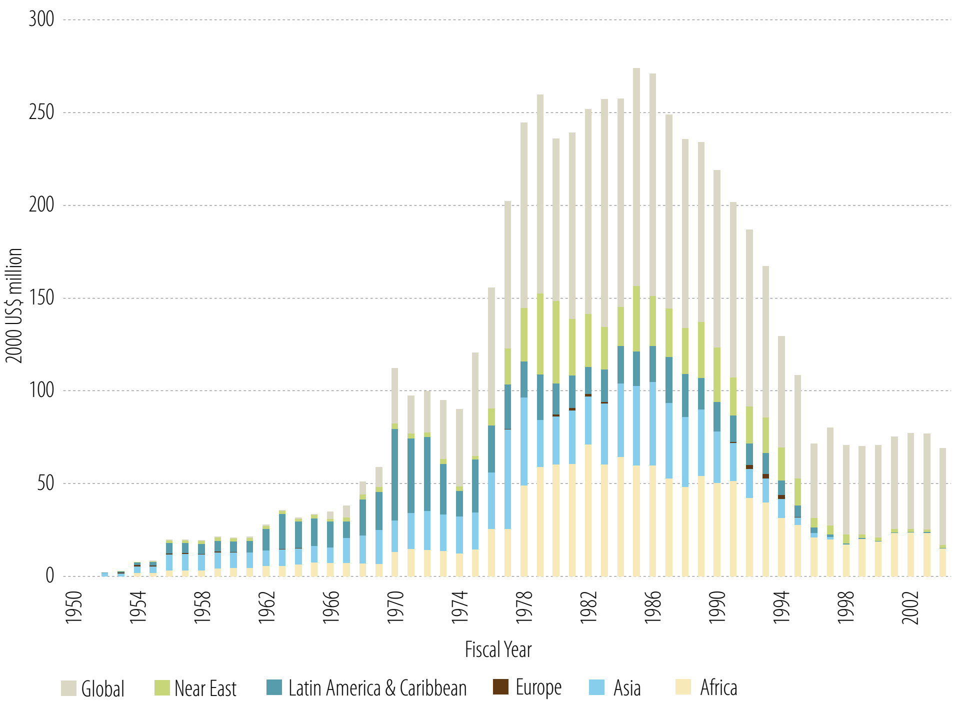


Figure 4.2 USAID funding for agricultural R&D (Pardey et al, 2006).

Part of the decline in support for agricultural research (*Figure 4.3*) has been due to changing priorities for aid organisations that have frequently focused on short term benefits. This has been partly due to the flawed belief that the rapid advances between 1960 and 1990 had reached a momentum that would continue without direct support.

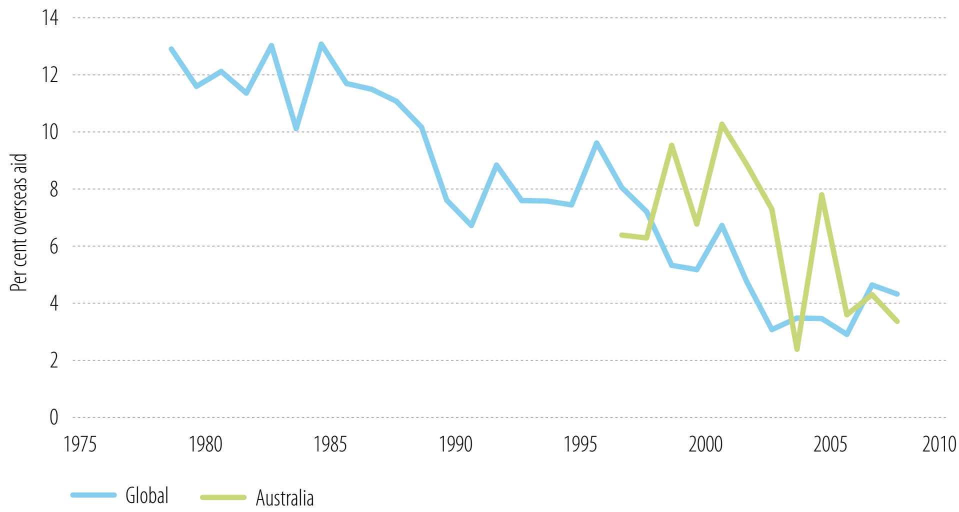


Figure 4.3 Agriculture's share of overseas development aid (Austin, 2010).

The recent rapid rise in food prices, the realisation that yield gains were in significant decline and the likely impact of climate change (discussed in *Chapter 2* of this report) have stimulated a re-evaluation of the role of R&D in addressing food security needs. The decline in support for agricultural research has now been recognised in many developed countries. Many are developing new programs to support agricultural R&D both nationally and internationally.

For example, the recent report from The Royal Society (2009) recommended that '*the UK needs to maintain and build its capacity to innovate, in collaboration with international and national research centres.*' Further, '*Research Councils UK (RCUK) should develop a cross-council "grand challenge" on global food crop security as a priority. This needs to secure at least £2 billion over 10 years to make a substantial difference.*' In the USA, there have also been several new programs initiated to support agricultural research related to global food security. The major initiatives are the National Institute of Food and Agriculture[5] funded through the US Department of Agriculture at around US$1.3 billion[6] and the Basic Research to Enable Agricultural Development (BREAD). BREAD is funded jointly by the US National Science Foundation and the Bill and Melinda Gates Foundation[7].

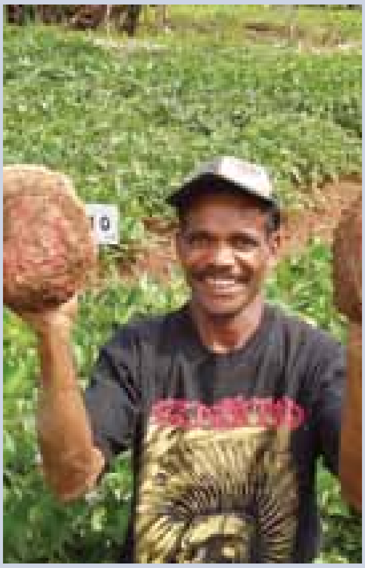
The World Summit on Food Security in November 2009 saw a renewed pledge for the global community to strive to achieve Millennium Development Goal 1—to reduce hunger by 50 per cent by 2015. This was followed by the announcement in April 2010 of the Global Agriculture and Food Security (GAFS) Program which will raise government and private funding to address agriculture and food security needs in developing countries. GAFS already has commitments of US$900 million from several G20 member countries and the Bill and Melinda Gates Foundation.

It is critically important that Australia participates in major global initiatives in food security.

5 http://www.csrees.usda.gov/
6 http://www.csrees.usda.gov/about/offices/budget/fy10_budget_table.pdf
7 http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503403&org=DBI

Case study 7

Seeds of life



Seeds of Life is a program within the East Timor Ministry of Agriculture and Fisheries (MAF), funded collaboratively by MAF and the Australian Government, through ACIAR and AusAID. The Australian-funded activities are coordinated by the Centre for Legumes in Mediterranean Agriculture at the University of Western Australia.

Since its inception in post-conflict East Timor, the program has tested and selected varieties of staple crops from international agricultural research centres, moving from testing on experimental stations to on-farm trials engaging East Timorese farmers. Since 2000, the *Seeds of Life* program has established a robust national variety release mechanism and substantially lifted the capacity of East Timorese research staff to conduct crop variety trials. MAF has to date imported and tested 210 prospective varieties of food crops.

In conjunction with MAF, ACIAR has released nine new varieties of five staple food crops (maize, rice, peanut, sweet potato and cassava). A survey of subsistence farmers prior to the second phase of *Seeds of Life* found seven out of ten families went without maize for four or more months each year, with many families gathering wild food and the worst affected families consuming the seed needed for the following year's crop. *Seeds of Life* has lifted food security in 114 of East Timor's 442 villages. The gain from higher yielding varieties released by *Seeds of Life* is sufficient to feed 1000 farm families a year, every year.

Interviews with a small group of farmers participating in the project found more than half sold a third of their increased crop production, particularly sweet potato and rice surpluses. The income generated is contributing to family health through the purchase of improved quality food, particularly protein rich food, and to children's education. The ability of farmers to sell small surpluses has proven a powerful driver in many parts of Asia for breaking out of subsistence farming. The third phase of *Seeds of Life* will commence in 2011, extending the dissemination of seed varieties to farming families and furthering the development of a truly national seed system, including engagement with the emerging private sector.

Prior to the World Food Summit in November 2009, the Consultative Group on International Agricultural Research encouraged leading government delegates to consider the case of East Timor – *'viewing it as an instructive microcosm of global efforts to achieve food security'*.

Source: Australian Centre for International Agricultural Research - http://aciar.gov.au/project/CIM/2003/014, http://aciar.gov.au/node/11921, http://aciar.gov.au/node/11503
Image: ACIAR

F. The Australian situation

R&D is a critical input into the process of innovation required to drive economic growth. It is often argued that Australia's R&D effort is low when compared with other OECD countries (ABS, 2007b). While business expenditure on R&D in Australia appears relatively low, this is to a significant extent a result of Australia's industry structure.

Despite these limitations, Australian research in agriculture has been highly successful and is well-regarded internationally. An analysis of the ranking of research organisations based on scientific citations showed that agricultural science was the only area of science where we have a national research organisation (CSIRO) in the top ten in the world (Thomson Reuters Web of Knowledge, 2010). This was closely followed by Plant and Animal Sciences where we have six organisations ranked in the world's top 10 per cent. Therefore, we have a very solid R&D base to build upon.

A national approach to food R&D should account for domestic and international agribusiness and promote growth in private R&D activities. Private investment and research activity in Australia's agricultural sector is low by international standards (*Table 4.1*). The private sector plays an important role in the commercialisation and marketing of innovation to drive agricultural productivity.

The low level of private investment in R&D in Australia suggests that there is an opportunity for this to improve. There are also benefits from encouraging private R&D activity, including the development of careers for Australian agricultural professionals as well as spin offs to the food processing industries and other sectors of the economy. However, Australian agricultural industries are small by international standards and the number of regulatory hurdles which exist may not present an attractive investment market for large agribusiness.

A national rural agribusiness engagement strategy could help to identify opportunities to encourage private R&D and address the barriers to private R&D investment.

	Public	**Private**
Developing countries	26%	2%
Developed countries	34%	39%
Australia*	60%	16%

Table 4.1 Proportions of total agricultural R&D investment (Mullen and Orr, 2007).
** Residual investment is accounted for by Australian universities.*

At an operational level, there is a range of opportunities to improve the food R&D system. Three key areas are:

- Improving the receptiveness of industry to taking up R&D.
- Improvements in government support and involvement.
- Encouraging increased business R&D investment in the food sector.

To improve the uptake of R&D in the food sector there needs to be:

- A viable farming sector which is able to make the capital investment in new technology and production systems.
- An educated farming sector which can make informed decisions on the adoption of new technology, production systems and practices.
- Appropriate rewards for the adoption of improved environmental practices that benefit the broader society.

Since the 1980s, agricultural R&D intensity has fallen from a peak of five per cent in the 1970s to just above three per cent in 2007 (Sheng et al, 2010; *Figure 4.4*). Agricultural R&D has demonstrated its ability to provide public and private returns through larger productivity growth than that observed in the broader economy (see *Sections 2.2C* and *3.3K*). Given the established lagged effect of R&D investment on productivity growth, productivity benefits can persist for many decades after the initial investment has been completed (Mullen and Orr, 2007). There is currently an urgent need for greater investment by government through new or existing R&D programs.

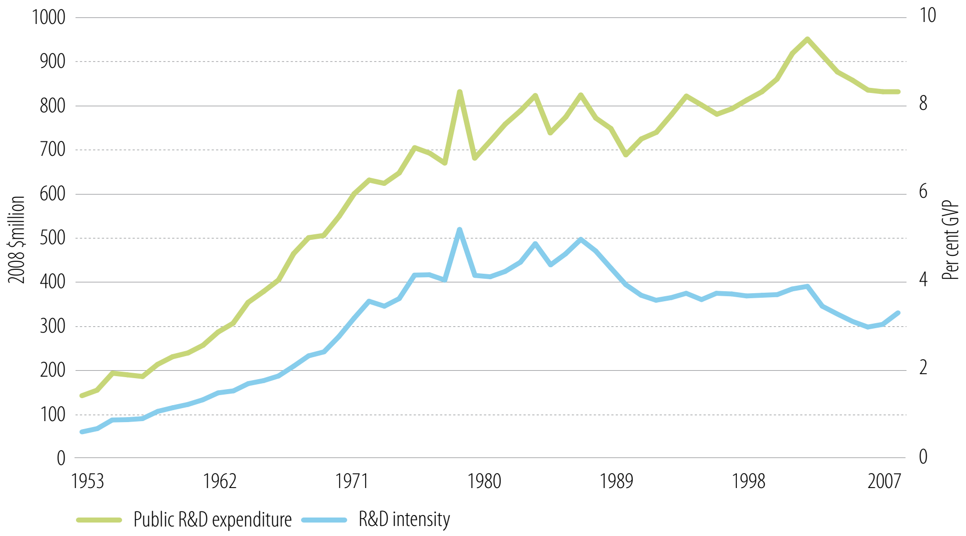


Figure 4.4 Agricultural research investment and intensity in Australia, 1953 to 2007 (Sheng et al, 2010).

G. Fostering international and national collaboration

Despite declining agricultural R&D investment, Australian research in agriculture has been highly successful in specific areas. We have built a strong international reputation, particularly in low input agriculture and in dealing with food production in difficult environments. As previously noted, agricultural science is the only area where we have a research organisation that ranks in the top ten of the world (Thomson Reuters Web of Knowledge, 2010). These skills and expertise are coming into greater demand as governments and private corporations try to adapt food production systems to changing environments. Consequently, Australia needs to ensure funding mechanisms are targeted to major changes in international and multidisciplinary research frameworks. The Cooperative Research Centre program has played a central role in building national collaborations but this model, and others like it, may need adjustment to more effectively include international partners and initiatives. In this way, there will be greater opportunities to build focused centres and increase the scale and impact of R&D activities. These changes require recognition of the value of international collaboration as a cornerstone for R&D on matters of national and global significance.

There is currently poor coordination between funding agencies both within Australia and between Australia and international partners. Importantly, there are few mechanisms for Australian researchers to become involved in international collaborations. Schemes such as the International Science Linkage program have been largely discontinued. Although there are numerous schemes to support travel and conference organisation, initiatives to directly support collaborative international research, on issues such as food security, need to be developed.

Direct support for collaborative international research would complement the recent infrastructure support under the National Collaborative Research Infrastructure Strategy program and the Education Investment Fund. These programs have established capabilities that are at the forefront of international research.

The advantages that Australia can bring to the international research agenda are:

- Expertise in technology development and delivery for agriculture in highly variable and generally low yielding environments.
- Strong links to national R&D programs in many developing countries through highly regarded ACIAR programs.
- A strong public sector technology development and delivery system that is now missing in many other developed countries.
- An education and training system that has built a strong reputation for its practical focus and has well-established links in much of the developing world.
- World leading infrastructure to support a wide range of agricultural research activities.

These capabilities could be leveraged to attract overseas investment as a first stage that would subsequently lead to global technology delivery.

H. The path forward

The international focus on developing agricultural research programs and capabilities that improve food production under highly variable and deteriorating environmental conditions has provided an important opportunity for Australian research organisations.

The international concern over food security issues will give Australian researchers a chance to take the lead and create the highest possible impact in research areas that confer both national and global benefits. It will also enable Australian researchers to capitalise on the new funding and support regimes recently established or under development in Europe and North America.

This strategy offers us several key advantages:

- Ensures a key role for Australia in setting the international agenda for the development and delivery of technologies designed to increase agricultural production under highly variable environments.
- Provides access to resources and capabilities available overseas and ensures rapid delivery of these technologies in Australia.
- Builds our strength in agriculture and enhances linkages to developing economies in our region.
- Permits the development and evaluation of technologies on a global scale.
  – Allows experiments to be conducted under a huge range of environments and scenarios thereby enhancing our ability to pre-empt the impact of climate change.

  – Allows the investigation of technology delivery under different sociological and political regimes in both the developed and developing world.
- Provides a framework for engaging the private sector both financially and intellectually in international research programs.
- Repositions the agricultural sector to help develop career paths and train future farmers, researchers and other professionals.

New research activities should target a small number of areas that are selected to match the priorities of new international programs, deliver significant practical outcomes for Australia and build on areas where we have internationally recognised expertise.

4.3. Intellectual capability

Future food security for Australia and the world will be dependent on an appropriately skilled workforce. We will need a new generation of people to run the farms, process our food, support, train and advise farmers and advise the community on what to eat. Just as importantly, we will need to nurture researchers of the future to undertake the required R&D for an innovative and vibrant food sector.

A key challenge facing Australia is to increase the flow of people into the agriculture and food sectors. This requires action at all education levels and starting at early education is important.

I. The early years

The role of agriculture and food training in schools has been recognised for some time. Where implemented, these programs address a number of important education and lifestyle issues in children. The opportunity exists through well-structured programs to generate interest and enthusiasm for food and food production. The programs involve children in healthy outdoor activities, such as gardening, to demonstrate issues related to land and environmental management and to teach respect for plants and animals. Importantly, these programs also show children the value and importance of science based decision making and emphasises the key role played by science in all aspects of food from production to consumption.

While many public sector programs have been initiated, there is no consistency in programs across Australia. Further, many schools do not offer such programs. The Primary Industries Education Foundation (PIEF) has attempted to document the programs currently underway and provides support in the form of resources and information to schools. A national stocktake of current Australian education initiatives on agriculture, fisheries and forestry has been undertaken and in March 2010, 122 programs were identified (*Table 4.2*).

National	ACT	NSW	Qld	Vic	SA	WA	Tas	NT	Total
47	2	41	45	23	28	19	10	6	221

Table 4.2 A stocktake of Australian education initiatives on agriculture, fisheries and forestry (http://www.primaryindustrieseducation.com.au/inits.htm).

The information in *Table 4.2* not only highlights the large number of initiatives underway but also demonstrates that the level of activity is not consistent across Australia. Greater coordination and sharing of resources would clearly be highly beneficial. In addition to the role played by PIEF, the agricultural science teachers have also joined together to enhance coordination and the development of school programs through the National Association of Agriculture Educators (NAEE)[8]. Despite these activities, it has not been possible to obtain reliable information on the actual number of schools that currently offer agriculture or nutrition programs or provide children an opportunity to work in a school garden or farm.

The development of a standard curriculum in the area of food production, processing and nutrition across Australia has been advocated by PIEF and NAAE. In a submission to the Australian Curriculum Assessment and Reporting Authority (ACARA), PIEF proposed a structure for a core program on agriculture and food (see *Table 3* in *Appendix D*).

A broad agriculture component in school curriculum would provide a good base for understanding agriculture and, if complemented with nutritional programs, could lead to a generational change in Australian attitudes to food. A cadre of people who have come through such programs would not only be able to engage in the food security discussion from an informed base but would also provide the future farmers, scientists and nutritionists for Australia. Curriculum content would be most effective if linked to farm or garden facilities and cooking activities to maintain a strong practical component.

An expansion in the education opportunities for children in areas related to food will require support through coordination processes, such as those initiated by PIEF and NAAE, and provision of additional resources to schools. Suitably trained staff would also be required through provision of incentives and appropriate professional development.

Case Study 8

Hands on agriculture

At Rostrevor College in Adelaide, South Australia, students are getting first hand experience with agriculture. Through agricultural courses combining theory and practice, students are able to engage with the systems which provide us with life sustaining food.

The school has a farm set out on two hectares of land. The farm has classrooms and is home to White Suffolk sheep, crossbred calves, poultry, goats, rabbits, bees and yabbies. There is also a vegetable garden where students can grow and harvest their own plants, learn about viticulture and wine production or become involved in native plant propagation.

The agricultural curriculum also overlaps with the scientific curriculum as many scientific principles can be investigated through agriculture.

Past students have gone on to a number of diverse careers within agriculture, including agricultural scientists, viticulturists, winemakers, farmers, rural property managers and aquaculture scientists.

Source: Mark Nitschke, Rostrevor College.
Image: Rostrevor College

8 http://www.naae.asn.au

J. Tertiary education and training

Skilled personnel for the agriculture and food industries and research organisations are trained in both Technical and Further Education colleges and universities or through work placements. A breakdown of the different sectors and the relative number of people undergoing training is shown in *Table 4.3*. Several areas, such as amenity (or ornamental) horticulture, compete with the food related sectors for staff. The trends shown in *Table 4.3* emphasise the declining numbers in key areas relevant to food security and land management.

Training Package	Persons in training 2008	In training trend from 2007		Learner completions in 2008 (full qualifications)
Food Processing	12275	↓	-2061	3576
Meat	11481	↑	310	3915
Racing	1288	↑	37	341
Conservation and Land Management	6659	↓	-583	1460
Rural Production	17583	↓	-1372	4082
Amenity Horticulture	19343	↓	-1155	4418
Animal Care and Management	6394	↑	950	1607
Seafood	2478	↓	-535	383
Total Activity	**77528**	↓	**-4409**	**19782**

Table 4.3 Publicly funded training effort in 2008 (in-training and completion) (Agrifood Skills Australia, 2010).

Until the late 1980s, agricultural colleges were a key source of qualified staff. These colleges were either closed or merged with universities during the early 1990s. Universities, however, are funded largely on the basis of student numbers. Consequently, the declining number of student enrolments in agricultural sciences has placed pressure on the ability of universities to maintain capacity. The result has been a steady decline in the number of university funded staff in agriculture faculties and a further erosion of agricultural training capacity.

Image: Shutterstock Images

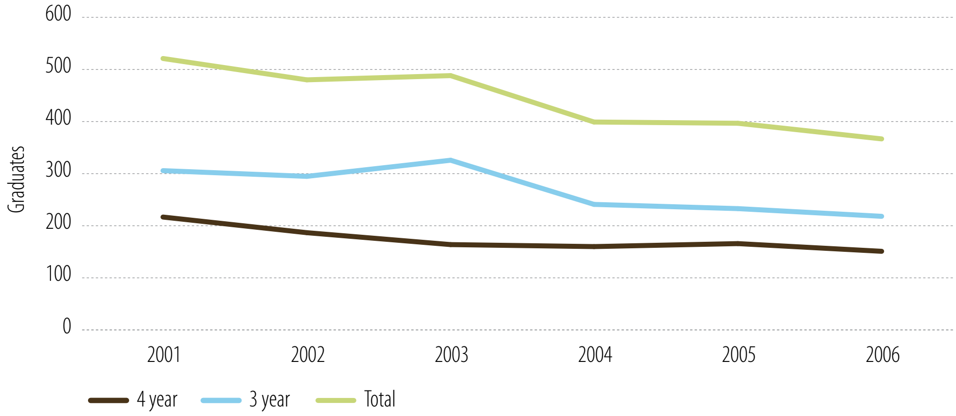


Figure 4.5 Total graduate completions in agriculture from Australian universities for the period 2001-06. Figures include three and four year graduates in agriculture but do not include graduates in forestry, food science and environmental science (Australian Council of Deans of Agriculture, 2009).

Recent work by the Australian Council of Deans of Agriculture has reviewed the human capacity constraints for the Australian agricultural industries (Australian Council of Deans of Agriculture, 2009). This work contains a number of significant findings, especially that the number of agricultural graduates produced nationally falls far short of the estimated needs, possibly by as much as six-fold. There are too few graduates taking up the opportunity to study for a higher degree by research to enter a career in agricultural research. This is likely due to postgraduate stipends being low and unattractive when compared with initial industry salaries offered to new graduates. Further, agriculture has a lower proportion of graduates working in it compared to the economy as a whole. Where agricultural enterprises do employ graduates, the enterprises are more productive (Australian Council of Deans of Agriculture, 2009). It should, however, be noted that many employees in the agricultural industries have been trained in related areas of science.

There were about 370 graduates in 2006 in agriculture programs and there was a decline of about 30 per cent from 2001 to 2006 (*Figure 4.5*). The decline is comparable for both four (31 per cent) and three (29 per cent) year degrees. In contrast, the agriculture industry is expected to generate over 32 000 new jobs annually, based on the conservative estimates of the Productivity Commission (2005). If the agricultural industry was to pursue 15 per cent of its workforce having university degrees, there would be 4800 new jobs per year for agriculture graduates.

Analysis of agricultural job advertisements from 2007 to 2009 showed that there were over 15 000 advertisements per annum during this period[9] (*Figure 4.6*; Pratley and Hay, 2010). This analysis by Pratley and Hay suggests that the job market in agriculture has been significantly underestimated and previous estimates of the demand for graduates have been exceedingly low.

Overall, the workforce data suggests that workforce planning at the professional level will be a major issue for the agriculture sector going forward. This is an issue which will impact significantly on the ability of the industry to improve productivity and address issues of sustainability and climate change.

9 The study period of the advertised job market in agriculture coincided with a protracted drought and the beginning of a global recession. The study recognised that there were many jobs that did not make it to the observed advertising sources.

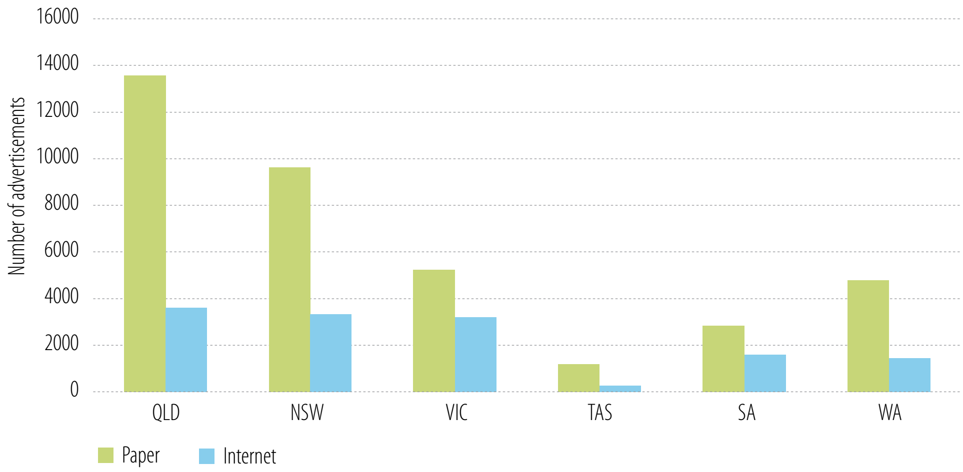


Figure 4.6 The number of job advertisements in agriculture for Australian states from the internet and newspapers for the years 2007 to 2009 (Pratley and Hay, 2010).

The current view is that over 50 per cent of agricultural scientists are likely to retire in the next few years. This will have a significant impact for agricultural research capacity. It will also have implications for the capacity of the agricultural industry to adapt to climate change. Deficits in human capacity can have serious consequences. For example, a lack of plant and animal pathologists impacts on our capacity to identify and assess biosecurity threats, putting in jeopardy industries and food security. Similarly, a lack of soil scientists has significant implications for the development of practices and policy to better manage soil carbon.

There are several options for increasing the flow of students into agriculture and food science training. A greater awareness and knowledge of food production, processing and nutrition amongst school children is expected to improve interest in tertiary studies. As knowledge of the scientific base to modern food systems increases in the community, the attraction of agriculture and nutritional sciences as a viable and valued profession will also develop. Incentives to study in these areas can also be provided along with the development of clear career paths for graduates.

The declining capabilities within universities to offer the full diversity of agricultural training could be addressed by coordination and complementation of expertise across the university sector. The current disparities between course structures do not encourage sharing components of training programs. Some areas of science have managed to achieve national coordination (eg. Geosciences) and a similar approach should be possible for agricultural science. A national, shared university program would allow each university to build specific areas of speciality and maintain international standing.

To build capacity in dealing with food security challenges, tertiary courses related to food could be more integrated. These courses could focus on major food security problems and take a multidisciplinary approach to solutions. Integration of tertiary studies in agriculture, food science, nutrition and engineering would be a novel way of educating tomorrow's food oriented workforce. This also would raise the value of food sciences in academic circles and lead to innovative higher degree research in multidisciplinary studies.

Similarly, increasing the food and nutrition components in medical and nursing curricula could lead to a better appreciation of the fundamental value of food and nutrition in preventing and ameliorating diet-related diseases.

4.4. A food and nutrition aware community

Food security is also dependent on people recognising the value of food and the importance of their own choices of food. These need to be considered at both the individual and societal level. At the individual level, it requires not only an awareness of how food is selected and consumed but also an understanding of the relative nutritional composition of different foods.

At the societal level, there needs to be an appreciation that food is not just a commodity. Food production, processing and marketing sectors carry a heavy responsibility for the health of consumers. At the same time, food is an integral part of the national economy, requiring appropriate regulation and commitment to innovation. This means that the nutritional content, affordability and access to food are key considerations alongside economic and environmental factors. A community which is informed about the food value chain and making appropriate food choices will exert a positive influence on food innovation (*Figure 4.7*).

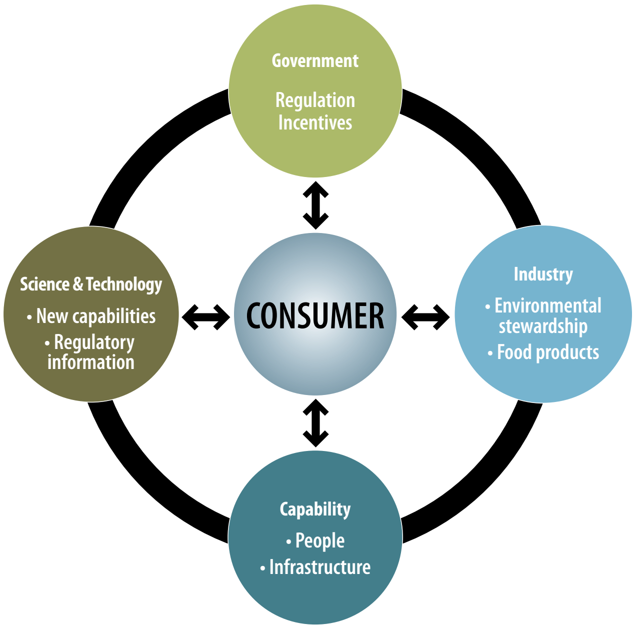


Figure 4.7 The food aware consumer can positively influence the framework for food innovation.

K. Community awareness and education

Linking agriculture, food and nutrition

Traditionally, Australians have been very supportive of farming and feel a strong cultural attachment to agriculture. In addition, Australia has a strong international reputation in agricultural training and education and many students from overseas, particularly South-East Asia, have studied here. This has built good cultural and political links in our region.

The Australian community has become increasingly aware of the role of food in health due to the prevalence of diet-related diseases (obesity, type 2 diabetes and cardiovascular diseases). This is reflected in the expansion of human nutrition courses. Both the primary production and food processing sectors have engaged in substantial R&D to develop healthier foods but the bottom line remains that individuals must not consume beyond their calorie requirements.

Australia has become a highly urbanised community, with connections to agriculture being eroded and fewer people having direct connections to farming. From some perspectives, this would appear to have resulted in a loss of respect for food with resultant waste, declining support for rural communities and low intakes in agricultural and food technology training programs.

The recent droughts and water restrictions in major cities have, however, reignited rural links and presented an opportunity for increasing interest and awareness of agricultural production. There remains a need to present careers in the food industry in a much more attractive form. The re-orientation of food marketing towards health and public–private partnerships in food development has helped build a more cooperative food–health environment. Combined with government investment in food standards and food and nutrition policy, there is ample opportunity to move forward. A national approach to food should address community awareness in the broader sense. Focusing initially on school and tertiary education would provide the foundations for a more food aware community.

Food and nutrition education in schools

Programs have been developed in an effort to start addressing the gaps in understanding of agriculture and food production, as well as assisting students in identifying careers in agriculture. Examples include the 'Foodworx' program of the Australian Institute of Food Science and Technology[10], PIEF and the Primary Industries Centre for Science Education (PICSE). PICSE focuses on students in science streams in late high school and provides science based curriculum materials to schools to increase awareness of science opportunities within the agricultural related industries[11]. A range of science disciplines, from chemistry, genetics, atmospheric physics, nanotechnology, biotechnology and natural sciences, provide an ideal platform for communicating science concepts to school children. Related work undertaken by PIEF and NAAE is discussed in *Section 4.3I*.

L. Public perception and visibility of agriculture and food production

Public perceptions of food are naturally mixed and reflect the complexities of contemporary society. The popularity of cooking shows and books related to food and diet is indicative of the central role food plays in people's daily lives. Choosing what you eat is part of self-care and self-identity. There is a powerful social aspect to food in that we share the intimacy of meals with others. However, our access to food is largely governed by social infrastructure, including the agricultural sector, food companies, supermarket chains and governments (eg. through regulation and trade).

Agriculture

While there is no indication that Australians have a lack of faith in the quality of the food produced in Australia, there appears to be a waning interest in agriculture and food production. With increasing urbanisation, Australians are no longer reliant on agriculture and rural success. We have moved on from 'riding on the sheep's back' although more than half of our land area remains in agricultural production. The differences between urban and rural areas are likely to grow but it is important that we continue to encourage an informed community. Key messages that need to be reinforced in the community include:

- People involved in agriculture are custodians of the environment.
- People engaged in food production have a responsibility for food standards and safety.
- Innovation in agriculture will make a substantial contribution in maintaining the integrity of our environment.

Food

Awareness of food at the individual level can begin with responsible behaviour towards food. This behaviour would be based on personal health and environmental considerations. For a start, perceptions need to change so that we eat what we need and recycle what we do not eat. An awareness of the extent of food waste is crucial. Consideration also needs to be given to possible tools that enable households to monitor food purchasing behaviour. This would encourage thought into what is best to eat for health and the environment.

From a societal perspective, the food sector could serve as social role models. New regulatory standards could be developed for the food sector to discourage food waste and minimise food loss along the food value chain.

10 http://foodworx.com.au/
11 http://www.picse.net/HUB/index.htm

Nutrition

Public perceptions of nutrition are often limited to the simple dichotomy of food that is good or bad for you. In reality, it is far more complex, particularly as the science of nutrition continues to uncover the mechanisms of action of food components and given the multifaceted relationship between food consumption and health. Compounding the problem are the multiple commentaries on nutrition that may deliberately or inadvertently claim expertise in the area. Support and recognition needs to be strengthened for science translation efforts such as:

- The evidence based dietary guidelines developed by the NHMRC.
- The establishment of nutrient reference values for Australians.
- Publically funded nutrition education materials based on the best scientific evidence.

There is a need to develop a better understanding of food composition and the relative value of different foods in a healthy diet. The prevalence of obesity and food wastage is indicative of a situation where individuals may not be aware of how food choices affect personal health and that of the environment. Alternatively, individuals may not care about food choices or are unable to do anything about it. Individual food choices need to be influenced through a better understanding of the links between personal choices, public perceptions and social infrastructure. Improving perceptions on nutrition will require harnessing the full extent of market, regulatory and health education forces to both inspire and empower the community to better look after their health and that of the environment.

From a societal perspective, building the concept of food—production, preparation and consumption—into multiple areas of social and environmental planning is required. This includes raising the standard and position of food in government institutions as well as in healthcare systems. At the primary healthcare level, this would see nutrition education being delivered in general practitioners' surgeries through printed material and nutrition professionals as part of the healthcare team.

The professional base for nutrition education would also need to be reinforced. This can be done by training:

- Nutrition scientists with expert knowledge of the biochemistry and physiology of nutrients.
- Public health nutritionists with expertise in population health and understanding of the social context of food and health.
- Dietitians with a science background combined with appropriate professional training (eg. clinical science, food service).

To create better linkages across the food value chain, nutrition scientists need to be working closely with agricultural scientists, food technologists and engineers, as well as food marketers. Such an approach would support the processing industry to improve the availability and affordability of healthy foods and reduce the availability of less healthy food. The role of the media should not be underestimated in this scenario, with significant investment required for science communication in the field of food and nutrition.

Addressing the population's needs for healthy food requires sub-analyses of different contexts so that dietary guidance can have relevance and meaning in terms of access to a healthy food supply. A special case needs to be made for at-risk communities, in particular remote and Indigenous communities. As with other aspects of healthcare, the social fabric of these communities needs to be considered alongside an appreciation of specific food and nutrition requirements. Store policies in remote communities need to be developed with members of these communities aided by nutritional, logistics and related expertise.

5. Recommendations

5.1. Preamble

On the surface, it is hard to imagine a crisis in food security directly affecting the Australian population. However, this view masks some worrying trends. Climate change is likely to exacerbate problems with water availability and climate variability. In 2008, following prolonged drought, our wheat exports dropped to nearly match the level of our domestic consumption. If our population grows to 35–40 million and climate change reduces food production, we can expect to see years where we will import more food than we export. There are further existing or emerging challenges for food security in Australia. As yet, we do not have a nationally coordinated approach to food. Productivity growth in our agricultural sector has been in decline since the early 1990s. Within our community, we have high levels of food waste while not everyone has access to high quality and nutritious food. Further, there is a prevalence of poor dietary choices that have created a wide range of health problems. We are also facing serious shortages in suitably trained staff across our food sector and our agricultural R&D base. Food shortages overseas are also likely to become more severe as population continues to grow and climate change limits production in many highly populated areas. These changes will have major impacts on several countries in our region. Any resulting political and social instability will affect our food security and, potentially, our national security.

There are positive steps we can take which will address these issues. Australia has been dealing with difficult food production environments throughout its recent history. We have internationally recognised expertise in technology development and delivery and in human nutrition. This strength can be expanded and linked into major international initiatives to tackle food production in the face of climate change and enhance our capabilities in the area of food and health. The success of this approach will rely on an informed and engaged Australian community and a regulatory environment and a food strategy that supports innovation in the food industry. We need to build a better understanding of food production systems and how food affects health. We should also revisit the ways in which we use land in rural areas and in urban and peri-urban situations. We have many of the structures in place to achieve these goals. These structures, however, need consolidation and expansion. Critically, they need cohesion and coordination through a national approach to food, to ensure long term food security in Australia.

5.2. Recommendation 1

Establish a National Food Security Agency.

The problem:

Lack of a nationally-coordinated approach to food

Outcome:

The Australian Food Security Agency would oversee regulation and research activities related to agriculture and food, including the national coordination and planning of related research.

Rationale:

At present, the diversity of issues related to food production, food trade and the role of food in community health are dealt with by several separate agencies (*Figure 5.1)*. An integrated approach to food policy is required to achieve food security, support growth in the food sector and address diet-related health issues. A National Food Security Agency would have responsibility for the implementation of the recommendations in this report.

Figure 5.1 Complexity in the food sector – list of some of the major players relevant to food security.

Proposed solutions:

1. Establish the Australian Food Security Agency to coordinate the development and implementation of policies and programs targeted to improving Australia's food security. The agency would report to an appropriate minister and liaise with states and territories through existing COAG processes such as the Primary Industries Ministerial Council.
2. The Australian Food Security Agency would be allocated appropriate funding to support its role and remit to implement the other recommendations in this report.
3. In collaboration with relevant agencies, the Australian Food Security Agency would ensure that the following issues are tackled:
   - Availability of nutritious food in Australia through coordination of government policy and programs across the food value chain. Support for data collection on the food producing environments, food production, food processing and distribution and consumption patterns, will be an important requirement for effective policy and program development.
   - Development of a Food Security Research Strategy to provide a framework for the future food production and processing environment, with resultant research targets. The Strategy would build on the outcomes of concurrent activities such as the Productivity Commission's review of the Rural R&D Corporations and the Rural R&D Investment Plan being developed by the Rural R&D Council. The Food Security Research Strategy would also promote:
     – Innovation across the entire food value chain.
     – Linkages to international research on food.
     – A consistent national approach to investment and priority setting for research through coordination between funding agencies.
   - A National Land Use Planning Framework, developed in conjunction with state and territory governments, to secure future food production. The scope of the planning framework should be guided by a landscape view of land use and food production and include:
     – Food production in rural, urban and peri-urban regions.
     – Investment decisions in food production assets considered in the context of strategic national interest.
     – Opportunities to reduce 'food miles' and transport costs.
     – Policies, including in areas of trade, to maintain resilience in the food supply chain and minismise impact of 'shocks' to national and international markets.
     – Opportunities for communities to be engaged in the production of healthy food.

4. Streamlining and harmonisation of regulatory procedures to support technology development, evaluation and delivery. The objective will be to ensure safe deployment of innovation for the production and delivery of nutritious food and to encourage domestic and international investment and participation in the food sector. The consolidation and centralised oversight of the regulatory responsibilities relevant to food, including health, food labelling and technology (eg. GMOs, chemicals and nanotechnology), would help create a better climate for private investment. The Australian Food Security Agency will take responsibility for driving the development of an appropriate regulatory environment.

5.3. Recommendation 2

Increase investment in agricultural R&D to harness national expertise and take a leading role in national and international programs targeted to improving low input farming systems.

Problem:

Decline in agricultural productivity growth related to progressively declining agricultural R&D investment

Outcome:

Established and well-supported national and international research programs targeted to improving productivity in low input food production systems.

Rationale:

Gains in agricultural productivity in the past have come at the expense of increased energy and water consumption. Future gains must break this nexus. Therefore, research should target low input food production systems. There is a direct, measureable relationship between the decline in agricultural productivity and the decline in R&D investment. In the 1970s, we were investing around five per cent of gross value of agricultural production in R&D compared to just above three per cent now. The strong productivity gains that followed this investment have underpinned production gains through to the early 1990s. Investment is needed now to rebuild capability and drive gains in the future. Although Australia represents only a small part of the global research on food and agriculture, we have developed great expertise in dryland agriculture and low input food production systems. We are strongly positioned to take the lead in developing international research programs in established areas of expertise.

Proposed solutions:

1. Increase aggregate agricultural R&D spending to at least five per cent of gross value of agricultural production and rebuild momentum in agricultural productivity growth.
2. Launch new national and international programs targeted to:
   - Dryland agricultural production under resource constraints.
   - Developing and managing food production systems under a variable climate.
   - Integrated land management strategies with particular focus on water, nutrient and energy use efficient agriculture.
3. Substantial research programs, based on themes in point (2) above, should be selected and supported through the Australian Food Security Agency in collaboration with existing research agencies, funding agencies and aid bodies. These programs will be linked to advanced international research organisations. They should target outcomes to food production systems in Australia and the developing world.

5.4. Recommendation 3

Develop incentives to recruit and nurture future generations of innovative and adaptive farmers, researchers and associated professionals for the Australian food production and processing sectors.

The Problem:

Age structure of current generation of farmers and demand for skilled professionals

Outcome:

A skilled workforce made up of innovative and adaptive farmers and a talented pool of researchers. This workforce will ensure sustainable food production and build the research and delivery capacity needed to meet the changing circumstances of food production in Australia and global food security. The aim is to build and train the next generation of farmers and scientists. The farmers and scientists of the future will need new competencies to deal with the new challenges of the changing food production environment.

Rationale:

Changes in the distribution of farm size will create new demands for highly skilled farmers, food professionals and researchers. In many areas, this skill base will be significantly different from the current expertise required to manage farms and provide advice to producers. The age profile of the farming and agricultural research communities will further increase the demand for highly skilled professionals. There are already clear signs of a looming human capacity gap in almost all areas of agriculture, food production and related research. This trend threatens the long term viability of the local industry and is expected to limit the role we will be able to play in international initiatives.

These problems need to be tackled early in our education and training system. Interest and knowledge about food, nutrition and agriculture will translate to improved technology adoption, better food choices and greater flow of students into agriculture and other food related professions.

Proposed solutions:

1. Studies on food production and nutrition should be included in the national school curricula with an emphasis on the sophisticated science that underpins modern agricultural and food industries and on the value of food in promoting health. The programs would include provision of resource material and develop support programs for teaching agriculture and food and nutrition sciences at primary and secondary schools. The programs could be built onto existing programs, such as by PIEF and PICSE, and link in with curriculum aspects of physical education and health.
2. Develop and support nationally coordinated tertiary programs built on core capabilities. These programs would encourage student movement across Australia and allow particular areas of specialty to be built by individual tertiary institutions, including an alignment of undergraduate and postgraduate programs across institutions. The inclusion of agriculture and human nutrition in the priority HECS band would encourage student uptake.
3. Enhance the career paths in agriculture and food processing for students trained in science and related areas. This can be achieved by building strong training programs into international research activities (*Recommendation 2*) and through the provision of postgraduate scholarships and research fellowships.
4. Provide cadetships and secondments to develop linkage and collaborative programs between school teachers, researchers and farmers to help understanding, adoption and adaptation of research outcomes. This activity would also include provision of resources to regional farmer groups to encourage technology adaptation and adoption.

5.5. Recommendation 4

Better engagement of the community and partner organisations to elevate the status of food in Australia and build cooperative commitment to an improved food value chain.

Problem:

Poor eating habits, food waste and lack of interest in agriculture and food

Outcome:

A community with heightened interest and awareness of food, its production and processing would result in greater appreciation and demand for high quality food, a robust food market for nutritious food, innovation in the food and agricultural sectors and a protected environment through reduced waste and sustainable food production practices.

Rationale:

Food is subjected to both supply and demand pressures. Improving food and nutrition awareness strengthens the demand side but support must also be given at the supply end to drive food innovation in a direction for the public good.

Information on food and health is plentiful in our society but its uptake has been variable. There has been a low level of interest and understanding of food production and processing. These, coupled with the low cost of food in Australia, have led to a cultural detachment from food production and preparation. This lack of attention to food can be seen in high levels of food waste and the prevalence of diet-related disease in the general community and in malnutrition in some groups.

Implementation of this recommendation will build on the findings of the National Preventative Health Taskforce and current and upcoming reviews, including the Review of Food Labelling Law and Policy and the Review of National Dietary Guidelines. Consideration will also be given to market and non-market mechanisms for better translation of food awareness to informed food choices and to changes in the food processing industries. For example, full costs of embodied energy, water and, potentially, greenhouse gas emissions would need to be reflected in food production.

Proposed solutions:

1. The Australian Food Security Agency would work with existing funding structures in state, territory and local governments to establish nutrition education programs that build knowledge and capabilities across the food value chain. These programs would cover food production, processing, composition and consumption.
2. Build partnerships with local governments and state and territory education departments to support community driven developments in food production such as school and community gardens. Projects would be co-funded through the Australian Food Security Agency to provide resources, equipment, materials and advice.
3. Community projects to encourage local groups to develop infrastructure that drives the supply of healthy food. For example, the production of fruit and vegetables in home gardens by improving access to materials (such as fertilisers, fruit trees, seedlings). The Australian Food Security Agency would provide funding support for training, materials and policy development.
4. The Australian Food Security Agency would support the development of nutrition guidelines and standards in community food outlets, institutional food service systems and school canteens. These would be linked with existing nutrition education programs for at-risk populations.
5. The Australian Food Security Agency would work with existing and expanded granting systems to engage and support the food processing industry in developing innovative and healthy food products

5.6. Implementation plan

Commencement times are suggested for implementing the recommendations in this report. The suggested times are from once this report has been tabled with PMSEIC.

Immediate activities (initiated in the first year):

- Establish the Australian Food Security Agency (*Recommendation 1*). The Agency would then take responsibility for the phased introduction and oversight of the remaining recommendations.
- Investing in research capability (*Recommendation 2*) is seen as an urgent task given the long lead times from research to industry uptake and the realisation of productivity gains. Investment activities will build on the outcomes of concurrent reviews such as the Productivity Commission's review of the Rural R&D Corporations and the Rural R&D Investment Plan being developed by the Rural R&D Council. Investment decision-making would be undertaken in partnership with existing funding agencies to develop co-funded programs as outlined in *Recommendation 2*. The scale of the new research activities would depend on the scale and timing of funding and the flexibility of existing research investment programs.
- Commence development of the Food Security Research Strategy and enhancement of data collection related to food (*Recommendation 1*) by building on existing initiatives. These activities can build on existing structures and activities in the Department of Agriculture, Fisheries and Forestry.
- Change HECS band (*Recommendation 3*) through existing structures and mechanisms.

Medium term activities (initiated in the second year):

- Identify suitable funding sources and launch scholarship and fellowship programs (*Recommendation 3*) linked to the new research programs (*Recommendation 2*). Again this program should link to and support existing schemes, such as the Australian Research Council's Future Fellowship program.
- Commence consultation with schools and farmers to identify opportunities for secondment and with farmers on appropriate support programs (*Recommendation 3*). Establishing these programs will depend on close liaison with school and farmer groups. Immediate consultations with PIEF and NAAE will be important in developing the teacher components and various farmer groups would be engaged for the farmer support initiatives.
- Initiate process to improve the food regulatory framework (*Recommendation 1*). This will involve:
  - Detailed mapping of the existing food regulatory structures.
  - Developing proposals for streamlining processes.
  - Consultation with industry, research and community groups.

Long term activities (initiated in the third year):

- Initiate consultation processes to coordinate and restructure tertiary training in agriculture and food and the introduction of food production and nutrition studies into the national school curricula (*Recommendation 3*). The Council of Deans of Agriculture and NAAE will be important partners in this process.
- Build on existing programs and the recommendations of the National Preventative Health Taskforce and current and upcoming reviews, including the Review of Food Labelling Law and Policy and the Review of National Dietary Guidelines, to implement the various programs outlined in *Recommendation 4*.
- Initiate consultation with relevant stakeholders on the development of the National Land Use Planning Framework. The recommendations of the Expert Working Group on energy, water and carbon regarding landscape considerations, pricing structures around energy and water and establishing the Resilient Rural and Urban Environments will be critical for this process.

6. Conclusion

Sustainably feeding the projected global population of nine billion people in 2050 requires a future version of the Green Revolution. However, the future revolution in food production will need to be achieved in conditions vastly different to those that catalysed the Green Revolution. We can no longer rely on increased water, land and energy use to drive the transformation of food production systems. The world is losing arable land at an alarming rate and inputs, such as phosphorus, are finite. Furthermore, future food production will be subject to the vagaries of geopolitical tensions and climate change.

Despite great advances in science in recent years and a large effort to tackle global hunger, the number of hungry people continues to grow. '*We have more hungry people in the world [today] than we ever had in the history of human kind*' (Kostas Stamoulis, the Secretary General of the Committee on World Food Security). In 2009, Jacques Diouf, FAO's Director General, said: '*No part of the world is immune. All world regions have been affected by the rise of food insecurity*.'

This report has outlined the complex and intersecting challenges and opportunities Australia faces in food security. As an internationally renowned net exporter of food, Australia is well-positioned to meet the challenges and opportunities in food security both internationally and locally. Through expertise in dryland and resource-constrained food production systems, Australia can take a leading role in increasing future food yields through the development and dissemination of innovative food production science and technologies. These would underpin the fundamental requirement for productivity growth in food production while maintaining environmental integrity.

The authors of this report recommend the:

- Development of a National Food Security Agency.
- Increasing investment in agricultural R&D to harness national expertise and taking a leading role in international programs aimed at specific major challenges in food production arising from a changing world.
- Development of incentives to recruit and nurture future generations of innovative and adaptive farmers, researchers and associated professionals for the Australian food production and processing sectors.
- Better engaging the community to raise public consciousness of how food is produced and its essential value to health.

These recommendations, if adopted, will:

- Create a national agency which would comprise at its core a whole of food value chain view of food production, with emphasis on the link between food and population health. The agency would also provide greater coordination between agencies and jurisdictions than is currently feasible and would help build an integrated approach to existing and emerging food security scenarios.
- Establish a world class R&D system that promotes innovation and productivity growth and positions Australia as a global leader in areas of established capability and expertise in agricultural and food sciences.
- Help build the research and delivery capacity needed to meet the demands and opportunities presented by the changing circumstances of food production in Australia and global food security.
- Encourage a community which is aware and informed about food production and the nutritional content of food. This will lead to a community that supports production of healthy food and demonstrates interest and enthusiasm for innovation in the food and agricultural industries.

The goal to achieve global food security will require us to traverse the complex landscape of economic, environmental, equity, health and security imperatives. As food is fundamental to humanity and intimately linked to Australia's economic interests, national health and national security, strategic decisions on investing in science, technology, policy and planning related to food cannot be delayed.

Appendices

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Appendix B Abbreviations and glossary

Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABARE–BRS	Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences, merged 1 July 2010
ABS	Australian Bureau of Statistics
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACIAR	Australian Centre for International Agricultural Research
AFMA	Australian Fisheries Management Authority
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQIS	Australian Quarantine and Inspection Service
ARC	Australian Research Council
AusAID	Australian Agency for International Development
BRS	Bureau of Rural Sciences
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DEEWR	Department of Education, Employment and Workplace Relations
DCCEE	Department of Climate Change and Energy Efficiency
DIISR	Department of Innovation, Industry, Science and Research
DFAT	Department of Foreign Affairs and Trade
DIT	Department of Infrastructure and Transport
DoHA	Department of Health and Ageing
DRARDLG	Department of Regional Australia, Regional Development and Local Government
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
FAO	Food and Agriculture Organisation of the United Nations
FAOSTAT	FAO statistical database
FSANZ	Food Standards Australia and New Zealand
GMO	Genetically-modified organism
GVP	Gross value of agricultural production
HECS	Higher Education Contribution Scheme
IEF	International Energy Foundation
IFPRI	International Food Policy Research Institute
KBBE	Knowledge-based bioeconomy
NAAE	National Association of Agricultural Educators
NEC	Not elsewhere classified
NCRIS	National Collaborative Research Infrastructure Strategy
NFF	National Farmers Federation
NHMRC	National Health and Medical Research Council
NLWRA	National Land and Water Resources Audit
OECD	Organisation for Economic Cooperation & Development
OGTR	Office of the Gene Technology Regulator
PICSE	Primary Industries Centre for Science Education
PIEF	Primary Industries Education Foundation
PhD	Doctor of Philosophy
ppm	Parts per million
R&D	Research and development
RDC	Rural Research and Development Corporation
TGA	Therapeutic Goods Administration
UNDP	United Nations Development Program
UNFPA	United Nations Population Fund
WHO	World Health Organisation

Glossary

Agriculture	science, art and business of cultivating land, producing crops (for food and fibre) and raising livestock.
Agronomy	application of the various soil and plant sciences to soil management and crop production.
Amenity horticulture	growing and culture of plants for landscape and garden purposes.
Aquaculture	science, art and business of cultivating marine or freshwater food fish or shellfish under controlled conditions.
Arable	land in use or capable of being used for the production of crops.
Biochar	charcoal created by heating of biomass (such as plant material) and used for storing carbon.
Biosecurity	set of preventative measures designed to reduce transmission of disease, pests and other invasive species.
Broadacre	use of a large area of land to farm a single crop.
Carbon	naturally abundant non-metallic element that occurs in many inorganic and in all organic compounds. It exists freely as graphite and diamond and as a constituent of coal, limestone and petroleum. Carbon dioxide is produced when carbon containing compounds are burned. Carbon occurs in Earth's crust as carbonate rocks and the hydrocarbons in coal, petroleum and natural gas. The oceans contain large amounts of dissolved carbon dioxide and carbonates.
Carbon dioxide	most abundant of the greenhouse gases. Carbon dioxide currently contributes to around 75 per cent of Australia's greenhouse gas emissions. It is produced as a by-product of oil and gas production, burning fossil fuels and biomass. All animals, plants, fungi and microorganisms also produce carbon dioxide.
Food miles	measure reflecting the distance and mode of transport of food as it travels through the food value chain. This enables simple comparisons to be drawn between energy use and the level of greenhouse gas emissions associated with different food products.
Food value chain	series of processes starting from food production and ending with food consumption and encompasses the 'paddock to plate' concept.
Extension	agricultural extension is the function of providing knowledge in agronomic techniques and skills to agricultural communities in a systematic, participatory manner, with the objective of improving production and farm income. The objective of extension is to bring about positive behavioural changes among farmers through knowledge and skills transfer.
Functional food	food or dietary components that may provide benefit beyond basic nutrition.
Germplasm	collection of genetic resources for an organism eg. seeds, sperm and eggs.
Greenhouse gas	greenhouse gases in the earth's atmosphere absorb and re-emit infrared radiation. The Kyoto Protocol lists six major greenhouse gases which vary in their relative warming effect. The six gases are: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride.
Gross value of agricultural production	value placed on recorded production of agricultural commodities at the wholesale prices realised in the market place.
Horticulture	science, art and business of growing fruit, vegetables, flowers or ornamental plants.

Multifactor productivity	productivity of a combination of production inputs eg. labor, materials and capital.
Productivity	measure of output in a production process from a unit of input.
Radiative balance	difference between the absorbed solar radiation and the net infrared radiation.
Rust	plant disease caused by a rust fungus, characterised by reddish or brownish spots on leaves, stems and other parts.
Salinisation	net increase of the salt content of the soil leading to reduced soil fertility.
Salmonid	family of fish which includes the salmon and trout.
Second generation biofuels	second-generation fuels are made from ligno-cellulosic biomass feedstock using advanced technical processes. Ligno-cellulosic sources include 'woody', 'carbonous' materials that do not compete with food production, use less land and have a favourable greenhouse gas footprint.
Sodicity	level of sodium content in soils. High levels of sodium lead to soil degradation and affect agricultural production.
Synoptic pressure patterns	distribution of atmospheric pressure measurements from several different locations recorded at the same time.
Terms of trade	ratio of the price of an export commodity to the price of an import commodity. The terms of trade for a country improve when the prices of its exports rise in comparison with the prices of its imports and vice versa. For farmers, it is the ratio of index of prices received by farmers and index of prices paid by farmers.

Appendix C References

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Appendix D Detailed technical information

Table 1 – Land use in Australia (ABARE–BRS (2010) – Version 4, 2005-06 dataset).

Land use	Area (km²)	%
Nature conservation	571 483	7.43
Other protected areas including Indigenous uses	1 015 359	13.21
Minimal use	1 242 715	16.17
Grazing natural vegetation	3 558 785	46.30
Production forestry	114 314	1.49
Plantation forestry	23 929	0.31
Grazing modified pastures	720 182	9.37
Dryland cropping	255 524	3.32
Dryland horticulture	1 092	0.01
Irrigated pastures	10 011	0.13
Irrigated cropping	12 863	0.17
Irrigated horticulture	3 954	0.05
Intensive animal and plant production	3 329	0.04
Intensive uses (mainly urban)	16 822	0.22
Rural residential	9 491	0.12
Waste and mining	1 676	0.02
Water	125 618	1.63
Total	**7 687 147**	**100**

List of policy, regulatory and program delivery agencies involved in areas related to food, inputs into food production and food distribution and trade:

- Department of Agriculture, Fisheries and Forestry (DAFF).
- Department of Climate Change and Energy Efficiency (DCCEE).
- Department of Regional Australia, Regional Development and Local Government (DRARDLG).
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPC).
- Rural Research and Development Corporations (RDCs).
- Department of Innovation, Industry, Science and Research (DIISR).
- Australian Quarantine and Inspection Service (AQIS).
- Australian Fisheries Management Authority (AFMA).
- Food Standards Australia and New Zealand (FSANZ).
- Australian Pesticides and Veterinary Medicines Authority (APVMA).
- Office of the Gene Technology Regulator (OGTR).
- Department of Health and Ageing (DoHA).
- Department of Infrastructure and Transport (DIT).
- Department of Education, Employment and Workplace Relations (DEEWR).
- Department of Foreign Affairs and Trade (DFAT).
- Australian Government Overseas Aid Program (AusAID).
- Australian Centre for International Agricultural Research (ACIAR).
- State and Territory Government Agencies.

Table 2 – Relationship between food and nutrition science and evidence for health claims.

Location of evidence	Science inputs
Food components	Mechanistic understanding of effects - Animal model studies - Cell studies - Controlled feeding experiments
Individual foods	Establishment of food–health relationships Population surveys
Whole diets	Direct evidence of effects Human clinical trials

Table 3 – Submission from the Primary Industries Education Foundation to ACARA for the inclusion of Primary Industries Education in the Australian Curriculum (www.primaryindustrieseducation.com.au)

Stage	At each stage of core learning for the Agriculture area students will develop understanding and an awareness of:
1 (K–Year 2)	■ Range of food and fibre products and how they are used. ■ The relationship between the products that are consumed and the commodities that are produced along the food value chain. ■ Simple processes that contribute to this relationship eg. planting, growing, breeding, harvesting, processing. ■ Conservation of the resources that are used in these processes. ■ Range of skills that are essential to this production and marketing eg. farmers, scientists, truck drivers, shearers.
2 (Years 3–6)	■ Production cycles for some commodities involving the physical, biological and social aspects eg. wheat grain from seed, germination, growth, maturity, harvest and the constraints and variables in this production. ■ Production depends on resources, their availability and management over the short and long term. ■ Programs for conservation of these resources i.e. soil conservation, composting, recycling water, growing trees. ■ Importance of agriculture in Australia's history and folklore. ■ Use of technology in making agriculture more efficient and sustainable. ■ Life in rural Australia-socially, economically and environmentally.
3 (Years 7–10)	■ Production of some commodities and the skills necessary for this production. ■ Range of plants and animals used in Australian agriculture and the products marketed. ■ Processing of some of the food and fibre commodities to produce goods that are safe for human consumption. ■ Changing environment in which production needs to continue. Changes are brought about by greater knowledge, technological advances, consumer demands, social issues and climate challenges. ■ Importance of agriculture in Australia's economy and culture. ■ Diversity of people involved in agriculture and their needs, careers and lives.
4 (Years 11–12)	■ Principles of agribusiness: On-farm management; product management; beyond the farm gate. ■ Natural resource management: climate and agriculture; soils and landcare. ■ Plant science: anatomy and physiology; propagation; plant health and pathology; genetics and breeding. ■ Animal science: anatomy and physiology; food and nutrition; genetics and breeding; health and pathology; animal behaviour. ■ Sustainable production systems.