ATSE

FOOD AND FIBRE

AUSTRALIA'S OPPORTUNITIES

A REPORT OF A STUDY BY THE
AUSTRALIAN ACADEMY OF TECHNOLOGICAL
SCIENCES AND ENGINEERING (ATSE)

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Australian Academy of Technological Sciences and Engineering (ATSE)

Australian Research Council

Australian Government
Australian Research Council

MARCH 2014

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ISBN 978 1 921388 28 6

Date of Publication: March 2014

Publisher:
Australian Academy of Technological Sciences and Engineering
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This work is also available as a PDF document on the ATSE website at www.atse.org.au

This project was funded by the Australian Research Council's Linkage Learned Academies Special Projects (LASP) scheme.

Design and production: Coretext, www.coretext.com.au
Printing: Southern Colour
Cover: iStockphoto

Contents

Executive Summary

Australia's agrifood industries are at an important crossroads due to a fortuitous confluence of geography and history. Do we respond to the immediate challenge of meeting the food and fibre demands of the emerging middle class of our near neighbours, who will express their new wealth in the clothes they wear and the foods they eat, or do we continue to be a price taker for bulk commodities into the future?

This is the regional expression of the dramatic rebalancing of the global food equation that is currently occurring. The combined forces of growing population and wealth-driven changes to dietary preferences are set to increase global food demand by 70 per cent in the next three decades. The world's capacity to meet these new demands is likely to be compromised by biofuel-driven competition for agricultural land and the effects of climate change.

This report evaluates the options available to Australia's agrifood industries in meeting this challenge through the prism of our competitive advantages, the availability of new natural resources for agricultural utilisation, and how Australia can take advantage of emerging opportunities.

Australia's agrifood industries currently utilise 405 million hectares, of which 32 million hectares are used to grow crops. Some two million hectares of this cropped land is irrigated, using eight gigalitres of water. These renewable natural resources generated a gross farm-gate income of $49 billion in 2011-12, of which $39 billion was exported. This national food production is sufficient to feed 60 to 80 million people, depending on their diet.

The land and water resources available to agrifood industries in southern Australia are almost fully developed, with some opportunities for further irrigation existing in Tasmania. Land and water resources available and suitable for agricultural development are currently being reassessed. On current indications it is very unlikely that new northern Australian developments would exceed more than five per cent of the current cropped and irrigated lands.

The relatively limited natural resources available for further agricultural development dictate that further increases in national food and fibre production for export will have to come from productivity increases within current industries.

A second, mutually compatible strategy to increasing the value of agrifood exports is to move up the value chain by transforming bulk commodities to increase the unit value of exports. In most cases, this would require the development of branded products. Such a strategy would enable Australian producers to demonstrate safety and create value from our well-regulated production practises, our reputation for safe and high quality food, and the management of our natural resource base through a 'Brand Australia' concept.

Considerable research, innovation and capacity development will be required to provide the technical and economic basis to successfully pursue these strategies towards capturing an increased share of the emerging Asian middle class food and fibre market. To meet this requirement, increased investment in agricultural innovation systems are required, noting that investment in the Rural Research and Development Corporation program has been shown to achieve investment return ratios of 10 to one over 25 years, as cited by the Productivity Commission[1].

1 Productivity Commission, 2011, *Rural Research and Development Corporations*, Report No. 52, Final Inquiry Report, Canberra.

The agrifood and fibre innovation system has undergone significant change over the past two decades, including governance changes within the Rural Research and Development Corporations, shifting focus and reduced levels of resourcing within the state and Commonwealth departments of primary industries, declining tertiary enrolments in agricultural programs, and changing research focus within universities. As a whole, the agrifood and fibre innovation system requires refocusing, reconnecting and better coordination to reinvigorate agricultural innovation in Australia.

This will only be achieved if Australia develops a long-term strategy and vision for its agricultural sector to remain competitive and relevant into the future.

Findings and Recommendations

1 Develop a long-term strategy

Australia needs a long-term policy vision with focus on export growth and high value-add, resulting in enhanced profitability that flows back to all sectors, including the farm-gate.

Recommendation 1 Develop a multi-decadal, bipartisan national vision and rolling five-year strategy to focus and direct the sustainable growth of agrifood and fibre export industries, guided by a high-level Australian Agrifood and Fibre Forum, representing governments, researchers, industry and communities, chaired by the Minister.

1.1 As part of this strategy, convene an agrifood investment taskforce incorporating industry, finance and superannuation sectors to recommend innovative mechanisms to encourage patient investment in all aspects of the Australian agrifood and fibre sector.

2 Leverage Australia's competitive advantage through 'Brand Australia'

To target high-value export markets, Australia needs to build and promote global brand recognition of Australia's food and fibre products – Brand Australia.

Recommendation 2 Develop and implement a robust 'Brand Australia' concept through industry and government collaboration with credible accreditation and authentication processes that utilise Australia's existing agrifood regulatory system.

2.1 'Brand Australia' accreditation and authentication processes should utilise strategic advantages in nationally available natural resource management systems, including environmental, phytosanitary and livestock identification, to demonstrate and authenticate the safety, traceability and environmental credentials of Australian agrifood and fibre produce.

2.2 The Rural Research and Development Corporation system should be supported to participate in cross-sectoral programs to develop the required accreditation processes and demonstrate and authenticate the superior safety and quality attributes of 'Brand Australia' agrifood and fibre produce.

3 Improve Australia's innovative capacity

To be globally competitive, Australia must stay ahead of the pack in innovation. This means the agricultural innovation system must be focused, coordinated and well-resourced to enable Australia's world-class research to be translated into innovative Australian agribusiness with a focus on value-add. There are opportunities to re-invigorate components of Australia's agricultural innovation system, including investing in knowledge creation, enabling uptake by industry and facilitating essential workforce development.

Recommendation 3 Significantly increase investment in agricultural and agrifood-based research, development, and advisory programs by industry and governments, including investment in substantial

international partnerships, to provide a platform for Australia to achieve the continued increases in productivity necessary to remain competitive and develop emerging export opportunities.

3.1 Encourage cooperation between industry, governments and research providers to better coordinate, connect and translate research, as well as identify future research needs.

3.2 Enhance student recruitment into agrifood-related education programs, including research.

4 Enable collaboration & translation for value-adding

To build a more robust Australian industry sector, we need enhanced networks and connectivity nationally between researchers, growers, industry producers and marketers. This requires rethinking current linkages. Global collaboration is an important aspect of enhancing the quality of our research as well sharing risks associated with deployment of innovation and development of new value add business opportunities. Collaborative networks such as the Food Innovation Australia Limited Collaborative Centre of Excellence provide a platform for agrifood businesses to connect with researchers through rural research and development corporations, universities, cooperative research centres and CSIRO.

Recommendation 4 Invest in collaborative networks connecting research organisations and businesses to encourage and enable Australian and international agrifood businesses to undertake local value-adding, through better access to new technologies and cutting-edge research, and to participate strategically in global value chains.

Acknowledgements

The Academy is most grateful for the contributions made by the authors of the report, the Steering Committee established to oversee the conduct of the project and input received from the external reviewers and contributors.

The principal author of this report was Professor Snow Barlow FTSE. Assistance was provided by Dr Kelvin Montagu.

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Dr Kelvin Montagu has held research and management roles across agriculture, horticulture and forestry sectors in Australasia and Asia, specialising in carbon and water cycles in forest and agricultural landscapes. He currently runs Colo Consulting, delivering natural resource outcomes for forest and agricultural landscapes through research and education projects.

The project was overseen on behalf of the Academy by a Steering Committee comprising:

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- Mr Peter Laver AM FTSE (Co-Chair)
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The draft report was reviewed by Dr Tony Fischer AM FTSE, Dr Bruce Kefford and Dr John Keniry AM FTSE.

The input and advice from ATSE Fellows to the project was invaluable. An expert reference group was consulted across Australia for input during the course of this study. This input is gratefully acknowledged.

ATSE gratefully acknowledges funding provided by the Australian Research Council (ARC) under the Linkage Learned Academies Special Projects program to conduct this project. The opinions expressed herein are attributed to ATSE and may not reflect the views of supporting organisations.

1 The Challenges and Opportunities for Sustainable Growth

The global demand for food and fibre is expected to increase by 70 to 100 per cent by 2050 as a result of a number of additive influences[2]. The major drivers of this increased demand are generally expected to be[2]:

- population growth; and
- wealth-driven changes in dietary preferences towards more resource-intensive animal protein.

These changes are inevitable and need to be considered in the context of major environmental perturbations and challenges to food production, climate change, and increasing competition for land and fresh water resources from biofuel production and urbanisation.

The object of this project is to identify potential opportunities for Australia within this global context of increased food demand and constraints on the availability of natural resources to produce this food and fibre. It will also identify the actions necessary to grasp the opportunities identified in this area.

In this context we define Sustainable Growth Industries as "*areas of potential economic growth within the Australian food and fibre sectors that could be expected to lead to significant increases in export earnings and ultimately national GDP*". This sustainable growth would have to be achieved *without any adverse impacts on the sustainability of Australia's natural resource base or perverse outcomes on Australia's national greenhouse gas emissions inventory.* A more comprehensive outline of how sustainable growth applies to agriculture is given in Section 3.

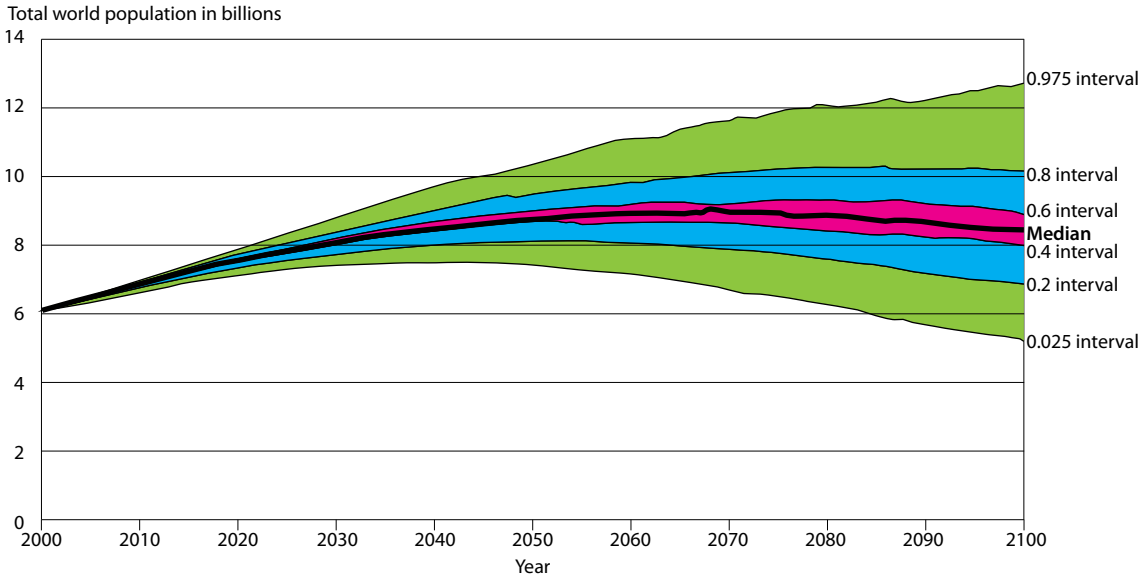
The Australian food and fibre sector has been defined broadly to include whole market chains – from inputs to the farm production system, extending beyond the farm gate to consumers nationally or internationally. In an increasingly interconnected world it is necessary to create value wherever possible along this market chain and thereby increase the value obtained by the involvement of Australia's relatively limited natural resources in food and fibre production. The case for this expected increase in food and fibre demand and the potential confounding factors influencing the globe's capacity to meet these demands are outlined in the following sections.

1.1 Population growth

The United Nations projects that the world's population will rise to eight billion in 2030 and nine billion by 2050[2]. The uncertainty of these projections, particularly those for 2050, is acknowledged to be due to possible different pathways of development. Probabilistic estimates consider the most likely range to be 8 to 10 billion by 2050 (Figure 1). There are critical global humanitarian issues of how these people are to be fed and pathways to meeting the millennium development goals.

2 Foresight, 2011, *The Future of Food and Farming: Challenges and Choices for Global Sustainability*, UK Government Office for Science, London.

Figure 1 Estimates of likely global population trends in the 21st century[3].



Probabilistic projections until 2100: green 95% interval, blue 60% interval, pink 20% interval.

The more important question in terms of food demand is where will this population growth occur and what will its capacity be to access and purchase food. This population growth will be predominately in urban areas, particularly in Asia where more than half the globe's population already lives. This urban population growth has very important implications for food distribution and dietary preference because of the increased per capita incomes of urban populations and the nature of the food distribution systems.

1.2 Changes in dietary preferences

Changes in dietary preferences resulting from increasing per capita income will dramatically influence global demand for food in both the short (2030) and medium term (2050). The World Bank has forecast that developing country per capita incomes will grow at an annual rate of 3.1 per cent through to 2030, resulting in the populations of these nations representing half of global purchasing power by 2030[4].

The growth in incomes will be led by East Asia, South Asia and the Pacific with forecast per capita income growth of between four and six per cent annually in this period[5]. The net result will be that the global middle class will grow from five per cent to almost 15 per cent of the world's population by 2030[6].

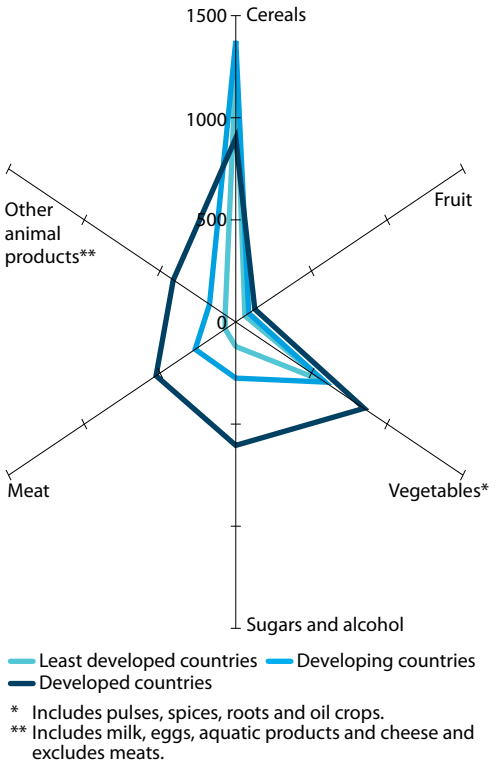
As per capita income rises dietary preferences change, with an increase in the calorific intake and a pronounced shift away from cereals to meat, dairy products, and sugar and alcohol (Figure 2). The key differences between developing and developed country diets are in the consumption of animal protein products, sugar, and alcohol, with some increase in the consumption of vegetables. These differences are underpinned by substantive decreases in direct cereal consumption. However, because of the cereal requirements of many animal production systems, these dietary changes give rise to substantive increases in total demand for cereals. Some food items require considerably more resources (i.e. land, water, and energy) to produce than others, as illustrated in Table 1.

3 Foresight, 2011, *The Future of Food and Farming: Challenges and Choices for Global Sustainability*, UK Government Office for Science, London.
4 The World Bank, 2007, *Global Economic Prospects: Managing the Next Wave of Globalization*, The World Bank, Washington DC.
5 Lutz W, and Scherbov S, 2008, *Exploratory Extension of IIASA's World Population Projections: Scenarios to 2300,* International Institute for Applied Systems Analysis.
6 Port Jackson Partners, 2012, Greener Pastures: The global soft commodity opportunity for Australia and New Zealand, *ANZ Insight* issue 3, Sydney.

Increases in the resource requirements are clearly reflected in the comparison between the land and water requirements to produce the constituents of these human diets. Although the increase in the dietary calorific requirements is relatively modest, the impact of the dietary changes the land and water requirements to produce them are very substantial. These increases in natural resources required to satisfy dietary requirements effectively increase the global demand for resources for food production.

A further important implication of these population and per capita wealth trends is that this growth will be predominantly urban[9]. Urban people generally purchase their food through supermarkets, compared to traditional street markets. This trend gives rise to the opportunity for food exporting nations to strive to place branded food products on those supermarket shelves rather than exclusively exporting undifferentiated bulk commodities. Branded products have the advantage of creating greater value through displaying the country of origin, its food safety reputation, and its environmental credentials.

Figure 2 Comparison in total calories consumed and their distribution between food categories of least developed, developing and developed countries[7].



1.3 Competition for land and water to produce biofuel feedstocks

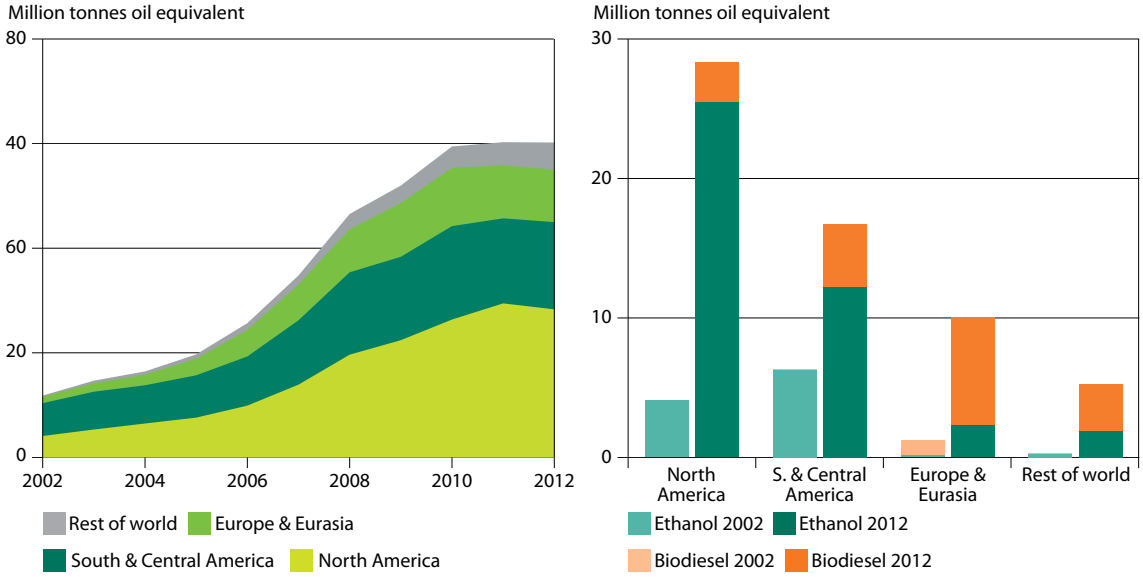
The rising price of liquid fossil fuels and the desire of nations to establish some energy security over liquid fuels have led to five-fold increases in first-generation biofuel production of ethanol and biodiesel over the past decade[10]. These biofuels are predominantly from sugarcane and oilseed crops, such as canola,

Table 1 Comparison of water and land requirements for average dietary preferences of least developed, developing and developed countries[8].

	Least developed countries	Developing countries	Developed countries	World
Population (billion)	0.8	4.8	1.0	6.6
Average calorie consumption (Kcal/day/capita)	2150	2770	3450	2800
Water requirements for agriculture (L/day/capita)	1600	2600	3900	2700
Water requirements per calorie consumed (L/Kcal)	0.74	0.94	1.13	0.96
Land requirements for agriculture (m^2/capita)	3.1	5.1	7.8	5.3

7 Ibid.
8 Ibid.
9 Foresight, 2011, *The Future of Food and Farming: Challenges and Choices for Global Sustainability*, UK Government Office for Science, London.
10 BP, 2013, *Statistical Review of World Energy June 2013*, BP.

Figure 3 Global growth of biofuel production in the past decade, particularly the growth of ethanol production in the US and biodiesel in Europe and Eurasia[14].



World biofuels production declined by 0.4% in 2012, the first decline since 2000. Increased output in South America and Asia-Pacific was outweighed by declines in North America and Europe. Global ethanol output declined by 1.7%, the second straight annual decline. Biodiesel production grew by 2.7% and has doubled in the last five years and now makes up 31% of total biofuel supply.

and therefore compete directly with food production for arable land and in some cases water resources. The potential competitive threat to food production has been well illustrated both theoretically by Pearman[11] for 11 countries, including Australia, and practically by the Bush Administration's energy security policy between 2000 and 2008 subsidising ethanol production. It is clear now that biofuels have only limited capacity to substitute for fossil fuels in supplying global energy demands. The use of tradeable agricultural products that have human food value to produce biofuels is even less efficient because the feedstock only represents a small proportion of the total biomass produced[12]. Hence, the land and water resource demands for biofuels production become even higher.

This is amply demonstrated by the biofuels policy initiated by the Bush Administration in the United States, which has led to up to 40 per cent of the US corn crop being diverted to biofuel production in recent years[13] and effectively tripled US biofuel production (Figure 3). As the United States is the largest global exporter of corn, this diversion has had a large impact on the global corn price.

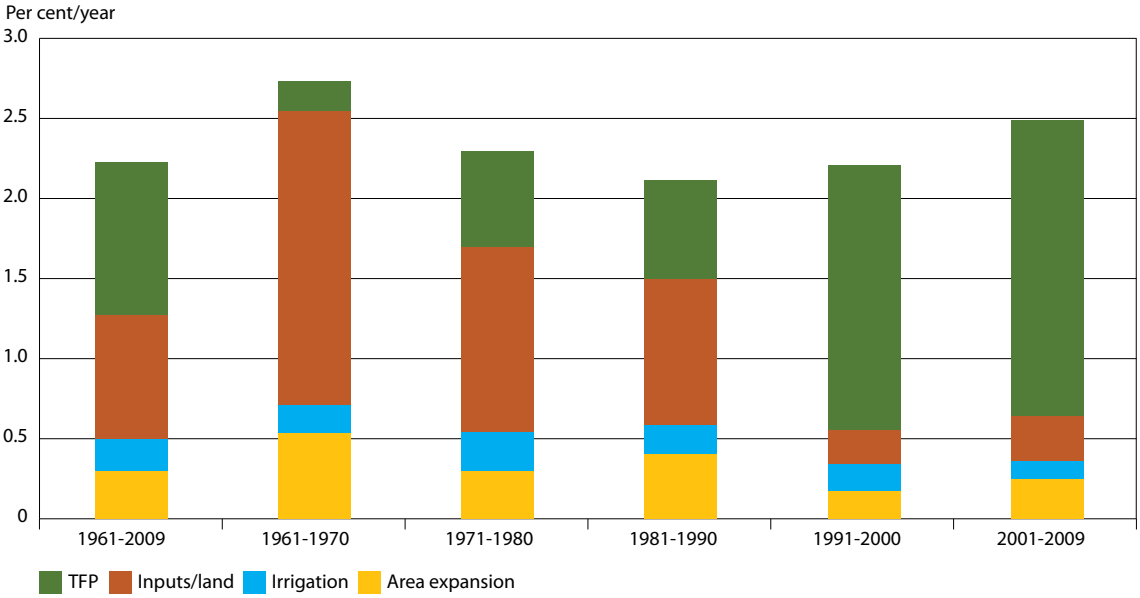
It is probable that the drive for some national security in liquid fuels, including aviation fuel[15], supported by policy incentives will continue to place pressure land and water resources globally. There is evidence that these pressures can and will be a major influence on global food production, trade and commodity pricing.

1.4 Competition for land and water resources

The so-called 'Green Revolution' of the second half of the 20th century, which was responsible for the doubling of global food production over approximately 30 years, was largely driven by improved crop

11 Pearman G, 2013, Limits to the potential of bio-fuels and bio-sequestration of carbon. *Energy Policy*, vol. 59, 523–535.
12 Ibid.
13 USDA, 2013, *World Agricultural Supply and Demand Estimates and National Agricultural Statistics Service,* United States Department of Agriculture, August 2013.
14 BP, 2013, *Statistical Review of World Energy June 2013*, BP.
15 Godfrey B, Sargent M, and Pond S, 2013, *Green Growth – Energy: Industry opportunities for Australia*, Australian Academy of Technological Sciences and Engineering, Melbourne.

Figure 4 Relative contribution to changes in global agricultural growth per decade from 1961 to 2009 of: expansion of irrigation and land area; input intensification per unit area of land (Inputs/Land); and total factor productivity (TFP)[16], including technological advances. The height of the bar shows the average growth rate in gross agricultural output during the specified period[17] .



genetics and intensification (increased inputs of fertiliser, agrochemicals and mechanisation) and the expansion of land and water resources. While the new genetics was a constant, the proportions of land, water and fertiliser inputs varied across the globe's food bowls. Globally, intensification and additional utilisation of natural resources drove increases in agricultural production up until the end of 1990[18]. During this period, 55 to 90 per cent of the growth in agricultural outputs was due to increasing use of natural resources coupled with intensification.

There is much debate[19, 20, 21] regarding the amount of land available for cropping to meet the projected increases in food demand. Recent estimates[22] indicate that a further 450 million hectares (Mha) of new cropping land may be available globally, which is about one-third of the 1400 to 1600 Mha currently cropped. Since 1990, cropping land has increased by a net 2.7 Mha per year. However, this net increase masks the 2.9 Mha per year decline in industrial and transitional economies, balanced by a 5.5 Mha per year gain in developing countries[8]. Because productivity differs markedly between industrial and developing countries, agricultural production grew by less than might be expected in terms of total land area utilised. Land has many uses of which agriculture is just one, and in many cases it is a low return use in relation to urban uses and mining uses such as coal seam gas extraction.

16 Total factor productivity is the ratio of total or agricultural output to total input including labour, capital, materials and services, and other natural resources.

17 Fuglie K, 2012, 'Productivity growth and technology capital in the global agricultural economy', in *Productivity Growth in Agriculture: An International Perspective*, CAB International, United Kingdom.

18 Ibid.

19 Foresight, 2011, *The Future of Food and Farming: Challenges and Choices for Global Sustainability*, UK Government Office for Science, London.

20 Hertel T, 2011, The Global Supply and Demand for Agricultural Land in 2050: A Perfect Storm in the Making? *American Journal of Agricultural Economics,* vol 93, 259-275.

21 Byerlee D, and Deininger K, 2011, Foreign Investment in Farmland: Worries about a land grab in Australia are unfounded. *Farm Policy Journal*, vol 8, 1-9.

22 Ibid.

Despite this apparent availability of new land for agricultural development the recent increases in food commodity demand have resulted in significant increases in the price of agricultural land in industrial, transitional and developing economies[23]. This underlines the obvious challenges of bringing new land into production where access to expertise, transport and infrastructure is constrained.

Australia is a good example of this with an apparent land reserve of 26 Mha. On closer inspection this is mostly located in northern Australia on land with poor access, little infrastructure and where new farming systems are required. Furthermore, these potential areas have considerable ecological, cultural and economic value[24] making it even more difficult and problematic to recruit them to agricultural activities. A recent scientific evaluation of suitable agricultural land in northern Australia[25] has indicated that, while the area of arable soils and suitable rainfall potentially available for cropping is between 5 and 17 Mha, it's most likely that only 10 per cent of this area is actually practicable, a maximum area of suitable arable soils of 1.7 Mha.

Water resources may well be a larger limitation than land resources in meeting future global food demands: food production in Australia and many other parts of the world are limited by freshwater availability, not land. Agriculture currently uses 70 per cent of the fresh water extracted from surface and groundwater resources[26]. The International Water Management Institute expects this usage to increase by 30 per cent by 2030 placing greater stress on global fresh water supplies.

However, there are many examples around Australia and the world where water resources appear to be overexploited. For example, major world food bowls such as the North China Plain and India's Punjab region are exploiting groundwater resources at a rate considerably higher than the recharge rate. Climate change will also influence the availability of water for use in agriculture.

The growing role of productivity driven growth, to overcome difficulties associated with finding new natural resources to exploit, is discussed in Section 3.

1.5 Climate change

Projected climate change will influence the productive capacity of the world's agricultural regions, potentially challenging our capacity to feed the projected population in 2050. Global temperatures are expected to increase and seasonal and regional rainfall affected[27]. These climatic changes will impact agricultural regions in different ways depending on their geographical location. Depending on the changes in rainfall and its distribution, tropical regions could become less productive while temperate regions may become more productive as they warm. Although a number of research groups have attempted to model the potential impacts of climate change by utilising spatial modelling techniques there is no consensus of the likely impacts[28, 29]. Australia is fortunate to be well served by climate and crop sciences fully engaged in these specific areas which have been used to determine the potential impact of climate change on Australian agriculture and the natural resources base. These issues are discussed in detail in Section 2.

23 Ibid.

24 CSIRO Land and Water, 2007, *Northern Australia Irrigation Futures: National Program for Sustainable Irrigation – CDS23 – Final Report*, CSIRO.

25 Northern Australia Land and Water Taskforce, 2009, *Northern Australia Land and Water Science Review 2009: Final report*, CSIRO.

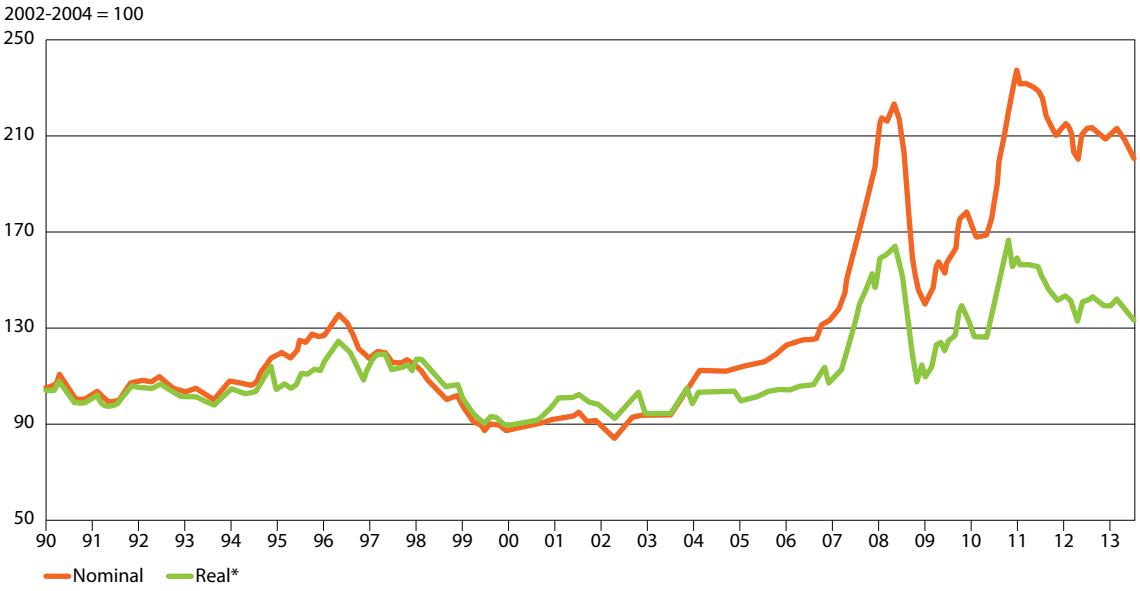
26 Foresight, 2011, *The Future of Food and Farming: Challenges and Choices for Global Sustainability*, UK Government Office for Science, London.

27 IPCC, 2013, *Climate Change 2013: The Physical Science Basis*, Cambridge University Press.

28 Parry M, Rosenzweig C, and Livermore M, 2005, Climate change, global food supply and risk of hunger, *Philosophical Transactions of the Royal Society B*, vol 360, 2125-2138.

29 Nelson G, Rosegrant M, Palazzo A, Gray I, Ingersoll C, Robertson R, Tokgoz S, Zhu T, Sulser T, Ringler C, Msangi S, and You L, 2010, *Food Security, Farming, and Climate Change to 2050: Scenarios, Results, Policy Options*, International Food Policy Research Institute (IFPRI).

Figure 5 Fluctuations in FAO World Food Price Index for the period 1990 to 2013[30].



* The real price index is the nominal price index deflated by the World Bank Manufactures Unit Value Index (MUV).

Despite uncertainties in projecting regional rainfall changes and influences of future carbon dioxide (CO_2) levels on crop and pasture growth rates, the general consensus is that global climate change will make meeting future food demands harder and therefore increase upward pressure on food commodity market prices.

1.6 Summary of demand and opportunities for Australian agriculture

This growing global demand for food, together with increases in per capita wealth and increasing competition for the natural resource base to produce food, will present opportunities for Australia as a major food exporting nation. The combination of these demand and supply pressures has resulted in two food price spikes in the past five years, as illustrated by the United Nations Food and Agriculture Organization (FAO) food prices index[31] (Figure 5). The FAO World Food Price Index is a measure of the monthly change in international prices of a basket of food commodities: cereals, vegetable oils, dairy, meat, and sugar. It was established in 1991 with an arbitrary value of 100. While remaining below 130 for 15 years to 2005, the index spiked above 200 in 2008, then again in 2011, and remained above 200 in 2013.

At a regional level these food pressures are particularly strong in Asia, as noted in the 'Asian Century' White Paper[32]. Currently more than 50 per cent of Australia's total food exports are sold to Asia, with China and Japan accounting for more than 30 per cent of the total[33].

The capacity of Australia's primary industries sector to capitalise on these emerging global opportunities in food export markets will depend on the competitiveness of the sector in international markets, its capacity to increase production to capture a proportion of this strong regional growth, and the ability to develop new food brands which leverage on Australia's reputation related to food safety, reliability and environmental credence.

30 FAO, 2014, *FAO Food Price Index*, Food and Agriculture Organization of the United Nations, available at http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en/

31 Ibid.

32 2012, *Australia in the Asian Century – White Paper October 2012*, Commonwealth of Australia.

33 DFAT, 2013, *Australia's major agriculture export markets (by value) – 2011/2012 financial year,* Department of Foreign Affairs and Trade, available at http://www.dfat.gov.au/trade/negotiations/trade_in_agriculture.html.

In this context the purpose of this report is to analyse where the major opportunities for Australia's food and fibre industries lie, what the major impediments to succeeding in capturing these opportunities are, and suggest what if anything could be done to overcome these impediments.

The next chapter will outline a framework for analysing the capacity of Australia's agricultural industries and regions to make substantive contributions to the national gross domestic product (GDP) through increasing food and fibre exports.

2 Australian Food and Fibre Industries

Historically the food and fibre industries have been an important part of Australia's economy. In the first half of the 20th century, agriculture's share of Australia's GDP hovered around 25 per cent before declining to its current level of four to six per cent. In the latter decades of the 20th century the tourism, international education, and services industries joined mining and agriculture as major export industries. In gross terms, agricultural industries continued to grow, albeit at a much slower rate than mining and the emerging export industries of tourism and international education[34].

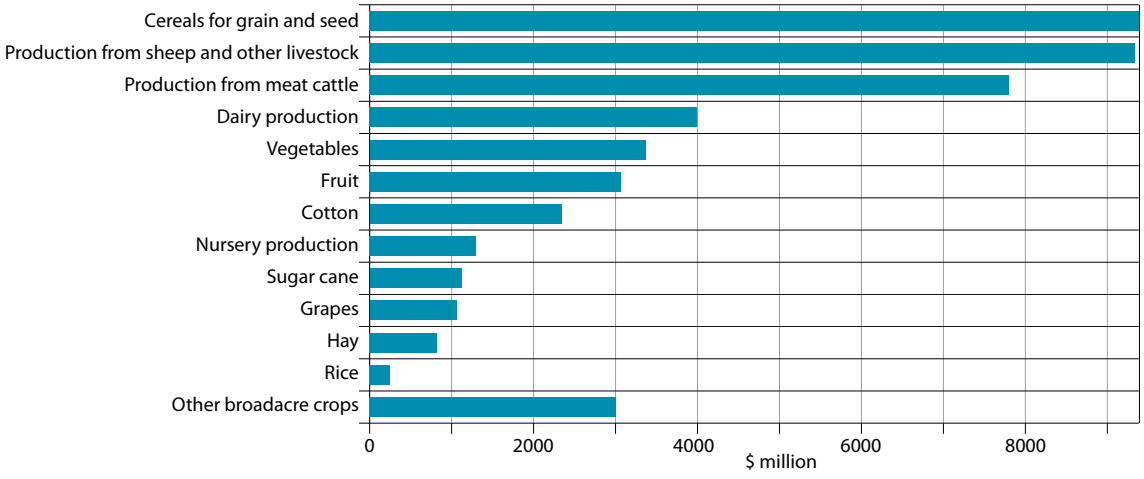
In the closing decades of the 20th century agricultural exports were confronted by difficult terms of trade and a general global food surplus as a consequence of the 'Green Revolution'. During this period, exports declined from 70 to 80 per cent of national agricultural production to the current levels of approximately 65 per cent.

Despite these difficult international trading conditions Australian agriculture has continued to grow, with a long-term growth in value of 2.4 per cent per year, and Australia has remained a major agricultural exporter. This was achieved through the development of new industries such as cotton, canola and lupins, and the dramatic expansion of some existing industries such as wine. The major grains, red meat, sugar and dairy export industries remained strong if variable, as a result of seasonable conditions, international markets fluctuations, and the loss of market protection during the Hawke/Keating reforms of the Australian economy.

2.1 Gross Rural Production and Export

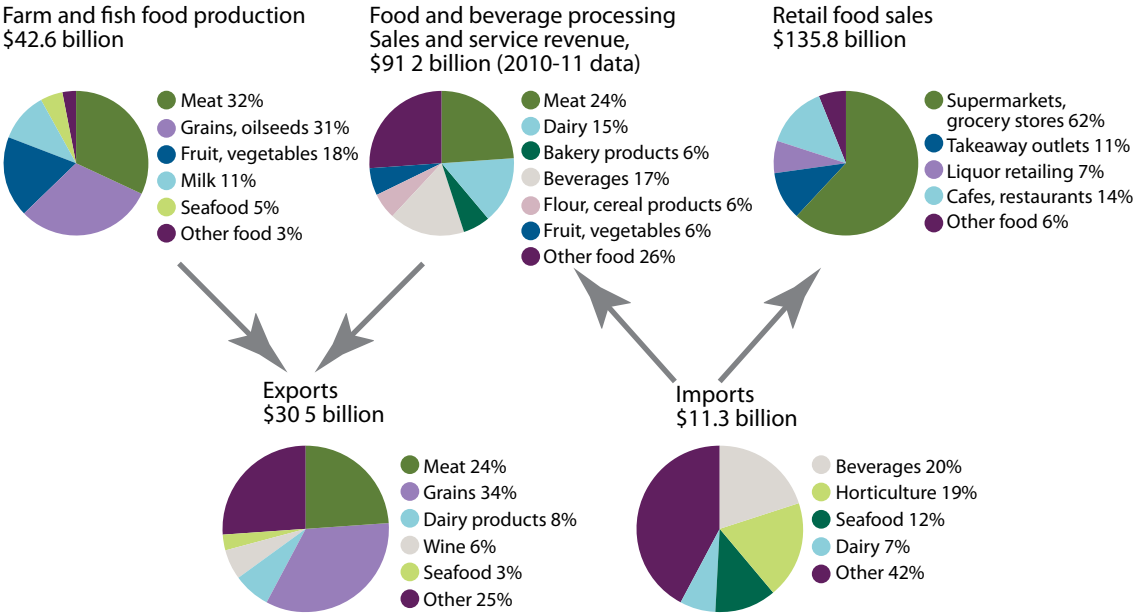
Australia's food and fibre industries had a total gross 'farm gate' value of more than $53 billion in the 2011-12 financial year (Figure 6). Agricultural industries generated a gross production of $48 billion[35],

Figure 6 Gross value of Australian agricultural production in financial year 2011-12[36].



34 ABS, 2013, *7121.0 - Agricultural Commodities, Australia, 2011-12*, Australian Bureau of Statistics.
35 Ibid.
36 ABS, 2013, *4610.0.55.008 - Gross Value of Irrigated Agricultural Production, 2011-12*, Australian Bureau of Statistics.

Figure 7 The value chain of the Australian food industry illustrating the largely untransformed nature of our exports and the predominantly transformed nature of our imports[37].



The Australian food and beverage industry in 2011-12 benefited from favourable production conditions in Australia and strong growth in world food imports. The performance of the export sector was strong in 2011-12 but was dampened by the continued strength of the Australian dollar. The food industry in Australia – ranging from farm and fisheries production to food and beverage service – employed about 1.64 million persons in 2011-12, around 15 per cent of total employment in Australia but 2 per cent lower than in 2010-11.

with fisheries and forestry contributing an extra $2.5 billion and $1.5 billion respectively, or 2.8 per cent of Australia's GDP in that year.

The majority of this farm, forest and fisheries production was exported. In 2012, 75 per cent, or $39 billion worth, of this rural production was exported. Grains including oilseeds, cattle, sheep meat, live animals, and wool constitute more than 70 per cent of these exports. In addition, cotton, wool, horticulture, wine, sugar, dairy, forestry, and fisheries are each billion dollar per annum export industries in their own rights with strong markets globally (Figure 6).

As an agricultural free trade nation there are a number of industry sectors in which significant food and fibre products are also routinely imported. Despite our substantial forestry and fisheries industries, Australia is a net importer of forest and fisheries products. On a seasonal basis, substantial quantities of horticultural products are also imported. Australia imports some raw commodities as food ingredients. Even taking these imports into account, Australia remains a strong net exporter of food and fibre commodities of mainstream agricultural, forestry, and fisheries products to global markets.

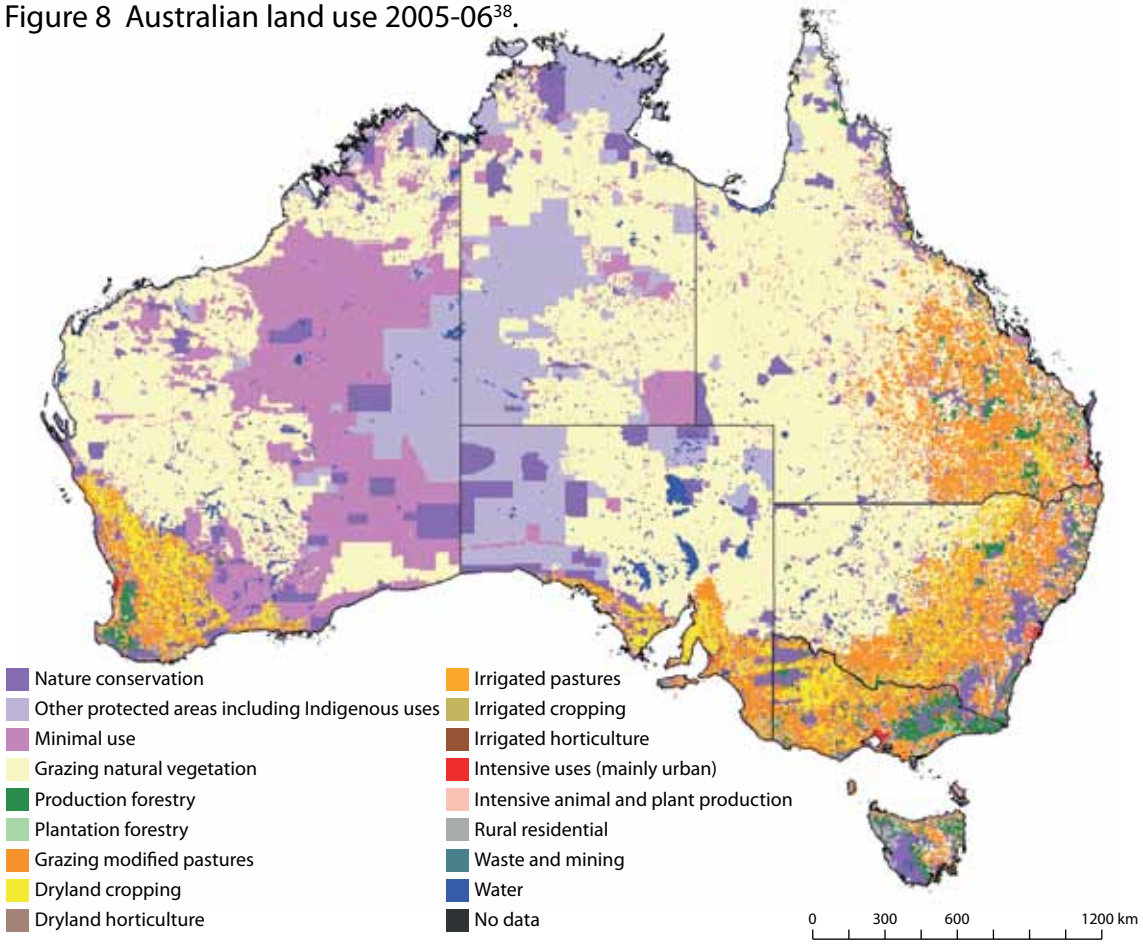
2.2 Australia's agricultural and food export markets

Australian agrifood production is not large in global terms, essentially producing enough food for 80 to 100 million people on a globe with a population of more than seven billion. Nevertheless, Australia is the sixth largest food exporting nation in the world. For example, Australia's contribution to the global wheat crop of 750 million tonnes in 2011-12 was only 30 million tonnes, yet it consistently ranks as the third or fourth largest exporter depending on season and demand.

The diverse nature of Australia's food and fibre export industries is illustrated in Figure 6. Australia is a very active exporter in foods identified in Section 1 as being in demand from the emerging middle

37 DAFF, 2013, *Australian food statistics 2011–12*, Department of Agriculture Forestry and Fisheries, Commonwealth of Australia.

Figure 8 Australian land use 2005-06[38].



classes in Asia. However, these exports are dominated by food commodities rather than substantially or elaborately transformed, branded food products. Grains, including oilseeds, sheep meat and cattle meat, and live animals are Australia's largest export commodities.

A feature of the Australian food value chain is that while more than 90 per cent of food imports are 'substantially transformed', less than 60 per cent of food exports are substantially transformed (Figure 7). In terms of the food value chain structure, only a small proportion of Australian exports appear in Asian markets as branded products. As exports are largely not branded as Australian, it is difficult to extract value from the market place for the quality and safety of these products. This aspect is further discussed in Sections 4 and 5.

2.3 Land and water use by Australia's farming industries

Australia is a large and ancient country with 770 million hectares covering a diverse range of climates from subtropical to cool temperate. Australia's farming industries utilise more than 50 per cent of the continent, some 405 million hectares. Much of this land use is for extensive grazing in the drier inland and northern parts of Australia (Figure 8).

The remainder of the Australian land mass is protected in conservation zones or is not suitable for agriculture because of aridity, soil type or terrain. Intensive arable agriculture currently utilises about

38 State of the Environment 2011 Committee, 2011, *Australia state of the environment 2011: Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, Department for Sustainability, Environment, Water, Population and Communities, Commonwealth of Australia.

32 million hectares for cropping[39] with another 60 million hectares utilised for intensive pasture grazing systems (Figure 8). The cropping/grazing interface in the moderate to higher rainfall zones of southern Australia is dynamic, influenced by climate and international commodity markets. After 200 years of European settlement in southern Australia this land utilisation is now relatively stable, with little land available for further development. With creeping urbanisation around our major cities and coastlines, land area available for agricultural businesses in the south is even expected to decline.

Table 2 The land and water resources of Australia currently being utilised for agricultural businesses[40, 41].

Land use by agricultural businesses (Mha)	
Area of Australia	769.2
Area of agricultural businesses	405.5
Area cropped	31.9
Area irrigated	2.1
Water use by agricultural businesses	
Volume of water applied	8174 GL
Average application rate	3.8 ML/ha
Total number of irrigation businesses	34,911
Total number of agricultural businesses	135,692

A recent World Bank study identified Australia as having as much as 26 Mha of land suitable for agricultural development or cropping[42]. Further clarification of this estimate has revealed that this potential cropping land is located in northern Australia and potentially subject to ongoing infrastructure and biological challenges to further development. Until these limitations are addressed intensive agricultural productivity will be difficult to achieve on this available land.

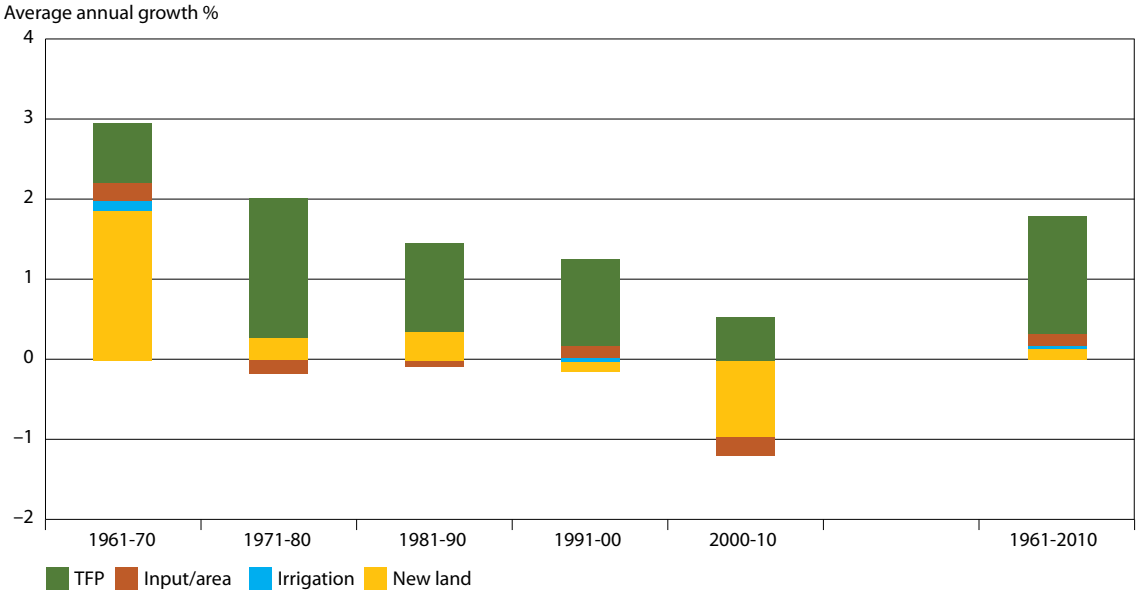
The second major limitation to the development of new sustainable agricultural industries, or expansion of existing industries, is the availability of water either as rainfall or through irrigation. Australia, as the second driest continent on earth, is able to irrigate only a small proportion of its agricultural area – approximately two Mha (Table 2). This represents less than 0.3 per cent of our land mass and about two per cent of the intensively utilised agricultural land.

The amount of irrigation water applied annually is approximately 8000 gigalitres (GL). This constitutes less than two per cent of the average national water yield of 431,200 GL[43]. Approximately 80 per cent of this irrigation water is currently applied within the Murray–Darling Basin which is now fully developed; the Murray–Darling Basin Plan[44] may result in further reallocation of water from agriculture to the environment in this area.

Furthermore, Australian agricultural growth driven by expansion of land and water availability slowed markedly in the 1970s (Figure 9). In the past two decades water constraints associated with drought have highlighted the water-limited characteristics of Australian agriculture. Reduced rainfall has reduced the effective area available for both more productive irrigated cropping and opportune dryland cropping. Without productivity growth during the same period, agricultural growth would have declined, thereby

39 ABS, 2013, *4627.0 - Land Management and Farming in Australia, 2011-12*, Australian Bureau of Statistics.
40 Ibid.
41 ABS, 2013, *4618.0 - Water Use on Australian Farms, 2011-12*, Australian Bureau of Statistics.
42 Byerlee D, and Deininger K, 2011, *Foreign Investment in Farmland: Worries about a land grab in Australia are unfounded,* Farm Policy Journal, vol 8, 1-9.
43 BoM, 2013, *Australian Water Resources Assessment 2012*, Bureau of Meteorology, Commonwealth of Australia.
44 MDBA, 2012, *Water Act 2007 – Basin Plan*, Murray Darling Basin Authority, Commonwealth of Australia.

Figure 9 Changes in the relative contribution to Australian agricultural growth by: total factor productivity (TFP)[45], input intensification per unit area of land (Input/area), rate of expansion of irrigation and land (New land). Bar height shows the average growth rate in gross agricultural output during the specified period[46].



highlighting the important role of new science and technology in maintaining productivity growth (see Section 3 for further discussion).

Further development of irrigation within Australia will have to occur outside the Murray–Darling Basin. There has been considerable interest recently in further investigating expanded irrigation in northern Australia[47] and the concurrent development of new irrigation in Tasmania. Both regions have considerable natural water resources at varying degrees of development which are currently being investigated. The magnitude and potential productivity of these new irrigation developments are considered in Section 4.

2.4 Potential impacts of climate change

2.4.1 Recent climate change

The Australian climate began to change significantly in the 21st century, warming by 0.9°C on average with the major part of this warning occurring in the past three decades[48]; since 1960 the mean temperature in Australia has increased by about 0.7°C. Some areas have experienced a warming of 1.5°C to 2°C over the past 50 years. Warming has occurred in all seasons, however the strongest warming has occurred in spring (about 0.9°C) and the weakest in summer (about 0.4°C). The summer of 2012-13 was the hottest on record, with the hottest ever Australian area averaged temperature of 40.3°C being recorded on 7 January 2013[49].

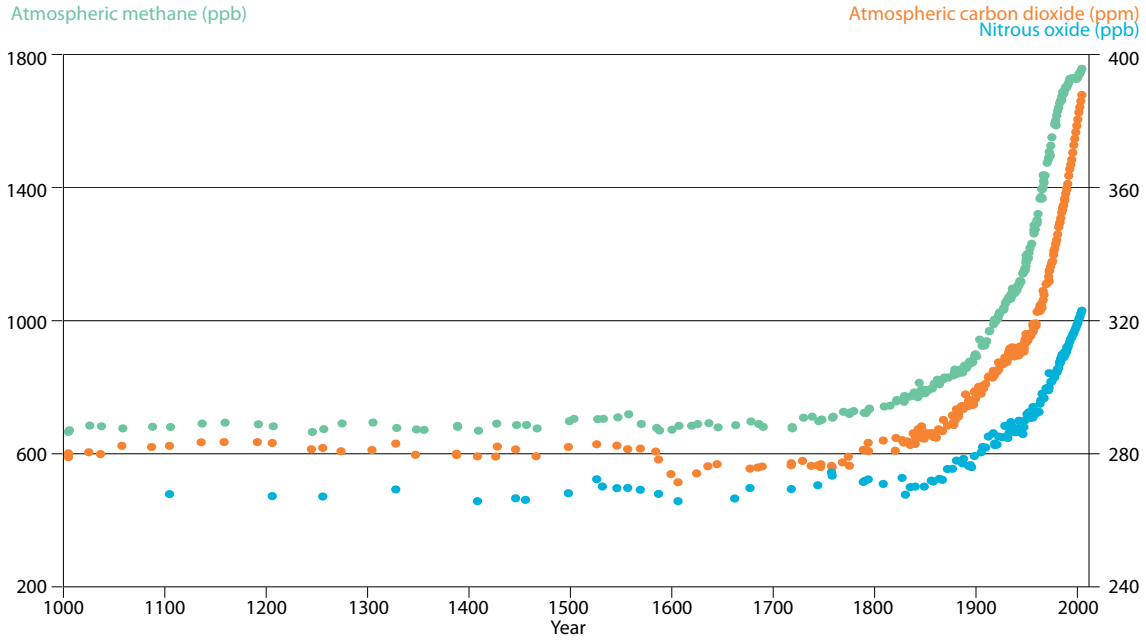
While total rainfall on the Australian continent has been relatively stable, the geographic distribution of rainfall has changed significantly over the past 40 years. Rainfall has decreased significantly in south Western Australia and in autumn and early winter in south-eastern Australia[50].

45 Total factor productivity is the ratio of total or agricultural output to total input including labour, capital, materials and services, and other natural resources.
46 Keith Fuglie pers. comm.
47 Northern Australia Land and Water Taskforce, 2009, *Northern Australia Land and Water Science Review 2009: Final report*, CSIRO.
48 BoM and CSIRO, 2012, *State of the Climate 2012*, Bureau of Meteorology and CSIRO.
49 Steffen W, 2013, *The Angry Summer*, Climate Commission Secretariat, Department of Climate Change and Energy Efficiency, Canberra.
50 CSIRO, 2012, *Climate and water availability in south-eastern Australia: A synthesis of findings from Phase 2 of the South Eastern Australian Climate Initiative (SEACI)*, CSIRO.

From 1870 to 2007 the global average sea level rose by about 210 millimetres. Sea levels rose at an average of 1.7 mm per year during the 20th century and about 3.0 mm per year during 1993 to 2009. These levels are global averages and, because of the differing movements of ocean currents around the globe, actual rises vary from place to place. Since 1993, sea levels around Australia have risen 7 to 10 mm per year in the north and west, and 1.5 to 3.0 mm in the south and east[51].

Global carbon dioxide, methane and nitrous oxide concentrations have risen rapidly over the past century[52]. The carbon dioxide concentration in 2012 of 393 parts per million (ppm) is much higher than the natural range of 170 to 300 ppm that has existed in the atmosphere for at least the past 800,000 years and possibly the past 20 million years.

Figure 10 Atmospheric greenhouse gas concentrations over the past millennium[53].



1000-year records of southern hemisphere background concentrations of CO_2 parts per million (ppm) (orange), N_20 parts per billion (ppb) (blue) and CH_4 ppb (green) measured at Cape Grim ,Tasmania, and in air extracted from Antarctic ice and near-surface levels of ice known as firn.

2.4.2 Projected climate change

Projected changes in Australia's climate will impact on both primary industry enterprises and the natural resource base on which they depend. By 2030 the temperature is projected to warm by about 1°C over Australia, relative to 1990. Inland areas are likely to experience stronger warming of up to 1.8°C. By 2070 average Australian temperatures are projected to increase by around 1.8°C with a range of 1.0°C to 2.5°C across the country.

In south-eastern Australia, El Niño events may tend to become drier and La Niña events may become wetter[54, 55]. By 2030 rainfall is projected to decrease by two to five per cent on average, and by about 7.5 per cent by 2070, compared to 1990. The exception is far northern Australia, where little change in rainfall is projected. Changes in rainfall are expected to vary widely across regions and seasons. For

51 BoM and CSIRO, 2012, *State of the Climate 2012*, Bureau of Meteorology and CSIRO.
52 Ibid.
53 BoM and CSIRO, 2012, *State of the Climate 2012*, Bureau of Meteorology and CSIRO.
54 Power S, Delarge F, Chung C, Kociuba G, and Keay K, 2013, Robust twenty-first-century projections of El Niño and related precipitation variability, *Nature*, vol 502, 541-545.
55 CSIRO and BoM, 2007, *Climate change in Australia – observed changes and projections*, CSIRO and Bureau of Meteorology.

example, rainfall in southern Western Australia is projected to decline by as much as 40 per cent by 2070 compared to 1990.

These projected changes in temperature, rainfall, atmospheric carbon dioxide levels, ocean currents and chemistry, winds, nutrient supply, and extreme weather conditions will have impacts on Australian primary industries. Without appropriate adaptation these changes in climate could have very significant negative impacts on agrifood production[56]. The distribution, growth, recruitment, and catch of marine fisheries are also forecast to be affected[57].These initial impact studies have identified strongly the need to consider climate change in future planning of the expansion of agrifood production. They also indicate the need to continue to investigate likely future climates and, most importantly, to concurrently explore adaptive strategies and potential opportunities that climate change could present[58].

An example of this is whether increased carbon dioxide concentrations could promote greater plant growth, improve water use efficiency and potentially change the nutrient content and requirements of crops[59]. Ways for potentially beneficial impacts of this effect to be incorporated into crop varieties, including wheat, are being investigated in a world class experimental facility in Victoria supported by industry[60].

These changes will impact on investment and natural resource use decision-making this decade – for example, in commercial perennial plantings, investment in irrigation and fishing infrastructure, and biodiversity plantings, water and fisheries management – and will have implications for at least the next 20 to 30 years. Improved knowledge is required to assist Australia's primary industries, communities and governments to make decisions and adaption strategies for the long term.

2.4.3 Greenhouse gas emissions from agrifood production

Agriculture and forestry is not only impacted by changing climate, it is also a significant greenhouse emitter in the form of carbon dioxide from energy usage, methane from ruminant animals and nitrous oxide from soil nitrogen transformations. In Australia agriculture is responsible for 15 per cent of greenhouse gas emissions, about the same proportion as the global average. Emissions from the agriculture sector, along with the transport sector, are the second most significant in Australia's greenhouse gas inventory, behind only the stationary energy sector.

Agriculture does not have any emission reduction obligations under the current policy settings (the Clean Energy Future legislation) and the current government's proposed Direct Action – Emissions Reduction Fund scheme will also not introduce any limitations on agricultural emissions. Agricultural enterprises may voluntarily participate in emissions abatement activities under the Carbon Farming Initiative[61] (CFI), such as carbon sequestration, and methane and nitrous oxide emissions reduction activities, to generate tradeable Australian Carbon Credit Units.

56 Gunasekera D, Kim Y, Tulloh C, and Ford M, 2007, Climate Change - Impacts on Australian Agriculture, *Australian Commodities: Forecasts and Issues*, vol 14, 657-676.

57 Hobday A, and Poloczanska E, 2008, 'Marine Fisheries and Aquaculure', in *An Overview of Climate Change Adaptation in the Australian Primary Industries – Impacts, Options and Priorities*, Report prepared for the National Climate Change Research Strategy for Primary Industries, CSIRO, pp. 307-331.

58 Rickards L, and Howden M, 2012, Transformational adaptation: agriculture and climate change, *Crop and Pasture Science*, vol 63, 240-250.

59 Tausz M, Tausz-Posch S, Norton R, Fitzgerald G, Nicolas M, and Seneweera S, 2013, Understanding crop physiology to select breeding targets and improve crop management under increasing atmospheric CO_2 concentrations. *Environmental and Experimental Botany*, vol 88, 71–80.

60 PICCC, 2011, *Crops for an evolving climate. The Australian Grains Free Air Carbon dioxide Enrichment program,* Primary Industries Climate Challenges Centre.

61 *Carbon Farming Initiative*, Department of the Environment, available at http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative

To date the major methodologies to be registered under the CFI are revegetation activities with woody vegetation, landfill gas capture, and manure management, soil carbon, methane from animals, and a range of vegetation management methodologies[62]. The potential to generate significant income streams from carbon sequestration in soils has received considerable attention, but scientific evidence has been presented that questions whether this avenue is likely to be profitable or to make substantive contributions greenhouse gas mitigation targets in managed agricultural systems[63].The economics of mitigation activities to generate Carbon Credits under the CFI are currently not attractive even under the $23 per tonne CO_2-equivalent Clean Energy Future legislation arrangements, and are likely to become less so under the proposed 'Direct Action' scheme as the carbon price is expected to fall[64].

Reducing methane emissions from livestock, nitrous oxide emission from nitrogenous fertilisers, capturing methane form manure management, and improving soil health and function through carbon sequestration may ultimately prove to be beneficial in improving the total factor productivity of agrifood production systems, quite apart from generating revenue through Carbon Credits[65]. Energy costs are an important component of farm productivity and have received attention for potential increased energy efficiency, conservation, recovery and generation.

Economic management interventions that reduce the greenhouse gas emissions intensity of agrifood products will almost certainly increase their production efficiency and productivity. Therefore, while climate change and climate change mitigation policy are almost universally seen as threats to agricultural productivity, with careful research there could be considerable upsides in the form of increased production efficiency.

2.5 Conclusions and the future

This consideration of the current structure and magnitude of Australia's food and fibre industries, and the natural resource base that supports them, leads to the conclusion that while Australia is a major food exporter it has limited capacity to fill the role of 'The Asian Food Bowl' in quantitative terms in the future. This largely flows from the limited availability of significant amounts of arable land that could be brought into production and the potential difficulty of developing further water resources in regions able to productively utilise them.

Natural resource limitations must also be viewed through the prism of potential climate change. Current scenarios indicate that the projected warmer future in southern Australia will also be drier, thereby further exacerbating the impacts of climate variability and water availability on agricultural output. In future, climates of northern Australia will almost certainly be warmer but the seasonality and average volume of rainfall are unpredictable. The implications of these scenarios are that climate change is unlikely to result in more natural resources becoming available for future food and fibre production and quite possibly there will be a contraction of natural resource availability in southern Australia.

Within the constraints of these natural resource limitations the subsequent chapter will explore opportunities for Australia to utilise its comparative advantages to participate in the emerging opportunities arising from increasing food demand, particularly in Asia.

62 Ibid.

63 Lam S, Chen D, Mosier A, Roush R, 2013, The potential for carbon sequestration in Australian agricultural soils is technically and economically limited, *Scientific Reports* 3, 2179.

64 Dr Richard Eckard, per. comm.

65 Henry B, Chamley E, Echard R, Gaughan J, and Hegarty R, 2012, Livestock production in a changing climate: adaptation and mitigation research in Australia, *Crop and Pasture Science*, 63, 191–202.

3 Sustainable Growth and Australian Agriculture's Competitive Advantage

Meeting the food and fibre demands of a growing and increasingly affluent global population within the natural resource constraints outlined in Section 1.4 has many challenges – but it also creates opportunities. Those countries which can further boost agricultural productivity, while simultaneously sustaining the natural resource base of farms and landscapes, have the potential to enhance their competitive advantage in the long term. To realise these opportunities, new ways of reconciling the short-term financial pressures on farm businesses with the long-term needs of natural capital are required.

Australia's natural resources are one of its greatest assets. The development and management of these natural resources has shaped considerable areas of the Australia and led to the development of the agricultural industries we see today. However, this has come at a cost to the natural capital with many indicators pointing to a slow and insidious erosion of the natural resource base of the farm and the landscape in which they sit – a rundown of the natural capital.

Australian agriculture appears to be entering a new set of circumstances – one where rapid increases in global demand for food and fibre are aligning with potential competitive advantage. With limited new natural resources to tap into, countries which are able to manage their natural capital to deliver long-term returns have the potential to increase both the reliability of supply and the safety of food – both of which are likely to be important elements in determining global competitiveness. Based on past experience in adapting to change, Australia is well positioned to manage this transition[66].

Balancing agricultural production and sustainability imperatives faces two big challenges:

1 Simultaneously meeting the growing demand for food while decoupling agricultural growth from increasingly scarce natural resources (water, carbon emissions, nitrogen, phosphorus, energy).
2 Ensuring agricultural businesses remain viable in the short term as sustainable growth has the potential to increase business costs and may constrain agricultural outputs as moves to sustainable levels of resource use restrict access, and pollution externalities are explicitly priced. These short-term financial impacts on individual business and industries can be substantial.

3.1 The state and trends of Australia's natural capital

Natural capital is the land, air, water, and living organisms of the biosphere. Agriculture is reliant on this natural capital to produce food and fibre but also has a major direct impact on the state of these assets. Below, the state and trends of this natural capital is summarised for Australia based on the most recent State of the Environment report[67].

66 Bryan B, Meyer S, Campbell A, Harris G, Lefroy T, Lyle G, Martin P, McLean J, Montagu K, Rickards L, Summers D, Thackway R, Wells S, and Young M, 2013, The second industrial transformation of Australian landscapes, *Current Opinion in Environmental Sustainability*, vol 5, 278-287.

67 State of the Environment 2011 Committee, 2011, *Australia state of the environment 2011: Independent report to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities*, Department for Sustainability, Environment, Water, Population and Communities, Commonwealth of Australia.

Figure 11a Australian soil conditions: soil acidity[67].

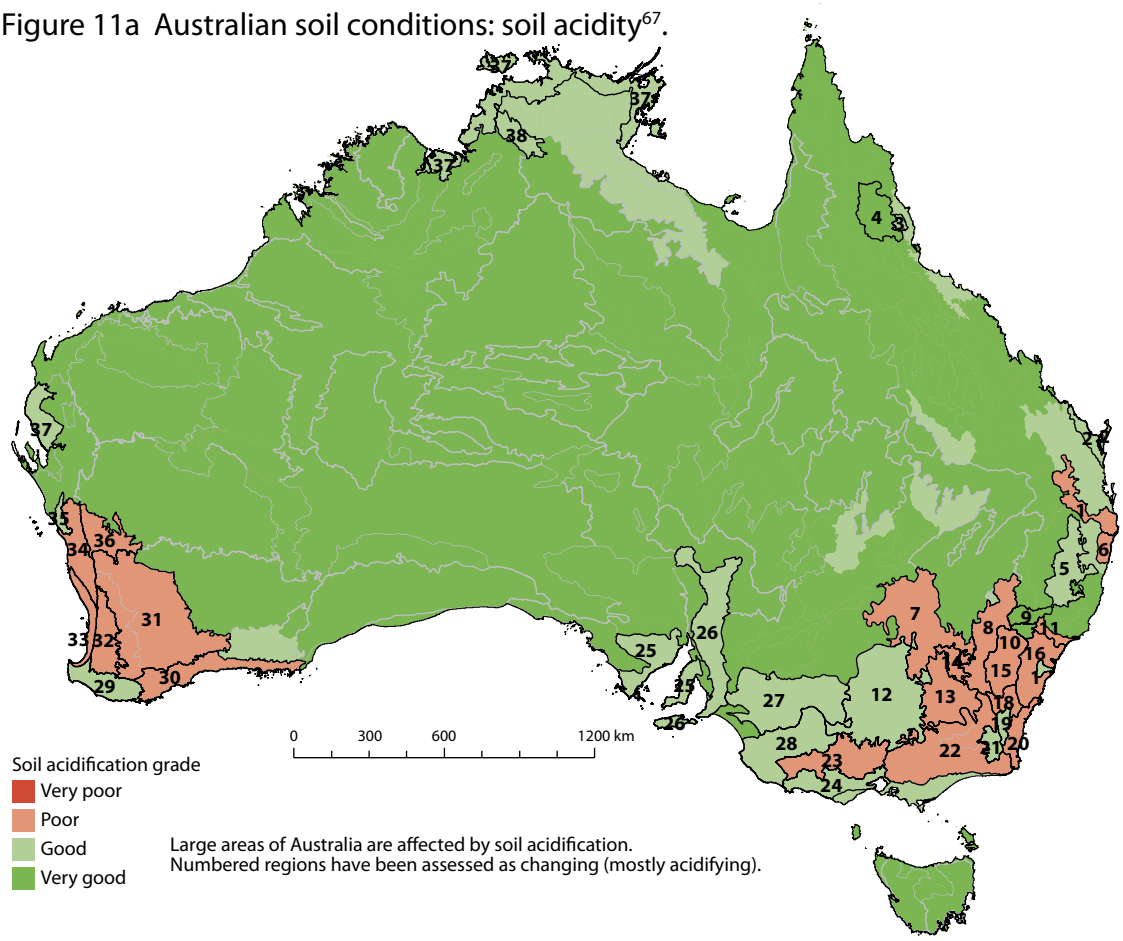


Figure 11b Australian soil conditions: soil carbon[67].

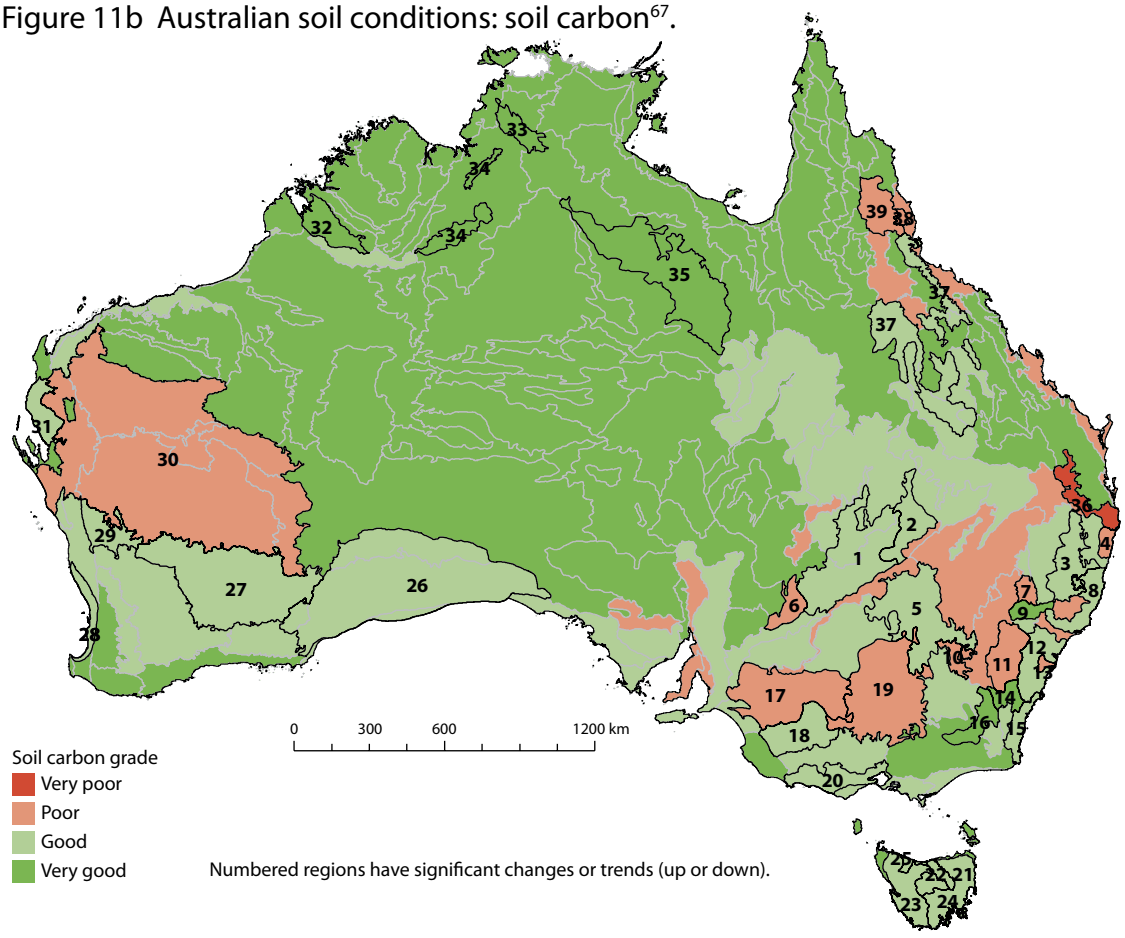
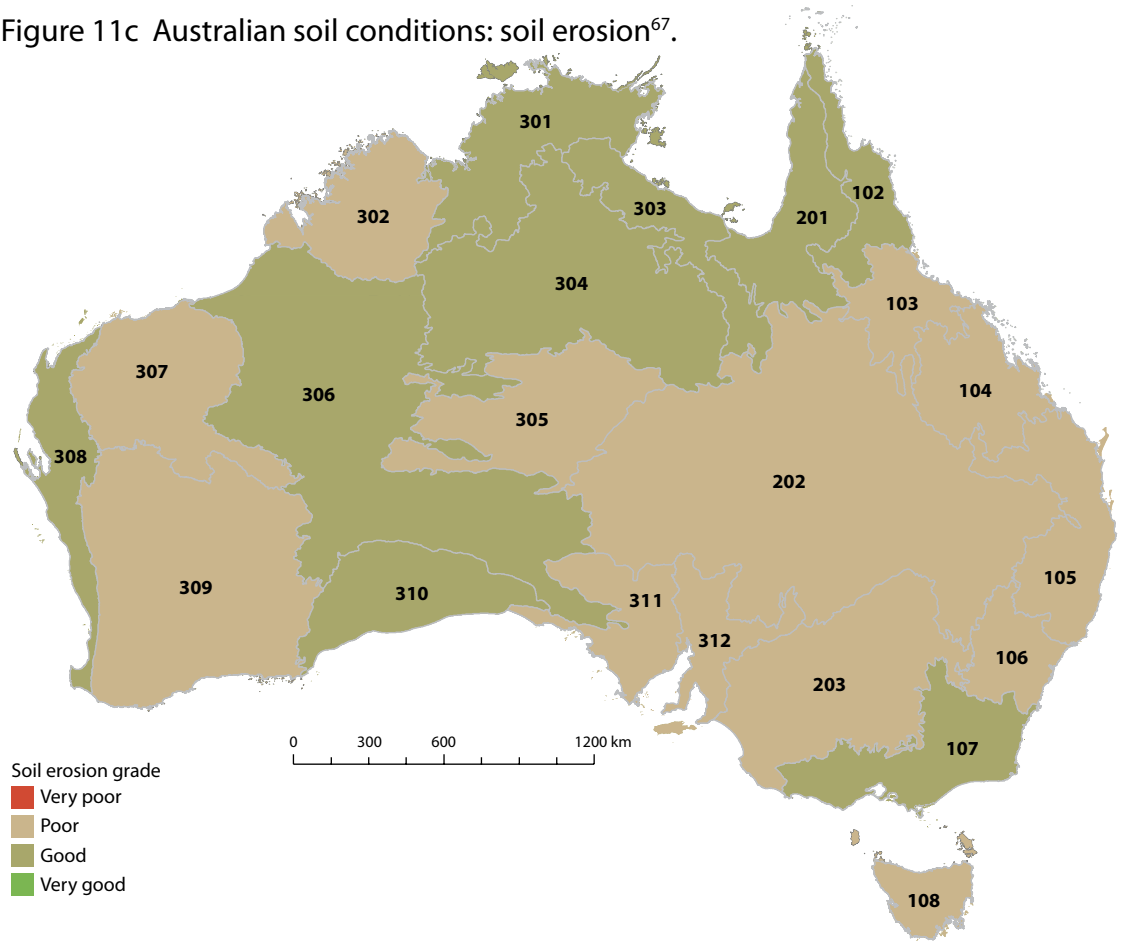


Figure 11c Australian soil conditions: soil erosion[67].



Soils

The processes of soil acidification, carbon dynamics and erosion are used as broad indicators to indicate the state and trends of soil conditions across Australia. A summary of these conditions are shown in Figure 11.

Soil acidity is widespread and in need of urgent amelioration (poor grade) in the extensive farming lands of southern Australia, with rates of lime application well short of those needed to arrest the problem. Acidification is also common in intensive systems of land use such as tropical horticulture, sugarcane, and dairying. Across the 38 regions assessed 95 per cent were considered to be deteriorating, with the other five per cent either stable or improving.

Soil carbon stocks have decreased across many agricultural areas (good to very poor). Conversion from native vegetation to agriculture typically reduces soil carbon by 20 to 70 per cent. Some of the cropping lands in southern Australia with naturally infertile soils are rated as good (30 to 70 per cent loss) or very good (<30 per cent loss) due to their initially low carbon stores and improvements due to the addition of fertiliser and the correction of trace element deficiencies. Of the 39 regions assessed 85 per cent were considered to be deteriorating, with the remainder considered to be improving.

Soil erosion by water and wind, is occurring at rates which exceed the rate of formation across much of Australia (good to poor). As well as reducing the soil and nutrients available to agriculture excessive sedimentation and nutrient delivery is detrimental to water ways. Across the 22 regions assessed 13 per cent were considered to be deteriorating, 63 per cent stable and three per cent improving.

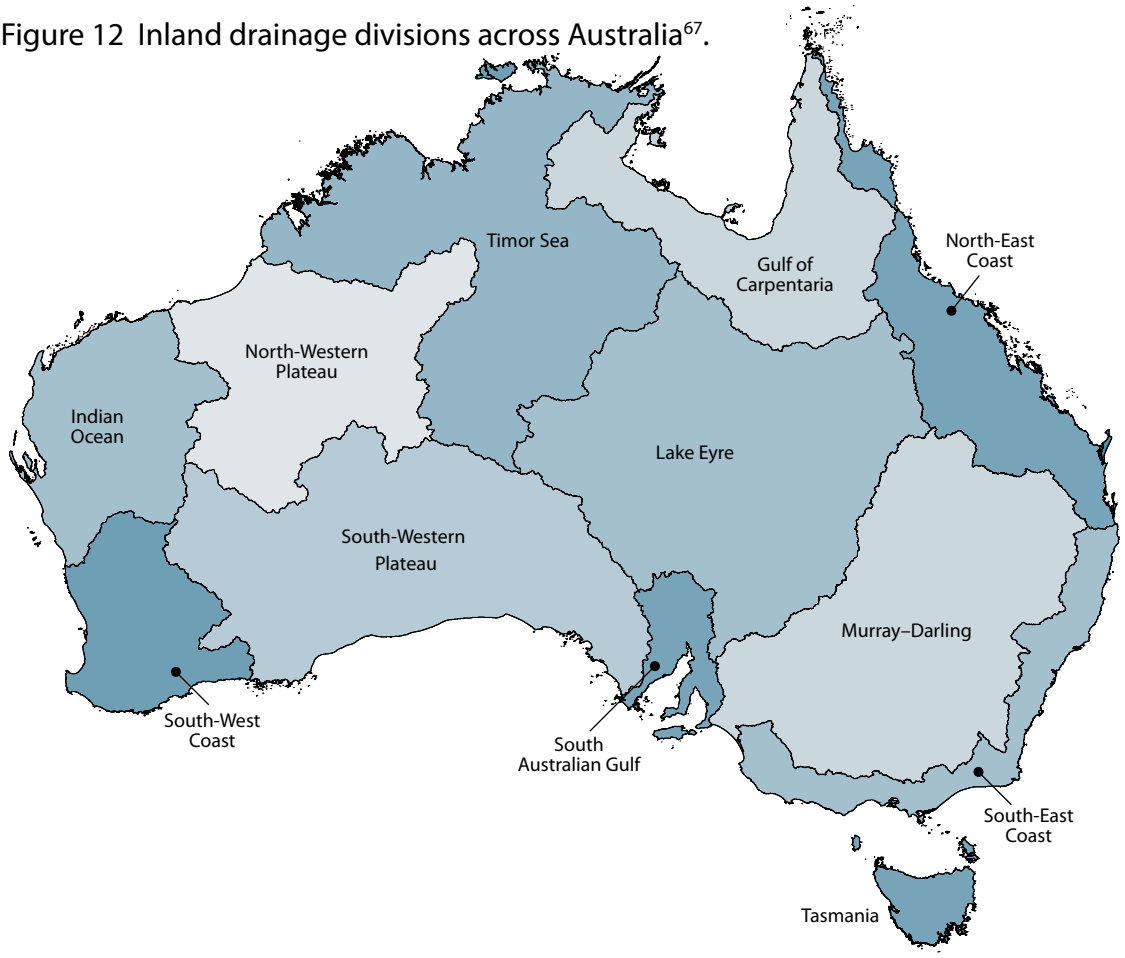
Inland water

Many of Australia's inland water environments are in a degraded condition, in southern Australia and the Murray–Darling Basin particularly. Much of the degraded condition is due to direct effects, through water extraction from surface and groundwater for irrigation and stock, or indirect effects, through changes in vegetation and excessive sedimentation and nutrient delivery to waterways. Considerable resources have been invested in water information systems which will improve the assessment of surface and groundwater resources. Future State of the Environment reports will be able to draw on yearly assessments[68] to better determine the state and trends.

The **freshwater flows** and levels in the major agricultural catchments, as shown in Figure 12, have changed substantially in some areas, to the extent that ecosystem function is significantly affected. High levels of development of surface and groundwater have reduced flows and levels. Freshwater flows and levels are improving in the Murray–Darling, stable in the North-East and South-East Coasts, but deteriorating in the South-West Coast.

The **water quality** of all major agricultural drainage divisions has changed substantially as a result of human activities and these changes are significantly affecting ecosystem function in some areas, but salinisation of land and water has reduced as a major threat to inland water quality. This has occurred principally due to the fall in shallow, saline groundwater levels during the widespread Millennium Drought across southern Australia. Water quality is assessed as being stable in the Murray–Darling, South-West and South-East Coasts, and improving in the North-East Coast.

Figure 12 Inland drainage divisions across Australia[67].



68 BoM, 2013, *Australian Water Resources Assessment 2012*, Bureau of Meteorology, Commonwealth of Australia.

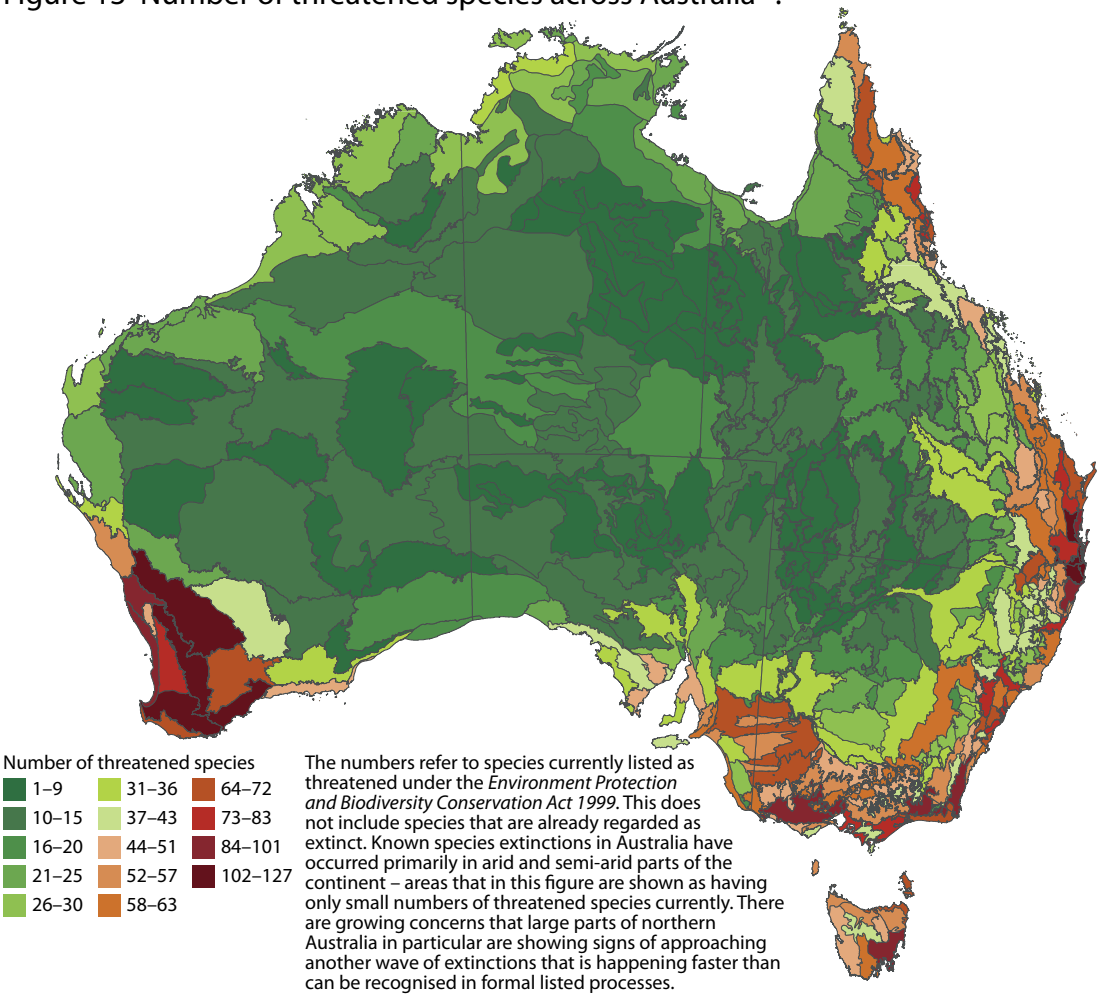
Inland water ecological processes and key species populations have been most affected in agricultural catchments subjected to extensive clearing. In the Murray–Darling and South-West Coast conditions have changed substantially over a wide area with the ecosystem function seriously affected in much of the region. Populations of a large number of species have declined significantly. In the North-East and South-East Coast zones, where the upper catchment vegetation is less disturbed, ecological processes have changed only in some areas but populations of a large number of species have declined significantly. Inland water ecological processes have been assessed as being stable the Murray–Darling, North-East and South-East Coast, but deteriorating in the South-West Coast.

Biodiversity

Agricultural activity sits within the wider landscape. Within this landscape biodiversity underpins the ecological processes on which agriculture depends, such as regulation of the atmosphere, maintenance of soil fertility, regulation of water flows and filtration of water, pest control, and waste disposal. Australia's biodiversity is also important globally due to its level of uniqueness, with 7 to 10 per cent of all species on Earth living only in Australia.

Across much of Australia there are ongoing decreases in population sizes, geographic ranges and genetic diversity of the biosphere, and increasing risks of population collapse in substantial proportions of most groups of plants, animals and other forms of life. This trend is variable, because components of biodiversity appear to be persisting well in some areas, especially where human impacts are minimal, but declining significantly in others. Historically, problems have been greater in southern Australia

Figure 13 Number of threatened species across Australia[67].



The numbers refer to species currently listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. This does not include species that are already regarded as extinct. Known species extinctions in Australia have occurred primarily in arid and semi-arid parts of the continent – areas that in this figure are shown as having only small numbers of threatened species currently. There are growing concerns that large parts of northern Australia in particular are showing signs of approaching another wave of extinctions that is happening faster than can be recognised in formal listed processes.

than in the north, especially in woodlands and grasslands of the agricultural zones of the south-east and south-west.

There have been major declines in many components of **biodiversity** since European settlement and data on ecological pressures suggest that many species continue to decline, as illustrated in Figure 13. In the agricultural regions (southern, eastern and south Western Australia) the extent and quality of native vegetation and aquatic species is poor and deteriorating. For terrestrial mammals, birds, reptiles, amphibians and invertebrates the assessment rate is poor to very poor across Australia and deteriorating.

3.2 Sustainable growth compared to 'business as usual'

A focus on increasing natural resource use efficiency and productivity, protecting the natural resource base, and reducing reliance on fossil-fuel-intensive inputs is consistent with many of the current drivers in agriculture. The core elements of sustainable growth build on previous drivers, events, and values that have progressively shaped Australian agriculture since European settlement (Figure 14). Across these public and private realms they produce an array of competing demands on landscapes and landscape managers.

The greatest point of potential conflict between sustainable growth and 'business as usual' arises due to differing time horizons. Agribusinesses operate under short-term financial cycles. Longer-term capital investment decisions are brought into the short-term cycles via discounted cash flows. Because debt carries interest, the discounting of all future costs or incomes often leads to short-term planning[69].

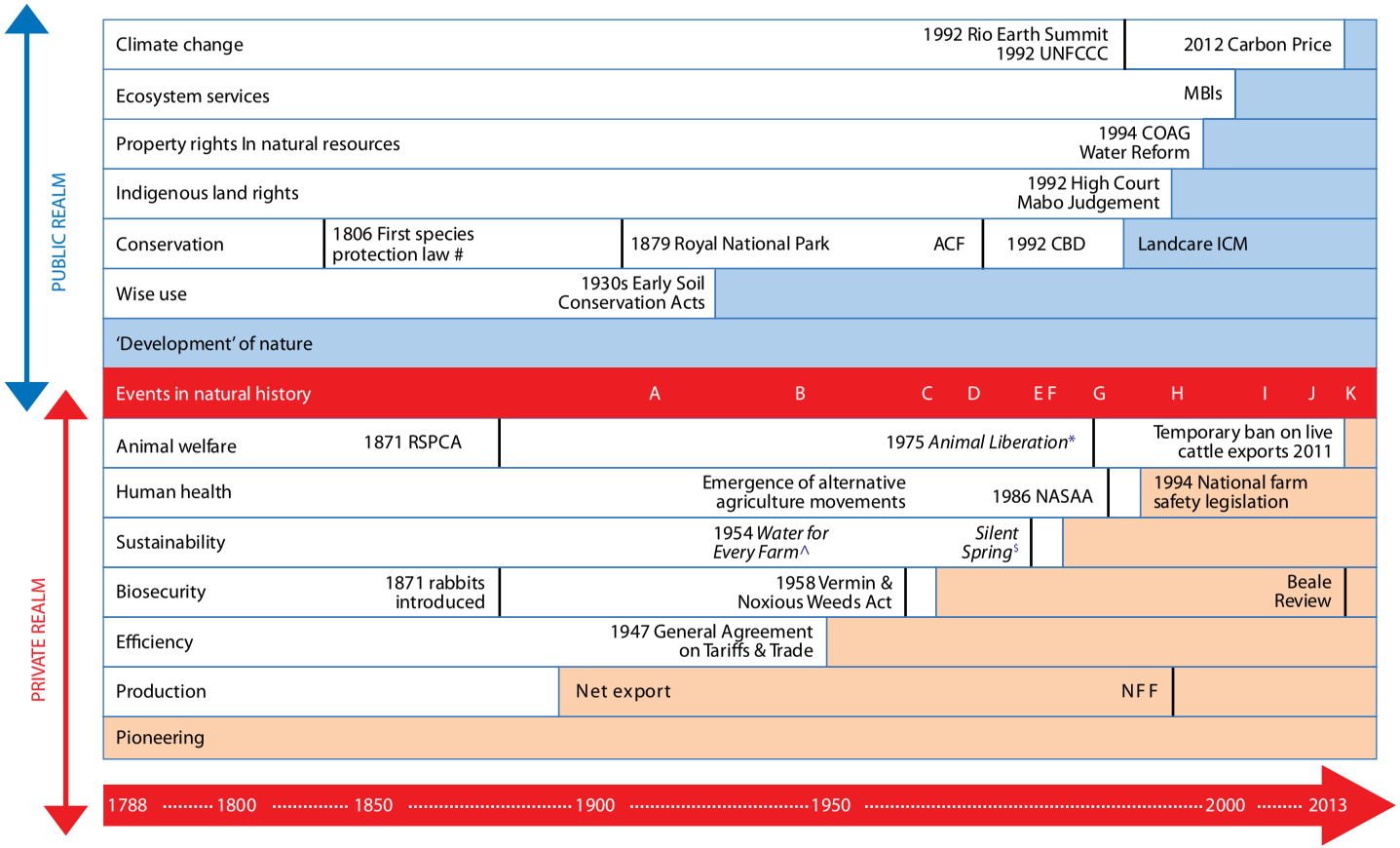
In the short term sustainable growth has the potential to increase business costs and may constrain agricultural outputs as moves to sustainable levels of resource use restrict access, and pollution externalities are explicitly priced. These short-term financial impacts on individual business and industries can be substantial.

By contrast natural capital regeneration operates under decadal to century-long biophysical cycles. As a result any erosion of the natural resource base, through over use or pollution, is either heavily discounted or does not appear on the balance sheet at all. While higher use of natural resources boosts both balance sheets and economic growth in the short run, it can decrease the steady-state economic level if use exceeds sustainable levels, thus permanently reducing long-run output growth[70]. Moving to new, unexploited resources (e.g. fisheries, regions, and forests) has been the historical response to over exploitation or degradation of natural resources. With natural resources now limited in most regions of the globe this option is no longer widely available.

Sustainable growth takes a longer-term view, whereby the natural resources on which future growth depends are better managed within their sustainable limits. Such an approach places a greater emphasis on the maintenance of the underlying natural capital, with food and fibre production essentially being the annual 'dividend' from this natural capital. This long-term view will inevitably lead to conflicts with short-term financial survival and profit imperatives and the direct costs and opportunity costs of maintaining natural capital.

69 Lietaer B, Arnsperger C, Goer S, and Brunnhuber S, 2012, *Money and Sustainability: The Missing Link*, Triarchy Press.
70 Chamber D, Guo J, 2009, Natural resources and economic growth: Some Theory and Evidence, *Annals of Economics and Finance*, vol 10, 367-389.

Figure 14 Representation of major defining events that helped to shape Australia's land use since European colonisation. Events reflect the evolution of societal values, attitudes and movements[71].



LEGEND

'Natural' events

- A 1890s Federation Drought
- B 1939 Black Friday fires
- C 1952 floods SE Australia
- D 1967 Hobart fires
- E 1974 Floods
- F 1974 Cyclone Tracy
- G Ash Wednesday and 1982-83 drought and dust storm
- H 1991 Darling River Algal Bloom
- I Millennium Drought
- J 2009 Black Saturday fires
- K 2011 floods

ACF	Australian Conservation Foundation
CBD	UN Convention on Biological Diversity
COAG	Council of Australian Governments
GBRMPA	Great Barrier Reef Marine Park Authority
ICM	Integrated Catchment Management
NASAA	National Association of Sustainable Agriculture
NFF	National Farmers' Federation
UNFCC	United Nations Framework Convention on Climate Change
$	*Silent Spring* by Rachel Carson, Houghton Mifflin, 1962
*	*Animal Liberation* by Peter Singer, Random House, 1975
^	*Water for Every Farm* by PA Yeomans, Keyline Design, 1954
#	*Pterodroma solandri* (*The Colonial Earth*, Bonyhady, 2000)

71 Bryan B, Meyer S, Campbell A, Harris G, Lefroy T, Lyle G, Martin P, McLean J, Montagu K, Rickards L, Summers D, Thackway R, Wells S, and Young M, 2013, The second industrial transformation of Australian landscapes, *Current Opinion in Environmental Sustainability*, vol 5, 278-287.

3.3 Australian agriculture's competitive advantage

"It's a global race to capture the food opportunity and to carve out a real competitive advantage."

– Mark Bennett, ANZ head of Agribusiness[72]

Australian agriculture is the result of a unique set of circumstances. Small population, large land area and a colonial history as an agricultural export platform[73] have combined to produce an industry with a strong export focus – more than 75 per cent of Australia's agricultural production is currently exported. In 2012, Australia was the sixth largest global exporter of agricultural products, largely in the form of unprocessed commodities.

With such a focus on exports Australian agriculture's long-term profitability and growth is strongly dependent on the maintenance and enhancement of its global competitive advantages. Australian agriculture's competitive advantage to date has been determined by a wide range of factors including geography, farming practices, supply chains, effective regulation, strong institutions and general economic factors.

Competitive advantage is a relative measure. Australia's competitors around the world are working to develop and enhance their competitive advantage. Australia's economy as a whole ranks 21st in the 2013-14 Global Competitiveness Index[74], while many of Australia's key agricultural competitors rank higher. Australia performs well in the basic requirements (institutions, infrastructure, macroeconomic environment, health, and primary education) and efficiency enhancers (higher education and training, goods market efficiency, labour market efficiency, financial market development, technology readiness, market size) but its overall competitiveness is diminished by its innovation and business sophistication ranking.

While country-level analysis is useful for policy development, it is individual industry sectors and business that are required to compete in global markets. Each industry sector will have its own set of competitiveness drivers. In agriculture, competitive advantage is realised through[75]:

- **lower cost:** the ability to produce and deliver products from farms to markets at a lower cost than competitors; and
- **greater differentiation:** the development of differentiated products or services through quality and reliability to win favour from markets and in some cases, to capture price premiums.

Prior to 1985 lower input costs, particularly for land and capital, secured a competitive advantage for Australian agriculture compared to Canada and the US. However, the lower cost advantage was eroded during the 1990s with comparatively rapid growth in costs of labour and intermediate inputs (for example, fuel, fertilisers and pesticides). These increases in input costs were substantially offset by strong growth in productivity, but not enough to prevent Australia's competitiveness slipping against our major competitors (Figure 15).

The ability of Australian agriculture to obtain a competitive advantage through product differentiation has been limited in the past. Agricultural commodities dominate Australia's export profile, with grains and red meats accounting for more than half of export value (Figure 6).

Over the past two decades Australia has broadened its range of agricultural commodities to include

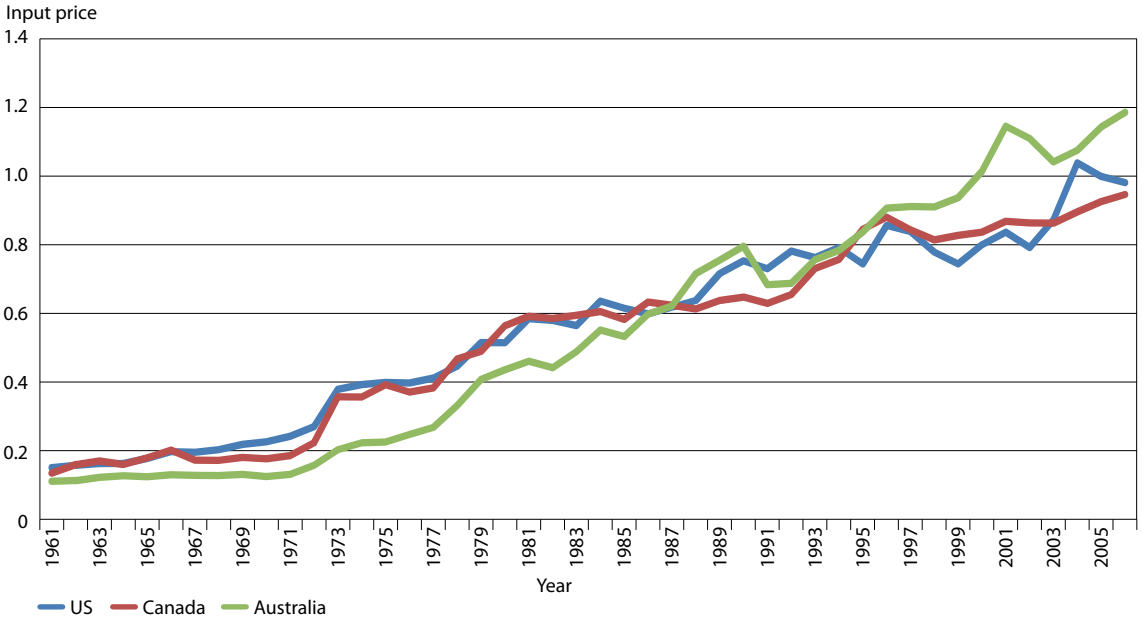
72 Bryant G, 2013, Opportunity enormous for Australian agriculture exports to Asia, *Australian Financial Review*, available at http://www.afr.com/p/opportunity_enormous_for_australian_KH9HFgWxyaCkVSE0hKgvsL

73 Pritchard B, 2005, Implementing and maintaining neoliberal agriculture in Australia. Part II: Strategies for securing neoliberalism, *International Journal of Sociology of Agriculture and Food*, vol 13, 1-14.

74 Schwab K, Sala-i-Martin A, 2013, *The Global Competitiveness Report 2013–2014: Full Data Edition*, World Economic Forum, Switzerland.

75 Port Jackson Partners, 2012, Greener Pastures: The global soft commodity opportunity for Australia and New Zealand, *ANZ Insight* issue 3, Sydney.

Figure 15 Relative changes in the input price of Australian, Canadian and US agriculture over the past four decades[76].



significant volumes of cotton and canola oil. There have also been increases in higher-value products being exported such as wine, almonds and, more recently, olive oil. These products have the potential to be differentiated in the market place through the establishment of internationally recognised brands, such as Penfolds in the wine industry.

Commodities such as wheat can be differentiated to create a competitive advantage. Australia's ability to provide a reliable and consistent supply of high quality wheat has been crucial to the development of new export markets in Asia where Australia cannot compete on price alone[77]. The competitiveness of a cross-section of existing agricultural sectors is summarised below.

3.3.1 Wheat

Australian annual wheat production over the last decade has exceeded 20 million tonnes (Mt) in all but very dry years, and has been approaching 30 Mt in recent years. With domestic consumption running at around 6 Mt this leaves a significant proportion 50 to 75 per cent of the annual crop for export.

The global wheat trade is very competitive for bulk commodities. For example, success in the Egyptian market came down to just two dollars per tonne separating the successful and unsuccessful bidders[78].

Australia's past competitive advantage has arisen due to strong productivity growth built on the back of strong investments in research and development (R&D). Across all agricultural sectors, the broadacre grains sector has experienced the strongest productivity growth.

76 Sheng Y, Nossal K, and Davidson A, 2013, Comparing agricultural total factor productivity between countries: the case of Australia, Canada and the United States, unpublished.

77 Rabobank, 2013, Seismic shifts in Australia's wheat export landscape. Competition, deregulation and opportunity, *Rabobank Industry Note* #375.

78 Keogh M, 2012, *A stark reminder of the need to be competitive in global grain markets - and minimise transport costs*, Australian Farm Institute.

Australia's reputation as a reliable supplier of superior quality agricultural commodities is a major competitive advantage which has allowed Australia to secure and hold higher priced markets[79]. The growing demand for grains in Asia has also delivered Australia a competitive advantage with reduced transport costs, particularly for Australia's largest customer Indonesia, compared to competitors[80]. Major challenges have been the continuing strength of the Australian dollar and supply chain costs, which can add more than 40 per cent on top of the farm-gate value of grains[81].

3.3.2 Beef

The Australian beef industry has a gross value of $7.4 billion, of which 67 per cent is exported to more than 100 countries – making Australia the third largest beef exporter[82]. A major strength of the Australian beef industry is its positive food safety, low disease status and animal welfare image. The adoption of the National Livestock Identification System has given Australia a competitive advantage, as the first country to introduce such a system, already allowing improved access to some markets.

3.3.3 Wine

Australian wine production has expanded rapidly in recent decades, with Australia's proportion of global production increasing from less than one per cent in 1970 (0.2 billion litres) to a peak of around five per cent in the 2000s (1.4 billion litres)[83]. The growth in wine production was largely driven by exports. In analysing the competitive advantage of major wine producers, Australia was found to have a strong overall competitive advantage due to economies of scale, cost-structure benefits, adaptability to industry change, and potential to attract foreign investment[84].

3.3.4 Vegetables

Australia's $3.3 billion (gross value, 2012-13) vegetable industry[85] contrasts with most other agricultural sectors by being domestically focused, with only seven per cent of production exported in 2007-08. The Australian vegetable industry provides the majority of fresh vegetables consumed by Australians, and also provides the vegetable inputs for a large proportion of the processed vegetable products consumed in Australia. With such a strong domestic focus the comparative advantage of local producers determines their ability to compete against imports. Trade results indicate the vegetable industry is struggling, for both fresh and processed vegetable producers. The value of imported fresh vegetables rose to $688 million in 2011-12[86].

Trade in vegetables has been one of the most rapidly growing and highly dynamic sectors of international food trade over the past few years. One of the main factors determining comparative advantage for vegetables is their perishable nature. As a result, trade is regionally focused and dependent on well-developed and efficient transport linkages. Other factors driving the competitiveness of the Australian vegetable industry include the currency exchange rate, tariff rates, importer sanitary and phytosanitary barriers, and the extent of subsidised production of competitors[87].

79 Fischer RA, 2012, *How does Australia keep ahead as a competitive grain exported?*, Grains Research and Development Corporation, available at https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/02/How-does-Australia-keep-ahead-as-a-competitive-grain-exporter.

80 Rabobank, 2013, Seismic shifts in Australia's wheat export landscape. Competition, deregulation and opportunity, *Rabobank Industry Note* #375.

81 Goucher G, 2011, *Transport costs for Australian Agriculture*, Australian Farm Institute.

82 MLA, 2013, *Australia's beef industry*, Meat and Livestock Austraila, available at http://www.mla.com.au/Cattle-sheep-and-goat-industries/Industry-overview/Cattle.

83 Trade Data and Analysis, 2011, *World wine production by country*, Wine Institute, available at https://www.wineinstitute.org/resources/statistics.

84 Castaldi R, Cholette S, and Hussain M, 2006, A country-level analysis of competitive advantage in the wine industry, *DEIAgra Working Papers*, vol 2, Università di Bologna, Italy.

85 2013, *Value of Vegetable Production*, Ausveg, available at http://ausveg.com.au/resources/statistics/domestic-industry/10-Value%20of%20Vegetable%20Production.pdf.

86 James I, 2012, *A discussion paper on vegetable import data and the implications for the Australian vegetable industry*, Ausveg.

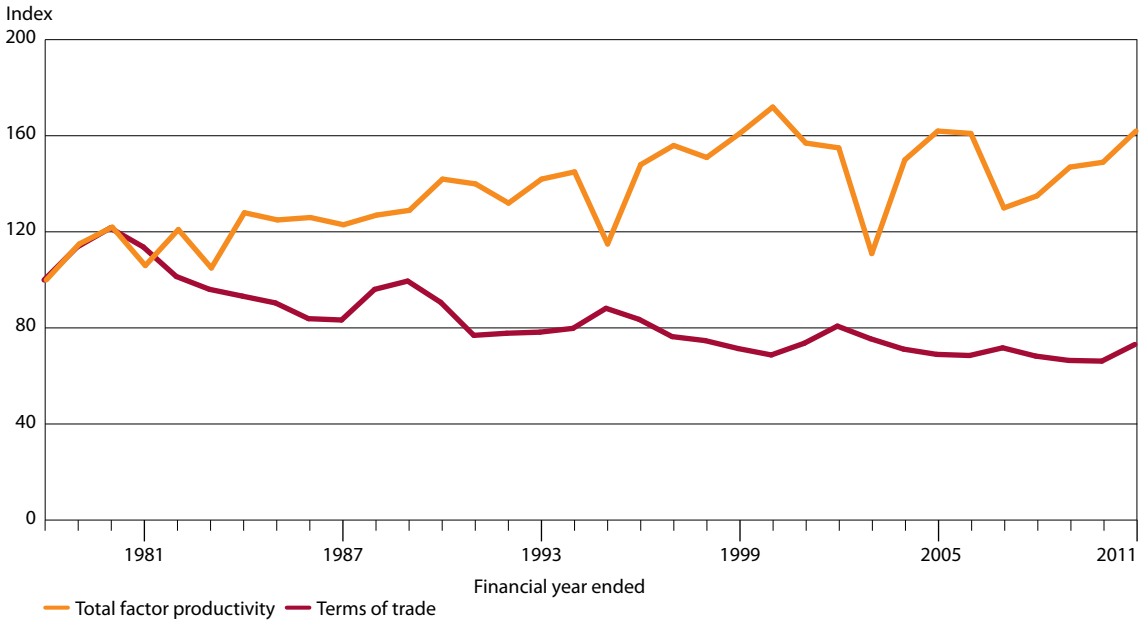
87 Apted S, Berry P, Short C, Topp V, Mazur K., and Mellor T, 2006, *International Competitiveness of the Australian Vegetable Production Sector,* ABARE eReport 06.5, Canberra.

3.4 Agricultural productivity: the core of price competitiveness

Australian agriculture has recently been through a very long period of decline in farmers' terms of trade[88] (Figure 16). Over the past 25 years world prices for many agricultural commodities have declined significantly in real terms, continuing a longer-term trend. Over the period 1977-78 to 2001-02, prices received by Australian broadacre farmers increased, on average, by 2.3 per cent a year, while input costs over the same period increased by 4.8 per cent a year – resulting in a decline in their terms of trade of 2.5 per cent a year on average. In more recent years the terms of trade have stabilised and even shown signs of improvement, as the prices of agricultural commodities have risen (Figure 5).

Offsetting this decline has been strong growth in productivity which has been central to the performance and international competitiveness of Australia's agricultural sector (Figure 16). Within the Australian economy, productivity growth in agriculture has been around three times that of the economy as a whole and has markedly outpaced the decline in the terms of trade facing farmers over the past 25 years[89]. To maintain competitiveness, significantly bigger improvements to productivity than we have observed in recent years will be required into the future[90].

Figure 16 Broadacre total factor productivity and farmer terms of trade, 1977–78 to 2010–11[91].



Note: Farmer terms of trade relate to all Australian agriculture; total factor productivity relates to broadacre (non-irrigated) agriculture only.

88 Mullin J, 2007, *The Importance of Productivity Growth in Australian Agriculture*, 51st Annual Conference of AARES, 13-16 February 2007, Queenstown, NZ.

89 Fischer RA, 2012, *How does Australia keep ahead as a competitive grain exporter?*, Grains Research and Development Corporation, available at https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/02/How-does-Australia-keep-ahead-as-a-competitive-grain-exporter.

90 Stevens G, 2011, *The Resources Boom: Understanding National and Regional Implications*, Victoria University Public Conference, 23 February 2011, Melbourne, Australia, available at http://www.rba.gov.au/speeches/2011/sp-gov-230211.html.

91 Dahl A, Leith R, Gray E, 2013, Productivity in the broadacre and dairy industries, *Agricultural Commodities*, vol 3, 200-220.

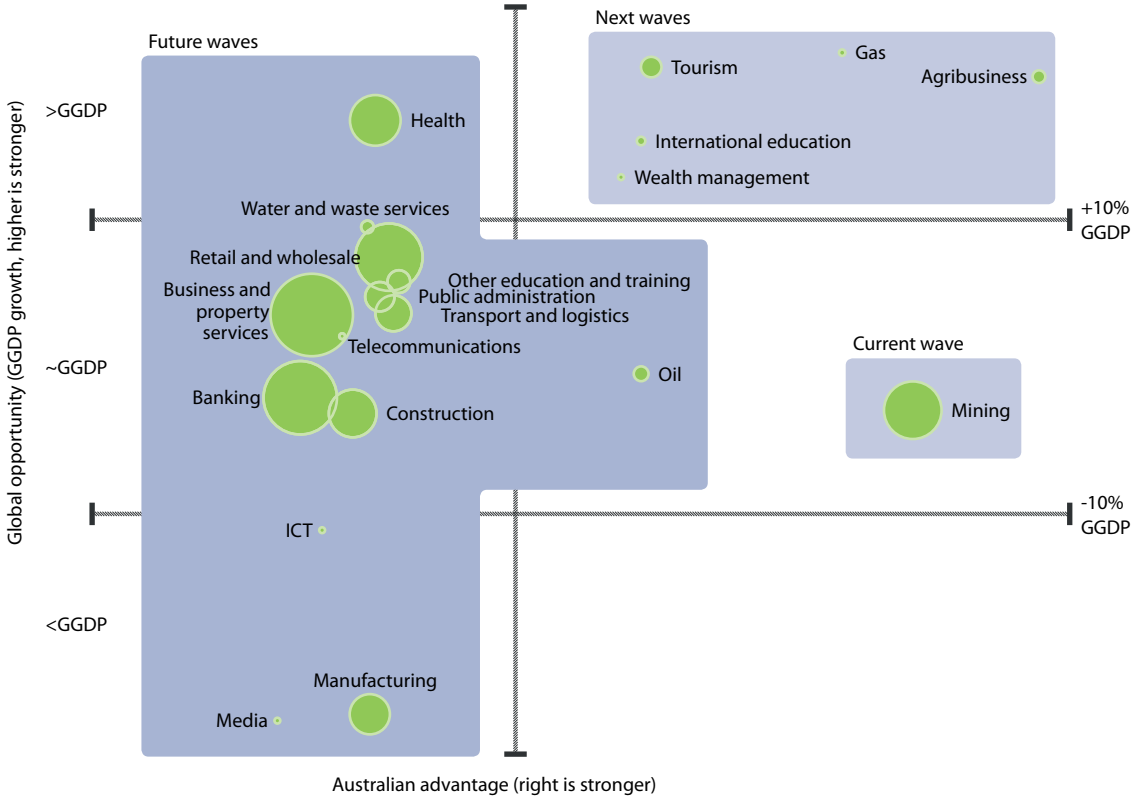
A major contributor to productivity growth is innovation, in which R&D plays an important role[92]. This is the focus of Section 5. However, it should not be overlooked that there are other sources of on- and off-farm productivity growth including[93]:

- economies of scale (farm and supply chain);
- education levels along the value chain;
- investments in public infrastructure such as transport and communication;
- microeconomic reform; and
- climate variability.

3.5 Looking forward: the Australian advantage?

Based on some strong fundamentals working in favour of Australian agriculture, a marked revival of interest and analysis of agricultural investment opportunities has occurred[94]. Looking across all 20 sectors of the Australian economy, agribusiness has been identified as having the strongest "Australian advantage" (Figure 17)[95].

Figure 17 Potential Australian export growth sectors for 2013-33. 'Global opportunity' identifies sectors which are expected to grow at a faster rate than the Global Gross Domestic Product (GGDP). 'Australian Advantage' identifies areas of strength which could act as a source of competitive advantage. Circle size indicates the relative current size of each sector[96].



92 Mallawaarachchi T, Walcott J, Hughes N, Gooday P, Georgeson L, Foster A, 2009, *Promoting productivity in the agriculture and food sector value chain: issues for R&D investment*, ABARE and BRS report for the Rural R&D Council, ABARE.

93 Mullin J, 2007, *The Importance of Productivity Growth in Australian Agriculture*, 51st Annual Conference of AARES, 13-16 February 2007, Queenstown, NZ.

94 For example: Webster J, 2011, *Outgrowing the planet*, Macquarie Agricultural Funds Management, available at http://www.macquarie.com.au/mgl/au/advisers/keep-up-to-date/oxygen/june-2011/agriculture

95 Deloitte Australia, 2013, *Positioning for prosperity? Catching the next wave*, Deloitte.

96 Ibid.

The potential of agriculture's global competitiveness is due to convergence of the rapid increases in global food and fibre demand meeting domestic comparative advantage. In this analysis agribusiness led a pack of six sectors (including mining, gas, tourism, oil, international education and wealth management) which were considerably ahead of the other 14 sectors with respect to global growth potential and competitive advantage.

Five big-picture advantages were identified which could offer a source of comparative advantage across Australia's industry sectors, including[97]:

- world-class resources in land, minerals and energy;
- proximity to the world's fastest growing markets in Asia;
- use of English, the world's business language;
- a temperate climate; and
- well-understood tax and regulatory regimes.

Of these advantages, world-class resources in land feature highly.

The key competitive advantages required for agribusiness to realise potential opportunities include:

- ongoing gains in productivity through innovation to keep Australian produce prices competitive; and
- reliability, in terms of both food quality and reliability of supply, as major points of differentiation. As the world's population and income rise, the potential premium on secure and clean sources of food supply will also increase.

The expected growth in demand for fresh produce is also expected to awaken the domestically focused fruit and vegetable sectors. The same factors that have driven higher-income consumers in the developed world towards fresh produce will do so for the vast numbers of people entering Asia's middle class. Within two decades, this group will likely comprise almost half of the world's middle-class consumers. With proximity of market and off-season production, and a strong drive of competitiveness, Australia's fruit and vegetable sector could see a turnaround with overseas demand for fresh, high-quality produce from Australian producers.

3.6 Can sustainable growth provide a competitive advantage?

"Effective balancing of sustainability and production growth should be a key competency of agriculture – these goals should not be mutually exclusive"[98]

Australian competitiveness and sustainability

A general understanding of the interrelatedness of environmental goals and industry competitiveness is in its infancy[99]. For decades the conventional wisdom has been that 'nature' is a constraint. Natural resources are either limited in volume, only renewed at a specific physical rate, or have a limited capacity to dissipate waste from production. This view casts nature as a 'limit to growth'.

The focus of economics has been on how economic growth impacts on the environment or vice versa, but the dynamics of these relationships are also important. Following the development dynamics of nations, the state of the environment tends to worsen at the early stages of industrialisation, but then improve as income increases – a concept known as the Environmental Kuznets Curve. The best examples are for air quality indicators, especially local pollutants[100], but the expectation that environmental sustainability will be achieved at a certain national income level is a simplistic view of a more complex relationship which is still not well understood.

97 Ibid.
98 Port Jackson Partners, 2012, Greener Pastures: The global soft commodity opportunity for Australia and New Zealand, *ANZ Insight* issue 3, Sydney.
99 Schwab K, Sala-i-Martin A, 2013, *The Global Competitiveness Report 2013–2014: Full Data Edition*, World Economic Forum, Switzerland.
100 Dinda S, 2004, Environmental Kuznets Curve Hypothesis: A Survey, *Ecological Economics*, vol 49, 431-55.

The newly emerging area of 'sustainable competitiveness' is seeking to understand how environmental and social sustainability relate to competitiveness and productivity[101]. Recent attempts have been made to expand the Global Competitiveness Index, where Australia ranks 21st (Section 3.3), to take into account both environmental and social sustainability. In this context sustainable competitiveness is defined as *the set of institutions, polices, and factors that make a nation productive over the longer term while ensuring environmental and social sustainability*.

Early analysis suggests a strong and positive relationship between environmentally sustainable practices and productivity gains can be achieved through three key areas:

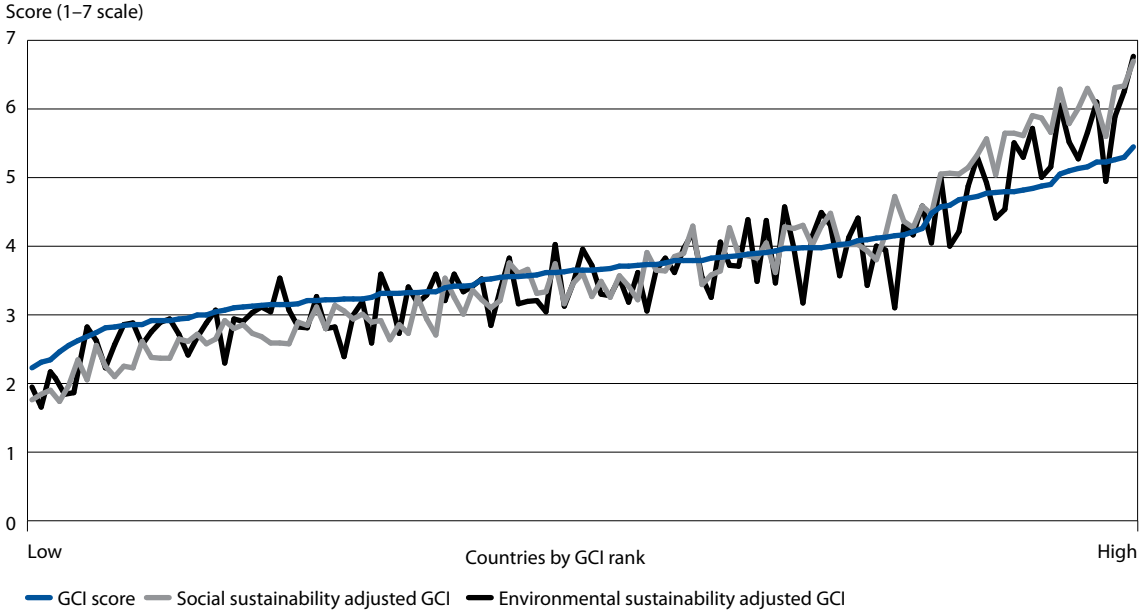
- the efficient use of natural resources;
- a high-quality natural environment which improves the productivity of the workforce; and
- conserving ecosystems which regulate water supply and air quality and protect biodiversity[102].

Rather than being mutually exclusive there is some evidence that sustainability can enhance the competitiveness of nations (Figure 18). Including indicators for environmental sustainability in general (environmental policy, use of renewable resources, degradation of the environment) enhances the Global Competiveness Index scores for the top ranked countries, relative to middle and lower ranked countries. Among countries performing well in terms of environmental sustainability, New Zealand emerges as an economy with a strongly articulated political commitment to environmental stewardship. It performs better than Australia due to the lower level of air pollution in New Zealand and the country's efforts to set aside protected land areas.

3.7 Agricultural competitiveness and sustainability

Australian agriculture's competitiveness is a function of producing at lower cost than competitors and/or the differentiation of products and services. So how would the pursuit of sustainable growth impact agricultural costs, and can 'clean and green' products be differentiated within the marketplace?

Figure 18 Ranking of 148 country Global Competitiveness Index (GCI) scores. Environmental and social sustainability adjusted GCI scores are also shown[103].



101 Schwab K, Sala-i-Martin A, 2013, The Global Competitiveness Report 2013–2014: Full Data Edition, World Economic Forum, Switzerland.
102 Ibid.
103 Ibid.

3.7.1 Costs of sustainable growth

Sustainable growth in agriculture would result in higher costs in the short term as discussed below. In the longer term, sustainable growth could improve the competitiveness of Australian agriculture. Managing the natural resource base sustainably would help ensure production could be maintained over time. If competitors faced severe natural resource constraints, due to over extraction or degradation of their natural resource base, then Australia could be in a better position to reliably supply export markets. Australia's world-leading management of water resources may provide the first example of how moving to a sustainable management of a natural resource can confer a competitive advantage.

3.7.2 Sustainable growth and differentiation

Sustainable growth in Australian agriculture could help to differentiate products from other suppliers, enhancing any competitive market advantage. Product differentiation based on credence attributes incorporates a wide range of fairly intangible and usually interrelated characteristics, such as environmental impacts, health, conservation impacts, and origin.

While personal health considerations drive much of the consumer's desire for 'clean' food, there is an explicit link between personal health and the health of the environment in which the food is grown.

Capturing a competitive advantage from sustainable growth opportunities will require a major shift in how Australian agriculture promotes itself to the world. Australian agriculture has not typically promoted a unified national brand image. The positioning of 'Brand Australia' in emerging Asian markets is an immediate issue. Without the development of such a coordinated brand, it will be more difficult for Australian produce to remain competitive in accessing these markets in the future as other nations forge ahead based on credence differentiation[104].

The consumer must believe that the product is addressing some need or gap that exists if credence attributes are to be used for differentiation in the marketplace. Branding for branding's sake will not increase the value of the product. Once seen as a differentiator between premium products in information-hungry markets, such as Japan, product traceability has now become essential in any market where products make claims such as provenance, GM-free, organic, fair trade, or other credence attributes[105].

In Australia, traceability has initially been seen as an additional cost to businesses. Producers are increasingly now seeing the benefits of having in place a traceability system. Traceability and the associated food safety advantage are preconditions rather than drivers in most markets – the traceability of the produce through the value chain allows consumers to have trust in the safety and quality of their food purchases.

3.8 Placing agricultural industries in the landscape

Agriculture prospers within its setting in the landscape. The ecosystem processes and functions within the landscape support water, nutrient, and carbon flows, which generate the wealth from food and fibre[106]. Historically, the natural capital of these landscapes has been drawn down to build the agricultural industries we see today. Agricultural growth has initially been driven by expanding land area and water extraction, up until the 1960s (Figure 9). This expansion of land area and water extraction has come at a significant cost to the natural systems that agriculture replaced.

104 Keogh M, Tomlinson A, 2013, *Does proximity to Asia breed complacency for agricultural trade?*, Australian Farm Institute.

105 Moser R, Raffaelli R, Thilmany-McFadden D, 2011, Consumer preferences for fruit and vegetables with credence-based attributes: A review, *International Food and Agribusiness Management Review*, vol 14, 121-142.

106 Williams J, McKenzie F, 2008. 'Australian agriculture: redesigning for resilience', in *Ten Commitments: Reshaping the Lucky Country's Environment*, CSIRO Publishing.

Sustainable growth cannot occur by just reworking the familiar areas of improving productivity sector by sector, but with a greater focus on natural resources. Instead, sustainable growth in agriculture needs to be built on a strong scientific, evidence-based foundation which determines the natural resource limits of landscapes. Great advances have been made in understanding the biophysical and economic processes of landscapes operating in agro-ecosystems. Identification of critical environmental limits – to resource use, development and environmental degradation, on the basis of clear principles and sound science – is a necessary extension of this work. Science can also provide the necessary tools for measurement, monitoring, management, and decision-support for local innovation and adaptation.

For agriculture to continue to prosper within environmental limits, new partnerships between government, researchers and scientists, the private sector, and communities will be required[107]. This is up to all Australians. Science needs to inform critical environmental limits and develop new ways of understanding the social processes underpinning transformational adaptation. Governments need to regulate environmental limits, streamline existing laws, institutions, and governance, and establish and support innovative local adaptation. The private sector needs to better engage with communities, participate in new markets for ecosystem services, and reduce the reliance on government for funding environmental management.

Despite already being subject to unprecedented pressure, individual landholders and communities have the responsibility to implement innovative, evidence-based, collaborative change. These are the first steps needed on an adaptive path to competitive sustainable growth in Australian agriculture.

107 Bryan B, Meyer S, Campbell A, Harris G, Lefroy T, Lyle G, Martin P, McLean J, Montagu K, Rickards L, Summers D, Thackway R, Wells S, and Young M, 2013, The second industrial transformation of Australian landscapes, *Current Opinion in Environmental Sustainability*, vol 5, 278-287.

4 Sustainable Growth Potential of Food and Fibre Industries

What are the best opportunities for Australia to participate in the global 'dining boom' resulting from increasing population, increasing wealth and increasing competition for arable land and irrigation water? Would the best strategy be to optimise production, value, and profitably from existing strengths, or are there opportunities to engage in new food and fibre industries that would generate better value from the renewable natural resources base? The national response to these opportunities must be secure, sustainable and smart.

Secure in the sense that national food security and exports are not threatened, while at the same time being perceived internationally, particularly by near neighbours, as an appropriate response from a developed nation aware of its global humanitarian responsibilities.

Sustainable in terms of intergenerational equity within Australia, by utilising natural resources in such a way that they are equally available for future generations with the capacity to produce food and fibre with equal effectiveness using the technologies of the day.

Smart in terms of optimising natural capital and competitive advantage to ensure the nation and regional communities dependent on wealth generation from food and fibre industries derive optimal benefit from these opportunities. This must necessarily mean that in the medium term Australia strategically seeks to derive the maximum value per unit of product by moving as far up the value chain as possible before sale. Smart also means strategically capitalising on the potential value of services as well as products from our food and fibre industries. These can arise throughout the full value chain including derivative technologies, education and research.

The ultimate goal of this secure, sustainable, and smart approach to sustainable growth in the food and fibre industries is to create a 'virtuous cycle'. In this cycle the application of knowledge, know-how, and technology to produce safe, high-value food and fibre products for international markets in a sustainable way generates an international demand for services as well as products, which in turn further enhances Australia's reputation as a smart producer of safe, high-quality food and fibre products.

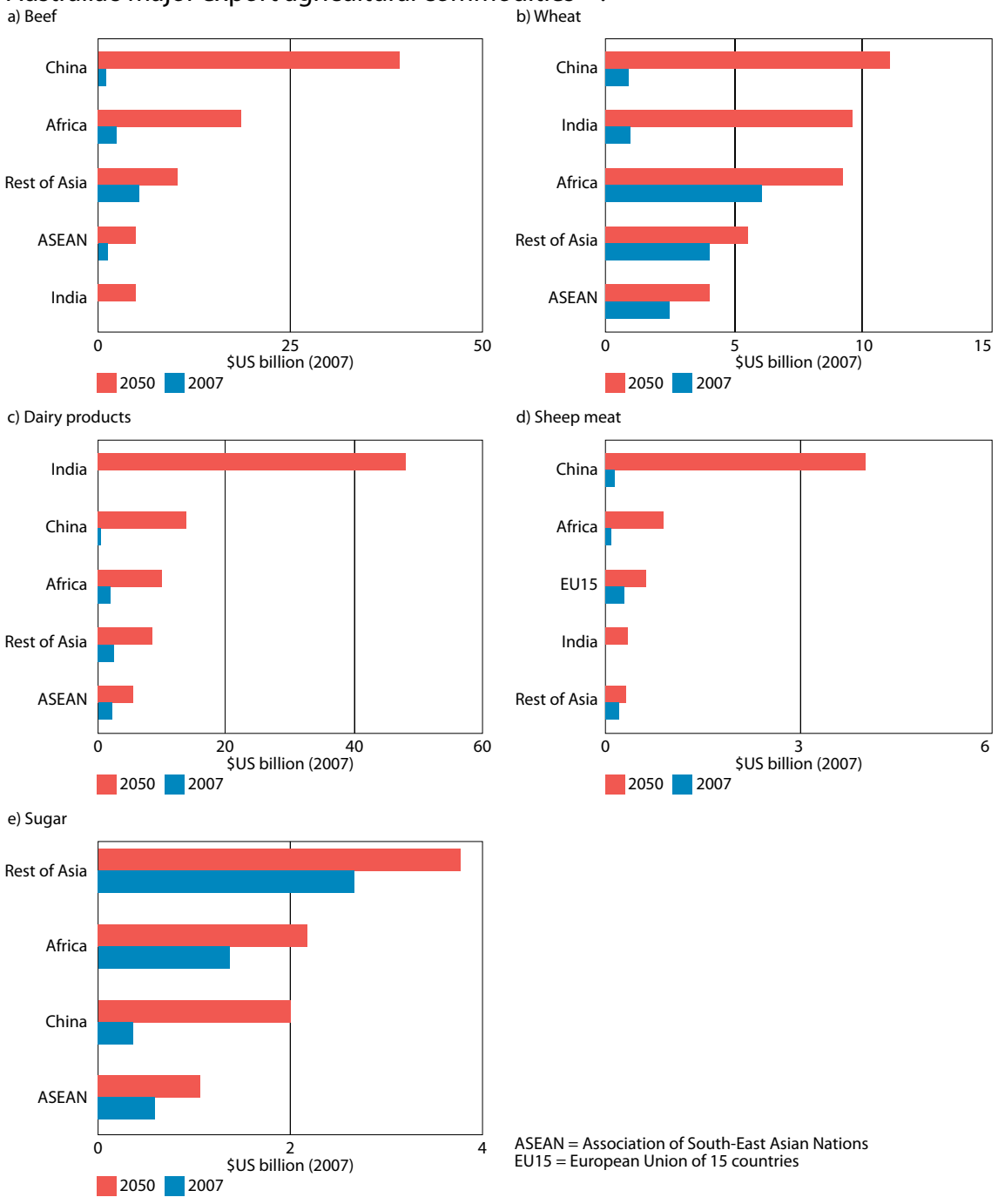
To assess the potential opportunities for sustainable growth within Australian food and fibre industries, the following discussion groups industries into three categories:
- existing food and fibre export industries;
- possible new industries and resources; and
- differentiation in existing industries.

Within each of these categories, sustainable growth potential is further evaluated by consideration of:
- future export demand;
- technological feasibility to expand production;
- available natural resource base and its sustainability;
- innovation capacity;
- potential externalities and infrastructure limitations; and
- sustainable growth potential.

4.1 Existing food and fibre export industries

A recent Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) modelling study[108] has identified that while global food demand is projected to increase by 77 per cent by 2020, food demand in Asia will double while the rest of the world will increase its food demand by only 48 per cent (Figure 19). Disaggregating Asian demand by nations reveals that China accounts for more than half of this increase. For many countries increased food demand is expected to be met by trade, rather than increases in domestic production.

Figure 19 Current (2007) and projected (2050) global food demand for five of Australia's major export agricultural commodities[109].



ASEAN = Association of South-East Asian Nations
EU15 = European Union of 15 countries

108 Linehan V, Thorpe S, Andrews N, Kim Y, and Beaini F, 2012, *Food demand to 2050: Opportunities for Australian agriculture*, 42nd ABARES conference, Canberra.
109 Ibid.

This projected increase in Asian demand for agrifood products maps well with Australia's export industries in beef, sheep meat, dairy, grains, and sugar (Section 2; Figure 6). This analysis did not consider substantially processed products such as wine or areas where Australia is not considered to have a competitive advantage such as fruit, vegetables and nuts. This modelling suggests that Australia has the potential to more than double its exports of major agricultural commodities, beef, wheat, dairy products, sheep meat, and sugar by 2050. In aggregate Australian exports of these commodities could increase by 77 per cent. These demand-based projections assume that Australia can increase its production in these industries to meet this demand.

This study undertakes a qualitative analysis, based on recent performance and projections, to indicate the major opportunities to achieve growth by increasing the total value of exports within sustainable production systems by 2050. For existing industries this analysis is summarised in Table 3. These projections are based on the assumption that new land and water resource inputs are not available and that production increases will have to come from annual productivity gains of two per cent. Australian agricultural industries are currently only achieving productivity gains of around 1.6 per cent on average[110]. This point is emphasised in Table 3 where the future sustainable growth potential of most of Australia's agrifood export industries is strongly dependent on achieving productivity gains in the immediate future. The evidence for the feasibility of this assumption together with some of the technologies that are likely to be used to achieve productivity are discussed in Section 4.2.4 at the end of this chapter.

110 Mullen J, Tester M, Goddard M, Carberry P, Keating B, and Bellotti B, 2012, *Assessing the opportunities for achieving productivity growth in Australian agriculture*, Australia Farm Institute.

Table 3 A qualitative analysis of the opportunities to achieve sustainable growth by increasing total export value of existing industries by 2050.

Target Industry	Future Export Demand	Technological Feasibility to Expand Production	Natural Resource Base and its Sustainability	Innovation Capacity	Potential Externalities and Infrastructure Limitations	Sustainable Growth Potential
Grains	✓✓✓ Well documented increasing global demand, particularly from Asia, for wheat, oilseeds, pulses, and feed grains. Currently little value adding and product branding.	✓✓✓ Currently a major exporter. Excellent capacity to increase productivity through innovation, and reasonable infrastructure.	✓✓ Arable land in southern Australia is fully developed with little potential for further expansion. Some coarse grain cropping potential exists in northern Australia. Future climate change could threaten some southern arable land. Soil health and condition need continued attention.	✓✓✓ Excellent RD&E capacity and organisation. Innovative farming industry. Industry technological capacity is high.	✓✓✓ Excellent grain handling facilities on and off farm. Transport costs at risk due to competition for rail transport from mining industry. Export facilities need to remain competitive. Comparative market disadvantage with lack of bilateral trade	✓✓✓ Continued investment needed to secure adequate scale, innovation, technology and trade access. Capacity for value adding through processing and branding.
Dairy	✓✓✓ Strong documented global demand, particularly in Asia, for commodities and branded products. Good capacity for product branding and differentiation.	✓✓✓ Currently a major exporter. Excellent capacity to increase productivity through innovation, and further land development. Reasonable infrastructure.	✓✓✓ Good expansion possibilities in southern Australia, particularly Tasmania. Potential water access and land competition problems in the southern Murray–Darling Basin due to climate change and water reforms.	✓✓✓ Excellent RD&E capacity and organisation. Innovative industry. Industry technological capacity is high.	✓✓✓ Export facilities in southern Australia are excellent. Comparative market disadvantage with lack of bilateral trade agreements with major trading partners.	✓✓✓ Continued investment needed to secure adequate scale, innovation and technology. Co-investment with off-take agreements may be an attractive possibility.
Beef	✓✓✓ Documented global demand, particularly in Asia and Middle East. Demand for live export.	✓✓✓ Considerable advantage in proximity to Indonesian markets for live exports. Some advantage in processed meat into Chinese markets. Significant productivity gains possible in the northern and southern industries through coordinated RD&E.	✓✓✓ Good expansion possibilities in northern Australia with innovative technology and improved processing and market infrastructure. Productivity and production improvements possible in southern Australia but significant land use competition with	✓✓ Good RD&E capacity and industry innovation. Greater coordination needed with national strategy. Continued technological innovation required in North Australia to achieve potential expansion.	✓ Live cattle trade is vulnerable. Lack of processing facilities in northern Australia. Comparative market disadvantage with lack of bilateral trade agreements.	✓✓✓ Co-investment, perhaps with production off-take deals, is needed to secure nearby markets and secure against animal welfare risks.

Table 3 A qualitative analysis of the opportunities to achieve sustainable growth by increasing total export value of existing industries by 2050. (continued)

Target Industry	Future Export Demand	Technological Feasibility to Expand Production	Natural Resource Base and its Sustainability	Innovation Capacity	Potential Externalities and Infrastructure Limitations	Sustainable Growth Potential
Cotton	✓✓✓ Global demand rising with increasing population and petrochemical feedstock costs. Australia is the third largest cotton exporter in the world.	✓✓✓ Strong capacity to grow cotton in a range of environments with low chemical usage and some of the highest yields in the world. Infrastructure investment is needed.	✓✓✓ Further expansion will depend upon the availability of irrigation water. Possibilities for expansion in northern Australia, only with the availability of insect resistance. Strong prospects for expansion in southern Australia, with climate change and competition for water with lower-return industries.	✓✓✓ Excellent RD&E capacity and organisation. Well coordinated national RD&E plan. Industry technical capacity is high.	✓✓✓ Industry has managed to improve its environmental image through education and the application of GMO technologies to reduce insecticide use.	✓✓ Growth possible, largely through productivity improvements. Modest potential to grow at the expense of other, less water efficient industries. Potential in northern Australia is very modest at 30,000ha – less than 6 per cent of the current industry.
Sugar	✓✓✓ Global demand is increasing with population and biofuel feedstock demand (2.5 per cent per annum). Australia in currently the third largest sugar exporter, but is not expanding as rapidly as international competitors.	✓✓ Industry has not been heavily production orientated recently. National yields are not currently increasing.	✓ As crop is grown on coastal lowlands with access to water, there are significant sustainability challenges in relation to the Great Barrier Reef in particular. New developments in northern Australia (Ord River) can provide some further capacity.	✓✓ Good RD&E capacity, currently being reorganised. Technical capacity needs modernisation.	✓ Difficult pathways for further expansion in North Queensland due to potential reef impacts. New developments in northern Australia will require significant infrastructure investment for processing and transport.	✓ Some moderate expansion could occur in northern Australia (Ord River and elsewhere). A further 50,000 ha would represent an increase of 10 per cent in sugarcane growing area. This will be dependent on the availability of investment for infrastructure.
Horticulture	✓✓✓ Strong international demand for vegetables, fruit and nuts. Currently Australia is a net importer of horticultural products.	✓✓ Great diversity of growing environments available. Production efficiency is not at the highest international levels of competitiveness. Export infrastructure needs investment.	✓✓✓ Ability to exploit new growing environments will depend on water and infrastructure availability. Horticulture can compete strongly on the water markets with high returns.	✓✓ Industry innovation capacity is strongly constrained by fragmented RD&E arrangements and subsequent lack of research scale and strategic focus.	✓✓ Processing capacity is declining nationally because of international competitiveness and local market access. Potential non-tariff trade barriers based on bio-security need to be addressed.	✓✓ Large production capacity to supply out of season fresh and processed produce. Capacity to access these markets will depend on market chain innovation and efficiency to be competitive.

Table 3 A qualitative analysis of the opportunities to achieve sustainable growth by increasing total export value of existing industries by 2050. (continued)

Target Industry	Future Export Demand	Technological Feasibility to Expand Production	Natural Resource Base and its Sustainability	Innovation Capacity	Potential Externalities and Infrastructure Limitations	Sustainable Growth Potential
Sheep and Sheep Meat	✓✓✓ Strong international demand for lamb in a broad range of markets. Demand for wool remains strong.	✓✓✓ Productivity improvements are possible in lamb production through improved feed base, new genetic diversity, and better animal husbandry.	✓✓ Competitive with other grazing industries for land resources in southern Australia. Production gains will come from improved productivity.	✓ Sound innovation foundations laid by CRCs. Industry RD&E culture, coordination, and commitment are not strong or well organised. Potential for productivity improvements remains high.	✓✓ Meat processing capacity is good but needs further investment. Wool processing remains problematic. Potential public perception issues exist with regards to animal welfare related to live exports and animal husbandry practices.	✓✓ Demand for animal protein from a broad range of markets is promising. Significant productivity growth improvements are possible.
Wine	✓✓ Strong demand from rapidly developing economies (e.g. China) and within particular price segments of developed economies (e.g. US). High levels of international competition and very price sensitive.	✓✓✓ Few barriers to further expansion. A diverse range of potential production environments are available. Strong technological services are available for development.	✓✓✓ Large capacity to expand because of the comparatively small amounts of land and water required and existing excess production capacity.	✓✓✓ Strong and well coordinated existing innovation system and a receptive industry.	✓✓✓ Capacity for further expansion and innovation is high. International markets are extremely competitive. Australian industry currently hampered by exchange rate and lack of critical free trade agreements.	✓✓ Moderate immediate growth potential. Industry consolidating and rebranding in preparation for expansion in more favourable trading conditions.
Aquaculture	✓✓✓ Very strong international and domestic demand for aquatic food products. Australia imports 70 per cent of current consumption. Future demand will need to be met from aquaculture due to pressure on natural fisheries. Protein from aquatic food is an important component of dietary preference changes in developing economies.	✓✓ High quality technological capacity available in limited areas. Very diverse and extensive range of marine and freshwater environments available. Infrastructure variable.	✓✓✓ Potentially extensive marine locations outside conservation and tourism zones. Freshwater niches can be shared with other enterprises.	✓✓✓ Excellent but limited RD&E capacity currently available in CRCs, CSIRO and universities. Rapid expansion would require a major increase in research capacity.	✓✓✓ Potential infrastructure challenges in remote marine environments. Labour costs could limit competiveness depending on the strategic industry direction. High value, high technology enterprises are required.	✓✓✓ Large potential for expansion given the availability of marine locations and the national scientific and technological capacity. Significant expansion will require considerable commercial investment supported by government.

4.2 Possible new industries and resources

The second group of potential sustainable growth opportunities in food and fibre is through industries that either utilise land or water resources that are currently relatively underdeveloped, or utilise existing agricultural systems in a new way. These opportunities are summarised in Table 4.

4.2.1 Irrigation in Northern Australia

The possibility of developing more intensive arable agriculture in northern Australia is being revisited through the current development of Stage 2 of the Ord River irrigation area at Kununurra in the north of Western Australia, and a number of research investigations seeking to identify opportunities for development of new or expanded irrigation in northern Australia[111]. The North Queensland Irrigated Agriculture Strategy[112] is a comprehensive assessment of sustainable water resource development and the potential for new irrigated agriculture in the Flinders and Gilbert catchments of north Queensland. It will also include an independent assessment of the viability of establishing new comprehensive meat processing facilities in north-west Queensland. These investigations are being considered as regional development opportunities. Preliminary data documenting the highly ephemeral nature of the Flinders River is confirming the challenges of developing large-scale irrigation in Australia's north.

Further irrigated agriculture may develop in northern Australia utilising water not currently being used for irrigation. Current estimates indicate that even if these developments were to be successful they would probably only add in the order of 100,000 ha of irrigation to the nation's existing 2.1 Mha of irrigated agriculture, or an increase of five per cent. While that would be significant regionally it would not be a large contribution to Australia's capacity to export food and fibre under the 'Northern Food Bowl' concept.

4.2.2 Biofuels

A recent report from ATSE[113] examining green growth potential for Australia in the energy sector identified sustainable aviation fuels as a potential new industry of strategic importance to Australia. While this report outlined the industrial possibilities for aviation biofuels it did not explore in any detail the source of the feedstocks for such an industry. Two major possibilities for feedstock, terrestrial and aquatic, have been analysed for their potential competitiveness in terms of costs as well as the natural resources required to produce significant scale (Table 4).

111 CSIRO Land and Water, 2007, *Northern Australia Irrigation Futures: National Program for Sustainable Irrigation – CDS23 – Final Report*, CSIRO.

112 *North Queensland Irrigated Agriculture Strategy*, Office of Northern Australia, Department of Infrastructure and Regional Development, available at http://www.regional.gov.au/regional/ona/nqias.aspx.

113 Godfrey B, Sargent M, and Pond S, 2013, *Green Growth – Energy: Industry opportunities for Australia*, Australian Academy of Technological Sciences and Engineering, Melbourne.

Table 4 A qualitative analysis of the opportunities to achieve sustainable growth through potential new agricultural industries.

Target Industry	Future Export Demand	Technological Feasibility to Expand Production	Natural Resource Base and its Sustainability	Innovation Capacity	Potential Externalities and Infrastructure Limitations	Sustainable Growth Potential
Aviation Biofuel *Terrestrial biomass feedstock*	✓✓ Strong international and national demand identified in ATSE Green Growth – Energy Report[114]. Import replacement with declining self-sufficiency. Costs are not currently competitive with traditional fuels.	✓✓ Considerable systems development required in growth, harvest, transport, and processing. Technologically and economically feasible.	✓ Possibilities to incorporate NRM objectives and salinity control. Natural resources base is limited for large scale industries of this type. Competing directly with food production, except if grown where food production not possible.	✓✓ Good background in farming systems. Considerable systems research required to optimise production, processing and transport. No obvious government RD&E funding at present.	✓✓ Harvesting, transport and processing infrastructure investment required.	✓✓ Questions remain over the capacity of the Australian landscape to meet the projected 14 GL/year of fuel required in 2030. Biomass could be limited to 5 to 10 per cent of Australian demand. Some comparative advantage in availability of landscape.
Aviation Biofuel *Algal feedstock*	✓✓ Strong international and national demand identified in ATSE Green Growth – Energy Report[115]. Import replacement with declining self-sufficiency. Costs are not currently competitive with traditional fuels.	✓ Large-scale algal open monocultures have proved difficult to maintain at this stage of development. Other culture and harvesting technologies are available. There is much international effort currently in this space.	✓✓✓ Large land area required in warm climates for year-round production. Open ponds will have significant water and nutrient requirements. Saline culture systems would be required.	✓ Some research efforts and pilot-scale developments at present, but no commercial-scale activities. Little comparative advantage as technology would be generic except possibly for marine or saline algal systems. RD&E capacity currently limited.	✓✓ Few impediments to establishment of facilities.	✓ Little comparative advantage in terms of land mass, the developmental phase of the technology, and likelihood of substantive R&D investment.
Northern Irrigation Industries	✓✓✓ Strong demand for agricultural commodities, food and fibre.	✓✓ Questions remain over capacity to sustainably produce high yields of major tropical commodities in northern Australia such as sugar, rice and cotton. Horticulture is successful to date but with limited markets available.	✓ Recent estimates indicate that potential is limited by scarcity of storage sites for water and suitable soils for irrigation. Potential new capacity is 50-100,000 hectares[116] or two to five per cent of current irrigation area.	✓✓ Considerable water and irrigation management RD&E capacity available. Coordinated funding for irrigation and water development is difficult with multiple industries involved.	✓ Considerable transport and irrigation infrastructure is required for production and export. Major environmental challenges to the development of new water storages.	✓ Modest production increases are feasible. Substantial infrastructure is needed to ensure sustainable growth. Substantial ongoing RD&E presence in the regions is required for sustainable production and exporting. Further development studies must consider all aspects of development including availability of infrastructure.

114 Godfrey B, Sargent M, and Pond S, 2013, *Green Growth – Energy: Industry opportunities for Australia*, Australian Academy of Technological Sciences and Engineering, Melbourne.
115 Ibid.
116 Northern Australia Land and Water Taskforce, 2009, *Northern Australia Land and Water Science Review 2009: Final report*, CSIRO

An earlier study by CSIRO[117] modelled the potential to supply 50 per cent of the Australian and New Zealand aviation fuels requirement from a range of biofuel feedstocks. This study emphasised the need to research the biology and economics of biomass production as a pathway to reducing costs. The Cooperative Research Centre (CRC) for Future Farming Industries[118] is currently conducting a major economic and sustainability feasibility study of a biofuel production system in the southern Western Australian wheat belt, based on biomass production from wheat stubble, Oil Mallee Belts within the wheat belt, and forestry waste from adjacent pulpwood plantations. This study indicates that modest production systems based on existing technologies and systems have the potential to be economically feasible if fully integrated into the unique set of existing agricultural and forestry enterprises in the area.

A recent analysis[119] examined the potential production costs of biofuel from three feedstocks: algae; *Pongamia piñnata*, a leguminous tree; and sugarcane. Under current market and technological conditions the estimated production costs of $1343, $374, and $301/bbl (per barrel) for microalgae, *Pongamia*, and sugarcane respectively are not competitive with current fuels. With technological and market development it was estimated that these production costs could decrease to a more competitive $385, $255, and $168 $US/bbl respectively.

Major new growth industries in Australia must be sustainable as well as economic. A key part of this sustainability is that they do not influence food security in terms of utilising the same production base and directly competing for natural resources. In global terms, Pearman[120] has demonstrated that photosynthetic efficiency may ultimately prevent biofuels from playing a significant role in bio-sequestration and energy production. Even through Australia is a country with relatively high incident radiation in relation to national energy use, the challenge of utilising agricultural systems operating at a conversion efficiency of about 0.1 per cent is considerable.

Sustainable growth industries in second and third generation biofuels could develop simultaneously along two different paths within the Australian context – an integrated agricultural landscape path or an algal bio-industrial path. For example, in the agricultural landscape sense, biofuels could provide another income stream through the utilisation of multiple biomass waste streams as proposed in the current Western Australian study, or alternatively the use of *Pongamia*, to produce oil as part of an extensive grazing system in northern Australia. In the case of algal systems the higher photosynthetic efficiency resulting from carbon dioxide enrichment mandates that these production facilities must have access to industrial sources of CO_2. The water requirements of open-pond culture would dictate that only saline systems would be feasible because of the limitations in the availability of fresh water for consumptive use.

In the context of increased demand for food and fibre the potential of northern Australia to support cropping industries including irrigation is worthy of a rigorous re-evaluation in the light of technological advances, the development of other industries, and preliminary studies[121] identifying promising areas for development. These studies indicate the immense amount of water falling on a seasonal basis across 55 coastal river catchments, but both rainfall and river flow are extremely seasonal with few opportunities to develop the deep storages necessary to combat high surface evaporation[122]. Similarly with regard to

117 CSIRO, 2011, *Flight path to sustainable aviation: Towards establishing a sustainable aviation fuels industry in Australia and New Zealand*, CSIRO Energy Transformed Flagship, Sustainable Aviation Fuel Roadmap.

118 FFICRC, 2013, *Annual Report 2012-2013*, Future Farming Industries CRC.

119 Klein-Marcuschamer D, Turner C, Allen M, Gray P, Dietzgen D, Gresshoff P, Hankamer B, Heimann K, Scott P, Stephens E, Speight R, and Nielsen L, 2013, Technoeconomic analysis of renewable aviation fuel from Microalgae, *Pongamia pinnata*, and sugarcane. *Biofuels, Bioproducts and Biorefining*, vol 7, 416-428.

120 Pearman G, 2013, Limits to the potential of bio-fuels and bio-sequestration of carbon. *Energy Policy*, vol. 59, 523–535.

121 Northern Australia Land and Water Taskforce, 2009, *Northern Australia Land and Water Science Review 2009: Final report*, CSIRO.

122 CSIRO Land and Water, 2007, *Northern Australia Irrigation Futures: National Program for Sustainable Irrigation – CDS23 – Final Report*, CSIRO.

soils despite 5 to 17 million hectares being identified as potentially arable they are distributed across a vast landscape resulting in only one million hectares being potentially suitable for irrigation. It is estimated that as little as 100,000 ha may have suitable soils adjacent to sufficient reliable water to justify development. As emphasised by the Northern Australia Taskforce, any further agricultural development will have to compete with ecotourism, mining and indigenous management.

In the light of these recent studies any systematic or regional re-evaluation of the potential of northern Australia for intensive agricultural development should consider all components of regional development rather than solely agricultural feasibility.

4.2.3 Differentiation in existing industries

A second and concurrent growth opportunity for Australia's food and fibre industries is to add value to our largely commodity-based industries where possible[123].

Adding value by moving up the value chain is a national growth strategy for food and fibre industries which, in most cases, does not place further stress on the natural resource base. The ambitious targets set by Commonwealth[124] and state[125] agriculture departments for growth in production and exports can only be achieved with an increase in value per unit as well as increasing total production. The latest iteration of the National Food Plan set a goal of increasing food exports by 45 per cent in the year 2025, in little more than a decade. Similarly, Queensland has adopted an agricultural strategy which calls for a doubling of production by 2040. Achieving these targets would require on-farm annual productivity increases of more than 3.5 per cent, approximately double the current rates[126].

This gradual progression of Australia's commodity-based food and fibre industries to capture greater value from the natural resource base relies on differentiating their produce through branding in one form of another. Given the limitations to increasing food production by utilising more natural resources, increasing the value of the food and fibre products produced has been proposed and an avenue of wealth generation[127]. Importantly, branding of both fresh and substantially transformed products allows Australian producers to realise some further value from their produce in return from its credence value developed by a well regulated and sustainable production system. This is not possible in bulk commodities where the next-stage processor brands the product.

The increasing predominance of supermarkets as a point of sale in Asia generally, and China in particular, creates the further opportunity to place branded products on the supermarket shelves of the rapidly growing Asian middle class. These branded products, whether they be substantially transformed or fresh produce with strong quality and safety credentials offer the opportunity to leverage Australia's reputation for safe and sustainable production.

This could be achieved by the further development of the 'Brand Australia' concept as an overarching generic brand within which specific food and fibre product brands would sit. New Zealand has achieved this with the generic 'New Zealand Fresh' brand[128]. The Australian wine industry used national branding in its successful export expansion in the 1990s – in that case the iconic Australian wine brands sat within the generic Australian brand.

123 Deloitte Australia, 2013, *Positioning for prosperity? Catching the next wave*, Deloitte.
124 DAFF, 2013, National *Food Plan: Our food future*, Department of Agriculture, Fisheries and Forestry, Commonwealth of Australia.
125 DAFF, 2013, *Queensland's Agriculture Strategy – A 2040 vision for doubling agricultural production,* Department of Agriculture, Fisheries and Forestry, Brisbane, Queensland.
126 Mullen J, 2012, *The Future Productivity and Competitiveness Challenge of Australian Agriculture,* in 'Assessing the Opportunities for Achieving Future Productivity Growth in Australian Agriculture', Australian Farm Institute.
127 DAFF, 2013, National *Food Plan: Our food future*, Department of Agriculture, Fisheries and Forestry, Commonwealth of Australia.
128 Port Jackson Partners, 2012, *Greener Pastures: The global soft commodity opportunity for Australia and New Zealand*, ANZ Insight issue 3, Sydney.

'Brand Australia' is not a new concept. Australia as a nation has invested heavily in sustainability, food safety and biosecurity in the past 30 years, in the form of Landcare, National Heritage Trust, Caring for Country, National Water Plan, National Livestock Identification System, Animal Welfare Plan, Plant Health Australia, and Carbon Farming Futures, among others. The outcomes of these programs and the management and regulatory systems they have put in place provide an excellent opportunity for Australian food and fibre industries to support Brand Australia without the imposition of new cost structures. The management systems, data collection, and monitoring systems that are currently in place can be used to derive and support demonstration of the safety, quality, and other credence values of Brand Australia products. The added value that this approach may produce can only be captured if we brand our agricultural products in a coordinated way.

4.2.4 Pathways to increased productivity for agrifood industries

Can Australia's current and emerging agrifood industries achieve the 2 to 2.5 per cent annual productivity gains that will be necessary to achieve these increased production goals? What will be the technologies that are likely to be used? Have we reached the biophysical limits of our agricultural production systems?

Agricultural production systems are ultimately highly managed ecosystems in which the whole can be more than the sum of the parts with highly skilled management. Recent analysis[129, 130] has concluded that it should be biophysically possible to double productivity per unit area in the next 35 years for both plant and animal based agricultural systems that have been identified with excellent export potential. In terms of total factor productivity and ultimate profitability it may be possible to obtain greater efficiency from labour and chemical inputs as well[131], using automation, information technology, and achieving greater value through product specification.

Further increases in productivity from Australian agricultural systems are likely to come from a combination of[132]:

- removing system inefficiencies;
- increasing the efficiency of resource use; and
- breakthrough technologies.

Agricultural production system inefficiencies arise from biophysical sources, such as soil degradation, as well as social, economic, and policy sources such as farm size, drought policy, inefficient irrigation systems, and practice[133]. Achieving progress in removing these inefficiencies is an ongoing process in all industries which can be influenced by good policy and excellent advisory services.

Means to increasing the efficiency of resource use is usually a combination of skilled management and technology. In recent decades agricultural productivity has been boosted by factors such as continual incremental genetic improvements, the application of spatial positioning systems in cropping, and the general application of information technology in risk management[134]. For example, the application of precision farming technologies using the Global Positioning System has achieved considerable system-

129 Mullen J, Tester M, Goddard M, Carberry P, Keating B, and Bellotti B, 2012, *Assessing the opportunities for achieving productivity growth in Australian agriculture*, Australia Farm Institute.

130 Carberry P, Bruce S, Walcott J, and Keating B, 2011, Innovation and productivity in dryland agriculture: a return-risk analysis for Australia. *Journal of Agricultural Science*, vol 149, 77–89.

131 Mullen J, Tester M, Goddard M, Carberry P, Keating B, and Bellotti B, 2012, *Assessing the opportunities for achieving productivity growth in Australian agriculture*, Australia Farm Institute.

132 Carberry P, Bruce S, Walcott J, and Keating B, 2011, Innovation and productivity in dryland agriculture: a return-risk analysis for Australia. *Journal of Agricultural Science*, vol 149, 77–89.

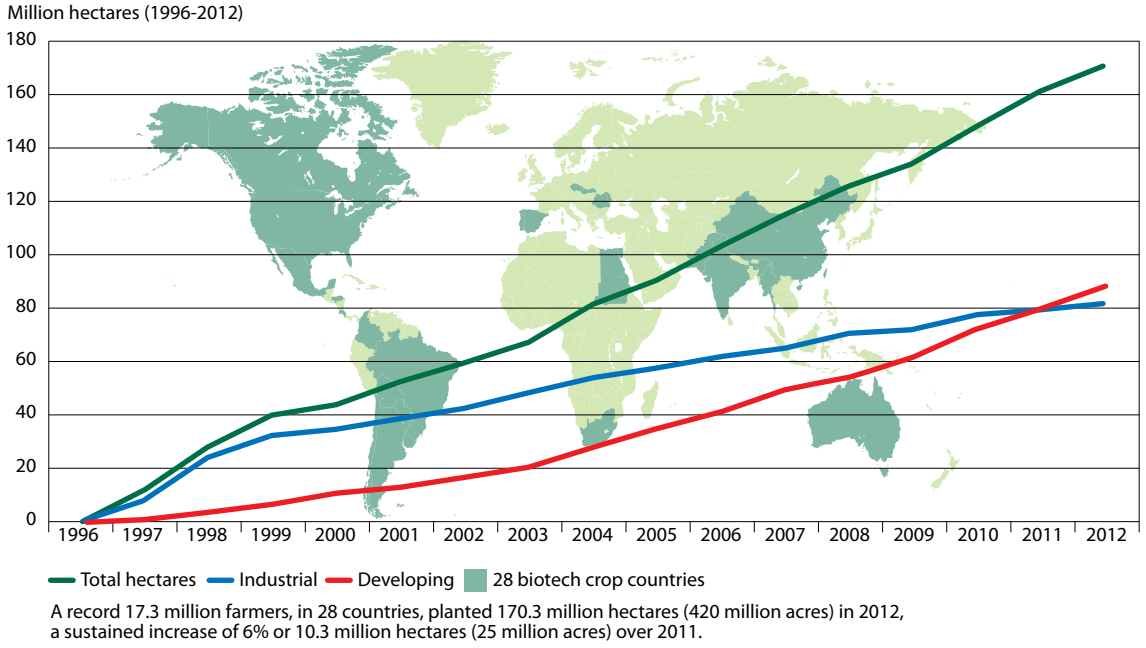
133 Ibid.

134 McLaren CG, Metz T, van den Berg M, Bruskiewich R, Magor N, and Shires D, 2009, Informatics in Agricultural Research for Development. *Advances in Agronomy*, vol 102, 135–157.

wide efficiencies and opened the way for further productivity gains by decreasing the area of the land compacted by machinery, through controlled traffic farming.

The most important breakthrough technology currently being applied in a number of industries is that of molecular genetics. This has lead in some cases to the use of genetically modified organisms (GMOs). In reality, GMOs are only one of a suite of genetic technologies being used to improve agricultural production[135, 136]. The introduction of this technology is proceeding rapidly across the globe in both developed and developing countries, with more than 160 Mha of crops currently planted cross all continents. The use of these technologies has not been without considerable public debate[137] and controversy, particularly in the European Union[138]. In Australia, the cotton industry has pioneered the use of these technologies to control major insect pests with considerable success, resulting in very significant reductions in chemical use and therefore contamination of the environment. If these ambitious productivity goals are to be met the full range of modern genetic technologies will be required[139]. Australia has an excellent regulatory system to ensure that both the experimental and commercial uses of these technologies are safe and responsible.

Figure 20 Penetration of biotech crops into global agriculture from 1996 to 2012[140].



A record 17.3 million farmers, in 28 countries, planted 170.3 million hectares (420 million acres) in 2012, a sustained increase of 6% or 10.3 million hectares (25 million acres) over 2011.

Ultimately, the commercial production of food and fibre is a managed biological system where science and technology is applied to optimise the outcomes. Increases in productivity are usually achieved through a combination of genetic and agronomic interventions, utilising chemical, spatial, and information technologies. An excellent example of this approach is the range of techniques that are being applied to increase the productivity of Australia's largest crop, wheat[141], as described in Table 5.

135 Langridge P, 2013, 'Food for thought', in *The Curious Country*, ANU Press, Canberra, pp. 62-65.
136 Tester D, 2012, 'Plant Breeding, plant nutrition, plant pest management in Horticultural and broadacre industries', in *Assessing the Opportunities for Achieving Future Productivity Growth in Australian Agriculture*, Australian Farm Institute.
137 Cormick, C (2007) Public Atitudes to GM Crops and Foods. *Agricultural Science* 21(2) :24-30
138 Langridge P, 2013, 'Food for thought', in *The Curious Country*, ANU Press, Canberra, pp. 62-65.
139 McLaren CG, Metz T, van den Berg M, Bruskiewich R, Magor N, and Shires D, 2009, Informatics in Agricultural Research for Development, *Advances in Agronomy*, vol 102, 135–157.
140 James C, 2012, *2012 ISAAA Report on Global Status of Biotech/GM Crops*, International Service for the Acquisition of Agri-biotech Applications, available at http://www.isaaa.org/resources/publications/briefs/44/pptslides/Brief44slides.pdf
141 Kirkegaard JA, and Hunt JR, 2010, Increasing productivity by matching farming system management and genotype in water-limited environments, *Journal of Experimental Botany*, vol 61, 4129-4143.

Table 5 Impacts of scientific developments on the potential yields of Australian wheat crops, indicating pathways to future increases in the face of climate change[142].

Changes to farming practices (cumulative)	Wheat yield (t/ha)	Increase in potential yield over standard practice (per cent)
Standard practice (1980s)	1.60	–
No-till farming	1.84	15
Fallow weed control	2.80	75
Break crop	3.45	116
Early planting	4.01	151
New varieties	4.54	184

The potential yield of wheat has more than doubled with the application of a cascade of technologies over the past three decades. The application of no-till farming and then fallow weed control led to dramatic yield increases due to much improved water conservation in the soils. This allowed farmers to utilise a greater proportion of annual rainfall to grow their crop. The next technology to be applied was growing a different crop in rotation, known as a break crop, to disrupt crop-specific disease cycles. With changes in climate resulting in more erratic autumn rains during crop sowing, the practice of sowing into dry soil has developed, known as early planting, to ensure the crop is ready for moisture whenever it arrives. Finally, new varieties in the research pipeline are expected to raise yields even further.

This example of productivity improvements for Australia's largest crop illustrates the need for a vibrant, coordinated and well-resourced innovation system to deliver the productivity increases required to achieve increased production goals while maintaining the natural resource base. These matters are discussed in detail in the following chapter.

142 Ibid.

5 Innovation

Australia is an innovation-driven economy. With Australia's high wages and associated standard of living, innovation is continuously required to create new industries and enhance the productivity of existing industries to keep Australia competitive.

In this section an overview of the Australian innovation system is provided to place agricultural innovation within an overall framework. This is followed by an examination of the performance of agricultural innovation in Australia.

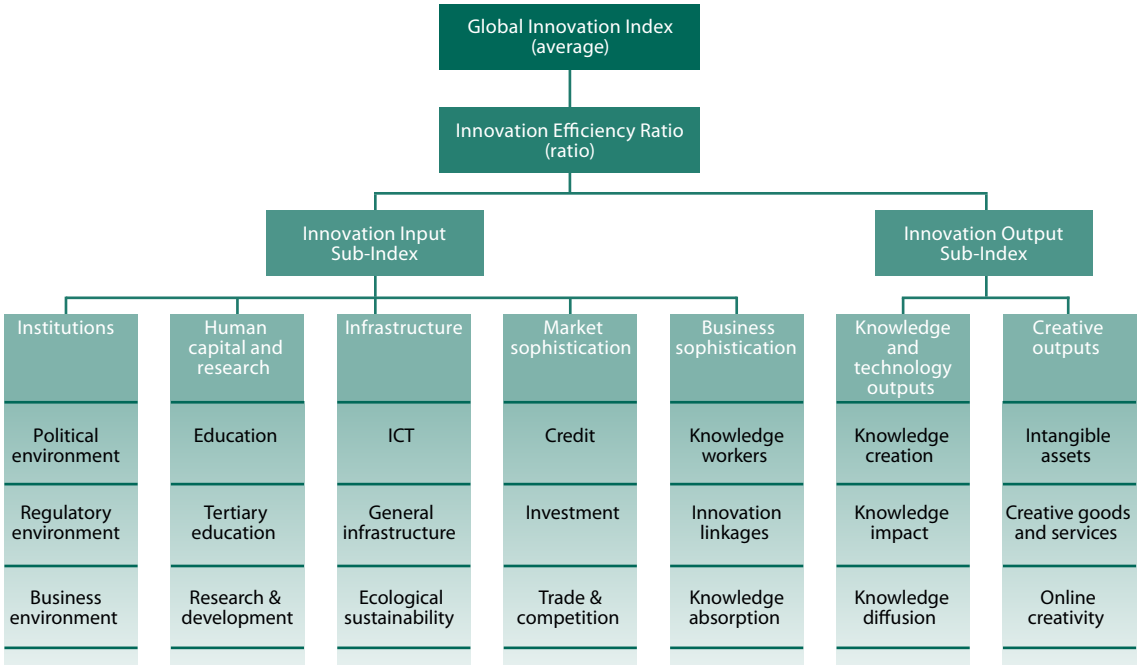
5.1 Australia's innovation system

Australia has a sophisticated innovation system. In 2013 Australia's innovation system ranked 19th in the Global Innovation Index[143]. This index examines five innovation input areas and two innovation output areas (Figure 21).

Australia's innovation strengths are predominantly in elements of the nation's economy which enable innovation activities – institutions, human capital, research, and market sophistication. Here Australia ranks 11th.

For the economy as a whole Australia trains people well, and has excellent institutions and market structures. What is lacking is the environment to realise this potential – to create and implement innovations. This is highlighted by Australia's poor performance in developing innovative linkages and its high dependence on knowledge imports. These aspects are discussed in greater detail below.

Figure 21 Framework of the Global Innovation Index[144].



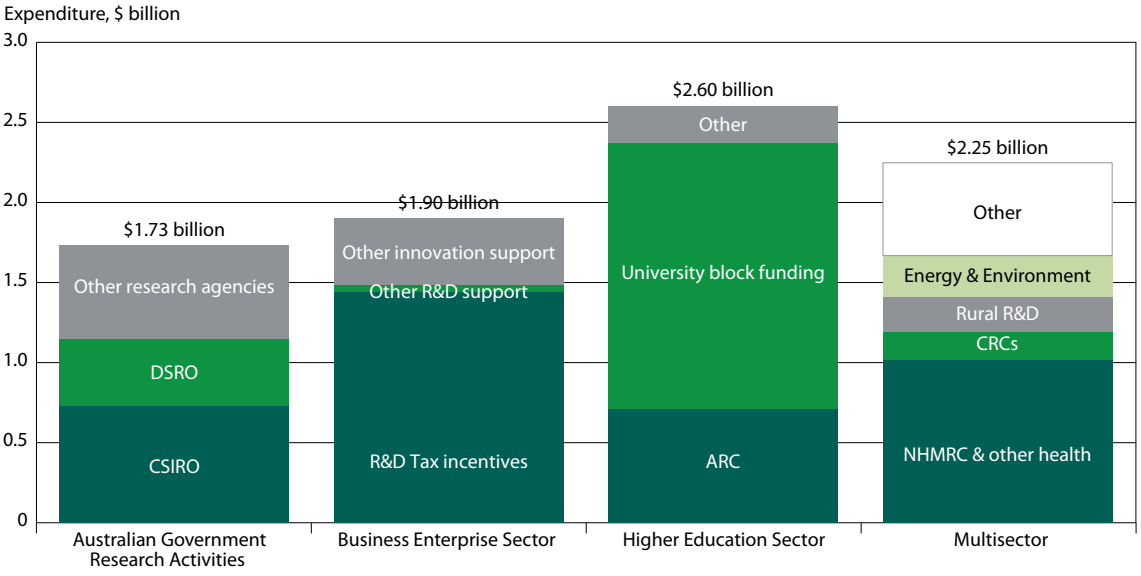
143 Dutta S, and Lanvin B [eds], 2013, *The Global Innovation Index 2013: The Local Dynamics of Innovation*, Cornell University, INSEAD, and WIPO.
144 Ibid.

Perhaps most telling is Australia's poor performance in the application of knowledge and technological outputs. While Australia performs well in the traditional research metrics of peer-reviewed publications and citations, the impact of this knowledge creation is low. Productivity growth, new business creation within Australia, and the export of innovative products and services is poor. This contrasts with the strength of Australia's innovation inputs, resulting in Australia sinking to 116th ranking based on the innovation efficiency ratio (i.e. the innovation input to output ratio, Figure 21).

5.1.1 Australian Government research investment

The Australian Government's total investment in science, research, and innovation was $8.47 billion in 2010-11 (Figure 22), ranking Australia 12th against OECD countries in research capacity investment[145]. Of the Australian Government's investment, approximately eight per cent ($0.72 billion) is committed to rural R&D[146] (Table 6). A further $0.78 billion is invested by state and territory governments and the private sector.

Figure 22 Australian Government expenditure on science, research and innovation, 2010-11[147].



The Australian Government invests significantly in universities. This investment, together with the Excellence in Research for Australia (ERA) program, translates into high-quality publications, with Australian researchers' productivity the 7th highest in the OECD and Australia performing well in citation indices[148]. Specifically for agriculture and veterinary science, publications rated at or above world standard[149].

Of concern is the apparent increasing disconnect between this quality research and the innovation system. It could be argued that the strong focus of the ERA on high quality publishing is producing research excellence that doesn't appear to be for the wider benefit of Australia. The impact of this quality research is not flowing through to innovation outputs[150]. This has significant implication for the whole

145 DIISRTE, 2012, *Australian Innovation System Report 2012*, Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia.
146 Productivity Commission, 2011, *Rural Research and Development Corporations*, Report No. 52, Final Inquiry Report, Canberra.
147 DIISRTE, 2012, *Australian Innovation System Report 2012*, Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia.
148 Ibid.
149 ARC, 2012, *Excellence in Research for Australia 2012: National Report,* Australian Research Council, Canberra.
150 Dutta S, and Lanvin B [eds], 2013, *The Global Innovation Index 2013: The Local Dynamics of Innovation*, Cornell University, INSEAD, and WIPO.

of the innovation system, with the Australian Research Council recognising that research needs to have a demonstrated wider impact to justify the significant investments made[151].

5.2 Agricultural innovation

Since the 1970s Australian agriculture has been reliant on innovation-driven productivity improvements to increase production and remain competitive (Figure 9). In agriculture, and across the economy, significantly bigger improvements to productivity than we have observed in recent years will be required to maintain competitiveness into the future[152].

This section draws on a number of recent reports examining productivity, innovation and R&D in Australian agriculture[153, 154, 155]. The objective is to identify potential changes in the innovation systems required to realise sustainable growth via new industries or the enhanced productivity of existing industries.

Investment in agricultural innovation in 2008-09 was about $1.5 billion[156]. About half of this investment came from the Australian Government, with agriculture accounting for 8.4 per cent of the Australian Government's total investment in innovation, as shown in Figure 22. A further $0.78 billion is invested by state and territory governments and the private sector.

Table 6 Australian expenditure on agricultural R&D, 2008-09[157].

Organisation type	Funding ($ million)	Share (%)
Australian Government		
Cooperative Research Centres	63	
Core funding for CSIRO	193	
Core funding for universities	118	
Research and Development Corporations (RDCs)	218	
Other departmental programs	114	
Forgone tax receipts arising from R&D tax concessions	9	
Total Australian Government	714	48
State and Territory Governments		
Project-related budget allocations	348	
Capital investment in R&D facilities	47	
Payments to other funders and suppliers	21	
Total State and Territory Governments	416	28
Private/Industry		
Levy payments provided to RDCs	248	
Other (for which a tax concession is claimed)	116	
Total Private/Industry	364	24
Total	**1495**	**100**

151 ARC, 2013, *Research Impact Principles and Framework*, Australian Research Council, available at http://www.arc.gov.au/general/impact.htm

152 Stevens G, 2011, *The Resources Boom: Understanding National and Regional Implications*, Victoria University Public Conference, February 23, 2011, Melbourne, Australia, available at http://www.rba.gov.au/speeches/2011/sp-gov-230211.html.

153 Mallawaarachchi T, Walcott J, Hughes N, Gooday P, Georgeson L, and Foster A, 2009, *Promoting productivity in the agriculture and food sector value chain: issues for R&D investment*, ABARE and BRS report for the Rural R&D Council, ABARE.

154 Dahl A, Leith R, Gray E, 2013, Productivity in the broadacre and dairy industries, *Agricultural Commodities*, vol 3, 200-220.

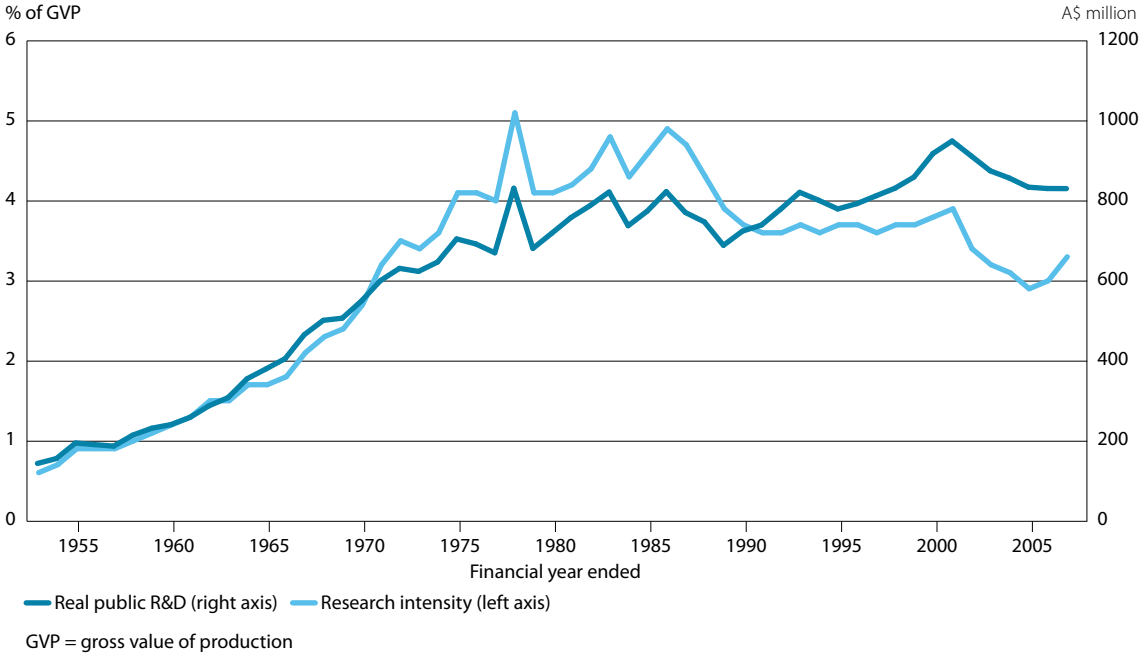
155 DIISRTE, 2012, *Australian Innovation System Report 2012*, Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia.

156 Productivity Commission, 2011, *Rural Research and Development Corporations*, Report No. 52, Final Inquiry Report, Canberra.

157 Ibid.

While Australia has a well-established rural R&D capability, funding has stagnated. Little real growth in rural R&D investment has occurred since the mid 1970s (Figure 23)[158]. This has been identified as a major factor in the observed slowdown in agricultural productivity growth.

Figure 23 Real public R&D investment and research intensity in Australian agriculture, 1952–53 to 2006–07[159].



GVP = gross value of production

In the past decade there has also been a decline in broader cross-sectoral rural research. The abolition of Land and Water Australia and reductions in the appropriation to the Rural Industries Research and Development Corporation for non-industry-focused R&D has seen research underfunded and under-provided for across land, water, energy and biodiversity. This was recognised as a major issue, and a new organisation was proposed[160], but no new entity has emerged and existing rural Research and Development Corporations (RDCs) have responded slowly to the government directive to increase cross-sectoral programs.

The lack of any broader cross-sectoral research capacity across land, water, energy and biodiversity has significant implications for the innovation required to achieve sustainable growth. The time lag between R&D investment and agricultural productivity improvements is measured in decades[161]. With broader cross-sectoral research investment orphaned and underfunded, the knowledge base for innovations in the coming decades will simply not exist when resource constraints such as land, water and energy, and the impact of potentially declining on-farm and off-farm natural capital, become critical.

Furthermore, Australia cannot rely on 'spill-in' from international research. Australia's unique natural resources call for innovations which may be uniquely Australian. Australia's reliance on 'fast-follower' innovation may leave agricultural industries unprepared to increase productivity in a more resource-limited environment.

158 Sheng Y, Mullen JD, and Zhao S, 2011, *A turning point in agricultural productivity: consideration of the causes*, ABARES research report 11.4 for the Grains Research and Research and Development Corporation, Canberra.
159 Ibid.
160 Productivity Commission, 2011, *Rural Research and Development Corporations*, Report No. 52, Final Inquiry Report, Canberra.
161 Alston JM, Andersen MA, James JS, and Pardey PG, 2010, *Persistence pays: US agricultural productivity growth and the benefits from public R&D spending*, Springer, New York.

Further up the value chain there is also concern about the lack of innovation investment in the food processing sector[162]. Innovation is crucial to Australian food exports moving to higher-value products. Innovation in both processes and products are required for Australia to continue to compete and expand both domestically and in growing Asian markets. The food processing industry is currently under-investing in innovation[163]. In the longer term a failure to invest in innovation may result in companies not being able to maintain their brands due to cost pressures or from new product offerings from competitors which cannot be matched.

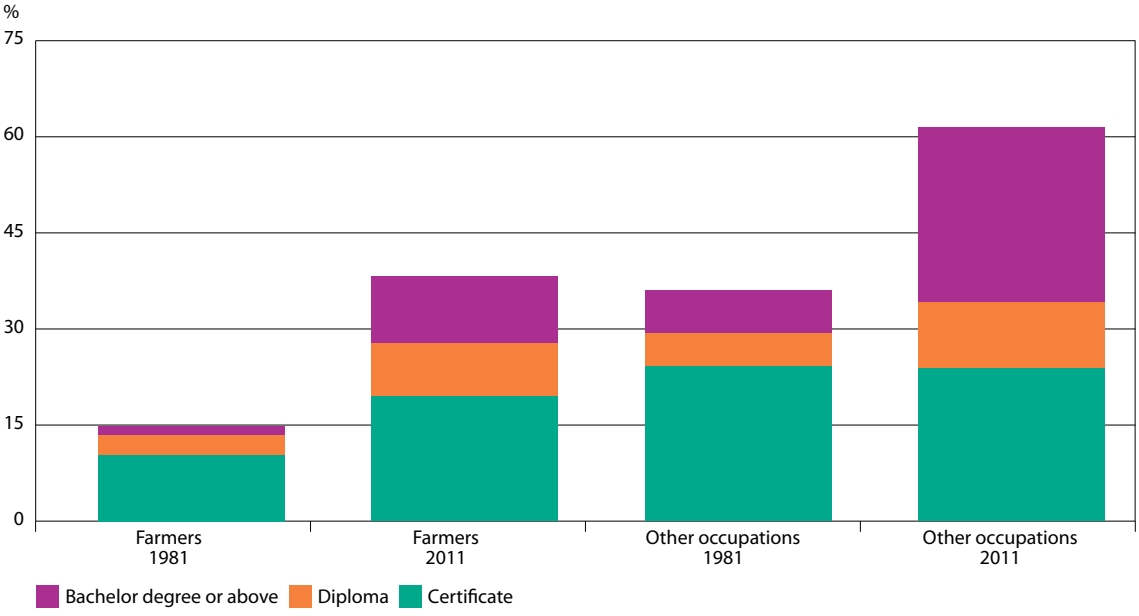
5.2.1 Skills and innovation

Innovation is about people. The generation and implementation of new ideas and products, adaption of new technological and organisational change requires a highly-educated and skilled workforce. Taken across the whole economy, Australia ranks well internationally in areas such as knowledge workers, and secondary and tertiary education[164], but a lack of skilled people has been the highest single reported barrier to innovation in Australian businesses in recent years[165].

For Australia to capitalise on future food and fibre export opportunities, a range of educated and skilled people will be required across the value chain. Furthermore, if sustainable growth is to be achieved this requirement will expand to include other supporting disciplines in the areas of environmental management, food processing, finance, marketing, and management.

At the farm level there are growing numbers of farmers pursuing formal educational qualifications[166]. This is in recognition of farm businesses becoming increasingly complex, requiring both technology and business understanding. Over the three decades to 2011, the proportion of Australian farmers with post-secondary qualifications more than doubled, from 15 per cent to 38 per cent (Figure 24). The largest increase was

Figure 24 Changes in tertiary qualifications of farmers compared to other occupations, between 1981 and 2011[167].



162 Australian Food and Grocery Council, 2012, Submission in response to the National Food Plan Green Paper, Australian Food and Grocery Council.
163 AFGC and AT Kearny, 2011, *2020: Industry at a Crossroads*, Australian Food and Grocery Council, AT Kearny.
164 Dutta S, and Lanvin B [eds], 2013, *The Global Innovation Index 2013: The Local Dynamics of Innovation*, Cornell University, INSEAD, and WIPO.
165 DIISRTE, 2012, *Australian Innovation System Report 2012*, Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia.
166 ABS, 2012, *4102.0 - Australian Social Trends, Dec 2012: Farmers in Australia*, Australian Bureau of Statistics.
167 Ibid.

in the proportion of farmers with a bachelor degree or above. This was most pronounced for the younger generations of farmers. For example, in 2011 half of farmers aged 25 to 44 years had post-secondary qualifications, compared with just a third of those aged 45 and over. However, despite this growth agriculture has the lowest number of workers with post-secondary qualifications of any economic sector.

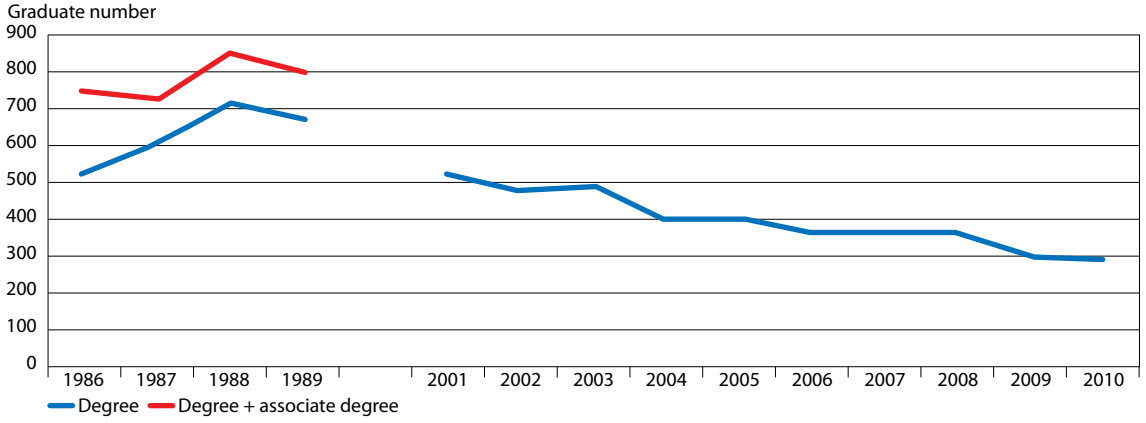
The increase in farmer education levels has a substantial effect on the rate and extent of adoption of innovations[168]. Skills training and education will become increasingly important to agriculture against a backdrop of a tightening labour market, increasingly sophisticated farm technologies, and the emerging importance of integrated management for both on-farm production (managing weeds, diseases and pests), and off-farm where the impact of farming practices on water, carbon, energy and biodiversity will become increasingly important.

In addition, farmers with a greater ability to effectively integrate innovations into farming systems – measured using farm-level indicators of innovative capacity – are also more productive, on average. Several relevant implications emerge from these results, particularly with regard to the role of innovative capacity as a driver of productivity growth. While some grain growers are highly innovative, considerable variability remains in the level of productivity that growers have achieved. These results imply that increasing the extent of innovation adoption and the ability of farmers to effectively integrate innovations into production systems are critical for improving productivity at the farm level[169].

University-level agricultural education has been in decline for the past 20 years, declining from around 800 graduates per year in the late 1980s to 300 in 2010 (Figure 25). This is despite workforce demand being estimated at 13,000 to 14,000 positions each year[170].

"In the agricultural sector, there is an ongoing labour market shortage in the field of agricultural science. In 2010, only 40% of advertised positions were filled and there were 1.1 applicants for each job. This is down from 65% filled vacancies and 1.4 applicants per job in 2009."[171]

Figure 25 Graduate completions in three- and four-year agriculture courses from Australian universities, for the period 2001–09 inclusive. Figures for 1986–89 are estimated from the McColl report, including two-year associate degrees[172].



168 Mallawaarachchi T, Walcott J, Hughes N, Gooday P, Georgeson L, Foster A, 2009, *Promoting productivity in the agriculture and food sector value chain: issues for R&D investment,* ABARE and BRS report for the Rural R&D Council, ABARE.

169 Nossal K, and Lim K, 2011, *Innovation and productivity in the Australian grains industry*, Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture.

170 Prately J, 2012, *Professional agriculture – a case of supply and demand*, Australian Council of Deans of Agriculture.

171 Elders Limited, 2011, Submission to the inquiry into higher education and skills training to support agriculture and agribusiness in Australia, The Senate Education, Employment and Workplace Relations Reference Committee, Commonwealth of Australia.

172 Prately J, 2012, *Professional agriculture – a case of supply and demand*, Australian Council of Deans of Agriculture.

There is a significant issue with regard to the 'people' part of innovation. This has the potential to impact negatively on Australia's ability to remain competitive and seize the new food and fibre opportunities. To address the skills shortage a broad range of measures are required[173].

5.2.2 Collaboration

As products and processes become more complex and their lifecycles shorten the importance of collaboration increases. This complexity and rapid turnover means few organisations have the necessary skills and knowledge to deliver innovation in-house. As a result organisations collaborate to: solve complex problems creatively; share knowledge, material resources and risk; build skills and other capabilities; stay abreast of new developments; and, in the case of businesses, expand their market reach and achieve economies of scale[174].

Collaboration is a feature of the Australian rural R&D landscape. The need for the RDCs to engage with multiple stakeholders and their role in mobilising funding from several sources means that they are inherently collaborative entities as indicated by the high level of collaborative research, development and extension (RD&E) investments (Table 7).

Table 7 Proportion of RD&E investments by RDCs which involve collaboration, 2009-10[175].

RDC	Collaborative investments %	Non-collaborative investments %
Australian Egg Corporation Ltd.	56	44
Australian Meat Processor Corp.	99	1
Australian Pork Ltc.	93	7
Australian Wool Innovation	89	11
Cotton RDC	88	12
Dairy Australia	98	2
Fisheries RDC	95	5
Forest and Wood Products Australia	70	30
Grains RDC	90	10
Grape and Wine RDC	55	45
Horticulture Australia Ltd.	71	29
LiveCorp	100	0
Meat and livestock Australia	51	49
Rural Industries RDC	98	2
Sugar RDC	98	2
Weighted average	**80**	**20**

173 The Senate Education, Employment and Workplace Relations Reference Committee, 2012, *Higher education and skills training to support agriculture and agribusiness in Australia – final report*, Commonwealth of Australia.

174 MacCormack A, Forbath T, Brooks P, and Kalaher P, 2007, *Innovation through global collaboration: A new source of competitive advantage*, Harvard Business School Working Paper 07-079; AiG, 2010, *Innovation: New Thinking New Directions*, report by the Innovation Review Steering Group, Australian Industry Group; Ternmouth P, Herrmann K, and Docherty D, 2010, *Absorbing Research: The role of university research in business and market innovation*, CIHE, London; D'Este P, and Perkmann M, 2010, Why do academics engage with Industry? The entrepreneurial university and individual motivations, *The Journal of Technology Transfer*, vol 36, 316-339; Cosh A, Fu X, and Hughes A, 2005, *Management characteristics, collaboration and innovative efficiency: Evidence from UK survey data*, University of Cambridge Centre for Business Research, Working Paper 311; Spoehr J, Barnett K, Molloy S, Vas Dev S, Hordacre AL, 2010, *Connecting Ideas: Collaborative Innovation for a Complex World, Australian Institute for Social Research*, Department of Further Education, Employment, Science and Technology, South Australia.

175 Productivity Commission, 2011, *Rural Research and Development Corporations*, Report No. 52, Final Inquiry Report, Canberra.

In recent years the Primary Industries Ministerial Council, the Australian, state and Northern Territory governments, RDCs, CSIRO and universities have been jointly developing the National Primary Industries Research, Development and Extension Framework to encourage greater collaboration and promote continuous improvement in the investment of RD&E resources nationally. Twenty-two sectoral and cross-sectoral strategies have been completed[176]. These are the first attempt to build cooperation across the formal innovation systems and have had variable success in implementation.

The Cooperative Research Centre program has run since 1990 during which time 200 CRCs have been funded. The Australian Government has committed more than $3.7 billion in CRC program funding. Participants in CRCs have committed a further $11.7 billion in cash and in-kind contributions.

The CRC program differs significantly from other R&D support measures. The program's medium-to-long-term funding cycle and the requirement for engagement with end-users make the program a unique mechanism to pursue relevant research to address major industry challenges in any industry throughout the economy.

In the first phase of the CRC program agriculture accounted for 27 per cent of the CRCs in operation. When CRCs with a focus on natural resources (Services Sector) are included this increases to 38 per cent of CRCs (based on CRCs operating in 1997)[177]. Today, agriculture represents just 19 per cent of CRCs and there are no natural-resources-focused CRCs. With many of the agricultural CRCs nearing the end of their funding cycle Australia's main collaborative R&D program will have little investment in agriculture at a time of lagging productivity growth and growing opportunities.

The economic benefits generated from these agricultural CRCs appear better than other sectors. In the period 1991 to 2012 agriculture CRCs generated 43 per cent of the direct economic benefits, but only accounted for 27 per cent of CRCs (Table 8)[178]. Furthermore, there is a significant tail to those benefits with agricultural CRCs projected to deliver 43 per cent of the direct economic benefits despite declining investment by the CRC program. By including sustainability within commercially-oriented research programs, environmental benefits including impacts on land, ecosystems, pollutants, natural resources, plants, animals, and biodiversity can also be contributed by CRCs.

If Australia is to achieve sustainable growth in food and fibre the investment in export-orientated industry CRCs that include cross-sectoral natural resources considerations will need to increase.

Table 8 The direct economic benefits of the CRC program by sector ($ millions 2012)[179].

Sector	1991-2012	2013–17	Average annual	Total current value
Agriculture	3649	2501	237	6150
Services	3125	2558	219	5683
Mining	1177	372	60	1549
Manufacturing	628	440	41	1068
Total	**8580**	**5872**	**556**	**14,452**

Note: It should be noted that in addition to reflecting on the relative performance of CRCs in different sectors, these impacts have also been influenced by changes in program objectives over the years and the availability of data.

176 NPIRDEF, Strategies, National Primary Industries Research, Development and Extension Framework, available at http://www.npirdef.org/strategies.

177 CRC Australia, 2011, CRC Directory: Cooperative Research Centres Program 2011-12, Cooperative Research Centres Program, Commonwealth of Australia, available at https://www.crc.gov.au/Publications/Past-publications/Pages/default.aspx.

178 Allen Consulting Group, 2012, *The economic, social and environmental impacts of the Cooperative Research Centres Program*, report to the Department of Industry, Innovation, Science, Research and Tertiary Education, Commonwealth of Australia.

179 Ibid.

6 Conclusions and Recommendations

Global trends in population growth, increasing wealth and urbanisation are projected to increase global food demand by 70 to 100 per cent by 2050. There is good evidence that demand is already rapidly increasing with the recent severe spikes and general rise in the United Nations Food and Agriculture Organization Global Food Price Index. Urbanisation and increasing wealth are resulting in increased demand for dietary animal protein, safe, high quality, fresh and processed food products. Urbanisation can also lead to significant changes in food distribution to the 'supermarket' model with corresponding opportunities for branded products to be placed on the shelves.

The supply side of the global food equation is also being challenged by the decreasing availability of unexploited renewable natural resources such as land and water and increasing competition for these natural resources from industrial crops such as biofuels. Productivity growth has stagnated globally following the significant gains of the 'Green Revolution'. This rising imbalance between supply and demand in the global food equation is being further exacerbated by global climate change. Rising temperatures and increased frequency of extreme weather conditions are negatively impacting upon the quest to further increase agricultural productivity.

Much of the global population growth and increasing wealth is concentrated in Asia. Over the past three decades Australia has developed expertise in supplying Asian markets with China, Japan and South Korea currently being our largest food export markets. Indonesia and India are also emerging as export markets of considerable potential. The proximity of these Asian markets and Australia's growing experience in servicing them underlines the potential growth opportunities for the agrifood sector. There is significant international competition to satisfy these growing global food markets from Australia's traditional competitors in North America, near neighbours New Zealand, and rapidly emerging economies such as Brazil and Chile. Any competitive advantage in these markets will vary on a national and as well as sectoral basis, with free trade agreements, transport and labour costs playing an important role.

Australia's capacity to capture a share of the growth in these emerging food markets is not unlimited. Australian agrifood industries are traditionally export-based, and currently export 60 to 80 per cent of their production, predominantly as basic commodities like grains, beef, sheepmeat, dairy products, cotton and wine. Despite being a major food and fibre exporter Australia is not a large agrifood producer in global terms because of its limited agriculturally exploitable natural resource base. In southern Australia agricultural land and water resources are almost fully developed with the exception of the possibility of some further irrigation development in Tasmania. Northern Australia is currently being reassessed for further cropping and irrigation development. Preliminary indications are that while some significant new regional resources may be available, they are not significant on a global export scale.

Australia's capacity to compete strongly in these evolving markets will largely depend on its capacity to innovate. Although not part of this report, favourable access to markets and capital have been identified elsewhere as critical components in further export development. Increasing export volumes will require continual increases in productivity through sustainable intensification in both existing and emerging export orientated industries. Australia has strong traditions and excellent institutions in agricultural innovation but productivity gains have slowed in recent decades with decreasing investment and increasing divergence and fragmentation within the innovation system.

The second major avenue of export growth in the agrifood sector is creating greater value per unit of production through moving further up the value chain towards the consumer. Australian agriculture has a well-earned reputation for producing safe, high-quality agrifood products from well-regulated production systems and environments. Generally we have not been able to extract significant extra value from these excellent credence attributes. This is related to the majority of our agrifood products being exported as raw or minimally transformed commodities. As such they are not immediately identifiable in international market places and therefore cannot command extra value. There is an opportunity for significant innovation in this area to establish an overarching 'Brand Australia' concept that can create further value for agrifood products in export markets. One challenge of this innovation will be to leverage existing national environmental, phytosanitary, and livestock identification systems to verify the quality and safety of Australian products without adding extra costs.

6.1 Future opportunities for sustainable growth

The national response to these agrifood export opportunities must be initially through the prism of limited availability of new natural resources for agricultural development. Therefore the pathways to seizing the emerging agrifood opportunities are largely channelled through:

- productivity increases within current export industries;
- development of new industries that are not necessarily competing for the natural resources currently being utilised by agricultural industries, such as high value aquaculture and to a limited extent biofuels; and
- increase the market value of agrifood products through;
  - capturing a greater portion of the value chain locally;
  - transformation of food commodities into higher value products;
  - production of high value fresh produce; and
  - credible certification and authentication of Brand Australia products as safe quality food of known provenance.

The recent National Food Plan and some associated state government goals require growth in economic agricultural outputs of at least four per cent per annum for the next two to three decades. These are very unlikely to be achieved through productivity increases alone. Achieving this national goal will require increasing both volume and value of the agrifood products produced by food and fibre industries.

As population and agrifood demand changes globally there are also medium-term possibilities for new industries that use currently unutilised natural resources or currently use resources in a different way. In this area aviation biofuels and fisheries in the form of prawns and lobster may be promising opportunities.

6.2 Challenges to capturing these opportunities

The greatest threats to capturing these agrifood opportunities as part of the global 'dining boom' are complacency, lack of national focus, and disaggregation of agricultural industries. International competition is strong and developing rapidly in the agrifood sector. Australia must concentrate on enhancing its few natural competitive advantages. Traditional competitors such as the US, Canada, the European Union and Eastern Europe will remain strong and generously supported. Emerging food exporters in Brazil, Argentina and Chile are already significant global suppliers and this can be expected to increase in the future. Our relative proximity and increasing engagement with Asia is a significant competitive advantage, but any freight cost advantages but are more than balanced by Australia's higher production costs in labour, inputs, and regulatory compliance.

Australia is going to have to be smart and compete aggressively in these rapidly emerging international markets if we are to capture a significant share of their value. This will require a significant broadening and strengthening of expertise as branded food and fibre exporters and organisation and coordination of

the well-established research and innovation base informed by responsible natural resource management. Australia's stable democracy and well-managed financial system also confer a competitive advantage in facilitating the further development of the nation's agrifood export industries by attracting essential additional capital investment, both from foreign sources and patient capital within Australia. Within this national agribusiness investment future also lies the opportunity for strategic food security foreign partnerships with food importing nations.

6.3 Findings and Recommendations

For Australia to be ready to take advantage of the strategic opportunities outline in this report, ATSE recommends the follow actions.

1) Develop a long-term strategy

Australia needs a long-term policy vision with focus on export growth and high value-add (resulting in enhanced profitability that flows back to all sectors including to farm gate).

Recommendation 1 *Develop a multi-decadal, bipartisan national vision and rolling five-year strategy to focus and direct the sustainable growth of agrifood and fibre export industries, guided by a high-level Australian Agrifood and Fibre Forum, representing governments, researchers, industry and communities, chaired by the Minister.*

1.1 *As part of this strategy, convene an agrifood investment taskforce incorporating industry, finance and superannuation sectors to recommend innovative mechanisms to encourage patient investment in all aspects of the Australian agrifood and fibre sector.*

The targeted sustainable growth of agrifood export industries should be substantial, add materially to Australia's wealth and should involve a whole-of-government approach. The pathways, potential impediments and goals for growth should be advised by a high-level Agrifood and Fibre Forum chaired by the Minister.

The need for significant investment in the sector has been strongly acknowledged by recent business consultancy reports. International investment in agricultural production and agrifood processing and trading facilities has not been matched domestically. The need for patient and committed capital indicates the potential benefit of partnerships with capital-rich export markets such as China, Korea and Japan in food production and processing, as well as jointly funded research, facilitated by bilateral trade agreements.

2) Leverage Australia's competitive advantage through 'Brand Australia'

To target high-value export markets, Australia needs to build and promote global brand recognition of Australia's food and fibre products – Brand Australia.

Recommendation 2 *Develop and implement a robust 'Brand Australia' concept through industry and government collaboration with credible accreditation and authentication processes that utilise Australia's existing agrifood regulatory system.*

2.1 *'Brand Australia' accreditation and authentication processes should utilise strategic advantages in nationally available natural resource management systems, including environmental, phytosanitary and livestock identification, to demonstrate and authenticate the safety, traceability and environmental credentials of Australian agrifood and fibre produce.*

2.2 *The Rural Research and Development Corporation system should be supported to participate in cross-sectoral programs to develop the required accreditation processes and demonstrate and authenticate the superior safety and quality attributes of 'Brand Australia' agrifood and fibre produce.*

Australian agricultural produce is some of the safest and highest quality in the world. To better leverage this comparative advantage, an accreditation system that guarantees the safety, quality, and provenance of Australian grown and processed agrifood produce should be developed, to be marketed through a 'Brand Australia' concept. Brand Australia-certified produce would command a premium position in both local and export markets. The guiding principle of the design of Brand Australia accreditation would be the utilisation of the latest technologies to collect and transform production, environmental, and statistical data that is already routinely collected, to minimise business costs.

Australia's investments in natural resource management through Landcare, the National Heritage Trust and now the Caring for Country program represent an asset that can be realised commercially by using audits, Australian Bureau of Statistics (ABS) surveys and national greenhouse inventories to authenticate the credentials and provenance of Australian food and fibre exports, including for livestock through the national identification system and smart tags.

This natural resource management planning, ongoing investment, and monitoring has not previously been utilised systematically to authenticate the safety, biosecurity and environmental credentials of Australian food and fibre exports. Utilised strategically at a national, regional and individual product level this attention to and monitoring of the safety and environmental performance of Australian food and fibre industries has the potential to provide a competitive advantage to generate premium returns in the growing middle-class markets of Asia.

3) Improve Australia's innovative capacity

To be globally competitive, Australia must stay ahead of the pack in innovation. This means the agricultural innovation system must be focused, coordinated and well-resourced to enable Australia's world-class research to be translated into innovative Australian agribusiness with a focus on value-add. There are opportunities to reinvigorate components of Australia's agricultural innovation system, including investing in knowledge creation, enabling uptake by industry and facilitating essential workforce development.

Recommendation 3 *Significantly increase investment in agricultural and agrifood-based research, development, and advisory programs by industry and governments, including investment in substantial international partnerships, to provide a platform for Australia to achieve the continued increases in productivity necessary to remain competitive and develop emerging export opportunities.*

3.1 *Encourage cooperation between industry, governments and research providers to better coordinate, connect and translate research, as well as identify future research needs.*

3.2 *Enhance student recruitment into agrifood related education programs, including research.*

Investments in research and development have been shown to produce high rates of return in both the Cooperative Research Centre and Rural Research and Development Corporation programs over extended periods. Over the past decade research, development and extension investment in the sector has waned and annual productivity gains have declined. The agrifood innovation system has also undergone significant change in the past decade, including governance changes in the Rural Research and Development Corporations, reorganisation and shifting of focus of Commonwealth and state departments, changes in university research and development, and educational focus.

The nature of Australia's international partnerships in agricultural research and development is also changing, with the rapid emergence of new trading and scientific powers raising the possibility of developing relationships and encouraging investment from target export markets.

4) Enable collaboration & translation for value-adding

To build a more robust Australian industry sector, we need enhanced networks and connectivity nationally between researchers, growers, industry producers and marketers. This requires rethinking current linkages. Global collaboration is an important aspect of enhancing the quality of our research as well sharing risks associated with deployment of innovation and development of new value add business opportunities. Collaborative networks such as the Food Innovation Australia Limited Collaborative Centre of Excellence provide a platform for agrifood businesses to connect with researchers through rural research and development corporations, universities, cooperative research centres, CSIRO, and state government research organisations.

Recommendation 4 *Invest in collaborative networks connecting research organisations and businesses to encourage and enable Australian and international agrifood businesses to undertake local value-adding, through better access to new technologies and cutting-edge research, and to participate strategically in global value chains.*

By investing in collaborative networks, governments can encourage and facilitate innovation across the whole food and fibre value chain, and better translation of new agrifood processing technologies. Being involved in collaborative networks with international agrifood businesses will also allow Australian small and medium enterprises to take advantage of greater opportunities to participate in global value chains.

The 'Brand Australia' accreditation system, which would apply only to Australian grown and processed products, will provide another incentive for agrifood and fibre businesses to undertake local processing and value-adding of Australian produce in favour of using other, lower cost-base environments.

Glossary

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
Agrifood	Agriculturally produced food commodities
ARC	Australian Research Council
ATSE	Australian Academy of Technological Sciences and Engineering
bbl	Standard barrel of oil, 42 US gallons
CFI	Carbon Farming Initiative
CO_2	Carbon dioxide
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ERA	Excellence in Research for Australia
Extension	Improving the practical application of knowledge and technology to agricultural production
FAO	Food and Agriculture Organization of the United Nations
GCI	Global Competitiveness Index, as produced by the World Economic Forum
GDP	Gross domestic product
GL	Gigalitres, billion litres
Mha	Million hectares
ML	Megalitres, million litres
Mt	Million tonnes
NRM	Natural resources management
OECD	Organisation for Economic Cooperation and Development
Phytosanitary	Relating to the control of diseases, pests or parasites of plants, usually agricultural crops, and in regards to international quarantine and trade
ppm	Parts per million
R&D	Research and development
RD&E	Research, development and extension
RDC	Rural Research and Development Corporation
Soft commodities	Any commodity that is grown, as opposed to being mined or extracted
TFP	Total factor productivity: the ratio of total or agricultural output to total input including labour, capital, materials and services, and other natural resources

ATSE – in brief

The Academy of Technological Sciences and Engineering (ATSE) is an independent, non-government organisation, promoting the development and adoption of existing and new technologies that will improve and sustain Australia's society and economy.

ATSE consists of some 800 eminent Australian Fellows and was founded in 1976 to recognise and promote outstanding achievement of Australian scientists, engineers and technologists.

ATSE provides a national forum for discussion and debate of critical issues about Australia's future, especially the impact of science, engineering and technology on quality of life.

ATSE links Australia with leading international bodies and worldwide expertise in technological sciences and engineering.

ATSE fosters excellence in science, engineering, and technology research and the critical education systems that underpin Australia's capacity in these areas.

ATSE tackles many of the most difficult issues governing our future, by offering fresh ideas, practical solutions and sound policy advice – and putting them on the public record.

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