

SECURING
AUSTRALIA'S
FUTURE

Australia's Agricultural Future

7

PROJECT

FINAL REPORT

AUSTRALIAN ACADEMY
OF THE HUMANITIES
AUSTRALIAN
ACADEMY OF SCIENCE
ACADEMY OF THE SOCIAL
SCIENCES IN AUSTRALIA
AUSTRALIAN ACADEMY
OF TECHNOLOGICAL
SCIENCES AND ENGINEERING



SECURING AUSTRALIA'S FUTURE

Funded by the Australian Research Council and conducted by the four Learned Academies through the Australian Council of Learned Academies for the Australian Chief Scientist and the Commonwealth Science Council. *Securing Australia's Future* delivers evidence-based research and interdisciplinary findings to support policy development in areas of importance to Australia's future.

EXPERT WORKING GROUP

Dr Joanne Daly PSM FTSE (Chair)
Professor Kym Anderson AC FASSA
Professor Rachel Ankeny
Professor Graham Farquhar AO FAA FRS NAS
Professor Bronwyn Harch FTSE
Professor John Rolfe
Professor Richard Waterhouse FAHA FASSA

AUTHORS

Dr Joanne Daly
Professor Kym Anderson
Professor Rachel Ankeny
Professor Bronwyn Harch
Dr Andrew Hastings
Professor John Rolfe
Professor Richard Waterhouse

PROJECT MANAGER

Dr Andrew Hastings

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Level 1, 1 Bowen Crescent
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Telephone: +61 (0)3 98640923
www.acola.org.au

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REPORT DESIGN

Lyrebird
joashley@live.com.au

Australia's Agricultural Future



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Acronyms

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACOSS	Australian Council of Social Services
AFF	Agriculture, forestry and fisheries
ALA	The Atlas of Living Australia
ASRIS	Australian Soil Resource Information System
ATSE	Australian Academy of Technological Sciences and Engineering
AUD	Australian Dollar
BSE	Bovine spongiform encephalopathy
CIE	The Centre for International Economics
COAG	Council of Australian Governments
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
DEEWR	Department of Education, Employment and Workplace Relations
DFAT	Department of Foreign Affairs and Trade
EU	European Union
EWG	Expert Working Group
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia and New Zealand
FTE	Full-time equivalent (employees)

GDP	Gross domestic product
GL	Gigalitres
GM/GMO	Genetically modified/ Genetically modified organism
GRDC	Grains Research and Development Corporation
GVP	Gross value of production
ICT	Information and communication technologies
Mha	Million hectares
ML	Megalitres
MLA	Meat and Livestock Australia
NFF	National Farmers' Federation of Australia
OECD	Organisation of Economic Cooperation and Development
PC	Productivity Commission
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
R&D	Research and development
RCL	Revenue contingent loan
RDC	Rural Research and Development Corporation
SAF	Securing Australia's Future
TFP	Total factor productivity
TOT	Terms of trade
UK	United Kingdom
USA	United States of America
USD	United States Dollar
WTO	World Trade Organization

All dollar values are in Australian dollars unless otherwise stated.



Project aims

Australia's agricultural sector is at a crossroads. Global population growth and increasing affluence in our neighbouring trading partners will present unprecedented opportunities for growth, but agriculture is also facing unprecedented pressures through climate change and climate variability, access to finance, and social and workforce issues.

Australia's Agricultural Future identifies these opportunities and barriers for the agricultural sector in the context of complex social and political issues around rural and regional Australia,

This project aimed to address issues including, but not limited to, the following:

- Identify the factors affecting Australian agriculture's comparative advantage (clean, green, safe, affordable, sustainable and ethical).



- Draw together, examine and articulate the multiple and competing factors impacting the short and long-term sustainability of Australian agriculture.
- Examine Australian agriculture's ability to predict opportunities and challenges and effectively respond and prosper.
- Examine how practices that ensure short-term profitability and producer survival, impact on (and can be reconciled with) the sector's long-term comparative advantage.
- Identify examples by which Australian agriculture can increase productivity without compromising its social licence to operate.



Executive summary

The focus of the report is on emerging issues that may impact on the capability of Australia's agricultural industries to respond to future increases in global demand, particularly in Asia. The report's major conclusions are outlined in Box 1. Overall, Australian agriculture's history of deep resilience, innovation and adaptability encourages optimism.

This report does not attempt to provide a comprehensive view of all opportunities and challenges facing the sector. Instead, it focuses primarily on on-farm issues that: draw on expertise across many areas of activity; challenge our perceptions of agriculture; and require radical thinking and analysis to understand their full impact.

The Federal Government released its Agricultural Competitiveness White Paper, *Stronger Farmers, Stronger Economy*, while this report was in press (Commonwealth of Australia 2015a). As such it was not possible to integrate a review of the white paper into this report's findings. Overall, there is remarkable resonance between the findings and conclusions of this report and the Government's White Paper.



The foundational needs that will stimulate growth in agricultural industries are shared across other industry sectors in Australia

The agricultural sector is often seen as special, and different from other sectors of the economy. This obscures the common threads that will underpin future economic development across the economy: the need for a highly skilled and technically savvy workforce; adequate access to high-quality infrastructure, including transport and telecommunications; and access to appropriate investment and financing to enable change.

Agriculture does face unique challenges due to the special status of food, our relationship to the land, and agriculture's importance for the prosperity of rural and regional Australia. Such challenges include the need to sustain Australian agriculture's international reputation for safe and sustainably produced food, and to satisfy consumer concerns about the quality of food and ethical considerations relating to the means of production.

Box 1: Major conclusions for Australia's agricultural future

1. Australia's agricultural sector has a bright future with continuing comparative advantage in the export of bulk commodities and increasing opportunities to respond to the growth in demand for high-value products domestically and in Asia.
2. Australia's reputation for 'safe, clean and green' food is a major comparative advantage that needs to be sustained and underpinned by internationally recognised standards and certification.
3. In order to meet increased demand, the sector will need to efficiently manage its soil and water resources, including the risks associated with climate change and climate variability.
4. The sector will need to attract capital and skilled labour in competition with other sectors of the Australian economy.
5. Accelerating the uptake of advanced technologies, communications and knowledge systems, and integrated workflows for decision making and planning, are critical for success along the whole value chain.
6. Ongoing investment in research and development, both private and public, is vital to underpin this uptake.
7. A range of community concerns with regulatory, social and political implications important to the future development of agriculture need to be acknowledged and managed sensitively. These include issues such as food safety, labelling, gene technology in plant and animal breeding, foreign investment and foreign workers, alternative land-use on pastoral leases and farm ownership.

Improvements in agricultural productivity will have flow-on effects on rural and regional communities. It will enhance economic activity in these areas, but may also generate significant social changes in these communities in the coming decades. Automation could see the reduced demand for some labour while at the same time increasing the need for new skills and presenting new career opportunities.

Understanding the heterogeneity in the agricultural sector is essential for securing its future well-being. Australia's agricultural sector contains a wide variety of farms, including tiny life-style farms, long-run family farms, and large corporate farms, representing diverse business enterprises. Most of agriculture's economic value is produced by a minority of high-performing farms. Not all farms will be able to, or want to, respond to increases in global demand. Governments will need a variety of policies that recognise this heterogeneity and recognise potential unintended side-effects. How Australia reforms institutions and policies affecting the key farm resources of land (including leases that restrict its use), labour (including temporary/seasonal workers from abroad), capital (including foreign investment and ownership), and water will determine the sector's capacity to expand

supplies to meet growing demand abroad. Life-style farms may play a significant role in land management, conservation, alternative energy and tourism, even if they do not contribute extensively to rising agricultural production. Understanding the economic and social drivers across this heterogeneous sector is essential if Government policies are to benefit both the sector itself and associated rural and regional communities.

Australian agriculture's comparative advantage will continue to be in the export of bulk commodities; high-value products will have niche markets with discerning consumers both domestically and internationally

Agriculture continues to be an important export sector in Australia. Agriculture accounts for about 2 per cent of Australia's total GDP (valued at the farm gate) and 15 per cent of the nation's non-services GDP. In 2013–14, the gross value of

agricultural production was worth \$53 billion, with exports of agricultural commodities valued at \$41 billion. While its total contribution to GDP declined throughout the 20th century, agriculture remains an important employer in rural and regional Australia with about 270,000 jobs in 2013–14 (excluding forestry and fishing).

Population growth will drive increased global demand for agricultural products, while growth in the middle class, particularly in Asia, will shift demand profiles. Understanding changing market opportunities will underpin Australia's capacity to respond to these opportunities. By 2050 Australia could see a doubling in the real value of its agricultural exports.

Despite the push to expand earnings by doing more processing prior to exporting, bulk commodities will continue to comprise the majority of Australia's agricultural exports, both in terms of volume and value. An increase in processing capacity in emerging economies will increase demand for bulk commodities and minimally transformed products. This will in turn challenge Australia's food processing sector as trade agreements open up the domestic market to cheap imports.

Australia's food processing industry has an annual turnover of over \$60 billion and added value of \$25 billion (2013–14), and with more than 220,000 workers it is the largest-employing sub-sector in manufacturing. Processors will continue to face strong competition from imported foods, particularly with the estimated 40 per cent of Australian consumers who are trading off price versus convenience. **Australia will be generally unable to compete on price internationally with processed intermediate products.**

'Brand Australia' will continue to be an important component of Australia's comparative advantage in agriculture, driven by consumers and by processors who seek particular attributes such as 'safe, clean and green' food. **Consumers in Australia and overseas will drive opportunities for high-value, branded, specialised products in both domestic and export markets.** The success of the wine industry and the dairy industry

demonstrate that Australia can develop niche markets for high-valued products.

Specialised products will be able to compete well in an expanding domestic market for those consumers who value product attributes, such as safety, sustainable production, high quality and perceived health benefits, over price. Consumer demands will also impact on the uptake of genetically modified food, and concerns about the environmental impact of farming practices will remain important to some. Private regulatory schemes driven by retailers are set to become increasingly influential in the food value chain.

Australia's market share and brand reputation will always be under threat of erosion by competitors as they seek to match our reputation for quality and safety. Understanding market dynamics and what the market is prepared to pay for are critical to maintaining or expanding our market share.

Governments will continue to play a role in creating market access for both imports and exports. While global demand for food is certainly increasing, government facilitation of market opportunities in both Australian and overseas markets will have a dominant role in how this translates to business opportunities.

There are opportunities to increase the supply of Australian agricultural products to meet increased demand

The ending of the mining investment boom will benefit agriculture. A return to historical exchange rates of the Australian dollar and less competition for rural labour by mining firms, coupled with rising demand for food exports, will provide more favourable growth conditions for Australian agriculture in the next ten years. Australian agriculture has a long history of innovation, resilience and adaptability and high levels of productivity growth compared with other Australian industry sectors. While productivity growth in agriculture remains higher

than many other industries, it is low compared to the growth seen in the 1950s to the 1990s. Improvements in productivity growth through increasing technology inputs and technical efficiency are necessary to increase production and profitability.

Most improvements in farm output will come from existing farms, both from increases in agricultural productivity and from capital deepening. Existing farming enterprises will move to more profitable commodities and will increase the productivity of traditional commodities. This will require ongoing adoption and adaptation of existing and new technologies, improvements in breeding made possible through advanced genomics, and ongoing improvements to management practices. Investments in infrastructure and capital improvements will be required to capture the benefits of new technologies and to exploit more sophisticated supply chains.

Farm production can also be expanded through intensification in some regions. Recent work on water access and availability indicates the potential for Tasmania and northern Australia to expand irrigation cropping and to convert some pastoral land to cropping. Capturing these opportunities will require addressing environmental, land tenure, infrastructure and capital constraints as well as conducting rigorous assessment of the costs and benefits.

Improving agricultural productivity growth is not without challenge. **Most empirical work suggests that Australian farmers are operating close to the limits of technical efficiency.** Having grown at an average of 2.4 per cent per annum between 1953 and 1994 total factor productivity has since become more varied with little overall growth from 1994 to 2013, in part due to the effect of the 'Millennium Drought' and other adverse climate conditions. There is also evidence that the stagnation in the intensity of public investment in agricultural R&D since the late 1970s has contributed to this slowdown. In the future, incrementally closing the gap between

potential and actual yields may be less important than new technological changes arising from ongoing fundamental research.

Transformational changes in technology and practices, advances in genetics and moves towards knowledge-driven systems are some of the keys to advancing productivity growth.

A higher level of R&D investment is needed in these areas into the future to build on excellent returns on past investments. Public investment in agricultural research and development appears to have stagnated or been in decline in recent decades, although recent changes in the way that these data are published has made it difficult to accurately assess this. Australia's highly regarded rural research and development corporation model, introduced in the late 1980s, has slowed this decline and led to significant interactions between researchers and industry. Both fundamental and applied research is needed to provide the essential pipeline of innovations that have characterised Australian agriculture throughout the last two centuries.

The agricultural sector depends on a healthy resource base to continue increasing productivity

Broadacre agriculture depends on healthy soil, water, and biodiversity. Australia has moved to a more inclusive approach to managing its rural landscapes in areas such as landcare, catchment management, and reductions in land clearance. Continuing to engage people in these activities will not only benefit agriculture but will also support healthy rural communities.

Agricultural industries' access to water markets has resulted in a more efficient use of this resource. It has also stimulated a more opportunistic use of irrigation for crops such as rice and cotton. **Future water markets will need to include all possible non-agricultural uses of water in rural landscapes.** This includes

competing sectors such as the unconventional gas industry that requires groundwater for extraction.

Climate change and climate variability present significant long-term risks to agriculture that need to be managed. As the driest inhabited continent, Australia is particularly vulnerable to climate change where it results in changes to rainfall patterns. While there is still some uncertainty about the regional impacts of climate change, it is already clear that southern Australia's rainfall is decreasing, particularly in the autumn when winter crops are germinating, which threatens Australia's international competitiveness in dryland farming. Climate variability has always been a feature of the agricultural production environment so there is an ongoing need to manage risks associated with fluctuations in production, and hence farm incomes, arising from periods of prolonged drought. R&D will be needed to provide transformational changes in productivity in the face of climate change.

Managing the interface between agriculture and community issues will be critical for the well-being of rural and regional Australia

Although the bush has held a special place in the traditional Australian identity, **rural and regional communities are under increasing stress because of low incomes, decreasing on-farm employment opportunities, reduced local access to services such as health and education, and high retail prices of nutritious food.** Farm employment has declined to just 270,000 (2013–14), or 2.3 per cent of the nation's workforce—just half of what it was in 2000. Technological changes, increased automation and shifts in commodity demands have all contributed to this.

Nevertheless, labour shortages remain a problem in rural areas. Harvesting in particular is increasingly reliant on foreign labour, whether guest workers or 'back-packers'. The profitability of farming and agribusinesses will depend increasingly on its ability to attract highly skilled labour and investment, in competition with other sectors.

Australians need to challenge community perceptions of agriculture as a 'sunset industry'.

This view does not match the resilience shown by the sector in its adjustment to economic reforms of the 1980s, in contrast to traditional manufacturing which declined as operations moved off-shore. Many agri-business entities remain profitable. In recent decades Australia has seen major expansion in wine, oilseeds and livestock exports.

Governments need to develop policies that address the diverse needs of the heterogeneous agricultural sector. Social problems faced by many in rural communities, particularly small, unprofitable farms, are not always those that stimulate economic growth in production, and the reverse is also true. The profitable parts of the rural sector also have a role—urban populations, particularly young people, need to be sold the message that modern agriculture provides significant business and employment opportunities drawing on contemporary skills.

Part of the pessimistic view of agriculture is based on the notion of 'aging farmers'. **In common with other developed countries, the median age of Australian farmers is increasing at a faster rate than general aging of the population.** However, this should not be an impediment to future growth of agriculture. Australia still has the second highest proportion of farmers under 35 years of age, 14 per cent, compared with twenty-nine other developed countries. This trend has four underlying causes: a fall in the number of farms which has reduced opportunities for new entrants; a decline in the number of people under 25 in the general population coupled with longer periods in

education; a delay in retirement of ‘baby boomers’; and an increasing age of marriage leading to fewer women entering farming through this pathway.

The view that the family farm is the preferred model of farm ownership should also be challenged. If the goal is to expand agricultural production to meet increasing global demand, it may not matter who owns the farm, but rather whether the farm has access to the capital and skills needed to grow and adapt the business.

Australian citizens and governments value the notion of the family-owned farm, which still accounts for 95 per cent of farms and 77 per cent of farmland. However, small family farm businesses are less able to access and adopt advanced technologies and may lack access to enough capital to underpin adaptation to changes in both the environment and market demands, and to manage income variability associated with the risks of agricultural production such as exchange rate movements or drought. Mergers of family farms have been occurring over recent decades leading to a reduction in the number of medium-sized farms. However, a range of different farm business models continues to provide diversity and flexibility.

Community groups have concerns about the extent of foreign ownership and foreign labour in farming, concerns that are much less evident in other sectors in Australia where foreign ownership is common and foreign investment is the norm. **The future of the agricultural sector could be constrained by ongoing community concerns about foreign investment and foreign labour.** Without more foreign investment in farms and agribusinesses, domestic capital providers including local superannuation funds may need to be encouraged to reduce their reticence to invest in potentially risky farming enterprises.

Accelerating the uptake of advanced technologies and communications is critical for success along the whole value chain

Farms of the future will be unrecognisable. The most-profitable farms today already have greater access to modern, advanced technologies. **Future farming will use knowledge-intensive systems that draw on technological developments in computing, engineering and data analysis.**

Farmers will use real-time information to tailor farm management of inputs to maximise yield and quality of outputs. Automation will continue to grow and robots will harvest and prune, ‘drones’ will survey fences in pastoral leases and check for problems in high-valued crops. Tractors are already ‘computers on wheels.’ Access to skilled labour not traditionally regarded as ‘agricultural’ will be critical—**farmers will need access to mechatronic engineers and ICT experts to run machinery.** This will place agriculture in competition with other sectors of the economy for these skills. High bandwidth internet access and advanced ICT will be needed in rural areas to enable remote access to these skills which will continue to reside in predominantly urban populations.

Farmers will also depend on real-time access to nationally consistent databases to underpin their environmental management.

These databases will need to be regionally and locally relevant. Australia is a world leader in creating national databases on water access and availability, on soil maps, and on biodiversity. These databases are overcoming barriers to interoperability among data collected by different

agencies—this means that data from different sources can be combined in a meaningful way. National databases on water availability have enabled water markets to operate based on real-time data. Governments will need to continue to invest in maintenance and development of these national databases. Investment in R&D, education and training will also be essential to realise the potential of this information flow, while enabling the agricultural sector to make the most of its limited resources in a more sustainable way.

Farmer-driven innovation has always been a feature of Australian agriculture. **Partnerships between farmers, researchers, communities and others in the value chain will foster innovation.**

The greater complexity of the farming system, the integration of 'big data' and the expectation of more efficient communication along the value chain, means that the different players need more than ever to form networks to enable knowledge aggregation, analysis and exchange. Some of the most successful agricultural groups already foster the formation and maintenance of these networks. Regular meetings between researchers and farmers, where knowledge and experience flow both ways, ensure a greater appreciation of current problems and possible solutions.

Agriculture does face unique challenges due to the special status of food, our relationship to the land, and agriculture's importance for the prosperity of rural and regional Australia.



Key findings

Demand for Australian agricultural products

1. Demand for agricultural products in Australia is expected to grow in line with both an increasing domestic population and international demand. The latter will be driven by global population growth and increased affluence, particularly from Asia.
2. Bulk commodities will continue to comprise the majority of Australia's agricultural exports, both in terms of volume and value. Australia is a major exporter of wheat, beef, cotton, wool, oilseeds, wine, lamb, sugar, barley, milk products, and horticultural products. This is driven both by our comparative advantage in these commodities and by the trustworthiness of our product in terms of perceptions of its quality and safety. Strong export performance is expected to continue, boosting that part relative to other parts of the sector.



3. **There are opportunities for Australia in high-valued branded, specialised products, but to exploit this niche segment of the market profitably will require state-of-the-art information systems and marketing strategies.** Australian producers and processors will need a sophisticated understanding of international markets, including the nuances of consumer preferences, and will need to form strategic partnerships with foreign marketing agencies, distributors and consumers.
4. **Increased global demand for food will also bring increased global competition in our markets.** Our comparative advantage could be eroded in the future as other countries also seek to respond to the most lucrative consumer demands, and as they improve their food safety and certification systems.

5. **Australia's reputation for 'clean and green' products will continue to be important.**

This will be true both for bulk commodities and processed products for domestic and international markets. Our claims must be supported by evidence and accreditation, and be more compelling than those of competitors. It is also crucial to develop a better understanding of domestic and international consumers' views on 'clean and green' attributes, including food safety, nutrition, environmental impacts or other factors, and what premiums they are willing to pay for products that meet particular standards.

6. **The domestic market will remain important for Australian produce even though food imports will continue to grow.** An ability to retain our share of the domestic market over imports will depend strongly on understanding how different consumers trade off price, convenience and perceived attributes to do with food safety, quality, variety, seasonality and presentation style.

7. **Globally, governments will continue to define opportunities and market access for Australian exports.** Policy interventions affecting food self-sufficiency, mandates on biofuels, stimulus to domestic processing industries, and market access rules—including for sanitary and phytosanitary quarantine measures—will all have significant effects. An ongoing public policy challenge is to ensure that demand growth is proportionate to population and income drivers through government actions to enhance access to markets and limit the growth in (and ideally reduce) agricultural protectionism. Governments will also need to be alert to the impact of global private regulation, such as GlobalGAP, and the potential trade restrictions arising from the quality demands of large transnational retail chains that sometimes are even stricter than international trade law disciplines.

8. **Our domestic market will continue to be influenced by global drivers, such as commodity prices, consumer preferences, seasonality, and changes to regulatory, trade and information systems.** Connectivity, adaptability and supply responsiveness among agricultural industries will be critical to success.

Potential for Australian agriculture to meet increased demand

1. **Prospects for increasing Australia's supply of agricultural produce to meet growing demands are positive, but with important caveats.** There are some opportunities to use land and water resources more efficiently in existing and new agricultural regions, through intensification of production supported by appropriate planning, research, capital investment, adoption of new technologies as soon as they appear, and better management and adoption of new practices.

2. **Securing the soil resource on-farm will underpin future productivity growth.** A holistic framework that enables farmers to make the best use of technology, data resources, knowledge and expertise to manage and secure their soil resource will underpin the future productivity growth and success of Australia's agricultural sector. This will require collaboration and coordination across the sector, including linking research, government planning, and information systems with farmers on the ground.

3. **Opportunities exist to expand and intensify agricultural production in northern Australia and Tasmania so long as underlying constraints and environmental impacts are addressed.** Any proposal should consider all major

impacts and be subject to rigorous appraisal, particularly in northern Australia where there may be a lack of necessary infrastructure. Developments may also require permission to change land use from grazing to cropping on pastoral leases—taking into account implications for native title.

4. **Future increases in total factor productivity will require significant new investments in research and development from both the public and private sectors.** Greater investment in basic and applied research, and greater capital availability, including human capital, are needed to overcome low farm profitability and prospective climate change impacts. Applied research outcomes need to be disseminated, demonstrated, and commercialised appropriately to increase the speed of uptake. Further increases in public expenditure will stimulate private investment in R&D.
5. **Continuing development of water markets is a vital part of Australia's agricultural future.** Regulatory and land-use planning reforms need to address water conflict issues between agricultural and gas production, and between agricultural and environmental needs to ensure this issue does not become a significant constraint to agriculture's future. Capacity to manage adjustment to water supply and demand through intra- and inter-state leasing and selling of water rights will be critical to success in this area.
6. **While agriculture and food production can be a driver of negative impacts on biodiversity, they can also play a very important role in conservation, for both private and public good.** Improved soil and land management by farmers needs to be part of Australia's agricultural future. This will require the right market signals and policy instruments.

7. **Increasing productivity growth and deepening capital investment are the key public policy challenges for increasing the supply of agricultural outputs in Australia.** Key mechanisms to improving productivity include increasing research outputs, increasing profitability and capital access, increasing availability of information and communication technologies, and improving the ability of managers to adopt and trial better techniques and to process and analyse market information. Investment policies will be required to ensure that agricultural industries can compete effectively for finance with other sectors.

Australian agriculture's social and political context

1. **There are an increasing number of social and economic stressors in the agricultural sector in Australia.** Increased productivity but relative declines in profitability have led to major declines in rural workforces, and an ongoing reduction in the number of enterprises, with knock-on effects on rural communities—particularly smaller communities.
2. **Australians' connections to the land are declining although cultural values relating to the inherent value of farming continue to be held across the community.** Direct links between a mainly urbanised population and rural Australia are declining at the same time that concerns about a range of issues associated with agricultural practices, including environmental sustainability, animal welfare, and food safety, are increasing.
3. **Access to services will continue to be problematic for rural and regional communities.** Difficulty in locally accessing quality healthcare, mental health services, education and other services is contributing to social stressors in rural communities.

4. **Solutions to problems facing rural communities will need to be grounded in a local context.** Many important issues need to be solved locally or regionally, so they require local community-level solutions that are targeted as precisely as possible so as to maximise their social benefit/cost ratio. One size does not fit all in terms of both opportunities for and threats to those rural communities.
5. **Trends towards concentration, intensification and vertical co-ordination may reduce the role of small family farms and increase foreign ownership.** Despite the need for new sources of investment in agriculture, this trend is generating community concerns.
6. **Land tenure and planning need to allow farming to evolve.** Tourism, biodiversity conservation, urban development, forestry and mining all compete for rural land. Governments need to work with communities to ensure that shifts in land use are beneficial while not being hampered by unnecessary or excessive regulations.
7. **Alternative models of farm financing, such as contingent loans, need to be developed to meet the needs for farm businesses faced with fluctuating incomes and reduced capacity to borrow.** Family farms are not only sites of production but also the family home, resulting in farmers tending to be risk averse towards debt. Better ways to encourage productive uses of capital and different investment models may improve access to finance while enabling older farmers to capitalise on their assets.
8. **Australia needs to address the erosion of its 'social licence to operate' in the agricultural and food sectors.** Scandals (animal welfare, food safety, labelling), romanticised views of agriculture that are incompatible with modern technologies, and perceptions of agriculture as damaging to the environment all contribute to that erosion.
9. **Genetically modified crops and foods represent both opportunities and risks for the Australian food industry.** This will largely depend on the perceived benefits and risks of particular categories of products. The industry has a role to play in how genetically modified food products are ultimately viewed by consumers. Retailer-led private regulatory structures will impact on the adoption of this technology, and retailers' marketing and voluntary labelling practices will impact on its public acceptance.
10. **Key public policy challenges include managing the ongoing restructuring pressures in the agricultural sector and the flow-through impacts to rural and regional Australia.** These include managing the major risks that agriculture is likely to face and developing the appropriate institutional frameworks, human capital resources and policy settings that will allow agricultural producers and their communities to be innovative and resilient including in their management of risks.
11. **There is a need for a shared, positive vision and narrative for agriculture in Australia.** This must be constructed through dialogue and consultation with various stakeholders, including the general public, and should not rely on an over-romanticised idea of farming. The place of agriculture in contemporary society needs clarifying via articulation of shared societal values regarding issues critical to agriculture's future including technology, health, rural and regional development, and education.

Farms of the future— transformative technology

1. **Future agricultural enterprises will rely more on automation, robotics and sophisticated data analysis, causing employment opportunities to shift towards more specialised knowledge, skills and training.** The success of future farming will depend on the degree to which farming communities can attract these skill sets to regional and rural Australia. While employment may drop in traditional farming activities, it will grow in these agribusiness service industries.
2. **The food value chain is increasingly utilising modern information systems.** This means that production from the most-informed sellers can better match consumer needs and demands of supermarkets and other buyers. Provenance information will be critical to providing the evidence for Australia's reputation as "clean and green". Agri-intelligence is a crucial national infrastructure asset that can provide Australia the knowledge-based information that markets demand. Data along the food value chain will see the creation of "data markets"—with a focus on timely delivery and analysis of relevant information. To best exploit these emerging trends, information collection needs to be both nationally consistent and locally relevant.
3. **Technological requirements of future farming may drive farmers to specialise in production whereas risk-reduction and sustainability drivers could push some farms to be more diverse.** Future farming will need to trade-off the need for knowledge intensity versus the opportunistic response to changes in weather, in markets, and consumer choices.
4. **Agriculture and food industries will need access to reliable, real-time information about markets, consumer preferences, and the conditions of the resource base.** Comparative advantage will rely on responsiveness to shifts in market and consumer trends both internationally and domestically, as well as on the productivity of the resource base.
5. **Profitable agricultural industries will support those farmers and their communities that are innovative and well connected.** Connections support vibrant rural and regional communities and provide an attractive environment for new entrants into farming. They also help to shift public perceptions of agriculture away from the misguided view that it is a sunset industry.
6. **Contemporary agricultural industries with strong participation in export markets have innovative partnerships between farmers, information providers and researchers and have more farmer-initiated innovation.** Institutional structures need to be investigated to reveal better ways to catalyse these connections and relationships.
7. **Agricultural production and marketing are increasingly knowledge-intensive activities, drawing on technological developments in computing, engineering and data analysis.** Robotic machinery and sensor networks will require fast internet connections and a skilled workforce to support them. Australian producers need to continue to upgrade their skill and knowledge base if they are not to lose markets to more-sophisticated and/or lower-wage suppliers abroad. Farmers and agribusiness can take better advantage of new technologies to improve connectedness, and knowledge exchange, such as via social media.

1

Introduction

1.1 Background

According to the 2015 report *Australia's Comparative Advantage* (Withers, *et al.* 2015) the following global trends are expected to affect Australia significantly over the next three to four decades:

1. the rise of Asia, particularly China, India, and Indonesia
2. a global rise in demand for natural resource-based products
3. increasing opportunities for the uptake of a wide range of new technologies
4. increasing and unprecedented information and communication technological advances in particular
5. an ageing, increasingly diverse, domestic populace.

Of particular note, and of relevance to this report, is that by 2050 global agriculture will be required to feed and, in part, clothe and fuel an anticipated world population of 9 billion people (Foresight 2011).



Demand for agricultural products will not only be stimulated by this growing population but also by increasing wealth and changes in dietary preference.

Agriculture has always been an important part of the Australian economy and an area of significant comparative advantage (ACIL Allen Consulting 2014). Opportunities abound for Australia to continue to supply parts of this growing demand abroad (through trade) as well as at home. Australian agricultural producers of primary and processed farm products will undoubtedly perceive many profitable business opportunities in this evolving space.

These developments will drive food and trade policy changes, create both opportunities for and barriers to Australian agricultural exports, and influence future demand for different types of food at home and abroad. The challenge for Australian producers is how to respond to these potential benefits. The strength of the sector's comparative advantage has varied with the mining sector's fortunes (having a negative impact on agriculture in the past decade), and it has been dampened in the past by both Australia's protection of its manufacturers and other countries' protection of their farmers.

A number of factors indicate that the future for Australian agriculture is bright. Australia has already demonstrated strengths that are relevant to its contribution to global food security, including (PMSEIC 2010):

1. raising agricultural productivity in one of the driest continents on Earth, on low quality soils, and in the face of a changing climate
2. strengthening international linkages and delivering technological spill-ins from other (including developing) countries
3. maintaining a strong and effective science, research, development and extension base in agriculture, in climate, and in human health and nutrition.

Australia's reputation for quality and safe food products, reliability as a trading partner, freedom from many pests and diseases, and environmental stewardship all contribute to its agricultural comparative advantage, allowing Australia to target existing, growing and emerging premium food, feed and fibre markets (ANZ Insight 2012).

Optimising production whilst maintaining our reputation, both nationally and internationally, will be critical to securing Australia's agricultural future. To meet this challenge the 2014 report *Food and Fibre: Australia's Opportunities* (ATSE 2014), proposed that Australia must:

- increase productivity and competitiveness in its agricultural industries
- manage competing demands on limited natural resources
- influence and respond to environmental sustainability and climate change adaptation plans
- expand investments in the agricultural and agri-food innovation systems
- develop a co-ordinated vision and strategy for sustainable growth.

Pressure to intensify farm production systems is inevitable in the face of issues such as climate change and climate variability, water scarcity, and conflicting land-use demands. Without productivity growth, it will be impossible for Australian agriculture to supply increases in domestic demand as well as to expand exports. Productivity on farms, along the value chain, and in the provision of post-farm gate infrastructure services, are all key contributors to Australia's agricultural competitiveness.

1.2 About this report

This report appears in an already crowded and highly contested space within the broader context of Australian agriculture and food. The Australian government has recently released two policy white papers on agriculture: one on the opportunities for developing northern Australia, including agricultural industries (Commonwealth of Australia 2015b) and a second one on agricultural competitiveness in Australia (Commonwealth of Australia 2015a)—its preceding green paper illustrated the plethora of publications and reports on various aspects of these issues (Commonwealth of Australia 2014). These two white papers were released as this report was in press, and as such it was not possible to include a detailed analysis of them here. However, both reports highlight the government's interest in agriculture as an important part of Australia's economic future.

The agricultural sector involves many large industries that contribute to value chains extending from primary producers through to final consumers. It overlays regional Australia and underpins the prosperity of rural communities, while intersecting with community concerns and aspirations for sustainable environmental management, natural and healthy foods, and ethical food production.

The complex interactions between science and technology, politics, economics and social issues around Australia's agricultural sector are explored in this multidisciplinary report. It seeks to deliver the greatest value to informing public policy development in this area by highlighting longer term and strategic opportunities and challenges in Australia's food and agriculture sectors.

The report does not address in any detail the opportunities in the downstream food processing sector but, as noted in Chapter 3, there are plenty of opportunities there too.

To continue to strengthen Australia's agricultural, food and fibre producing industries in an increasingly uncertain and rapidly changing world, we challenge some of the myths and generalities surrounding this dynamic and highly contested sector.

In order to cover all the key issues identified here, taking into account the large pre-existing body of academic research and grey literature, three consultancies were commissioned by the project.

In brief, the broad focuses of these commissioned consultancies were:

- *Drivers of demand for Australian agricultural products*, The Centre for International Economics
 - Drivers of and barriers to demand for Australian agriculture, including drivers from external and internal markets and barriers to trade.
- *Australia's Agricultural Future: Returns, Resources and Risks*, Professor R. Quentin Grafton, Dr John Mullen, and Dr John Williams
 - Drivers of and barriers to agricultural supply in Australia, including issues impacting agricultural and food production, sustainability, and resource availability.

- *Australia's agricultural future: the social and political context*, Professor Stewart Lockie
 - Australian agriculture's social and political context, including social licence to operate, the urban-rural divide, and issues around rural communities in Australia.

The reports of these consultancies are available as supporting information to this report online at <http://acola.org.au/index.php/saf07-contributing-reports>.

Building on the points identified in *Food and Fibre: Australia's Opportunities* above (ATSE 2014), this report finds that Australia's agricultural future relies on:

- building and using knowledge-intensive systems, including robotics, sensors and data analytics
- developing a better understanding of consumers and their preferences and adjusting business systems to meet those preferences
- developing nationally consistent and locally relevant databases for environmental variables to underpin planning and decision making
- investing in agricultural R&D to build transformational technologies and break current yield barriers
- suggesting agricultural policies that recognise the resilience and adaptability of agricultural producers and allow the sector to evolve more appropriate new models of enterprise and production in the future
- reconciling agriculture's social benefit in underpinning rural and regional communities with its place as a profitable business sector subject to market forces.

2

Nature and development of Australian agriculture to date

This Chapter explores the history of Australian agriculture to give context to its future development, both as an economic sector and the role it plays in Australia's regional and rural communities.

Agriculture has successfully developed in Australia over the past two centuries; at present it makes use of roughly 60 per cent of the country's land area, mostly for livestock production followed by dryland cropping, with only a tiny area under irrigation (Grafton, *et al.* 2015).

This is despite the country being one of the driest parts of the world and having by far the most infertile and nutrient-leached soils of any continent. Development, adoption and adaptation of technologies have generated long-term farm productivity growth, and the adaptability of producers to variable seasons, markets and real exchange rates has allowed most farm families to stay in business even through tough times.



2.1 The long history, briefly

The history of agriculture in Australia reveals the resilience of farmers and farming. Almost as soon as the colony of NSW was settled, the colonists began to experiment with agriculture. The experiences of the British plantation colonies had demonstrated that the success of agricultural staples could generate enormous wealth for the colonies concerned.

The new colony in New South Wales experimented with wheat, rice, wine grapes and maize, but in the end it was wool, shorn from imported merinos, that became the staple that produced prosperity and generated expansion.

The great age of agricultural and pastoral expansion lasted from the late 1820s until about 1914. As the pastoralists and farmers moved into territory previously unoccupied by Europeans they found the need to experiment further for marginal lands, in particular, requiring new methods of cropping and grazing as well as the development of hardier breeds of sheep and cattle.

2.1.1 “Riding on the sheep’s back”

Agriculture, especially wool, helped to establish Australia’s economy as one of the world’s richest per capita prior to World War I.

Right up to the 1950s, the Australian economy was reputed to be ‘riding on the sheep’s back’. Agriculture was the dominant part of non-services GDP before the gold discoveries in Victoria in the 1850s, and then again until the discovery of gold in Western Australia in the 1890s. Agriculture’s share of non-services GDP only began to fall below 60 per cent following World War I when protection of manufacturing from import competition encouraged diversification through industrialisation.

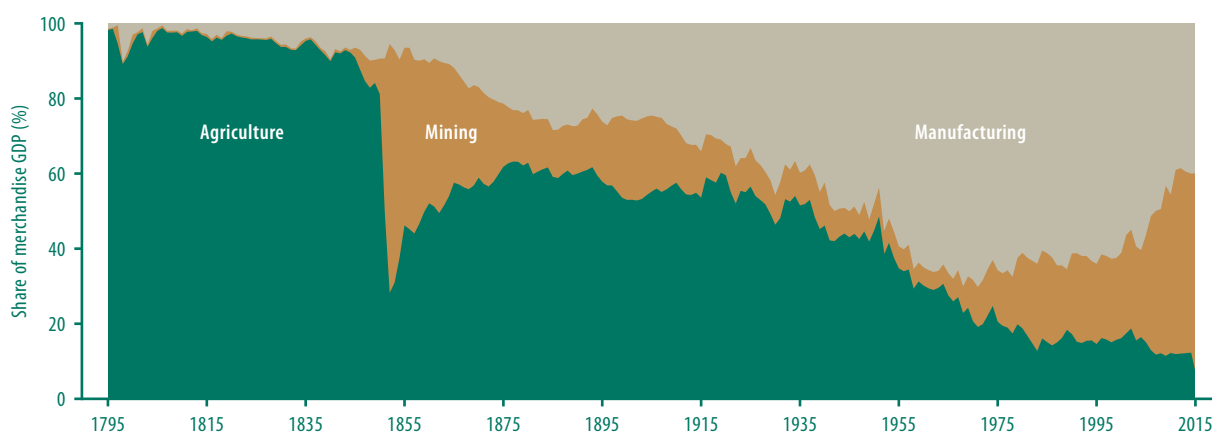
Even during the most recent mining boom, when the share of manufacturing shrank, agriculture’s

share of non-services GDP remained above 10 per cent, as shown in Figure 2.1.

Pre-1914, wool and gold accounted for most of the country’s exports, with gold dominating wool only in the 1850s. For the first half of the 20th century, wool contributed between two- and three-fifths of the country’s agricultural exports. Wool’s share of agricultural exports gradually diminished to just one-tenth by the turn of the 21st century. By then beef and cropping had become more profitable, as shown in Figure 2.2.

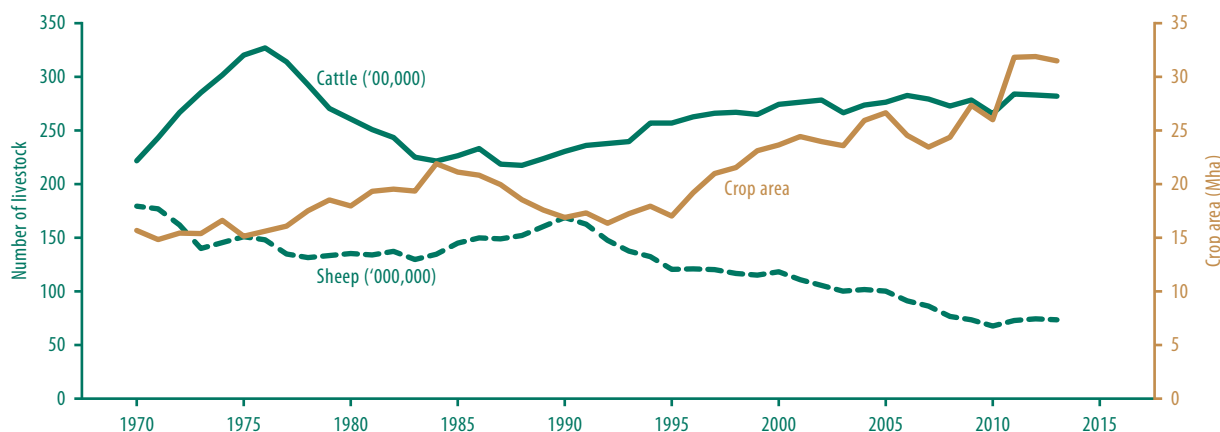
Across nations the share of primary products in exports has typically declined historically as industrialisation increased. A distinguishing feature of Australia is that, despite being one of the highest income countries in the world,

Figure 2.1: Sectoral shares of Australia’s merchandise GDP (per cent, excluding services), 1795 to 2013



Source: Anderson 2014a, drawing on data in Butlin, *et al.* 2014.

Figure 2.2: Changes in cropping and grazing since 1970, Australia



Source: Anderson 2014a.

its primary products' share of exports remained above 90 per cent through to the 1950s. That share dropped to just 56 per cent by 2000, as both manufacturing and services exports grew following the phasing down of manufacturing protectionism and declines in trade costs. Then the recent mining boom caused that share to rise back to above 70 per cent—although the consequent real appreciation of the Australian dollar reduced agriculture's competitiveness, causing its share of exports to fall significantly, as shown in Table 2.1.

Overall, agriculture's export dominance has fallen from around 80 per cent in the early 1950s to only

about 15 per cent of all merchandise exports in the past decade, which can be seen in Figure 2.3.

Despite the periodic mining booms over the past 150 years, agriculture has directly employed far more people than the mining sector, although the difference has been decreasing over time, as shown in Table 2.1. Currently, agricultural activities provide indirect employment in Australia totalling 270,000 jobs in 2013–14 not including forestry and fishing, or about 2.3 per cent of the Australian workforce (ABS 2015).

This kind of long-run decline in agricultural shares of GDP and employment is normal for countries with rising incomes (Anderson 1987).

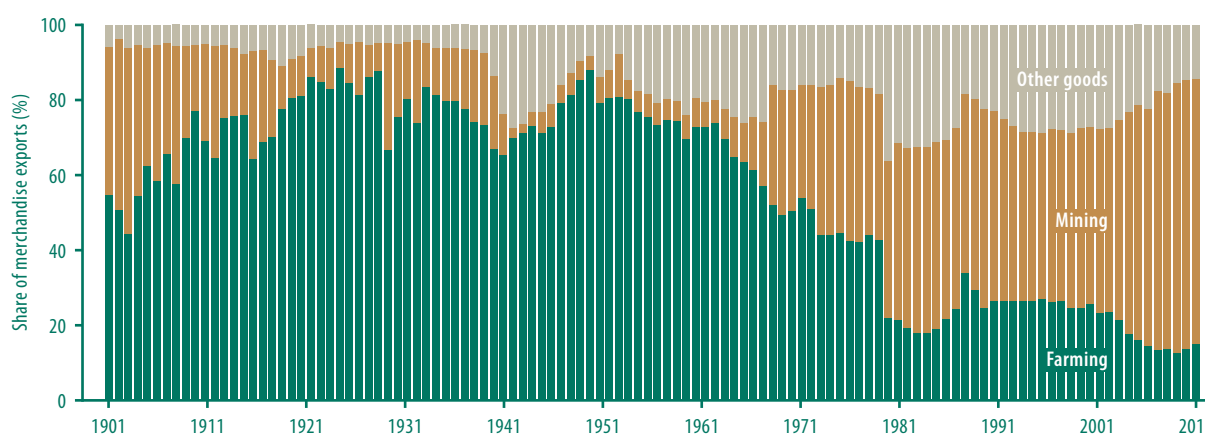
Table 2.1: Rural and mining shares of Australia's GDP, employment, and exports of goods and services, 1900–01 to 2012–13 (per cent)

Year	GDP share		Employment share		Export share	
	Rural	Mining	Rural	Mining	Rural	Mining
1900–01	19.3	10.3	20.6 ^a	6.3 ^a	56	38
1930–01	21.2	1.8	23.9	2.4	86	10
1950–01	24.0	2.3	16.3	2.0	86	6
1970–01	7.4	3.0	8.2	1.4	43	28
1990–01	2.6	9.1	5.6	1.2	23	37
2000–01	2.3	9.5	4.8	0.9	19	37
2010–11	2.3	8.7	3.1	1.8	12	60
2012–13	2.3	9.4	2.8	2.3	14	59

Note: 'a' denotes 1911.

Source: Anderson 2014b.

Figure 2.3: Shares of farming and mining in Australia's merchandise exports, 1901 to 2013 (per cent share)



Source: Anderson 2014a, drawing on data in Butlin, *et al.* 2014.

2.1.2 Decline in Australia's trade with the United Kingdom, growth of Asian markets

Until the 1950s the United Kingdom had been the destination for the majority of Australia's exports, and the main source of its imports. Since that time, demand for Australian primary exports has steadily grown in Asia due to its increasing industrialisation, replacing the UK as an export destination. Korea and Japan, in particular, are densely populated and relatively natural resource-poor. Even China and India, which have greater natural resources per worker, have a need to import primary commodities to fuel their growing economies. Their rapid industrialisation makes them highly complementary to relatively sparsely populated economies that are well endowed with agricultural land and/or mineral and energy resources, such as Australia. In the case of bulky primary products whose trade costs are high relative to their value, this trade complementarity is stronger for neighbouring trading partners.

East Asia's dominance as a destination for Australian exports continues to grow, with China currently leading and the region as a whole taking more than two-thirds of all merchandise exports and over 80 per cent of Australia's mineral exports. The share of food exports going to Asia is somewhat lower, but it already exceeds 40 per cent. The growing potential for Australian agricultural exports, particularly to Asia, is explored in more detail in Chapter 3.

2.1.3 The strong Australian Dollar

The metals and energy intensity of China's rapid rate of growth over the past dozen years has led to an unprecedented improvement in Australia's terms of trade, and especially its export prices of iron ore and coal. This led to a huge burst of investment in mining exploration and capital expenditure, much of which involved foreign investments.

As a consequence, the value of the Australian dollar (AUD) rose from a low of 52 US cents in 2001 to an average of 102 US cents from 2011 to 2013. This massive exchange rate appreciation dampened Australian dollar prices for, investment in, and output of, the country's other tradable sectors, including agriculture. The contrasting price effects are captured in Figure 2.4.

For this reason, the rise in international food prices in the latter half of the past decade benefitted Australian farmers much less than farmers in other countries. Recent declines in the Australian dollar are likely to see a net increase in farm sector incomes of around \$320 million in 2014–15 (ABARES 2015) through better terms of trade.

2.2 Value of Australian farm production and exports

In 2013–14 the gross value of total Australian agricultural production was \$53 billion. The most important agricultural commodities by value are

Figure 2.4: Index of prices of primary product exports from Australia in AUD, 1998–99 to 2012–13



Note: 1989–90 = 100 in current AUD.

Source: ABARES 2013; BREE 2013.

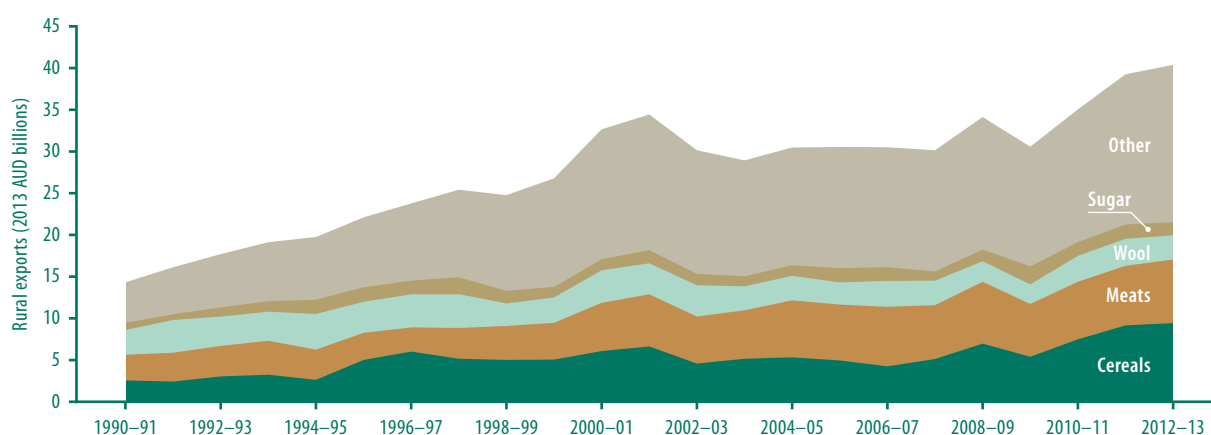
livestock meats (\$14 billion) which is dominated by beef and veal followed by poultry and sheep meats, while cereal crops earned \$12 billion. In addition, the food processing industry has an annual turnover of more than \$80 billion and value added of around \$25 billion (Department of Agriculture 2014).

The value of Australian agricultural exports grew considerably in the 1990s, and again from 2008—as shown in Figure 2.5—even when expressed in Australian dollars which appreciated strongly over the past decade. These trends show that the country's rural and mining exports vary with their relative prices and the import-restricting policies of trading partners on the demand side, and with mineral discoveries, extreme weather events such as droughts and floods, and government policies on the supply side.

By world standards, Australia is a small food and fibre producer, supplying around 1 per cent of the gross value of agricultural production globally. In 2011, Australia was the 19th largest exporter of agricultural commodities in the world (FAO 2014).

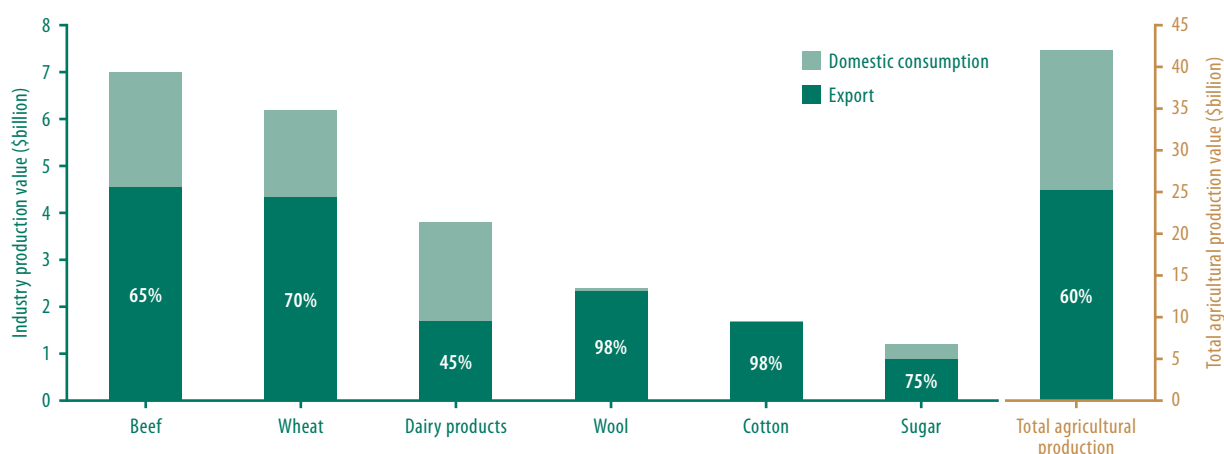
Despite this, Australia is a major contributor to world trade in several agricultural commodities and is well known internationally for its exports of farm products. Australian farmers continue to export around 60 per cent of domestic farm production and as much as 98 per cent of their wool and cotton output, as shown in Figure 2.6. Other major crop exports include broadacre grains, oilseeds and legumes plus more intensive crop products such as wine, rice, sugar, grapes, bananas, and potatoes. Australian livestock exports include beef and dairy products, and sheep, pig and poultry meats.

Figure 2.5: Value of Australian rural exports, 1990–91 to 2012–13



Source: ABARES 2013.

Figure 2.6: Share of agricultural production exported, key products, Australia, 2010–12



Note: Values averaged from 2009–10 to 2011–12; exports valued at the farm gate.

Source: Unpublished ABARES data.

2.2.1 Exports have tended to be unprocessed, and Australia is now a net importer of processed food

Traditionally, Australia has processed only a small fraction of the food and fibre it produces, and it remains an exporter of largely unprocessed, bulk agricultural commodities. Thus an increasing share of food products consumed by Australians is processed overseas, in some instances involving agricultural farm products grown in Australia and shipped overseas before being re-exported back in processed form. Over the past two decades processing of Australian agricultural products within Australia has declined, to the point that in 2011 Australia became a net importer of processed foods. Imports of edible preparations in 2013 were valued at \$1.99 billion while exports were valued at \$0.99 billion, a \$1 billion trade deficit.

Australia's top five source countries for food imports in 2012–13 were New Zealand, the United States, China, Singapore and Thailand, responsible for \$5.7 billion worth of imports. Of Australia's total food imports worth \$11.6 billion in 2012–13, over 93 per cent by value were either substantially or elaborately transformed (Department of Agriculture 2014).

2.2.2 Factors contributing to Australia's agricultural comparative advantage

Significant factors in agriculture's international competitiveness and comparative advantage include access to large areas of suitable land and water, use of technology, workforce skills and education, market proximity, institutional settings and policy frameworks. Successful export industries generally involve extensive, rather than intensive, production systems, although in economic terms, irrigated agriculture has a high value (see Chapter 4).

Water availability for dryland and irrigated agriculture has always been a major limiting factor in Australian agriculture, so average rain-fed crop yields are less than a third of crop yields in North America, Europe and China.

Nonetheless, Australian broadacre crop farmers are world leaders in grain yield per millimetre of growing season rainfall and per unit of fertiliser, and thereby are internationally cost competitive. Also, livestock in Australia can be grazed on pasture year-round. The use of native and improved pastures, coupled with crop rotations, has allowed this sector also to remain cost competitive internationally (Keogh 2014). Chapter 4 explores in more detail the ability of Australian farming sector to capitalise on this comparative advantage.

2.2.3 Low profitability but still competitive

On average, profitability in Australian agriculture is low. The average rate of return, including capital appreciation, across all broadacre farms over the 20 years to 2012–13 was just 4.2 per cent, and only 1.1 per cent if capital appreciation is excluded. Over the same period, dairy farming averaged a 4.4 per cent rate of return, or 2.2 per cent excluding capital appreciation. For horticulture, the average return over the five years to 2011–12 was 3.2 per cent.

These average rates of return, however, mask considerable variation, with the best farms performing considerably better (Commonwealth of Australia 2014). Larger farms generally earn higher rates of return. This may arise because larger farms can be better managed and have better access to new technologies (see section 6.3).

Martin (2013) reports that while farm debt has doubled since 1998 for both broadacre and dairy farms, the equity ratio has remained high at 90 per cent for broadacre farms and 80 per cent for dairy farms. He notes that in 2012 just 6 per cent of broadacre farms and 15 per cent of dairy farms had equity levels of less than 70 per cent. The increase in average debt per farm arose from on-farm investment and higher working capital requirements associated with larger farms and a higher proportion of cropping. Most debt is held by a small proportion of the larger broadacre and dairy farms.

One difference with our competitors is that Australian farmers suffer greater market, price and production risks than their counterparts in many other OECD countries. Market risk is greater because Australia exports a higher proportion of the value of its agricultural produce and, thus, is subject to greater potential interference in terms of market access. Production risks are also higher in Australia in key crops because of our more variable climate (Grafton, *et al.* 2015).

Profitability is a function of productivity and the terms of trade (the ratio of prices received for outputs to prices paid for farm inputs). Productivity growth is critical to maintaining competitiveness in the agricultural sector and is discussed further in Box 2.1. Consistent with broad international trends (ANZ Insight 2012), total factor productivity (TFP) growth in Australian broadacre agriculture has fallen from an average rate of over 2 per cent per year from 1952 to the mid-1990s to less than 1 per cent now, even when adjusted for the greater climate variability between seasons in the latter period (Hughes, *et al.* 2011).

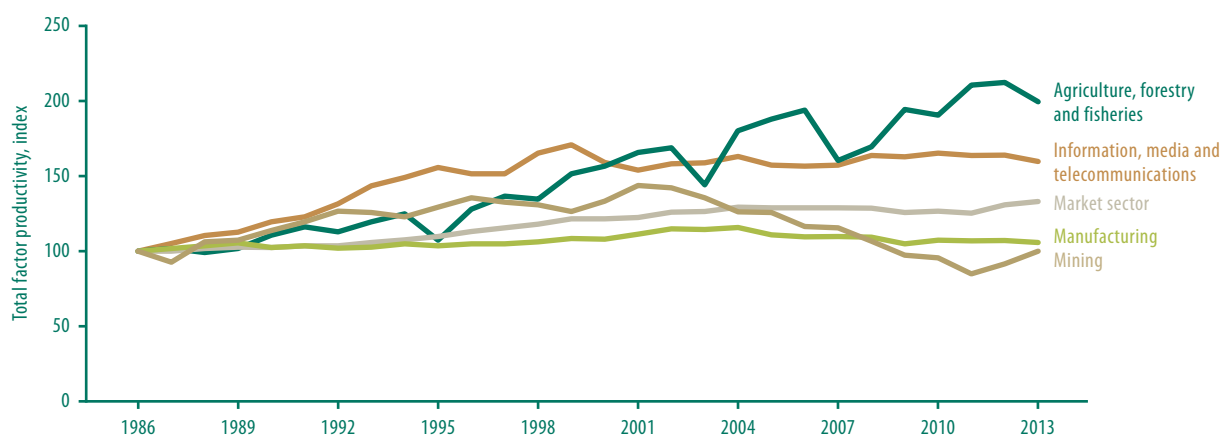
Despite the drop in its share of GDP and the plateauing of its TFP in recent decades, Australian agriculture has retained its competitiveness compared with the Australian non-agricultural sector. TFP for agricultural, forestry and fisheries (AFF) as a group out-performed other industry groups in Australia over the period 1986 to 2013.

Since 2006, agriculture, forestry and fisheries has been the only sector to experience growth in total factor productivity compared with the other sectors that have been flat, as illustrated in Figure 2.7 (Grafton, *et al.* 2015).

Apart from the adverse impacts of drought and other climate influences on productivity, agriculture has struggled to attract the necessary level of investment, adoption of technical improvements, and the labour force it needs to sustain ongoing productivity growth (see section 5.3.2), which may help to explain the slowdown in productivity growth in recent years. The challenge for the agricultural sector is to use available inputs more profitably than other sectors of the economy and to ensure that future market signals give a clear view of this opportunity.

Performance within the sector has been mixed over the past three decades, with the cropping industry recording the highest productivity gains and the sheep and mixed sheep-beef industries recording the lowest (Productivity Commission 2005). Sheng *et al.* (2010) estimate that a significant proportion of this slowdown can be attributed to a stagnant or declining level of public investment in agricultural R&D since the 1970s (see Box 2.1 and section 4.5), although O'Donnell (2010) notes that declines in TFP performance may also be related to improving terms of trade.

Figure 2.7: Trends in total factor productivity by selected sectors since 1986



Note: 1986 = 100.

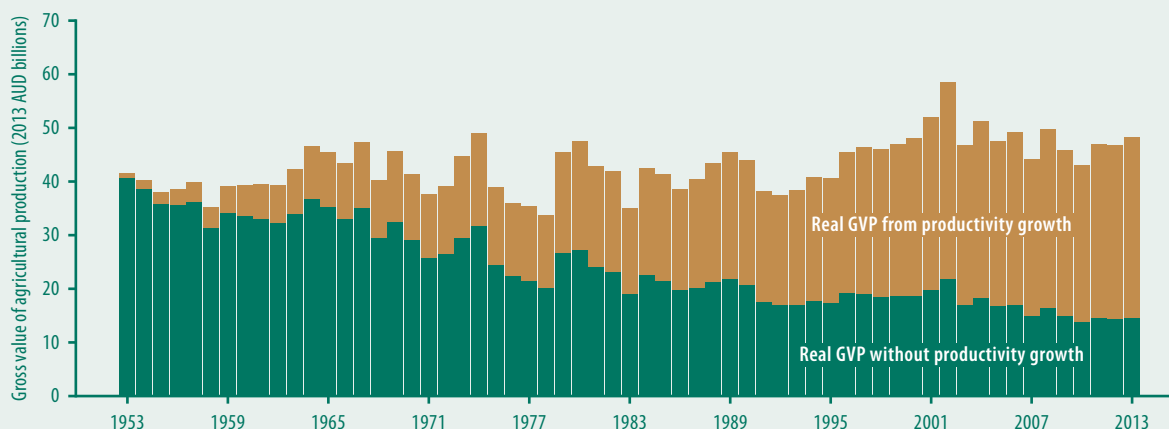
Source: Grafton, *et al.* 2015, p. 40, derived from ABS data.

Box 2.1: Productivity growth in Australian agriculture

Adapted from Grafton, *et al.* 2015

Productivity improvements have contributed strongly to Australian agriculture's output growth over the past six decades, as shown in Figure 1. Productivity growth since 1953 accounts for about half the growth in the real gross value of agricultural production (GVP) in 2013.

Figure 1: The value of productivity growth to Australian agriculture, 1953–2013



Source: Derived from ABARES data in Australian Commodity Statistics.

Productivity is measured by Total factor productivity (TFP), which is the ratio of farm outputs to farm inputs; more productive farms generate more outputs per unit of inputs. Productivity growth identifies improvements in the generation of outputs for a given set of inputs, due to improvements in areas such as scale of operations, the mix of products, technical inputs and technical efficiency. Growth in TFP is necessary for an industry to maintain competitiveness.

Agricultural productivity is difficult to measure but there is general consensus (e.g. Sheng *et al.* 2010, 2011; Khan *et al.* 2014; Grafton, *et al.* 2015) that productivity growth in Australian agriculture has declined from high rates of growth in the mid-50s to the mid-90s, with the recent period characterised by generally low growth but with high variability. Grafton *et al.* (2015) identify that TFP in Australian agriculture grew at the rate of 2.3 per cent per annum from 1953 to 1994 followed by a period of almost no growth between 1994 and 2013 (Figure 2). The TFP series is highly variable, with falls in 21 of the 61 years recorded. The largest falls follow the 1992 drought and the 'Millennium Drought', particularly for broadacre farms.

2.3 Technological advances and productivity

The dramatic increases in productivity since the Second World War have been stimulated by increased use of technology and higher rates of investment in innovation (see section 4.3). Examples include the use of superphosphate fertiliser and the establishment of legume-based exotic pasture improvement, developments that had a profound effect on the carrying capacity of pasture-based livestock systems and boosted the effectiveness of rotations in the dominant sheep-wheat farming enterprises. Conservation

tillage, introduced in the 1980s, helped to control soil erosion and to conserve soil moisture, increasing crop yields especially in lower rainfall years (Bowmer 2011). This change required new tillage equipment and herbicide technology and drove or sustained profits, so much so that during the 'Millennium Drought' wheat yields did not decline as much as expected because of greater water use efficiency (van Dijk, *et al.* 2013). These new approaches may also have the potential to introduce unwanted consequences such as herbicide resistance or alteration to patterns of deep drainage.

TFP has grown each year since 2007, but this might represent a run of good seasons rather than a return to the higher rates of technical change of earlier decades, as underlying factors such as investment in R&D have remained low.

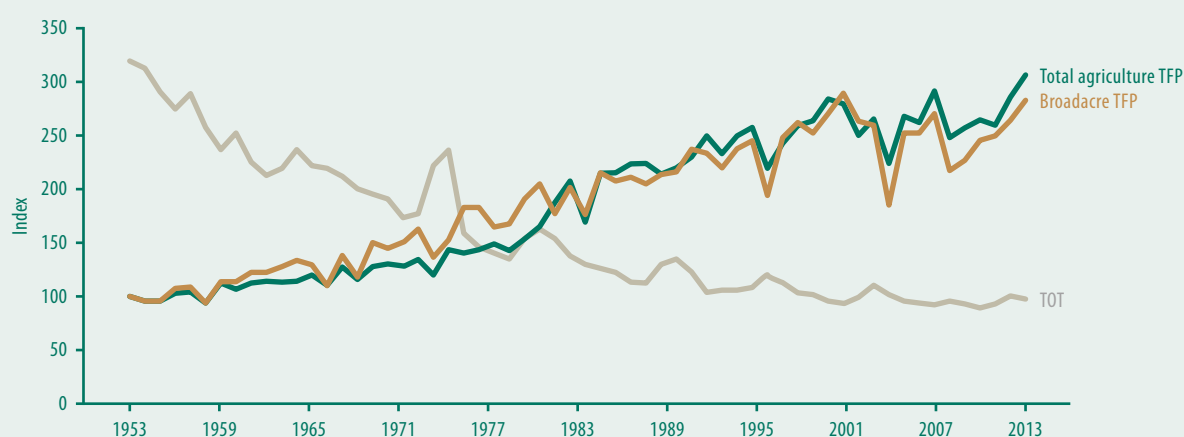
The international competitiveness of Australian agriculture can be assessed by comparing changes in TFP with changes in the terms of trade faced by farmers. While agriculture's terms of trade declined for about 40 years from 1953 (see Figure 2), the rate of decline has been much slower since the early 1990s. The TFP index grew from 100 in 1953 to 281 in 2012, while the terms of trade index declined from 317 to 97, at a rate of 2.1 per cent per year over the same period—faster than the rate of productivity growth in broadacre agriculture.

Because growth in TFP has largely been offset by the decline in the terms of trade, there has been little change in the profitability of the sector as a whole. This may explain, in part, why the real value of agricultural production has hovered around the A\$45 billion mark (in AUD2013) consistently for only the past decade.

There is evidence that productivity growth has slowed not just as a result of poor seasons but also due to declining levels of public investment in agricultural research and development. Climate change may also threaten agricultural productivity growth by eroding natural capital and requiring greater inputs and higher interest rates on borrowings, and is expected to impact Australian agriculture to a greater degree than other exporters.

Regardless of future movements in agricultural terms of trade, the profitability of Australia's agricultural sector will depend on ongoing improvements to TFP underpinned by adequate investment in R&D.

Figure 2: Total factor productivity (TFP) and terms of trade (TOT) in broadacre and total agriculture, 1953–2013



Note: 1953 = 100 for TFP. This series has a longer time scale and a more narrowly defined agricultural sector than the data displayed in Figure 2.7.

Source: Derived from ABARES data.

Key reasons for the productivity growth slowdown include continuing gaps in basic and applied research, limited capital availability driven in part by low profitability, impacts from adverse market access and weather effects, large gaps between the most and least efficient producers, and limited adoption of new technology and practices (Grafton, *et al.* 2015) (see Chapters 4 and 5).

Multiple studies show that investment in agricultural R&D has made a significant contribution to agricultural productivity growth in Australia (Council of the Rural Research and Development Corporations 2010; Productivity

Commission 2011; Sheng, *et al.* 2011) and overseas (Pardey, *et al.* 2013). Issues relating to the benefits of new technologies to farmers are discussed in Chapter 6.

Despite favourable statistics, the rates of investment in public agricultural R&D in advanced economies, including Australia, have been in decline since the 1970s, as discussed in Box 2.1. This is in contrast to emerging economies such as China, India and Brazil, which are investing more in agricultural R&D than Australia per dollar of farm output (Chen, *et al.* 2012).

In a 2010 report, the then Prime Minister's Science Engineering and Innovation Council

identified the need to increase investment in agricultural R&D to harness national expertise, a view supported by the National Farmers Federation (PMSEIC 2010; NFF 2013).

Further productivity increases are likely to depend on advanced technologies, particularly in future decades, and that requires ongoing innovation and research—a key finding of this report, as discussed in Chapter 6, and of reviews of other sectors of the Australian economy (Bell, *et al.* 2014; Withers, *et al.* 2015).

2.4 Policy framework for Australian agriculture

Agriculture has been subjected to a long history of policy reforms. These policies have sought to create a favourable environment for agricultural industries by providing appropriate incentives and removing barriers and to assist farmers manage risks (see section 4.4).

The dominant policy narrative up to the 1980s was one of protectionism accompanied by a concern for income stabilisation. Since then, the focus has been one of deregulation, privatisation and trade liberalisation. These latter narratives were not specifically targeted at agriculture but reflect the shift in overall policy for the Australian economy and the macro- and micro-economic reforms undertaken in the 1980s and 1990s.

More specific to agriculture have been policy reforms in land tenure as a result of native title legislation (Productivity Commission 2002), natural resource management at the catchment level through the National Landcare Program (DAFF 2003), and the introduction of water markets that have allowed water to be allocated to the most profitable use while balancing the needs of the environment (issues that are discussed in Chapters 4 and 5). Privatisation of grain storage facilities in the 1990s and abandoning the ‘single desk’ approach to marketing wheat internationally are examples of policies that triggered major economic reforms in the agricultural sector, consistent with this view

of trade openness and the importance of the ‘market’ as a driver of productivity.

While some industries, such as dairy, underwent structural adjustment involving farm exit, others grew significantly under this new economic regime, including the wine industry which became for the first time a significant global player that re-shaped perceptions of good quality, reasonably priced wine (see Box 2.2).

Australia’s comparative advantage in agriculture persisted while the sector was restructuring, both socially and economically. Its ability to continue to thrive contrasts with traditional manufacturing that has greatly declined in Australia in recent decades (Bell, *et al.* 2014).

In recent years, there has been much public discourse on agriculture’s contribution to the Australian economy and the factors that affect its long-term profitability and competitiveness. The table in Appendix 1 summarises the major social and political trends shaping the future of agriculture. Some of these are explored further in this report, in Chapters 4, 5 and 6.

Of particular note are the Australian Government’s key policy documents *Agricultural Competitiveness Green Paper* (Commonwealth of Australia 2014) and the subsequent *White Paper* (Commonwealth of Australia 2015a). The Government has set out its agenda for five key priorities. This report independently and explicitly recognised the importance of four of these areas:

1. creating a stronger and fairer business environment for farm business
2. investing in new water, transport and communications infrastructure (Chapter 4)
3. facilitating more effective risk management for farmers in dealing with long-term drought (Chapter 4)
4. underpinning productivity growth through a strong research and development system and more effective natural resource policy (Chapters 4 and 6)
5. opening up access to premium markets (Chapters 3 and 5).

Also relevant are the 2013 National Farmers' Federation's *Blueprint for Australian Agriculture* (NFF 2013) and the Pew Trusts' report on *The Modern Outback—Nature, People and the Future of Remote Australia* and the previous government's 2013 *National Food Plan* (DAFF 2013).

2.5 Social and cultural issues

Australians have long equated rural and regional Australia with resilience and adaptability. Until relatively recent times, the dominant Australian identity has been associated with a set of values acquired in the course of turning the natural environment into farms and pastoral leases by the European men and women who explored and occupied inland Australia. The 'Pioneer Legend' that emerged in the 1870s argued that by their determination and sense of common purpose these settlers tamed the 'wilderness', and brought 'civilisation' to the colonies and nation (Hirst 1978). The pioneers came to be valorised on state and national days of celebration. They were lovingly portrayed in art, poems, stage plays and melodramas, and were even memorialised in a whole series of Pioneer Parks.

Australian identity during much of the 19th and 20th centuries was based on these rural stereotypes (Waterhouse 2005). Although Aitken (1985) summed up the characteristics of 'countrymindedness' in terms of the ideological foundations that led to support for a distinct rural politics, the term itself has been in use since about the 1920s. Here, primary producers are elevated to special status and the "future prosperity and security of the entire nation are seen to depend ... on a productive and growing family farm sector" (Lockie 2015, p. 5). These characteristics reflect an agrarian discourse common across much of the Western world and which dates back to Aristotle. In Australia, policy developments, particularly from the mid-19th century, concentrated on allocating land to family farmers, protecting farmers from import competition, providing programs aimed at income stabilisation and support for voluntary participation in a variety of environmental measures.

2.5.1 Agriculture's place in Australian society

Agriculture is critical to the vitality, culture and well-being of rural communities and, indeed, contributes more to the economic vitality of Australia as a whole than many appreciate.

(Lockie 2015, p. 1)

Understanding the future of Australia's agriculture requires us to chart the changes in community attitudes, both between urban and rural communities, and within rural communities themselves, that affect agriculture's 'licence to operate' and its ability to attract the skills and investment needed to sustain profitable farming enterprises.

In recent times, communities and consumers have expressed a range of passionate views on production methods (e.g. mulesing, pesticide usage) and technological innovations (e.g. genetic modification, irradiation of food). While this also occurs in other industry sectors (nuclear energy, wind farms, nanotechnology) the agricultural sector attracts considerable political attention, perhaps more than other industries, because it is connected deeply to Australian's perception of national identity and because food is a fundamental part of life, the safety of which is considered paramount (see sections 5.4).

The period extending from 1861 through until the post-World War I period witnessed the implementation of a great experiment, an attempt to create a large class of yeoman farmers via the *Selection, Closer Settlement and Soldier Settlement Acts*. This grand scheme was based on the notion that a truly civilised society was settled and agricultural, while one based on pastoralism was partly nomadic and only half civilised. But those who conceived these policies also believed that the establishment of intense small-scale farming would bring prosperity to the farmers, the colonies and the nation. Indeed the architects of the post-World War I Soldier Settlement scheme were convinced that its success would provide the means by which the nation could meet the debts it had accumulated in the period 1914–18.

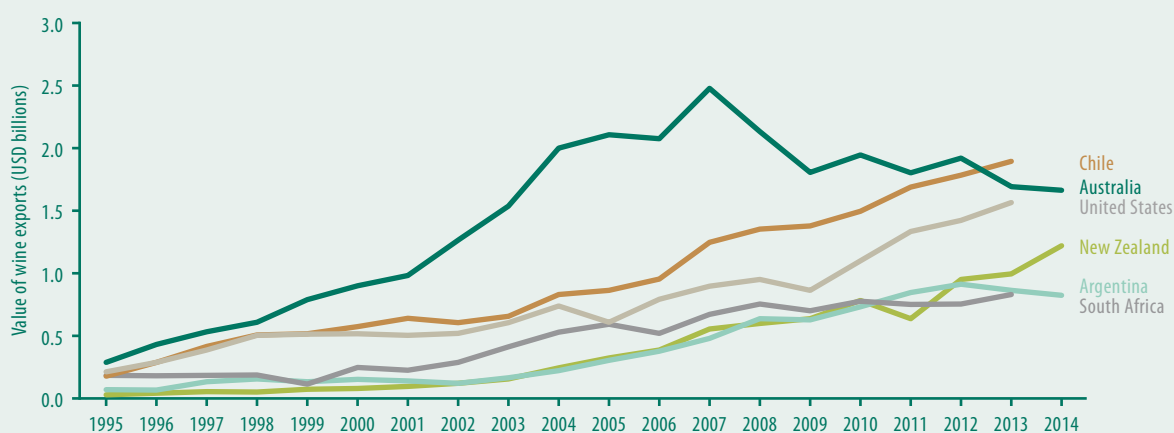
Box 2.2: Lessons from the wine industry's export-led growth

The recent explosive growth of the Australian wine industry after a half-century plateau illustrates how government support and protection for industries can be counter-productive to generating sustainable export competitiveness, and how the wine industry benefited from a collaborative approach to creating a global market niche for Australian wines from the mid-1980s.

Australia was a net importer of wine during its first 100 years of European settlement. Prior to the 1950s wool and gold dominated exports so strongly and raised Australian wages so high that few other industries were able to become internationally competitive. Protection of manufacturing from import competition also strengthened the country's real exchange rate, making other sectors less competitive. It was only when the country's real exchange rate reached a record low in the mid-1980s that sustained export-led growth emerged in the Australian wine industry.

Two lessons can be drawn from the Australian wine industry's growth experience. One is that government support can be counter-productive to generating sustainable export competitiveness. By restricting the interwar export subsidy to fortified wines, and making it a volumetric rather than value-based subsidy, producers were diverted from still wines—in which they were beginning to build a reputation in Europe—to low-quality fortified wine production. After that subsidy was removed in 1947, and preferential access to the UK's fortified wine market was phased out, wine exports dwindled as the industry continued to be hampered indirectly by import protection for manufacturers.

Figure 1: Value of wine exports, Australia and other New World countries, 1995 to 2014



In those areas of good rainfall and arable soil, that have ready access to large urban markets, small-scale farming proved a modest and sometimes an outstanding success. But its overall failure and heavy cost (to government) led to widespread disillusionment with the prospects for small-scale farmers to make a good living on the land (Pike 1929). With the adaptation of modern technology (e.g. electricity) to widespread use and the arrival of new, mass production factories in the nation's major cities in the interwar years, people now associated opportunity, comfort and prosperity with urban life.

Yet optimism about the economic opportunities that rural Australia provided was revived in the 1950s as a result of the following factors:

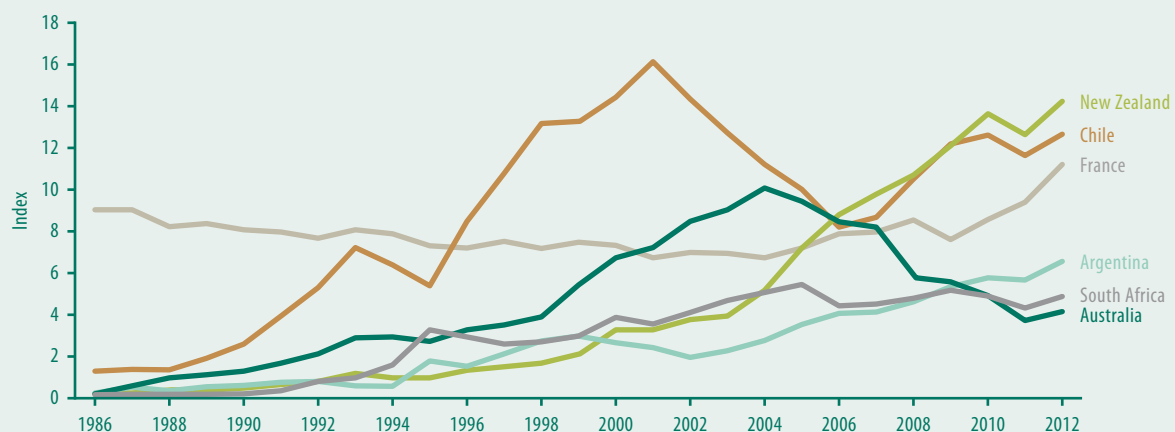
- the high prices of wool and wheat
- the success of the introduction of myxomatosis that wiped out a billion rabbits and led to a regeneration of pastures, resulting in a dramatic increase in income of woolgrowers
- pasture improvement involving the use of leguminous plants and fertilisers leading to dramatic increases in production and encouraging mixed farming

The second lesson is that a collaborative, industry wide approach to generic and brand promotion successfully built a global market niche for Australian wines from the mid-1980s. Rapidly growing affluence, plus deregulation of liquor retailing in the United Kingdom and Australia, expanded greatly the demand for affordable still wines. Supermarkets especially sought large volumes of reliable supplies that could attract return buyers and be advertised nationally. Australian wineries were the first to respond to this market growth opportunity, drawing on mechanical innovations and clever branding plus innovative generic marketing. In effect, they invented a third quality category in between the world's super-premium fine wine and non-premium wine categories. This new commercial-premium category not only encouraged consumers of non-premium wines to move up-market but, much more importantly, attracted a new group of buyers to bottled still wine consumption.

However, the viticultural, winemaking and wine marketing skills and technologies and stocks of market niche knowledge used to succeed in the commercial-premium category are easily learned. Knowledge transfer to other countries has been accelerated by the globalisation of several large wine companies and the emergence of flying vigneron consultants. This, together with the strengthening real exchange rate in the early 21st century following our latest and longest mining investment boom, meant Australia rapidly lost its comparative advantage in wine. The value of its wine exports was more than twice that of any other New World wine-exporting country in 2007, but that gap has since shrunk rapidly (Figure 1). Australia's ratio of wine exports to all merchandise export value peaked at 10 times the global average in 2003, before falling to below four times (Figure 2).

References: see Anderson & Aryal 2015.

Figure 2: Index of revealed comparative advantage in wine, Australia and other key exporters, 1986 to 2012



Note: Wine's share of a country's exports divided by wine's share of global exports (1.0 = world average).

- the exploitation of new crops and mineral resources: rice, tobacco, cotton, macadamia nuts and avocados, uranium (Radium Hill and Rum Jungle), silver, lead and zinc.

This led to rhetoric suggesting that the Australian land had only just begun to reveal its secrets, that it had 'infinite room for growth' (Walkabout 1951). Some claimed that much of the land that was claimed to be arid was actually fertile and all that it needed was rainfall (Walkabout 1954). This optimism inevitably resulted in yet another set of attempts to settle marginal land in places like the Ninety Mile Desert, Humpty Doo, Tipperary Station, and Willeroo Station.

Britain's bid to join the Common Market put a damper on this optimism and led to demands that subsidies and policies that encouraged denser settlement be abandoned in the interests of a more efficient rural sector. There was great concern about where new markets were to be found.

However, the emergence of new markets in Asia and the Middle East in the 1970s and the 1980s led to a revival of optimism. The buoyant agricultural markets in recent years have allowed rural producers to remain optimistic despite two periods of extended drought in the past 30 years.

3

Demand for Australian agricultural products

3.1 Findings

1. Demand for agricultural products in Australia is expected to grow in line with both an increasing domestic population and international demand.
2. Bulk commodities will continue to comprise the majority of Australia's agricultural exports, both in terms of volume and value.
3. There are opportunities for Australia in high-valued branded, specialised products, but to exploit this niche segment of the market profitably will require state-of-the-art information systems and marketing strategies.



4. Increased global demand for food will also bring increased global competition in our markets.
5. Australia's reputation for 'clean and green' products will continue to be important.
6. The domestic market will remain important for Australian produce even though food imports will continue to grow.
7. Globally, governments will continue to define opportunities and market access for Australian exports.
8. Our domestic market will continue to be influenced by global drivers, such as commodity prices, consumer preferences, seasonality, and changes to regulatory, trade and information systems.

3.2 Growing global population, incomes, industrialisation, urbanisation, and changing consumer preferences

3.2.1 Demand for food is growing, and changing

Global population growth and increasing incomes and wealth in developing economies are forecast to generate a strong growth in demand for agricultural products over coming decades, particularly in the Indo-Pacific region (Alexandratos & Bruinsma 2012; Foresight 2011). These trends will also see changing consumer preferences towards more protein, more highly differentiated products, and higher overall food quality and safety, as average income levels and urbanisation in developing countries increase. That income growth is generating a huge emerging middle class in these countries, with some 80 per cent of this growth occurring in Asia (Kharas & Gertz 2010).

Large emerging middle classes in countries such as India, China and Indonesia, along with increasing urbanisation and rising average income levels will drive significant changes in the pattern of global demand for farm products (The CIE 2015). Research by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) shows the potential for vast increases in imports of beef, sheep meat, dairy products, sugar and wheat into Asia by 2050, as illustrated in Figure 3.1. By 2050, the real value of global agrifood demand is projected to increase on 2007 levels by 77 per cent, which equates to an annual rate of increase of 1.3 per cent (Linehan, *et al.* 2012).

Markets are diversifying and urbanisation is increasing, resulting in a spectrum of customer requirements from low-cost unbranded commodities to highly differentiated branded products attracting much higher prices and customer loyalty. Australia is expected to

experience strong growth in demand for a wide range of agricultural commodities, products, and preparations, as will other food-exporting nations (The CIE 2015).

The effects of urbanisation, industrialisation, and population and income growth on global trade in farm products will depend on how developing countries approach their changing perceptions of food security. Pre-existing food self-sufficiency policies will likely need to be reconsidered in order to avoid shortages and price spikes, but some developing countries will seek to expand their agricultural production wherever possible to meet increasing domestic demands.

These trends will also encourage increased investment in local food processing industries and capabilities in developing countries. This has local benefits of providing employment for urban populations while developing capabilities to better meet changing domestic demands (The CIE 2015). The growth of food processing industries in developing countries is expected to expand this demand for unprocessed raw commodities, which can be blended across different sources to meet the quality requirements in local and export markets for substantially or elaborately transformed products.

Overall, the projected population and income growth over coming decades will see a range of new opportunities for agricultural producers and exporters across the spectrum of raw primary commodities to highly transformed, niche preparations. The key to exploiting these opportunities will be in developing a thorough understanding of evolving international markets and customer requirements, while delivering product of a consistent and reliable quality at a competitive price.

Strategic partnerships between Australian producers and target market-based producers, marketing agencies and distributors have the potential to increase market access and consumer awareness of Australian produce in those countries.

3.2.2 Australia's role in a changing global food marketplace

The scarcity of land for agricultural production in the growth markets in Asia provides a significant opportunity to Australia; over the next four decades this could result in \$710 billion (in 2011 dollars) of additional revenues for Australia from agricultural exports (ANZ Insight 2012).

Australia is a major exporter of wheat, beef, cotton, wool, oilseeds, wine, lamb, sugar, barley, and dairy products, as shown in Figure 3.2 (Grafton, *et al.* 2015). This is driven both by our comparative advantage in these commodities and by the trustworthiness of our product in

terms of perceptions of their quality and food safety attributes.

The expected overall growth in demand for food, as well as the shifting composition of that demand, will translate into ongoing opportunities for Australia's bulk commodity exporters. According to the Centre for International Economics:

Australia's comparative advantage is in exporting bulk, minimally transformed agricultural commodities and these commodities are likely to continue to account for a large proportion of the value and volume of Australian agricultural exports.

(The CIE 2015, p. 35)

Figure 3.1: Current and projected (2050) global demand for major Australian agricultural export commodities



ASEAN = Association of South-East Asian Nations.

EU15 = European Union of 15 countries.

Source: Adapted from Linehan, *et al.* 2012.

Australia's export growth is expected to remain strong in primary commodities or minimally transformed products. This is possible—despite high wage levels—because of economies of scale and labour-saving technologies. The area of processed food will be much more highly contested, and Australia would find it difficult to compete on price in this segment of the market. But there are also expanding opportunities at the other end of the spectrum, in the high-value branded, specialised products.

The interplay of these factors means that the major growth opportunities for Australian agriculture are primarily bimodal, in raw bulk commodities and high-value specialised products—although both types of opportunities may be met by different aspects of a common industry, as illustrated in Box 3.1 for Australia's beef industry. Opportunities in standard processed product markets will be much more difficult to come by. There may be scope for Australian food manufacturers to develop a comparative advantage through increased automation and mechanisation, although this may be difficult to maintain in the longer term and would require access to highly competitive financing arrangements. This is a challenge faced across the whole manufacturing sector in Australia, not just food manufacturers, as described in detail in the 2014 report *The role of science, research and technology in lifting Australian productivity* (Bell, et al. 2014).

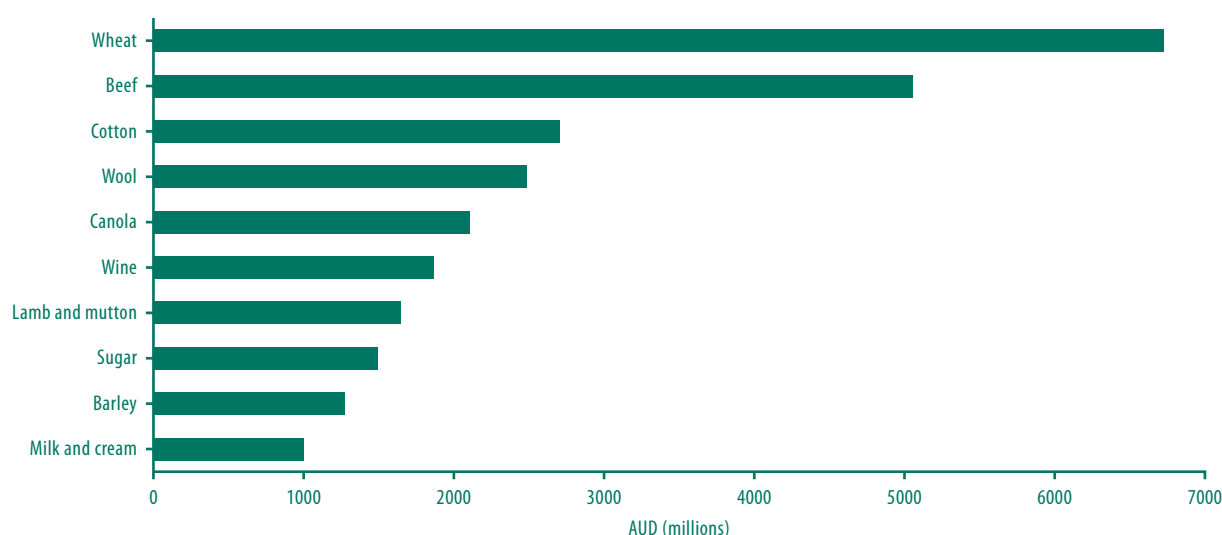
To focus on profitable export opportunities in the area of high-value branded, specialised products, Australian agricultural producers and food processors will need to connect with researchers and multinationals to invest in the innovative products and techniques that will be increasingly in demand (ATSE 2014).

Other major opportunities exist for Australian agriculture in providing the knowledge, experience, skills, technology and other raw materials to increase agricultural productivity and efficiency in developing countries. This includes opportunities such as:

- exporting of genetic material with specific desired traits to improve the breeding capacity of other nations' ruminant livestock industries
- farm management techniques and technologies, including robotics and sensor networks, precision tracking systems, etc.
- post-farm gate techniques and technologies, including in food processing, transport and storage
- research collaborations.

While the magnitude of these opportunities will be small in comparison to the value of exports of bulk commodities, they reflect the importance of Australia's involvement and integration into the global agricultural community, particularly in the face of future challenges to food security.

Figure 3.2: Australia's top 10 agricultural export commodities (by value), 2012–13



Source: Data from DFAT 2014.

Box 3.1: Australia's northern beef industry

Australia's beef industry comprises diverse operations across the continent targeting many export markets segments, including live animal export, high-quality premium chilled beef, and ground beef for hamburger meat. This industry is expected to enjoy major new export opportunities into Asia, but logistics and adequate transport infrastructure remain significant barriers.

Australia produces about 4 per cent of the world's beef supply and is the third largest exporter of beef worldwide. Beef is Australia's second largest agricultural export commodity after cereals, with about two-thirds of total production exported for about \$5 billion.

Beef production is typically disaggregated between southern and northern Australia, with the latter including Queensland, the Northern Territory and the northern half of Western Australia. While northern Australia accounts for about 75 per cent of the land area used for beef, it holds just under 50 per cent of the national herd. Beef enterprises tend to be larger in the north, with about 8000 producers out of a national 77,000 enterprises with cattle.

Natural systems constrain beef production in northern Australia through harsh climate conditions, poor and fragile soils, and an extended wet season. Most northern herds are infused with Bos Indicus cattle for their heat and tick resistance and ability to cope with harsh conditions. In contrast, southern Australian producers use more European and British breeds which are generally seen as having better meat quality.

Beef production in northern Australia is largely destined for export markets, with three key routes of market access. The most northerly areas, covering approximately 1500 producers, specialise in younger cattle destined for live export to south-east Asia. Better quality pastures in central and southern Queensland, together with feedlotting enterprises, produce chilled beef for export to high value markets, including Japan, Korea and Russia. The remainder of production is exported as frozen beef into the hamburger or grinding beef market, including to the United States.

Logistics and market access are constant challenges for northern producers. Distances are very large, road and rail networks are limited, and the only abattoirs are located on the Queensland coast south from Townsville, and more recently at Darwin. The development of the live export trade over the past two decades has provided more options for far northern and western beef producers who are otherwise isolated from markets. Many cattle are transferred between specialist producers along the breeding, backgrounding, finishing and feedlotting parts of the beef production supply chain, which provides some flexibility for producers to substitute between different live cattle and slaughter markets.

The northern beef cattle industry may enjoy significant opportunities relative to the southern industry. Both segments of the industry operate in a liberalised market environment, independent from government subsidies. The industry is free of major diseases, and the National Livestock Identification System provides the platform to safeguard its 'clean and green' credentials. The large scale of many enterprises, rapid improvement in the management of production risks and efficiencies, opportunities for greater intensification and proximity to emerging Asian markets all provide a base for future growth.

The northern beef cattle industry also faces headwinds. Market access remains a key challenge; the suspension of live exports to Indonesia in 2011 over animal welfare issues lowered market prices and threatened the viability of many northern producers. Efficiency and productivity lag behind southern operators and vary significantly between producers. Meeting public expectations about animal welfare standards and environmental management are becoming more important. Infrastructure is inadequate, transport networks are limited, processing plants are concentrated on the eastern coast and dominated by major firms, and communications and other services are generally poorly available in small regional communities. Other threats include increased input prices, disease and pest incursions, and climate change and variability.

3.3 Competing comparative advantages

3.3.1 New opportunities come with increased competition

Australian agriculture will face strong competition in attempting to seize the above opportunities as they arise, in two ways. First, insofar as fast Asian economic growth and industrialisation also expand the global demand for minerals and energy raw materials, it will strengthen Australia's comparative advantage in those non-farm primary products, just as it did over the past decade (Anderson & Strutt 2014).

Second, the projected increasing demand for food will affect Australia and our trading competitors alike. For Australian agriculture to capitalise on these opportunities there is a need for better information systems. Opportunities exist where there are gaps in product offerings or seasonal supplies of our competitors, and changing trends in consumer preferences. To be able to capitalise on the growing market for agricultural products, Australian producers and exporters need to solve the matrix of what

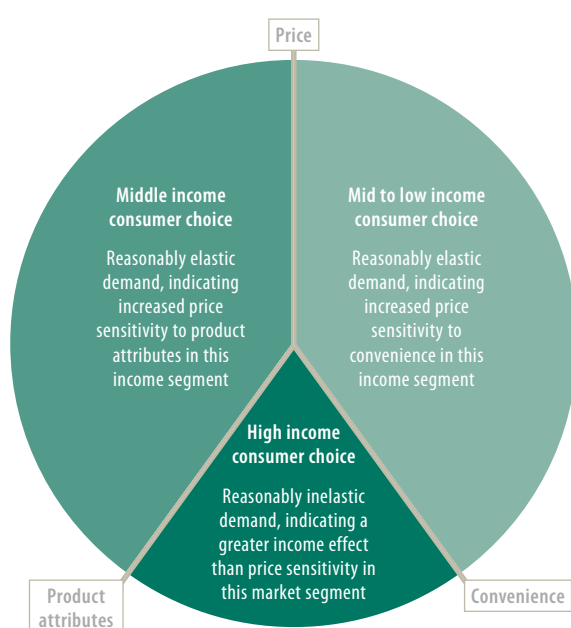
consumers want, when they want it, how much they want and how to get it to them.

According to The CIE (2015, p. 6) "recognising that across the range of traditional and potential exports Australian exporters are relatively small players indicates the importance of market research to identify strengths and weaknesses of competitors". This will require understanding the complex trade-offs in various segments of the consumer market and carefully targeting the appropriate values, as illustrated in Figure 3.3.

As discussed above, local food processing industries are an attractive target for investment by developing economies. This trend will increasingly result in both increased competition for substantially transformed foods within the Australian domestic market, as well as increased demand for raw bulk commodities in target export markets (The CIE 2015).

Australia's domestic market will remain important for agricultural producers, but local suppliers will have to work hard to maintain their position in the face of increased competition from cheaper imports of processed food. There is significant potential for local producers to trade on the perception of Australian produce as being of higher quality, more environmentally friendly, and safer, as illustrated by recent public conversations around the importance of country-of-origin labelling. However, producers will need to characterise the extent to which Australians really value Australian grown food for its perceived premium attributes, versus access to cheap, imported food. That is, to what extent these issues actually affect Australian consumers' purchasing behaviours, and how this can be exploited.

Figure 3.3: The spectrum of consumer demand—market section tradeoffs on price, convenience and attributes



Source: The CIE 2015.

3.3.2 Australia's advantage: clean and green

Part of Australia's key comparative advantage in food is based on our 'clean and green' reputation (as discussed further in section 5.4.3). Australian produce tends to have relatively low levels of contaminants such as pesticides and herbicides and other food-safety attributes. It is also

produced in a relatively environmentally friendly and sustainable way, and it is generally of a high quality.

This reputation can help to build and maintain markets in Asia for both high-value niche products as well as bulk raw commodities. But to sustain those comparative advantages in the face of competition from other exporters requires ongoing investment in not only R&D but also in credible compliance indicators. Robust and internationally recognised certification and assessment schemes to guarantee the high safety and environmental standards of Australian produce would assist in that regard. However, producers operate on very tight margins and the added cost burden of complying with these schemes can be a deterrent.

Therefore, it will be crucial for Australian governments, producers and industry organisations to coordinate closely on the application and development of these kinds of schemes, and leverage existing arrangements to achieve the desired outcomes at least cost while streamlining any necessary regulation. The potential ongoing benefits to Australian exporters of this approach to building our 'clean and green' brand should far outweigh short-term costs.

3.4 Issues affecting import demands for Australian farm produce

The growth of food demand in target overseas markets will largely depend on population growth, increasing incomes and changing diets and the interplay between those factors (Anderson & Strutt 2014; Pardey, *et al.* 2014; Pinstrip-Andersen 2014). These countries can also be expected to develop, and possibly protect, their own agricultural and food processing sectors, so the demands for food imports in target markets will be the net effect of their own supply and demand changes. Simultaneously, Australia will not be the only country increasing food production to target new opportunities, and there will be strong

competition to supply food into target markets and for other uses of agricultural land such as for biofeedstocks. While advanced modelling efforts (e.g. Anderson & Strutt 2014; Pardey, *et al.* 2014) are predicting that agricultural production and trade will largely increase to meet growth in demand, the exact pattern of both growth in global food demands and supply responses will vary over time.

The opportunities for Australian agriculture to meet growing international demands for food will depend on both bilateral relationships with specific trade partners as well as the development of global markets and trading rules.

3.4.1 Market access

Ongoing access to target markets is central to the success of Australian exports, particularly agricultural products, and government support has a key role to play in this regard.

The transformation of growth in international demand into market opportunities is not automatic. Successful development of trade relationships is likely to depend on three key factors:

- the development of relationships and soft power, e.g. networks and the ability to interface with culture and language in trading partners
- trade rules, e.g. the extent to which regulations and institutions allow open access into specific markets
- logistical and trading mechanisms, e.g. the extent to which transport and transaction mechanisms operate efficiently, lower transaction costs and risks, and provide Australian exporters with cost advantages over international competitors.

Industry and governments can facilitate the development of markets and trade in agricultural products in a number of ways, including:

- mechanisms to develop closer 'soft' relationships with key trading partners, including language and exchange programs, trade shows and visits, and industry collaboration

Box 3.2: Market access: is agricultural protectionism rising or falling?

Agricultural protectionism of various forms may present increasing barriers to the growth in exports of Australian producers in the future. It is in Australia's interests to continue efforts to liberalise agricultural trade through bilateral and multilateral mechanisms.

One of the most persistent policy trends in economies as they develop has been the rise of agricultural protectionism, mostly through barriers to imports. It began in Britain even before the Industrial Revolution, spread to other European countries in the second half of the 19th century, then to Japan in the early 20th century and to East Asia's tiger economies from the 1970s. Most recently it has spread to middle-income countries such as China, India and Indonesia (Figure 1). Meanwhile, in lower-income countries where farmers have been effectively taxed relative to manufacturers, the extent of that taxation has been gradually phased out since the 1980s. When protection rates for these two groups of developing countries are aggregated, their average rate of assistance to farming has transitioned from highly negative to slightly positive.

Figure 1: Extent to which producer prices exceed international prices in China, India and Indonesia



- clear trading rules and the development of trade agreements
- improvements to transport, logistics and exchange arrangements, and the development of integrated supply chains through foreign investment and other complementary arrangements.

Australia has been increasingly entering into bilateral and regional trade agreements with key target export markets, most recently with China and potentially under the Trans-Pacific Partnership. These agreements have an important role to play in maintaining market access, even though their utility is limited relative to what could be achieved through a multilateral agreement such as proposed under the elusive Doha Round of the World Trade Organization.

Issues around market access are described further in Box 3.2, where it is clear that the

early protectionism of agriculture in advanced economies has decreased since the 1980s. However, there are concerns about the rise of protectionism in developing countries as they seek to protect their local production from import competition. Such distortions of the global market for food and other agricultural products reduce market signals to farmers and discourage investments to increase farm productivity.

3.4.2 Part of a global market

Ultimately, Australia is part of a global market for food and agricultural produce. This market is influenced by a range of factors beyond our farmers' control, including extreme weather events and climate change, government policies such as food self-sufficiency and biofuel mandates, and trends in consumer preferences.

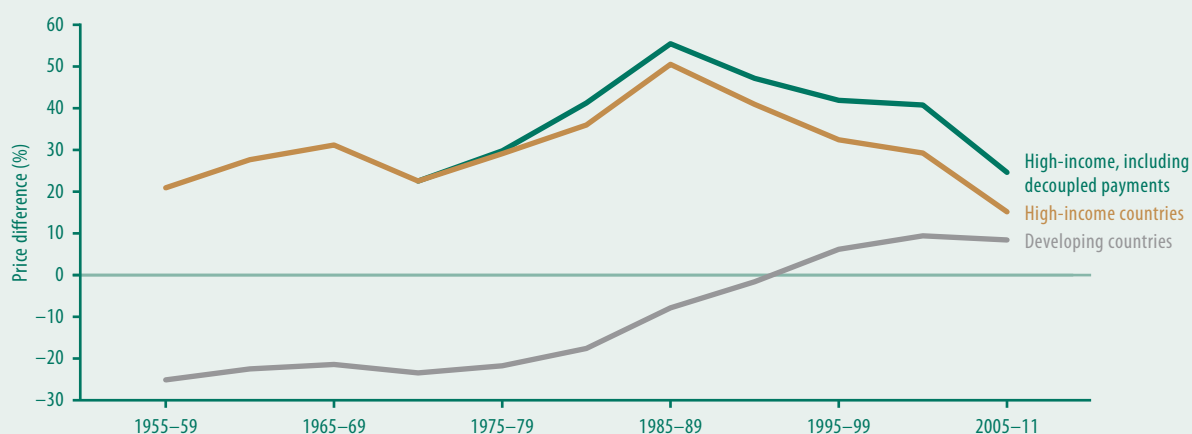
Partly as a result of the centrality given to agriculture in the Uruguay Round of multilateral trade negotiations, led by Australia through the Cairns Group, the historical upward trend for protectionism in most high-income countries reversed after the mid-1980s (although there was some re-instrumentation to domestic support measures that were somewhat decoupled from current production). Hence the average rate of assistance to their farmers has converged on the average rate for developing countries (Figure 2).

However, those averages for the two country groups hide a great deal of diversity in protection rates, both across countries within each of those groups and between commodities within the farm sector of each country. Hence the world is still a long way from being free of distortions to agricultural prices. As well, barriers to highly processed foods tend to be greater than for the primary or lightly processed products that are included in the Figures here.

These facts underscore the importance of including agricultural policy reforms in preferential trade agreements and ensuring an ambitious set of liberalisations are included in the agricultural part of the multilateral WTO Doha Agreement if and when it is reached.

References: see Anderson 2009, and Anderson & Nelgen 2013.

Figure 2: Extent to which producer prices exceed international prices in high-income and developing countries



Demands from individual trading partners, and prices paid, will ultimately be driven by net global supply and demand balances. Factors that enhance global demand for agricultural products and enhance Australian suppliers relative to competitors will improve the prospects for our agricultural exports.

As a major food exporter, Australia has a clear interest in agricultural trade liberalisation. The continuing liberalisation of trade in food will be of increasing importance to underpin food security into the future, especially as climate change adds to national volatility of annual crop yields. Australian governments have an important role to play in continuing to advocate for trade liberalisation in the World Trade Organization and other international fora and through bilateral and regional trade negotiations.

Operating in a global market also requires suppliers to be nimble. Taking advantage of modern communication technologies can improve connectedness with target export markets, enabling agricultural industries to react to changing market conditions and to take advantage of emerging opportunities. Producers and exporters will need to be flexible and adaptable to anticipate and react quickly enough to rapidly changing and sometimes ephemeral market opportunities and to understand consumer requirements (ANZ Insight 2012).

This exposure to global market conditions can also provide new opportunities for Australian farmers, such as in the market for biofuel feedstocks as described in Box 3.3.

Box 3.3: Beyond food—the rise of the bioeconomy

Susan Pond, United States Studies Centre at the University of Sydney.

In addition to helping deliver global food security, nutrition and health, agriculture is playing an increasingly important role in the production of building blocks for renewable chemicals, materials and fuels.

This global renewable bioproducts industry is seen as a near-term, game-changing and value-adding opportunity for agriculture (Erickson, *et al.* 2012). Sugars, oils, proteins and fibres derived from agricultural biomass, including from currently underutilised waste streams, can be converted into bio-based versions of existing petroleum-based products or entirely new molecules and materials. This process is illustrated in Figure 1, showing some of the possible combinations of feedstock, processing and products based on the sugars platform.

Bioplastics have already become commercially viable in the packaging industry. In the past six months alone, 12 advanced bioeconomy companies in the US raised USD 1.262 billion in new capital for pilot, demonstration and commercial-scale projects (Lane 2015).

In its 2010 report on industrial biorefineries, the World Economic Forum noted that although the global bio-based industry was nascent and fragmented, larger players were starting to invest at a gathering pace (King 2010). King estimated that, on the input side, biomass production offers new business opportunities for farmers and grain processors, associated with potential additional revenues of US\$90 billion by 2020. Australian farmers can participate in this market.

A recent Deloitte Access Economics study of the economic impact of a future tropical biorefinery industry in Queensland concluded that it could be a “viable source of economic growth and diversification”, have an estimated annual economic impact of \$1.8 billion and, by 2035, “support over 6640 FTE employees, many of which are in regional Queensland” (Deloitte Access Economics 2014). Agricultural feedstocks considered included sugarcane, sugarcane bagasse, and sweet sorghum and sorghum stover.

Commercial airlines around the world see the development of a domestic, competitively priced, sustainable supply of renewable aviation fuel as fundamental to their future. In Australia, the industry has led studies to assess the feasibility and opportunities associated with development of the sustainable aviation fuel industry in Australia (CSIRO 2011; LEK Consulting 2011; Qantas Airways Ltd 2013).

In its 2013 Report, the Academy of Technological Sciences and Engineering concluded, “if price-point competitiveness and reliable high volume supply can be achieved, sustainable aviation fuel production represents a tangible and major green growth industry opportunity for Australia” (ATSE 2013).

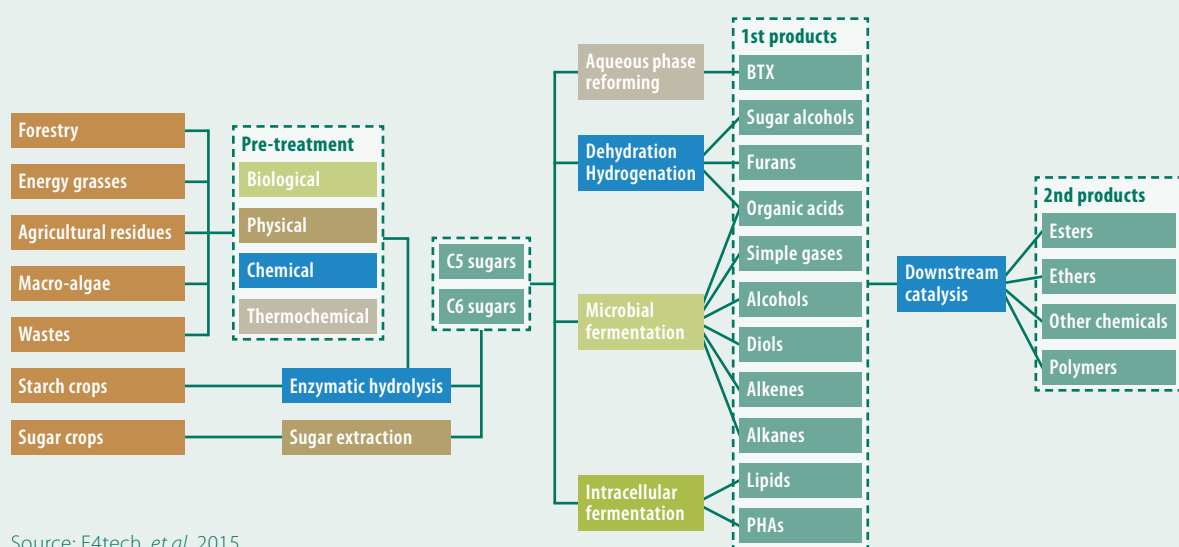
These barriers of price-point competitiveness and reliable supply are common to production of any renewable bioproducts in Australia or elsewhere.

As most of the pre-treatment and conversion technologies are now available 'off-the-shelf', the barriers to be overcome in Australia relate to securing: feedstock in sufficient quantities, year round and at affordable prices; capital, to finance projects; public acceptance of bio-based products; strategic demand side policies, including uniform standards for bio-based products; workforce skills; and collaborative, operational alliances along the new value chains.

Although nascent and fragmented, the bioproducts industry is growing in Australia. Companies already competing in the commercial market are manufacturing biofuels, including ethanol and biodiesel, bioplastics, finished-product packaging, and renewable chemical precursors.

The opportunities for stronger commercial activity are there to be taken if Australian agriculture can present the attractive feedstock and investment conditions necessary to compete in this global market.

Figure 1: Schematic of biproduct pathways via the sugar platform



Source: E4tech, *et al.* 2015.

3.5 Policy challenges

In order to capitalise on the opportunities to increase demand for Australian agricultural products, policy makers need to consider approaches that ensure that:

- demand growth is sustained in line with population and income drivers (so as to provide stability for investment and growth)
- there is access to markets, particularly international
- agricultural protectionism is limited
- the diversity of consumer demands is reflected in market and regulatory processes.

4

Potential for Australian agriculture to meet increased demand

4.1 Findings

1. Prospects for increasing Australia's supply of agricultural produce to meet growing demands are positive, but with important caveats.
2. Securing the soil resource on-farm will underpin future productivity growth.
3. Opportunities exist to expand and intensify agricultural production in northern Australia and Tasmania so long as underlying constraints and environmental impacts are addressed.



4. Future increases in total factor productivity will require significant new investments in research and development from both the public and private sectors.
5. Continuing development of water markets is a vital part of Australia's agricultural future.
6. While agriculture and food production can be a driver of negative impacts on biodiversity, they can also play a very important role in conservation, for both private and public good.
7. Increasing productivity growth and deepening capital investment are the key public policy challenges for increasing the supply of agricultural outputs in Australia.

4.2 Overview—the future is optimistic

The prospects for increasing supply of Australian agricultural products to meet demand are positive, but cautiously so. Australian farmers have a history of resilience and adaptability, responding to new opportunities and threats. Major restructuring has occurred in a number of farming sectors, and profitable farms are incorporating advanced technology to manage their resources and risks. The end of the mining boom will see Australia's currency return to levels that are more favourable to our agricultural exports.

Increased global demand in overseas markets will not necessarily translate into realised benefits for Australian agriculture if industry is unable to increase output or meet changing market expectations. Chapter 2 provides the background to agricultural development in Australia and its contribution to the economy. Here we explore the potential for agriculture to respond to the growing demand outlined in Chapter 3.

4.2.1 Farming sector as a focal point of discussion

The prevailing mood in key policy narratives and debates (see section 2.4) is that agricultural industries are a part of our economic future. This is a move away from the sentiment prevalent a decade ago during the mining boom that they were 'sunset industries'. Withers *et al.* (2015) in their review of Australia's comparative advantage across all industry sectors noted that the agricultural sector is part of the 'post-mining boom' economy and that barriers to growth in agriculture are shared by a range of other industry sectors. Important issues to address included infrastructure, skills development, the need for strong partnerships among players in the supply chain, innovation and R&D, and the ongoing need to boost investment. These foundations are essential if sector-specific policies are to have significant impact.

Supply of agricultural goods can be increased by: *expanding inputs*, particularly land and water resources; *improving the availability of current*

inputs especially capital, technology and skills; and *increasing the efficiency (productivity)* in the use those inputs. Options to improve production have to be consistent with a sustainable resource base and must take into account endogenous constraints, such as:

- inadequate investment in research, development, and extension
- physical factors such as climate change and climate variability, including an increase in extreme weather events, biosecurity hazards, and other supply risks
- domestic economic conditions that may shift inputs (investment, employment) away from agriculture to other sectors of the economy
- inadequate access to information systems and communications technologies.

Chapters 4, 5 and 6 focus attention on areas where there is a need for an integrated approach across these issues if productivity and profitability are to increase. These areas include:

- agricultural expansion into new areas such as northern Australia and Tasmania that is realistically planned against evidence-based assessments of water availability and infrastructure development
- adaptations to the impacts of climate change that will affect Australia's ability to lift its productivity, including through the provision of nationally consistent, regionally significant databases for soil, water, and biodiversity assets, plus regionally appropriate weather forecast
- supply of a highly skilled workforce to support the rapid uptake of knowledge and skill intensive approaches to farming (section 5.2.3)
- land tenure and planning that enables farmers to adapt land use to the most productive, profitable activities, including non-agricultural uses (section 5.3.1)
- strong partnerships between the agricultural sector, the supply chain, the markets and researchers to stimulate innovation in response to market signals and a changing resource base (section 6.4.1).

4.3 Increasing productivity and supply

Australian agriculture needs to be profitable and sustainable in its use of natural resources while effectively managing evolving risks including a variable and changing climate and biosecurity hazards.

A significant barrier to increasing supply of agricultural products is that productivity growth has been slowing in agriculture in recent decades (section 2.2.3). Australia is not alone in this slowdown. Our traditional trading partners face many of the same challenges including a flattening of productivity growth. As mentioned in section 3.2.1, global agrifood demand is expected to increase at a rate of 1.3 per cent per annum out to 2050. This aligns with targets recommended by Fischer *et al.* (2014) for annual productivity increases in grain production to 2050. In order to meet this demand, supply must increase at a similar rate—which will require an increase in inputs, a constant increase in the efficiency with which current inputs are used (i.e. TFP), or more realistically, a mixture of both. It will be difficult to increase certain inputs to agriculture, such as land and water (see sections 4.3.2 and 4.3.3), in a sustainable way. This places further importance on continuing to increase TFP through a range of mechanisms.

Growth in total factor productivity can be affected by shifts in the relative contribution of technical change (new technology) versus technical efficiencies (better adoption of

existing technology). There are signs that broadacre cropping in Australia is close to the productivity frontier of existing technologies and practices (Fischer, *et al.* 2014; Hughes, *et al.* 2011) suggesting that future changes will require development and adoption of new technologies.

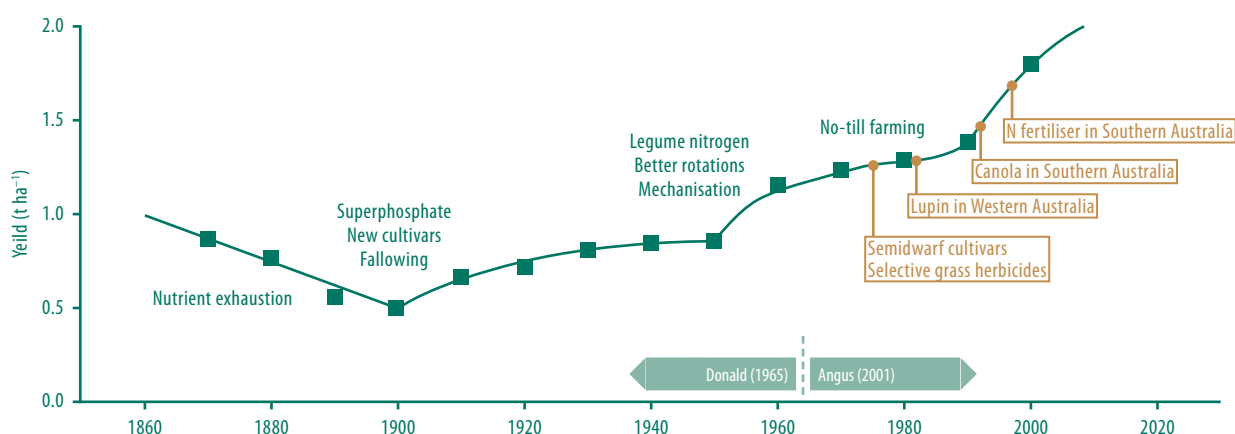
4.3.1 Maintaining the resource base—soil

Soil is a critical engine for agricultural productivity. The challenge for Australia is that it has limited areas of high quality soils, and soil degradation such as acidification, erosion, dryland salinity and now soil carbon remain major problems; many farming soils require careful management to maintain production.

Agriculture (cropping and grazing) uses about 60 per cent or 456 million hectares of the Australian continent. Livestock raising accounts for 94 per cent of this usage in the arid and semi-arid regions, most of the rest is dryland cropping with less than 1 per cent used for irrigated crops (Grafton, *et al.* 2015). Over recent decades the area under cropping has increased, in part in response to the shift from wool to oilseed production.

Much of the dramatic increase in productivity in wheat from the 1950s onwards can be attributed to the use of fertilisers, either added as superphosphate or through biological fixed nitrogen through crop rotations with legumes and oilseeds, as illustrated in Figure 4.1. However, there are concerns that the quality

Figure 4.1: Decadal growth in Australian wheat yields and technologies driving changes



Source: Grafton, *et al.* 2015, p. 22.

and accessibility of phosphate reserves in the future is decreasing with estimates of supply for phosphate ranging from 30 to 300 years (Cordell & White 2011). The use of fertilisers in some form is critical to Australian productivity on our nutrient-poor soils and greater attention needs to be directed to this issue.

Effective incentives for improved soil and land management need to be found as part of Australia's agricultural future (Grafton, *et al.* 2015, p. 84). Examples of better management techniques include the adoption of precision

farming by grain growers, where both profitability rates and soil health have increased.

In spite of the importance of soil management, the science is lagging behind farmer innovation. Big data analysis, combined with a range of soil sensing technologies and 3D soil mapping, will provide farmers with a view of the soil system in their paddocks in real time (see Box 4.1). Already, farmers are using automated systems on tractors to deliver fertiliser and lime to minimise yield variation within a field (see Chapter 6).

Box 4.1: Soil security for a competitive agricultural future

By Andrea Koch, United States Studies Centre, University of Sydney.

A holistic framework that enables farmers to make the best use of technology, data resources, knowledge and expertise to manage and secure their soil resource will underpin the future productivity growth and success of Australia's agricultural sector. This will require collaboration and coordination across the sector, including linking research, government planning, and information systems with farmers on the ground.

Soil security is defined as the maintenance and improvement of soil condition so that the soil can continue to provide food, fibre and fresh water, contribute to energy and climate sustainability, and help to maintain biodiversity and the ongoing delivery of ecosystem goods and services (Koch, *et al.* 2012; Koch, *et al.* 2013). In order to secure soil, farmers and land managers must understand the inherent capability of the soil they work with, have the knowledge and resources to maintain and improve its condition in the context of production, and understand its economic value (McBratney, *et al.* 2013).

While soil security leads to broader positive natural resource and sustainability outcomes, it is primarily an agricultural concept (Koch, *et al.* 2015). Australian farmers own, manage and care for 61 per cent of Australia's landmass (NFF 2012), but over recent decades governments have increasingly tended to address soil as a broader natural resource management issue rather than a farm-level issue (Campbell 2008). This is understandable given the ongoing issues of soil degradation in Australia's ancient and highly weathered soil resource (State of the Environment 2011 Committee 2011), and the need for catchment-scale responses. Agricultural soil science research has tended to focus on solving specific issues that negatively impact productivity such as increasing pH, the loss of soil organic carbon, acid sulfate soils and water repellent soils.

This approach has failed to view soil as a critical engine for agricultural productivity. Some innovative farmers have taken a 'from the soil up' approach to production, through practices such as 'no-till' farming, and have reaped the benefits of increased productivity, often with lowered inputs and a far more resilient and drought-proofed landscape. These results are largely anecdotal and are recorded as case studies rather than in scientific papers (Soils for Life 2012). The science is lagging behind farmer innovation. Now is the time for governments to refocus on soil productivity as a route to step changes in agricultural productivity.

Agricultural productivity growth is declining (Sheng, *et al.* 2011). Getting more out of our agricultural and grazing lands without further soil degradation is the key challenge for the industry (Koch, *et al.* 2015).

Recent advances in technology now make the industrialisation of soil management possible. In the near future, 'big data' analysis combined with a range of soil sensing technologies and 3D soil mapping will provide farmers with a view of the soil system in their paddocks in real time. Ultimately, agronomic decisions will be based on optimising the functional capability of the soil system, including biological interactions around the all-important plant root zone.

The technical capability to achieve this vision largely exists already, but there are knowledge gaps that must be filled in order to fully harness the potential of soil productivity. In addition to coordinated scientific research, government planning and investment to link up relevant information systems, education for farmers and a regulatory framework for data management will be needed.

The soil security framework provides a holistic approach with which to frame the effort—ensuring that farmers understand the capability of their soil system, have the knowledge and resources to optimise its condition and productivity, and understand its economic and capital value.

4.3.2 Water resources

Australia is characterised by highly variable rainfall, both seasonally and across the continent. Availability of, and access to, engineered storages and aquifers has been critical to the development of agriculture in Australia. Even water used for irrigation is dependent on rainfall patterns (see Box 4.2 for a case study of Australia's rice industry) and irrigated farming can drop off markedly during times of drought.

Overall, agriculture accounts for 50 to 70 per cent of all water consumed in Australia. Irrigation agriculture, while accounting for only 0.5 per cent of agricultural land in Australia, contributes between 28–32 per cent of the gross value of agricultural production (Grafton, *et al.* 2015).

The scarcity of irrigation water, and the introduction of water trading in recent decades, has led to increases in water use efficiency in Australia, resulting in some of the highest productivity levels per litre of water in the world. For example, Australia's best wheat crops have increased water productivity four-fold over the past century and are now world leaders thanks to R&D-driven agronomic and breeding advances (Barlow, *et al.* 2015).

The scarcity and tradability of irrigation water in Australia has encouraged farmers to increase water-use efficiency in terms of growing irrigated crops and horticulture. However, there remain significant opportunities to increase water productivity in irrigated agriculture, particularly the most widely used gravity flow systems.

By increasing the efficiency of each step in the irrigation chain, the efficiency of the whole system can be vastly improved. Better management techniques to squeeze as much productivity out of every drop of irrigation water will rely on the deployment of sensor technologies and closed-loop information systems to provide real-time information to water and farm managers, which will enable automation and inform manual decision making (Barlow, *et al.* 2015).

These kinds of advanced irrigation management systems coupled with broader water monitoring tools (see Box 4.3) and more accurate seasonal

weather forecasts will enable Australia's national and regional water markets to ensure that irrigation water is used by farmers for the highest potential economic returns (Barlow, *et al.* 2015). This will require continued investment in research and development to underpin an innovative integrated systems approach to optimising water production efficiency.

4.3.3 Expanding land and water resource inputs

There appears to be some scope for agriculture to grow from increased access to land and water resources, particularly in northern Australia and Tasmania, so long as environmental, land tenure (including native title considerations), capital and uncertainty-related constraints can be addressed.

The *Agricultural Competitiveness Green Paper* (Commonwealth of Australia 2014) supports investments in irrigation development based on consistent, robust analysis of costs and benefits. The Economists at Large (2013) have argued for more rigorous analysis of existing schemes prior to investment in new schemes (Grafton, *et al.* 2015, p. 76).

Northern Australia: The recently released white paper on opportunities for developing northern Australia (Commonwealth of Australia 2015b) highlights the opportunities for intensifying and expanding agricultural production in this area. Extensive evidence-based reports now exist for reviewing the potentially exploitable water resources in northern Australia, including the CSIRO Northern Australian Sustainable Yields Project (CSIRO 2009a). Areas for irrigation development do exist (e.g. the Flinders Catchment). However, even in areas where rainfall is plentiful there are constraints in water storage because of flat terrain and high evaporation rates and, where storages could be built, the rainfall is sporadic.

Overall, Grafton, Mullen and Williams (2015) postulated that the water available for agriculture from both ground and surface water combined was around 10,000 GL—significantly less than previously proposed resources of around 23,000 GL (Petheram, *et al.* 2010). They argue that “there is increasing evidence that the volumes of water

that can be captured tend to be much smaller than broad scale assessments.”

Current evidence suggests that mosaic irrigation patterns may be preferred to large scale irrigation systems (Grice, *et al.* 2013; Story, *et al.* 2008).

Tasmania: Similar results are also available for Tasmania where mosaics of small scale irrigation systems offer potential for expansion. Figure 4.2 shows the potential exploitable water in Tasmania.

Nevertheless, intensifying agricultural development, particularly in northern Australia, is not without challenges and continues to draw controversy. The Northern Australia Land and Water Taskforce (Commonwealth of Australia 2009) cautioned that while water availability would drive development opportunities, competing interests of tourism in pristine environments, commercial fisheries, and indigenous livelihoods needed to be factored into debates about possible increases in consumption of water. The white paper on northern Australia (Commonwealth of Australia 2015b) acknowledges these challenges and proposes an action plan. It is too early for detailed analysis of these ideas although commentary in the media is already appearing (e.g. Campbell 2015; Turton 2015).

Despite the optimism for future growth, studies over the past 15 years in northern Australia and Tasmania have shown that the water that can be potentially captured and the land area that can be irrigated are very much smaller than initially anticipated (Grafton, *et al.* 2015, p. 74).

Consideration of economic, social, cultural, and environmental sustainability factors must also be included (Commonwealth of Australia 2015b; Grafton, *et al.* 2015, pp. 69–70). Existing analysis of public good ‘welfare’ gains in northwest Queensland have shown little to no benefit and the costs of turning northern Australian into an irrigated food bowl exceed even the most optimistic benefits (Dent & Ward 2014; Wittwer & Banerjee 2014).

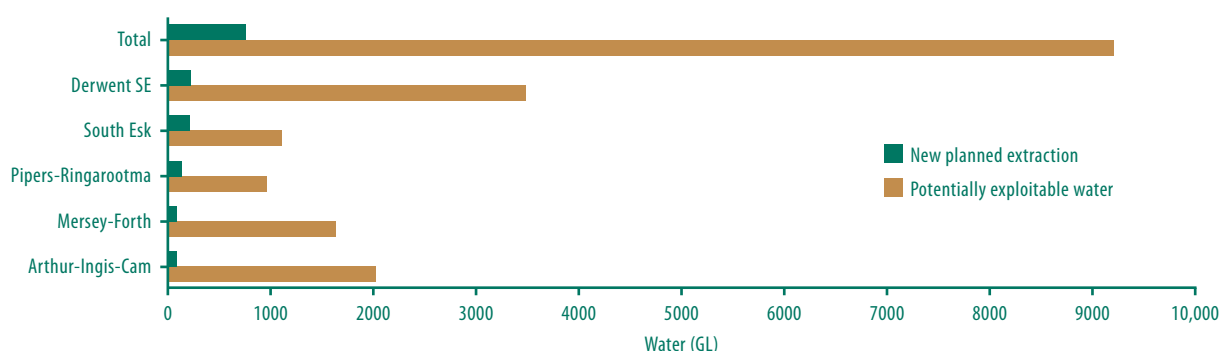
Given these potential limitations, it is important that any proposals to use additional natural resources for agriculture should consider all major impacts and be subject to rigorous appraisal.

Australia’s agricultural future will be shaped by the need to examine public and private investment and market failure, where it occurs, to determine how exploitable water resources in Australia are best utilised. The need to apply good science and robust economics to public policy is fundamental to supporting an internationally competitive agricultural sector.

(Grafton, *et al.* 2015, p. 76)

Another option for Australia is the opportunistic intensification of irrigated crops that are only grown when sufficient water is available, within environmental limits. This is already practised by Australia’s cotton and rice industries. The area of irrigated cotton production has varied over the past decade from a low of around 60,000 hectares to a peak of over 500,000 hectares. Cotton growers may choose to grow rain-fed cotton, if soil moisture is high but irrigation allocations are

Figure 4.2: Planned surface water extraction and estimated potentially exploitable surface water in Tasmania



Source: Based on CSIRO 2009b; Petheram *et al.* 2010 methodology.

Box 4.2: Riverina rice: some characteristics of opportunistic diversification and sustainable intensification

Adapted from Grafton, *et al.* (2015).

The development of water trading markets has enabled Australian farmers to grow opportunistic irrigated crops in times of high water availability. Australia's rice industry takes advantage of this capability to produce one of the most water-efficient rice crops in the world.

Australia's annual rice production is directly related to the amount of irrigation water available. Most rice is grown by general security irrigators who receive their water last in the hierarchy of allocations. They are also the first to have allocations reduced in times of water shortages. Traditionally, Australian farmers produced around 1.2 million tonnes of rice each year from approximately 150,000 ha. However, during the Millennium Drought, production levels dropped to 19,000 tonnes due to water restrictions. In recent years production has returned to pre-drought levels.

A rice crop forms one part of a farming system. It is only planted when the conditions are suitable. Rice is grown from October until March and in rotation with other crops such as wheat, barley and maize. Many of these crops grown in rotation with rice utilise the residual soil moisture after the rice crop is harvested. This means that rotations do not require further irrigation and allows for further water savings and more efficient water usage, and effectively provides growers with two crops from one application of water.

Essentially, the rice industry is able to operate in an opportunistic manner by using water when it is available and close down production when it is not. This makes it well-suited to Australia's variable climate. Rice growers have introduced a number of adaptations to respond to reduced water availability, including water trading, on-farm water-use efficiency and diversification. When water is not available or is too expensive, other sources of income are generated including integration with livestock, particularly sheep, off-farm sources of income through investments in the share market, off-farm employment, contract sowing and harvesting and operating related retail enterprises. One such activity is rice processing: Sun Rice, through progressive food processing and innovative food products development, can turn rice into a ready-to-eat meal that has a value equivalent to over \$10,000 per tonne of harvested rice.

Water can account for 20 to 30 per cent of the total variable cost of rice production. Growers have strong incentives to reduce water use without affecting productivity to improve profit margins. In the past 15 years, rice growers have increased production per hectare by 60 per cent while at the same time decreasing water use per hectare by 30 per cent. As a result, Australian rice production uses less water per hectare than other countries and is consistently in the top 4 of water-efficient producers world-wide.

While the world average yield is around 4 tonnes/ha, Australia's average yield is 9 tonnes/ha, with some farms recording yields as high as 14 tonnes/ha. Productivity with improved management technology over a 15-year period has increased from 0.4 to around 1.0 tonne of rice per ML of water.

When water is available for irrigation, rice is a major user of water in Australia, accounting for some 11 per cent of irrigated water use. Despite the high and increasing productivity per unit of water the dollar-value per unit of water for rice is low.

Careful water management of rice farms is needed to ensure both environmental sustainability and rice productivity. Land and Water Management Plans are the cornerstone of environmental initiatives in the irrigation areas of the Riverina.

low, or may revert to crop production, pasture or leave land fallow. The rice industry is also noted for its ability to respond to the changing availability of water (Keogh 2014) as described in Box 4.2.

Grafton *et al.* (2015) note that it may seem counter-intuitive that annual irrigated crops are ideally suited to Australia's variable climate (Keogh 2014). However, it enables farmers to maximise production when water is available. Another example is pasture cropping (Bruce, *et al.*

2005), particularly in high rainfall zones including the use of dual-purpose wheat, canola and other crops (GRDC 2009).

4.3.4 Competition for water with other sectors—the energy sector

Significant gains have been made in the past two decades to improve the efficiency of existing resource use by agriculture, improving both the returns to agriculture and the impact on natural resources. The establishment of water markets

Box 4.3: New water information services assist Australian industries

Australian farmers now have access to national water information services that draw together information from over 180 different agencies. This knowledge network provides access to how the water availability in river systems, water storages and groundwater reservoirs is changing, and allows predictions of future availability.

The 'Millennium Drought' resulted in Australia's most serious water security crisis, affecting most capital cities, many rural towns and significant 'foodbowl' catchments such as the Murray Darling Basin. Streamflows declined markedly and many water storages became severely depleted. This led to aggressive water restrictions and significant reductions in water allocations for irrigation, impacting many industries including agriculture. The severity of this event exposed many frailties in the way water was being managed in Australia.

In early 2007 the Australian Government announced the *National Plan for Water Security*, significantly increasing the involvement of the Commonwealth in national water affairs. This 10-year plan was introduced to deepen national water reforms and fund programs to increase our water security. It strove to do so by setting sustainable diversion limits for the Murray Darling Basin, refurbishing inefficient irrigation and water delivery systems, removing constraints to water trade, building up a reserve of water entitlements for the environment and augmenting water supplies.

As part of that reform, the Bureau of Meteorology (the Bureau) was funded to establish a national water information capability. This entailed the capture of water information collected by over 180 different agencies and the provision of a variety of water information products and services. The addition of this new function to the Bureau complemented existing capabilities in weather forecasting, seasonal climate forecasting and flood warning.

The Bureau now provides an extensive suite of water information services, many of which are of direct benefit to the agriculture sector. Streamflows across the nation can be monitored at *Water Data Online* (Bureau of Meteorology 2015a) and long-term trends in runoff can be assessed at *Hydrologic Reference Stations* (Bureau of Meteorology 2015b). *Water Storage* (Bureau of Meteorology 2015c) provides continuous updates on the amount of water held in public storage, *Water Market Reports* (National Water Market 2015) tracks the ownership and trade of water, and *Water Restrictions* (Bureau of Meteorology 2015d) indicates where constraints on water access apply. The *Australian Groundwater Explorer* (Bureau of Meteorology 2015e) and the *Atlas of Groundwater Dependent Ecosystems* (Bureau of Meteorology 2015f) provide comprehensive insights into our nation's groundwater resources. *Climate Resilient Water Sources* (Bureau of Meteorology 2015g) details the production of water at more than 240 water recycling and desalination plants around Australia. The *National Water Account* (Bureau of Meteorology 2014) is now published annually, detailing the availability, ownership and use of water in Australia's eight most significant water resource systems. *Seasonal Streamflow Forecasts* (Bureau of Meteorology 2015h) are provided for 101 locations across the nation and updated monthly for the three months ahead. Finally, *Short-term Streamflow Forecasts* are available for 114 locations and are updated daily for the seven days ahead. These complement the extensive range of services available to the agricultural industries, accessible via the Bureau's *Water and the Land* (Bureau of Meteorology 2015i) web page.

Via access to these new water information services and others that will emerge in the next two years, Australian industries and communities will have far better insight into the changing status of our water resources. These services provide *perspective* on how things have changed over time, *situational awareness* of current conditions and *foresight* into the future availability of water. Increasingly, this new intelligence is being deployed into decision making by Australian industries, enabling them to better cope with our highly variable and changing climate.

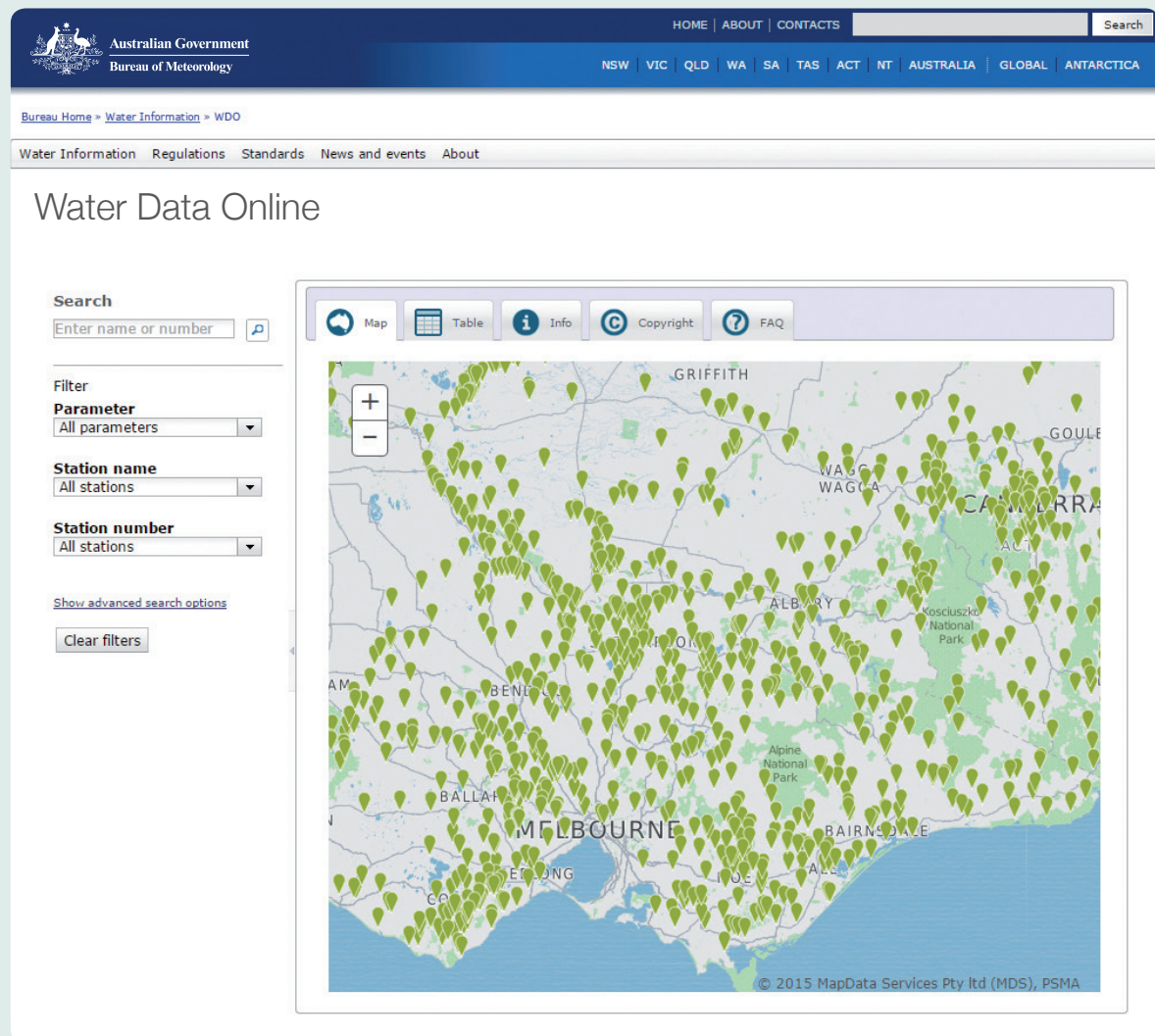
Provided by the Bureau of Meteorology.

has been the most important aspect of these changes, as demonstrated by the resilience of agricultural production to the effects of the Millennium Drought. A CSIRO study showed that water for the environment during the Millennium Drought reduced irrigation by around \$542 million but created environmental benefits of \$3 to \$8 billion (CSIRO 2012).

In more recent years, agriculture has been facing conflicts around ground water from unconventional shale gas and coal seam gas

exploitation. Shale gas exploitation requires significant amounts of water, potentially putting this industry in direct competition with agriculture where they intersect. Coal seam gas exploitation can result in the production of significant quantities of brine, which can benefit agriculture with appropriate treatment, but it also raises concerns about potential adverse impacts on aquifers, which could affect agriculture. Competition for surface water has also increased, particularly for environmental purposes. The

Figure 1: The Bureau's *Water Data Online* web page provides free access to current and historical data on streamflows for about 3500 sites across Australia



Source: Bureau of Meteorology 2015a.

Murray Darling Basin Plan has impacted on farmers as they have faced a reduction in water availability to facilitate the environmental goal of restoring the health of the Murray Darling Basin system.

Cook *et al.* (2013) describe the need to resolve the competition for ground and surface water for the environment versus that for unconventional gas. In their review of the future of unconventional gas production, they supported the extraction of water within a regulatory framework.

If this is to happen there must be a transparent approach to the collection and dissemination of reliable data (NSW Chief Scientist and Engineer 2014) (see Box 4.3), and a continuation of the vigorous reform process focusing on governance, productivity and environmental issues associated with water markets. This in turn will require a level of commitment from all parts of the relevant communities to work within agreed principles, such as the National Water Initiative. Ongoing reforms will need to encourage innovation in

the productive use of water while also returning sufficient water to support environmental outcomes.

These findings support an integrated and transparent approach to the allocation of water resources in rural landscapes. There is a strong evidence-based case for continuing the development, facilitation and regulation to support water markets as a vital part of Australia's agricultural future (Grafton, *et al.* 2015, p. 62). The way forward is for rural landscapes to be managed in a whole-of-landscape framework that takes into account the long-term cumulative impacts of all these different users (Williams, *et al.* 2012; Williams, *et al.* 2013).

4.3.5 Integrated landscape approach

Farmers face competition for land use. Not only do they use land for agricultural production they are expected to meet community expectations for the conservation of biodiversity.

Australia has experienced the largest documented decline in biodiversity of any continent over the past 200 years. Much of this decline is attributed to land clearing (Taylor, *et al.* 2014) and since European settlement about 13 per cent of the native vegetation has been cleared, although this varies among habitat types. It is highest among the land used for broad acre cropping such as lowland grasses in the temperate areas and the Mallee. A number of studies has suggested that mechanisms are needed to enable farmers to capitalise the intangible value of biodiversity on their land (Bell, *et al.* 2014). As noted above, farmers also compete with environmental assets for water, and water trading in recent years has seen substantial water returned to river systems to improve their health and the ecosystems adjacent to them.

The disappearance of so much native woodland has made pessimists of many scientists. The partnership between agriculture and science that has proven so productive is no longer focused on common goals and there is a need, as Farley emphasised, for a common care for country that

unites scientists, farmers, Aboriginal leaders and environmentalists (Farley 2003).

The solution involves integrated management at landscape or catchment level, but Bowmer (2011) notes that integration of land and water management appears to have been downplayed and under-funded in recent years. Building agricultural production systems that meet both farmer needs for profitability and community expectations for sustainable ecosystems can be described as a 'work-in-progress' (Grafton, *et al.* 2015; McKenzie & Williams 2014).

Strategic regional scale land-use planning, coupled with regional governance and ownership by industry, community and government, should become an important tool for agricultural industries and communities to manage the competition for agricultural land (Grafton, *et al.* 2015, p. 86).

Diversification can be particularly important in marginal agricultural land where the aesthetic qualities of the landscape may create opportunities for farm-based tourism (Jackson, *et al.* 2011; Pearce 2013). Conservation activities may also enhance farm productivity particularly including weed control (Stoeckl, *et al.* 2015). A variety of studies point to the support by Australians to the wellbeing of ecosystems (Lockie 2015, p. 25), although finding ways to reward farms for preserving biodiversity and other landscape attributes is challenging.

4.4 Managing risk

Agricultural businesses are subject to a range of hazards and associated risks, some of which are common across many industries and some of which are unique to agriculture. The ability of farmers to manage risk effectively will determine the strength and profitability of Australian agriculture in the future. There is an important role for governments to play in this area, both at the global, national and regional scale, and at the individual farm and business scale.

4.4.1 Climate change and climate variability

Climate change and variability will impact on total factor productivity in Australian agricultural systems in many ways: long-term trends in rainfall both in volume and seasonality; increase in extreme weather events; changes in farm yields, both increases and decreases depending on geographical location; changes in biosecurity threats; and so on (Hughes, *et al.* 2011).

There remains large uncertainty surrounding the effects of climate change on agriculture, although it is clear that the impacts will vary across the country. According to Heyhoe *et al.* (2007), “Some models predict an increase in agricultural productivity in Australia, whereas other modelling suggests a substantial fall in productivity in many regions.” Some crop yields may increase initially with increased CO₂ levels, but ultimately yields in southern Australia will be negatively affected by reduced rainfall and temperatures, and extreme weather events may become more frequent or more severe (CSIRO and Bureau of Meteorology 2015; Fischer, *et al.* 2014).

There is strong agreement that temperatures are likely to rise but there less is certainty about changes to rainfall patterns. There are already signs of decreasing rainfall in south-western Australia (Holper 2011).

Farmers will need to adopt new technologies and practices at an increasing rate to compensate for the negative effects due to climate change, or to take advantage of new opportunities. Heyhoe *et al.* (2007) have argued that farmers will need access to information to make adaptive decisions that are cost effective.

During the next few decades, when the effects of climate change remain modest, a total factor productivity growth rate of 2 per cent per annum would largely compensate for the effect (Grafton, *et al.* 2015). Longer term studies, however, predict that Australian agriculture will need transformational and system-wide changes, including through new technologies, to deal with climate change beyond 2030 (Crimp, *et al.* 2014).

Whatever the impacts of climate change in the future, it is clear that policy settings for Australia’s agricultural sector will need to ensure that farmers are supported to adapt their enterprises to the new opportunities, including new crops, new rotations, and different farm management practices. Farmers will also face the ongoing need to manage the risks associated with existing high levels of climate variability.

The agricultural sector also has a significant role to play in climate change mitigation, primarily through reduction of greenhouse gas (GHG) emissions. According to the 2014 report *Food and Fibre: Australia’s Opportunities*, actions such as reducing methane emissions from livestock, nitrous oxide emission from nitrogenous fertilisers, capturing methane from manure management, and improving soil health and function through carbon sequestration could have beneficial effects on farm performance and profitability, as well as mitigating the contribution of one of Australia’s biggest GHG emitting sectors (ATSE 2014).

Agriculture contributes a non-trivial 15 per cent of Australia’s total carbon emissions, but it also has the potential to sequester carbon in soils, given the right incentives and agricultural practices to promote soil organic matter.

Climate change policy in Australia has been slow to reach broad consensus. Agriculture has been excluded from the most recent government’s carbon trading policy, primarily due to the difficulty in measuring associated carbon emissions. The Carbon Farming Futures program, implemented in 2014 by the Australian Government, is intended to ensure that advances in agricultural practices enhance agricultural productivity and sustainable land use under a changing climate. Beginning in April 2015, farmers will be eligible to compete, based on the lowest cost emission reductions, for support from a \$2.55 billion fund available to businesses, households and landowners to verifiably reduce their emissions. This will provide a new income-earning opportunity for some farmers.

4.4.2 Biosecurity risks

A crucial policy area relates to managing risks to human, animal and plant life that involves the early recognition, containment and prevention of pest and disease threats. Despite a record of preventing the establishment of some diseases endemic in other countries, Australian agriculture remains vulnerable to existing pests and emerging pest and disease threats because of its relative isolation as an island continent. As a result of this isolation, a number of pathogens and diseases that are found elsewhere in the world, such as foot-and-mouth disease, do not currently exist in Australia.

Given that the potential catastrophic economic losses associated with biosecurity risks could be in the billions of dollars, Australia's agricultural future is dependent on effectively preventing or at least managing biosecurity risks. Biosecurity risk management includes monitoring, surveillance and risk analysis. It also involves assessments of complementary risks. For example, climate change may increase the extent and range to which farm land is vulnerable to disease and pest incursions.

Government will also need to remain diligent in ensuring that the disciplines of the WTO's Sanitary and Phytosanitary Agreement continue to allow Australia to retain the level of quarantine protection necessary to manage its unique biosecurity risks.

4.5 Investment in agricultural R&D

As reported above, there is evidence that the more productive farms in Australia are nearing their yield potential for existing technology. Responding to increased global demand for food by raising productivity using current technologies and practices may be challenging. Shifting weather patterns, higher temperatures and changes in rainfall patterns are likely to also depress yields in some regions across a range of produce (Melbourne Sustainable Society Institute 2015).

The slowdown in productivity growth is common across the developed world, although it has been accelerating in developing countries (Fuglie 2010). This has been attributed in part to the reduction in overall support for agricultural R&D over recent decades. As stated by Fischer *et al.* (2014, p. 514) "Substantially increased investment and institutional improvements in agricultural R&D ... are now needed to boost growth in total factor productivity."

This implies that the component of total factor productivity that is due to increases in technical efficiency may be less important than research-driven technical change.

Private sector investment in Australian agriculture has been rising. Keogh and Potard (2010) found that private investment generally complemented public sector investment. They also proposed that nearly all the private sector investment would be invested down the spectrum of application, i.e. enabled by publicly funded basic research. However, major public institutions involved in plant sciences in Australia, such as CSIRO and the Victorian Centre for AgriBioscience have partnerships with major life science companies to support areas of basic discovery.

While investment in agricultural R&D is a key policy intervention it appears to be no longer possible to track trends in investment due to changes in publication practices (Grafton, *et al.* 2015, p. 49), which will make it difficult in the future to assess its contribution to productivity growth. Yet as discussed above, breaking through the yield barrier in Australia, particularly in the face of climate change will only be possible through transformational change and new technology. The research needed is broad and encompasses productivity, environmental issues, climate, water availability, soil, biodiversity, biotechnology, and many other complementary fields.

Underinvestment in the research that underpins the development of low cost technologies and the management of natural resources, the collective management of risks such as invasive pests and diseases, climate variability and climate change, and the provision of information is a significant market failure that risks the future capacity of Australian agriculture.

There has been little real growth in public investment in agricultural R&D since the mid-1970s and research intensity (R&D investment as a percentage of GVP) has been stagnant or falling since 1985, as illustrated in Figure 4.3.

The challenge is the lag-time between the investment and the return, often as long as thirty years (Grafton, *et al.* 2015). Pardey *et al.* (2013) warn that the long rundown in scientific capability in the USA means that attempts to rebuild it will need to be phased in over years. This is likely also to be the case for Australia.

What is less obvious is the benefit to agriculture of other kinds of R&D that lie outside areas traditionally regarded as 'agricultural'. Many of the new technologies are information-based and require public sector involvement in "building capacity, sharing information, supporting training and facilitating R&D" (Sheng, *et al.* 2010, p. 21). The use of automation, sensors and robotics in agriculture (see Box 6.1) is likely to change the face of farming, yet relies more on engineering, ICT and informatics R&D than traditional agricultural research (see Chapter 6). The challenge will be to attract researchers to agricultural applications in the face of competition from other industries for their skillsets. Finding ways to attract and retain these highly skilled researchers in agriculture is essential.

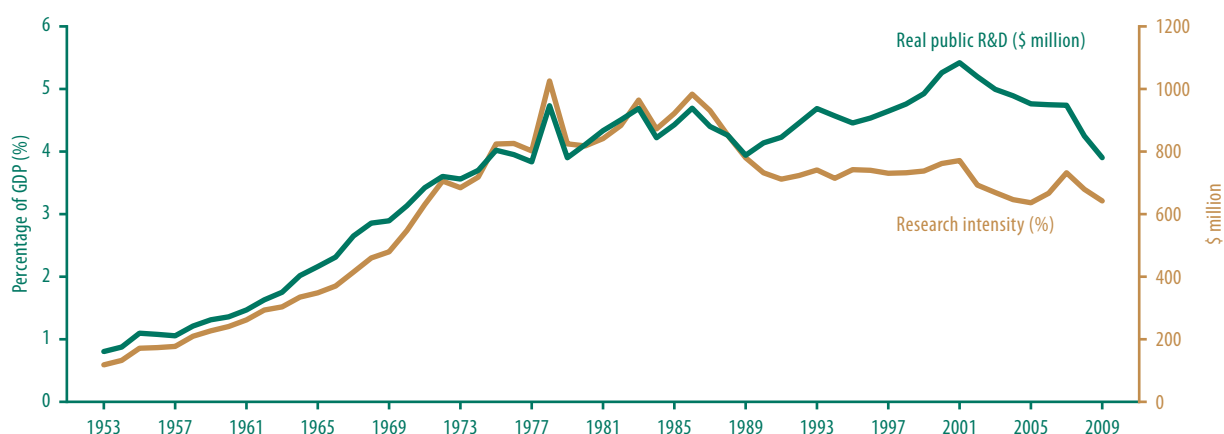
As in most areas, Australia will not necessarily develop these technologies domestically, but will be a fast adopter of technology developed

overseas. Private sector investment will play a major driving role in this development, but effective adoption will require ongoing research in adaptation and localisation of these technologies to Australian conditions. This has been an important role of publicly and privately funded researchers in the past, through the rural research and development corporation (RDC) system for example, and will remain so into the future.

The RDC model that fosters investment in agricultural research has been particularly successful at maintaining long-term investment. Box 2.2 and Box 6.2 illustrate the close working relationship between researchers and a variety of industries. The cotton industry, for example, invested in a voluntary levy to fund research well before the introduction of the Research and Development Corporation model from the late 1980s. Annual meetings between growers and other industry representatives with researchers to get an update on the latest results shortened the communication channels and led to rapid feedback on priorities and problems.

The Cooperative Research Centre (CRC) program has supported a generation of researchers to remain active in agricultural research. Both of these systems (RDC and CRC) are now under review by the Commonwealth Government. Whatever the outcome of these reviews, agricultural science policy needs to support productivity growth. R&D investment, both

Figure 4.3: Real public R&D investment and research intensity in Australian agriculture, 1952–53 to 2009



Source: Grafton, *et al.* 2015.

government and industry, is needed to support new technologies, and new knowledge.

This report supports this view and it is well supported by numerous studies here and overseas. Given the long lag time between investment and productivity gain, it is likely that immediate investments will take a decade or more to have significant impact in raising productivity growth rates.

The case for further investment is compelling, and overcomes concerns about 'free-riding':

The challenge for agricultural science policy is to generate productivity growth. One way this may be supported is to secure higher rates of investment by both government and industry that exploits the [synergy] between industry outcomes in the form of new technologies and public-good outcomes in the form of gains in scientific capacity, and new knowledge about the management of environment and human health issues. The gains to society from exploiting the non-rival nature of new knowledge and ameliorating market failure seem of far greater significance than those from additional efforts to reduce 'free-riding'.

(Grafton, *et al.* 2015, p. 54)

4.6 Policy challenges

The future of agriculture depends on sustainable use of natural resources. Globally competing land-use pressures, limited surface water supplies and depleting reserves of groundwater are constraining the resources available for farming. Australian farmers, even more so than their global competitors, must adapt to climate variability. Effective management of environmental risks facing agriculture is likely to help safeguard future productivity and competitiveness.

(Commonwealth of Australia 2014)

Improving productivity is the key to improving returns on agriculture into the medium term, and is a key strategy for making agriculture more resilient to climate change impacts in the longer term. The agricultural sectors are essentially price takers, as they are either reliant on export markets or closely integrated with export markets, and have little control over input prices. Given these constraints, and the limited opportunities to increase inputs of natural resources, the key option for future growth is to generate increased outputs for a given set of inputs. These improvements could be gained by selectively reinvigorating stalled industries, by strengthening existing high growth industries, and by fostering new and emerging industries with high growth potential (ANZ Insight 2012).

Australian farmers face considerable challenges in dealing with highly variable rainfall and poor soils. Consistent national frameworks and databases, and functioning markets for water, will assist Australian farmers to adapt their enterprises to manage these assets productively in an uncertain future.

Options to improve efficiency include investment in R&D; reductions in support for other sectors of the economy, easing of restrictions in foreign investment in farms and business and investment in infrastructure to lower costs along the food chain, including the cost of transport to port in export industries.

Key challenges for government and the community relate to:

- a. expanding land and water resource inputs within environmental limits
- b. improving the availability, quality and management of current inputs
- c. improving multi-factor productivity
- d. maintaining the resource base
- e. managing the risks to agriculture
- f. supporting an increase in both public and private sector R&D.

Increasing productivity growth and deepening capital investment are the key public policy challenges for increasing the supply of agricultural outputs in Australia.

5

Australian agriculture's social and political context

5.1 Findings

1. There are an increasing number of social and economic stressors in the agricultural sector in Australia.
2. Australians' connections to the land are declining although cultural values relating to the inherent value of farming continue to be held across the community.
3. Access to services will continue to be problematic for rural and regional communities.
4. Solutions to problems facing rural communities will need to be grounded in a local context.
5. Trends towards concentration, intensification and vertical co-ordination may reduce the role of small family farms and increase foreign ownership.



6. Land tenure and planning need to allow farming to evolve.
7. Alternative models of farm financing, such as contingent loans, need to be developed to meet the needs for farm businesses faced with fluctuating incomes and reduced capacity to borrow.
8. Australia needs to address the erosion of its 'social licence to operate' in the agricultural and food sectors.
9. Genetically modified crops and foods represent both opportunities and risks for the Australian food industry.
10. Key public policy challenges include managing the ongoing restructuring pressures in the agricultural sector and the flow-through impacts to rural and regional Australia.
11. There is a need for a shared, positive vision and narrative for agriculture in Australia.

5.2 Vibrant rural and regional communities—social and political challenges

Agriculture has long been central to narratives about Australian identity and prosperity; the wellbeing of farmers seen as crucial to the wellbeing of all.

(Lockie 2015, p. V)

The need to innovate and adapt in the face of emerging challenges and opportunities never goes away. It is easy to look at the social, economic and environmental issues currently confronting the agricultural sector and forget the determination with which people have tackled equally serious issues in the past.

(Lockie 2015, p. 5)

Agriculture has an important place in Australia's social, economic and political landscape, and the agricultural and rural sectors face a number of inter-related social and economic stressors that may threaten their future prosperity and success.

These issues include: depopulation of rural areas; declining participation in agricultural education; low levels of entry into farming as an occupation, particularly by young women; comparatively poor health outcomes for farmers and other rural residents, including mental health and suicide; low incomes and poor rates of return for the majority of farm businesses; and challenges to the social licence to operate.

Rural and regional communities have undergone considerable change over the past two centuries. A range of factors have affected their health and well-being during this time. While agricultural industries continue to provide the main direct and indirect sources of employment, they have been affected by the economic reforms in Australia begun in the 1980s (see section 2.4). Farm numbers have declined (section 5.2.2); there has been a shift to intensive farming production systems; there is more vertical integration along the supply chain; and the mining industry has provided significant competition for labour. At all farm scales, there is evidence that the most efficient and profitable farmers are expanding while less profitable landholders are selling up (Hooper, *et al.* 2002).

5.2.1 The changing image of agriculture in contemporary Australia

Australian agriculture still enjoys strong support from the Australian community, despite the decline in the percentage of the population engaged in agriculture, and the relatively low contribution of agriculture to GDP. This does not mean that consumers and civil society groups favour all agricultural policies. This chapter explores a range of contentious issues such as foreign investment in land and agricultural industries is much stronger than for other industry sectors (e.g. most major food brands are now part of foreign-owned companies). Food retains a unique place in people's lives, both culturally and materially and strong positions of advocacy will continue. Consumers are not the enemy that needs educating, but are advocates that need to be negotiated with (Lockie 2015).

There are also signs that the influence of rural Australia on the nation's culture is declining. In the past 40 years the Pioneer Legend has lost some of its influence, status and relevance. It has much less relevance in a multi-cultural, urban society, although it continues to influence popular culture. In recent decades the narrative for Australian agriculture has been that it is a 'sunset industry', contributing less and less to GDP over the course of the 20th Century (as can be seen in Table 2.1). The declining terms of trade for agricultural exports experienced by Australia, the lack of profitability on 75 per cent of Australian farms (Lockie 2015), the apparent aging of farmers (see section 5.2.4), labour shortages at harvest time, and the more recent slowing of productivity growth all add to the 'doom and gloom' view of the agriculture sector.

It is likely that a negative image of agriculture has knock-on effects on the attractiveness of the sector to investors and to skilled workers. Shifting the image from 'woeful to wonderful' is part of the challenge facing Australia's agricultural future (ACIL Allen Consulting 2014; Bell, *et al.* 2014).

This image also contrasts with the historical resilience and adaptability of the farming sector,

particularly in the face of adversity (Waterhouse 2005). Successful change and adaptation to variability in climate and shifts in markets are long-standing features of Australian agriculture. The shift from wheat/sheep mixed farming to wheat/other crop rotations in the past two decades and the rise in the oilseed industry are testament to this, as can be seen in Figure 2.2.

5.2.2 Farm size and profitability

The number of Australian farm businesses decreased from 145,000 in the late 1990s to 135,000 in 2011 (Grafton, *et al.* 2015). Much of this decrease was due to farm mergers, but some also resulted from farms being taken out of production and used for other purposes, such as urban expansion or conservation.

The two largest groups of farm enterprises in Australia in 2011 were mixed crop and livestock, accounting for 22 per cent of the total, and beef cattle production, making up a further 20 per cent. Other common farm enterprises include: mixed livestock farming (8 per cent), specialised sheep farms (7 per cent), dairy cattle (6 per cent), mixed sheep-beef cattle farming (5 per cent), and grape growing (4 per cent) (Grafton, *et al.* 2015, p. 18).

The average area of broadacre farms in Australia increased from about 5000 ha to 7000 ha between 1977 and 2013. Over the same period, average whole-of-farm receipts grew from about \$300,000, to just over \$400,000. Greater intensification and shifts to more high-value crops from the mid-1990s saw farm receipts grow faster than average farm area. This trend was also observed in dairy, where the quantity of milk grew by 2.5 times, compared to the area farmed which only grew by 1.5 times (Grafton, *et al.* 2015, p. 19).

The size distribution of Australian farms is increasingly becoming bimodal; that is, the majority of farms are either very large or very small, with relatively few farms occupying the intermediate size range. While agricultural production is increasingly concentrated in large farms, with some 20 per cent of farms accounting for 80 to 90 per cent of production, the majority of Australian farms are actually quite small in area. In 2010–11, just over half of all farms had an

estimated annual value of agricultural operations of less than \$100,000 (ABS 2012), while 7700 large farms (just 6 per cent of the total) had operations valued at over \$1 million per annum. Around a third of farms cover less than 50 ha and there is a similar proportion between 50 and 500 ha. By contrast, in 2011 there were 100 massive farms that each occupied more than 500,000 ha—more than twice the land area of the Australian Capital Territory (ABS 2012).

Smaller farms have less access to capital and advanced technologies, and often rely on off-farm income sources to remain viable. The smallest third of broadacre farms have been found to be the least productive on average, while larger farms have generally recorded better profitability and returns on investment than smaller farms. Sheng *et al.* (2014) found that this could be explained by the limited capability of smaller farms to improve their productivity through investment in production technology, and their ability to adopt more complex management, financial, technical and operational techniques, rather than simply an effect of efficiencies of scale.

The consequence of these long-term changes to farm size is to create a sector that is very heterogeneous, containing both highly profitable corporate and family farms, and ‘lifestyle’ and hobby farms.

5.2.3 Employment in agriculture

Agriculture provides employment to around 2.3 per cent of the Australian workforce (ABS 2015). It is unusual compared with other sectors for the number of self-employed or casual workers. The largest contributors to employment are the sheep, beef cattle and grains sectors and yet ‘these are the same sectors in which job losses due to productivity improvement have been most acute’ (Lockie 2015, p. 18). There are predictions that employment in occupations related to livestock farming will grow, but will shrink in broadacre cropping due to productivity, innovation and technology.

This paradox that profitable farms need to innovate through increasing use of technology,

which will in turn reduce labour requirements, has the potential to reshape rural and regional communities in the coming decades.

Lockie (2015) notes a number of trends for rural labour markets that provide challenges and opportunities for agriculture:

1. Rural depopulation and competition from other industries for seasonal workers has increased the reliance on the international labour market (Argent & Tonts 2015). While historically farms have sought labour from backpackers, some use particular countries to source labour on a regular basis, for example, Korean workers on a lettuce farm in northern Tasmania and Pacific Islanders for a citrus farm in Queensland (Daly 2013). The citrus example is particularly interesting as the grower contracts with the same community in the Pacific to work on the farm at harvest time. This increases the reliability of the workers who have previous experience. The workers are also supported culturally during their time in Australia.
2. Internal migration in Australia to regional and rural areas of high social and economic amenity provides a broader range of employment opportunities and enhances rural vitality (Argent, *et al.* 2014). Knowledge intensive agricultural enterprises will need the attractiveness of these rural centres to retain skills in allied industries to support the 'high-tech' production systems, although much of this skill may be accessed from

urban areas using remote technology (see also Chapter 6).

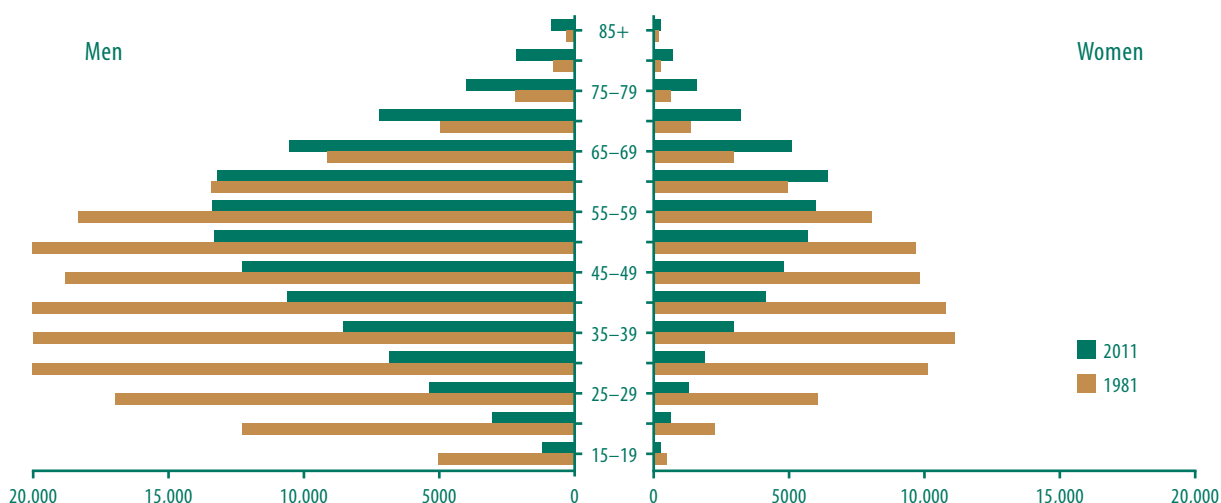
3. Migration to mining centres for high paying jobs has drained agricultural communities of workers. The decline in the mining boom over the next decade may see a reverse in this trend.
4. There has been an increase in linguistically diverse people entering agriculture, particularly in vegetable, fruit and nut growing and poultry farming, in peri-urban areas around capital cities.

Gender balance within the agricultural workforce is also an important but difficult and complex issue. Marriage into farming households is still the most common route into agriculture for women, but a general trend towards later marriages increases the likelihood that women already have established careers (Lockie 2015, p. 19) (also see Box 5.1). This is important, as many farm households sustain themselves financially through off-farm income, the vast majority of which tends to be contributed by women (Alston 2012). This can have the effect of obscuring the contributions of women to agriculture and rural communities.

5.2.4 The changing workforce and aging population

In addition to these trends, the agricultural workforce is characterised by a relatively older workforce with lower education levels and

Figure 5.1: Change in age distribution of Australian farmers over 30 years from 1981 and 2011



Source: ABS 2012.

employee wages. About one-third of farmers are women (Grafton, *et al.* 2015). This pattern is changing. Over the past two decades there has been an increase in the number of employees and a fall in the number of employers and contributing family workers, as a result of farm mergers and increasing corporatisation of farming. Levels of formal education have also been increasing (Productivity Commission 2005).

The age profile of farmers has changed markedly over the past few decades (see Figure 5.1). The median age of farmers has increased by nine years between 1981 and 2011, while the median age of non-farm workers in Australia increased by just six years.

Off-farm income has also become important with 45 per cent of farm families now deriving some of their income outside of farm activities. There are

Box 5.1: Are farmers aging and is this a problem?

Adapted from *New Entrants to Australian Agricultural Industries? Where are the young farmers?* Barr 2014.

Widespread concern exists in rural communities about the increasing median age of farmers. Neil Barr has demonstrated that this trend will not affect Australia's ability to respond to increased demand for agricultural products. However, the demand for health and aged-care services in rural communities will increase.

There is general concern in rural communities about the lack of opportunities for young people to enter farming, particularly farm ownership, and it has been noted that the average age of Australian farmers is increasing. There has been a 75 per cent decrease in the number of farmers under 35 years old since 1976. This is often perceived as having a negative impact on Australian agriculture.

There is, however, an optimistic alternative analysis of this trend in Australia. Concerns about the apparent aging of farmers tend to focus on four issues:

1. Food security—will there be enough farmers meet the demand for food?
2. Loss of economic benefits—can Australia respond to future opportunities in agriculture?
3. Community sustainability—will rural communities continue to decline?
4. Should governments increase resources for aging populations in rural areas?

There are four major reasons for the drop in the number of farmers under 35:

1. A fall in the number of farms (because of farms mergers), resulting in fewer entry opportunities—this accounts for 68 per cent of the decrease.
2. A decline in the recruitment of under 25s—in part, because of the general decline in the proportion of people under 25 coupled with younger people staying in education for longer.
3. A delay in the age that farmers are 'retiring'—since 1991 there has been a 55 per cent increase in farmers over 65—the 'baby boomers' are staying in farming for longer.
4. An increasing age of first marriage that has reduced the number of women entering farming.

60 per cent of the rise in the median age of farmers may be due to factors in common with the rest of the community. These changes are not a great cause for concern in farming per se, but they will impact on the support services needed in rural and regional Australia, particularly with the aging of rural populations. The slowing rate of retirement has had a major effect. Younger farmers tend to be found on larger farms whereas older farmers were on smaller farms. Older farmers were more likely to remain actively involved in agriculture on grazing properties as it is more 'age friendly'.

Overall, farming has become less accessible to younger entrants because of its capital requirements. Farmers of tomorrow will require higher education qualifications than in the past, and declining terms of trade mean that many farms can only support one generation. These factors mean that young people train and work in non-farming occupations until later in their lives.

The proportion of younger farmers in the profitable band of farms has remained between 80–100 per cent since 1986, so the evidence suggests that there is no shortage of young farmers to contribute to productive and profitable farming in the future (Barr 2014, p. 7).

The agricultural sector will adjust to Australia's shifting demographics and will be able to capture future opportunities in agricultural markets. However, rural populations will be challenged by human services delivery for aging populations (see Chapter 5 for further discussion).

There is scope for governments to address the shortcomings in national data collections relating to the demographics of farming communities in order to address the issue of service delivery.

also concerns that formal education in agriculture is in decline at the tertiary level (Pratley & Copeland 2008; Pratley & Hay 2010).

Barr (2014) has tackled the issue of the 'aging farmer' and proposes that the increase in median age will not be a serious impediment to farming in the future. This issue is explored in detail in Box 5.1. However, the pathways into farming are changing, with younger people employed more by corporate or large family farms and only entering farm ownership when they are able to raise the necessary equity and have the requisite skills to manage an increasingly complex enterprise. Increasingly, the skills important to success in agricultural enterprises include sophisticated business management and marketing expertise. The need for better business management skills in Australian industry more broadly was explored in detail by Bell *et al.* (2014 pp. 97–101).

Succession planning has also become a major issue of concern amongst family farms, with older farmers increasingly delaying retirement. This was identified as a major issue of importance in the Government's *Agricultural Competitiveness Green Paper* (Commonwealth of Australia 2014).

Overall, Barr indicates that the changing demographic will not impede Australia's ability to respond to increased demand.

5.2.5 Social wellbeing of farming communities

Only about 25 per cent of Australian farmers achieve an income that can support a median Australian family and fund business growth. Over half of Australian farm households are at risk of poverty or are running down the farm's capital, without off-farm income (Barr 2014). Data on income levels and farm poverty is generally very poor at a finely detailed scale.

ACOSS (2013) estimates that poverty becomes progressively worse from cities, to regional areas, and then to remote areas. Added to this, 'it costs rural residents five-times as much to access essential services as it does metropolitan residents' (Lockie 2015, p. 21). This disadvantage is compounded by poorer health outcomes

for diseases, injuries as a result of accidents and suicide (Lockie 2015, p. 22). There may be significant potential for technology to improve service delivery, such as through telehealth, but this may require further investment in improving ICT infrastructure in rural and regional Australia.

Farm poverty has not been an area of specific government policy attention, with farm welfare measures tending to be developed as part of industry structural adjustment packages or in response to drought, rather than in response to individual farm family needs. There has not been a comprehensive study of the nature and extent of farm poverty in Australia since the Henderson Inquiry of the 1970s, leaving an evidence gap in terms of the development of sound welfare policy for farm families in need.

Many (perhaps a majority) of families on both large and hobby farms rely on a diverse source of off-farm income to supplement earnings from agriculture. Future rural prosperity may require further diversification on some farms to expand non-farming activities, whereas on other farms the need for knowledge intensive production systems may limit the diversity of production-related activities.

5.3 Policy approaches

A series of policy initiatives over the past thirty years has had significant influence in rural communities. Native title legislation in pasture land and the National Landcare Program over recent decades have changed the relationship of farmers to the land. The Landcare Program in particular encouraged community partnerships that shared knowledge and resources and undertook catchment-level activities (Lockie 2006). Subsequent changes to this program and its long-term impact remain controversial (Lockie 2015). Nevertheless, farming will in future depend even more on these community level partnerships for stimulating and spreading innovation (see also section 6.4.1).

Government is again seeking community input into agricultural policy reform in its *Agricultural Competitiveness Green Paper* (Commonwealth of Australia 2014). Included in the nine principles

outlined in the Green Paper is the idea of keeping families as the cornerstone of farming in Australia (see section 5.2.2). This is in contrast to the development of other industry sectors over the 20th century that have moved away from family owned businesses toward more corporate structures, however it reflects ongoing community support for the family farm.

Lockie (2015, pp. 7–8) recounts that:

1. the narrative in the Green Paper has a striking degree of overlap with issues raised by other discussion papers over the past three decades
2. the paper focuses on the *needs of agriculture* and specifically *the needs of family farmers*. Yet, agriculture in the future may need to evolve in new directions if Australia is to truly grow supply and attract the investment it needs into rural enterprises
3. there is an emphasis on profitability of the family farm as underpinning vibrant rural communities, however, it may be the corporate farms and larger family farms that have the ability to attract capital, use advanced technology and employ young people.

Thus, it appears that the late 20th century narrative of trade liberalisation and deregulation is being married with the early 20th century narrative about ‘countrymindedness’. From an economic perspective there may be advantages in Australia’s transitioning from the existing model of predominantly family-run small to medium sized farm businesses to a corporate model with higher levels of foreign ownership, however at present this potential future is largely at odds with prevailing societal values. There is limited evidence to date, however, that foreign owned or other corporate farms are any more productive than large, family owned farms. Nonetheless, diversity in the enterprise model for farms may provide more resilience and more stable rural communities.

A key question that requires further consideration is ‘whether new narratives and policy approaches are required to deal with future social and political issues?’ (Lockie 2015, p. 8).

5.3.1 Tenure regimes

While many farms are managed through freehold title (21 per cent of land), 42 per cent of land is leasehold, 23 per cent is public land and 14 per cent are indigenous lands (Geosciences Australia 2014).

Pastoral leases are concentrated in the arid and semi-arid regions of northern Australia. These types of leases have been criticised for the limitations that they put on land use. This can include alternative and possibly more economic or more sustainable types of land use, such as conservation or tourism activities. There is also a need to simplify and clarify development approval and landscape level planning practices (Dale, *et al.* 2013).

Native title implications are crucial to consider in the potential reform of pastoral leases, for broader primary production activities and non-primary production (Commonwealth of Australia 2015b; Dale, *et al.* 2013; Productivity Commission 2002).

5.3.2 Investment and finance

Farmers face significant challenges in sourcing finance, which is necessary to fund both business growth and farm turnover (ANZ Insight 2012). Financing agricultural activity is an ongoing issue for the sector. Although many of the risks faced by farmers are not confined to agricultural businesses, there are several that are unique or more pronounced in farming that affect the financial risk to investors (Grafton, *et al.* 2015, p. 111):

- access to markets can be affected by supply chains
- sovereign risks associated with trade barriers and competing subsidies
- price risks around input costs and commodities prices
- impacts of weather, lack of water, and also pests and diseases that can be unpredictable and change over time.

Australia is more exposed to market risks than other major agricultural exporting nations because we export a greater proportion of our production, we have no major price support systems for major commodities, and because of currency fluctuations.

Box 5.2: The potential for income contingent loans in the management of farm financial risks

Access to appropriate finance is a perennial issue for Australian farmers, and will continue to be critical to meet the challenges and seize the opportunities of the coming decades. Revenue contingent loans could provide an innovative and cost-effective alternative to support the agricultural sector in comparison to traditional loans and government grants.

Income or revenue contingent loans (RCL) can provide a cost effective mechanism to support farmers in managing the risks facing their agricultural businesses, and compare very favourably to the use of other forms of loans or grants by governments. An RCL provides farmers with access to financial resources when they are most needed (e.g. during drought) but are repaid only when conditions improve. Conventional bank finance, and indeed government-backed concessional loans, requires regular repayments irrespective of the borrowers' capacity to pay, while an RCL only requires repayment when the borrower is in a position to do so. RCLs therefore potentially provide a mechanism for smoothing disposable income fluctuations over the business or climate cycle.

A major point for farmers in comparing an RCL to extensions of normal loans is that there is no risk that they will lose their farm from defaults. RCLs simply spread repayment to periods when the farm can afford it, and thus ameliorates risk. The farm asset is protected from default and loss of the property due to poor revenues, properties that in many cases have been in the same family for generations.

For governments, RCLs have the advantage over grants or subsidised loans because a significant portion of the loan monies are repaid, meaning that finances can be redirected to other public sector priorities (Botterill & Chapman 2009; Kelly, *et al.* 2004). It is arguably fairer to taxpayers to benefit from repayment of monies delivered to the farm sector, since most citizens typically do not have the assets of those benefitting from the largesse of current drought policy.

A revenue contingent loan for agriculture would mirror the very successful Farm Management Deposits (FMDs) scheme in which farmers draw down funds from past good years. Thus, RCLs could be combined with FMDs in a single farm business financial risk program through which farmers first draw down their FMDs, and then have access to an RCL once their reserves are exhausted. This would also address a limitation of FMDs, which is that new entrants to agriculture have not had time to accumulate reserves before they encounter a downturn.

A final and important point about contingent loans made by Joseph Stiglitz (2014) is that of the "transactional efficiencies" of governments operating contingent loan schemes. For example, it costs about 4 per cent or less of annual HECS revenue to collect, which means the risk management benefits of such loans can be achieved for close to zero administrative costs. This has to be compared with the significant bureaucracy associated with all the other typical government agricultural loans, including contemporary versions.

Issues that need to be addressed through policy considerations include:

- improving alignment between financial and investment systems and those of the farming sector
- attracting investment into agricultural industries from a diversity of sources, potentially including foreign capital and Australian superannuation funds
- encouraging growth of highly profitable farms, that may involve more automation and reduced workforce, while sustaining rural communities
- efficiency of supply chains including transport infrastructure from regional Australia to export ports.

Governments have intervened in the market for farm financing since the 1930s, reflecting a sense that commercial financial markets are not responsive enough to the particular needs of the sector. These interventions have been in the form of long-term concessional finance, the direct provision of loans and through subsidies on the interest paid on commercial borrowings (interest subsidies). The difficulty of financing agriculture relates to the relatively low returns on investment and the variable nature of farm revenues due to fluctuating commodity prices, interest and exchange rate movements and climate variability. There are also social constraints on borrowing that may prevent smaller farmers from taking on debt as they are risk averse in terms of the potential for losing the farm.

A possible approach to addressing the limitations and risks to government revenue of long-term concessional loans, and one which provides farmers with default protection, is the use of income contingent loans, possibly in cooperation with the commercial financial sector. This form of finance would provide a tool for managing the risk of income fluctuations (see Box 5.2).

5.3.3 Foreign investment and ownership in Australian agriculture

Foreign investment in Australian agriculture includes the purchase of both farm land and agricultural and food-processing companies. Foreign investment, primarily from the United Kingdom, has been a key factor in the historical development of Australian agriculture over the past two centuries. Recently, however, there appear to be increasing public concerns about foreign ownership of farms and agricultural processing and trading companies. In recent years, public debate has revealed disquiet over the purchasing of dairy and cotton farms by Chinese investors. Historically, pastoral leases in northern Australia have had a long record of foreign ownership. Lockie (2015) points out that these debates are not unique to Australia and the lack of transparency in land deals makes it hard to evaluate the benefit or otherwise of such investments (Lisk 2011).

In response to community concerns, the Australian Government is in the process of establishing a foreign ownership register for agricultural land. Currently the threshold above which investments must be approved by the Foreign Investment Review Board is far lower for agriculture than for other sectors.

The 2014 Agricultural Land and Water Ownership Survey released by the Australian Bureau of Statistics reports an increase of 4.7 million hectares of agricultural land with some level of foreign ownership, relative to 2010 (ABS 2014). In 2010, around 11 per cent of Australia's agricultural land was fully or partially foreign owned, compared with 6 per cent in 1984 (Moir 2011). Overall, there is now around 50 million hectares out of a total of 450 million hectares,

or one-ninth of Australia's total agricultural land, that has some degree of foreign ownership, however much of that is low-value pastoral land in low-rainfall, drought-prone areas.

A recent survey by the ABS indicates that about 99 per cent of agricultural businesses in Australia are entirely Australian owned. The largest private land owner, the Australian Agricultural Company, controls 7.2 million ha and is reportedly 60 per cent owned by interests in the United Kingdom, the United States and Malaysia (Keogh 2009). Foreign-owned agribusinesses play an important role in, among others, the dairy, grains, sugar, cotton and meat processing industries.

A downside to foreign ownership is that at least a portion of after-tax returns are repatriated to owners overseas. It has also been argued that large foreign-owned multinationals may be able to use their market power to disadvantage Australian farmers on price. But the upsides of foreign ownership are that foreign investors may enhance market access through their global supply chains, introduce new practices and technologies that increase profitability, and provide working capital that may otherwise not be available to increase production and value in the sector.

Ultimately, it may not be matter who owns the farm, but whether farms can attract the necessary capital. ANZ Insight (2012, p. 3) proposed a range of structures such as equity partnerships, modern variants on share farming, and the use of off-take agreements, as in the mining sector.

It is interesting that community concerns about foreign ownership and investment have largely evaporated, or have never been present for other industry sectors, such as mining. For the food processing sector in Australia, foreign ownership is increasingly the norm. What is unique to agriculture is the investment in land by state-owned enterprises from Asia and the Middle East to enhance their own food, water and energy security (Mann 2010).

What is not clear is whether foreign investment either on farm or further down the processing chain has had an impact on productivity and there is a need to evaluate this.

5.3.4 Drought policy

Australian agriculture is well adapted to dealing with climate variability—indeed, this is a key strength (Crean, *et al.* 2013). However, drought continues to shape and characterise Australian agriculture in both social and economic ways. Governments therefore have a long history of intervening and providing drought support for farmers in what were deemed to be ‘exceptional circumstances’.

Drought policy reform has been an exception to the trend towards liberalisation in agricultural policy. The Federal Government’s 1992 National Drought Policy that framed drought as a business risk to be managed by agricultural producers along with the other risks facing the farm business. Support to business was offered alongside increasingly generous welfare support for drought-affected farmers. Farmers unable to adjust were assisted to exit farming with the Rural Adjustment Scheme and its successors (Higgins & Lockie 2002). However, these exit schemes had a limited impact on the adjustment of marginal operators out of farming.

The exceptional circumstances program was abolished following a tripartite review of the national drought policy. This was replaced in 2013 with an Intergovernmental Agreement on National Drought Program Reform that remains based on risk management approaches to drought, supported by programs to address the welfare impacts of drought on farm families, such as long-term concessional loans. Of the measures developed under the National Drought Policy, the key remaining program is the Farm Management Deposit Scheme that allows farmers to set aside pre-tax income in good years for use in low-income years (ABARES 2012).

An alternative form of support to farmers during drought could be revenue-contingent loans as discussed in Box 5.2. Indeed they could cover any shortfall in income, not just ones due to drought. This alternative is likely to be both more efficient and more equitable than current drought-relief programs.

5.4 Consumer preferences and Australia’s ‘clean and green’ image

Populations in emerging economies, such as China and India, are not the only ones undergoing shifts in food preferences. Changes in domestic consumption are also driving changes in domestic production systems. Over the past four decades, Australians have increased their consumption of chicken and pork and reduced consumption of red meat (MLA 2011). We have also increased our consumption of seafood and fresh fruit and vegetables and wine (ABS 2000). These shifts have not been accompanied by increased consumption of local produce, with up to 70 per cent of all seafood in Australia being imported. Imported pork products also compete with domestic supply and year-round availability of fresh fruit and vegetables is enabled by imports.

Australians are eating more meals away from home and a higher proportion of convenience foods than in the past, and are buying from the large supermarkets, although farmers’ markets are growing. These trends mirror those observed overseas (as seen in Chapter 3) and reflect the changing and sometimes conflicting demands from local consumers.

These factors mean that producers and food manufacturers cannot take the Australian domestic market for granted. Understanding shifts in consumer preferences is critical. Hajkowicz *et al.* (2012) have highlighted the increasing demand for personalised products and services that are ethically certified. The CIE report (2015) noted this as one dimension of food preference with other members of the community trending towards convenience, and low cost food.

5.4.1 Image is everything—*Brand Australia*

In recent years, the Australian food industry has promoted itself, and the foodstuffs grown and produced in this country, as ‘clean and green.’

A number of state governments and industry sectors tie promotion of local food and wine to one or both of these concepts, stressing that both the domestic and international markets should prefer Australian products because they are 'clean and green.' The use of this terminology is no doubt highly successful, because it trades simultaneously on multiple meanings and often provides a rationale for a price premium associated with Australian made products.

At the same time, the food and agricultural sectors must recognise that the plasticity of the terms 'clean and green' means that consumers' expectations are not homogeneous. A backlash may occur if these terms are found not to align with these expectations, or there may be collateral effects if problems were to occur with one part of the food system. At the same time, Australia is in competition with other locales, including New Zealand, who also use the banner of 'clean and green' to promote their products. Hence, the local industry must be aware of both the advantages and potential disadvantages in aligning with this concept, and the need for ongoing development of and investment in the concept.

5.4.2 Clean food

The term 'clean' can refer to a number of different types of considerations when it comes to food. In the simplest terms, many consumers view 'clean' food to be food that is safe: it is monitored to make certain it does not contain harmful additives, it has been processed using high standards of hygiene and food safety and hence is not contaminated in any way, and it is labelled correctly so that those with allergens or other issues can choose foods appropriately.

In general, trust has been extremely high in the regulatory systems that oversee food safety in Australia for domestic, import, and export products, largely via Food Standards Australia New Zealand (FSANZ), although levels of trust can differ across various demographics (Taylor, *et al.* 2012). This is in contrast with levels of distrust in food elsewhere (e.g. see Kjærnes, *et al.* 2007). However, specific food scandals and recalls

(such as the recent Hepatitis A contamination of imported frozen berries) no doubt affect levels of trust both in regulation and the food system more generally. On an international level, trust in Australian food safety regulations is extremely high, that provides a clear market benefit for those seeking to export our products.

Other consumers may view 'clean' as referring to healthy and nutritious foodstuffs or even unprocessed, unrefined, 'pure,' or 'natural' foods. Hence these consumers choose foods because they are viewed as being 'clean' for the body, that is, unaffected by what are seen as non-nutritious or even harmful additions. Many who pursue this type of diet focus on whole fruits and vegetables, particularly in their raw forms, eliminating meat and dairy, and on preparing their own food so as to be aware precisely what goes into it. Australia's general reputation for healthy lifestyles may lead those in international markets to associate our food products with this understanding of the value of 'clean.' However, such an association undoubtedly is of most value to those producing fruits, vegetables, and other whole food products, and organic and health food lines, and may well be problematic to those who produce processed foods of any type and also for the uptake of GMOs in the food supply as this group of consumers is likely to have concerns about genetic modification.

'Clean' is also taken as referring to the conditions for producing food because it is claimed that Australia has a clean, uncontaminated environment, including clean air, water, and soil. Here many in the industry as well as in various governmental departments trade on an implicit comparison to conditions in other locales that are viewed as much more polluted due to the density of the population, fewer controls on emissions of various types, looser regulation about what types of chemicals can be used in agriculture, and so on, particularly from Australia's neighbours in a number of Asian countries. At the extreme, Australia no doubt has benefited from various natural and human created disasters such as the UK BSE, or mad cow, scandal and melamine contamination in China, that reinforce Australia's reputation as 'clean.'

Finally, Australia's notoriously strict quarantine restrictions further solidify its reputation as a clean producer. In this sense, the term 'clean' overlaps significantly with 'green,' though it may not always equate to it for reasons to be discussed below. The 2015 food scare with imported berries also highlighted that Australian consumers assumed that all food available for consumption in Australia is 'safe' and that the standards of production expected in Australian food production are not necessarily being applied to imported foods.

5.4.3 'Green food'

The term 'green' similarly has a range of meanings: by many the term is taken to indicate a broad category of supposedly 'environmentally friendly' or even 'environmentally-responsible' products. With reference to food, consumers may be concerned about a range of issues, including environmental impacts, water use, appropriateness of various crops to climatic conditions, and even various production standards such as those relating to animal welfare. More narrowly, some consumers understand 'green' products to be lacking in certain sorts of inputs such as pesticides and herbicides, so may equate organic certification with 'green,' and may seek out foods clearly labelled as free of genetic modification, which in turn is equated with the idea of 'pure' foods.

'Green' may also be associated with those products that have travelled shorter distances during their production, processing, or through other parts of the supply chain, and hence are perceived as not associated with high 'food miles', contributing to a carbon footprint. As the methods for devising more precise measurements of food miles associated with various products are relatively limited and generally not available on product labelling in Australia, many consumers resort to the use of proxy measures such as seeking out locally-produced foodstuffs that are assumed to be more 'green.'

But in some instances, local goods may well travel interstate to centralised food processing or packaging facilities to then be returned to

the original locale at the point-of-sale, which means reliance on such proxy measures can be inaccurate. Further, overseas studies have established that a large carbon footprint in relation to food can be created during the production phase due to use of fossil fuels and other factors that affect emissions, and much less so during the transport phase; so for instance airfreighting to the UK of strawberries grown in New Zealand or roses grown in Tanzania has less carbon footprint than the same products grown in the UK when the carbon footprint of the whole value chain is taken into account (Edwards-Jones, *et al.* 2008).

Even preference for Australian made products in order to reduce carbon footprints is a complex matter, given current country-of-origin labelling standards in Australia that result in many products being labelled as having mixed local and imported components, or are made or packaged in Australia from imported raw ingredients. Again in this case, although the food industry can capitalise on consumer demand for such products, particularly where foodstuffs are truly local in all stages of production and provision, there is a danger of backlash where products may be legally labelled as 'green' or 'local' but not aligned with consumers' understandings of these relatively plastic and ill-defined categories.

This paradoxical situation, in which we see an increasing pressure for Australian-made and Australian sourced products side-by-side with the widespread availability of 'home brand' food products in supermarkets sourced globally from the cheapest source, plus confusing country of origin labelling adds to the complexity of the branding of Australian food as 'clean and green'.

5.4.4 Consumer confusion

Similar to many other food-related categories the terms 'clean and green' are unregulated, except in the sense that cases can be pursued by the Australian Competition and Consumer Commission (ACCC) if marketing attached to particular products is viewed as fraudulent or misleading to consumers.

The ACCC has issued specific advice with reference to environmental claims (ACCC 2011), but there have been a limited number of cases pursued in relation to these terms. An exception is cases recently in the spotlight associated with country-of-origin claims, which may in turn cast doubt on the validity of marketing based on the image of being 'clean and green.'

As noted above, many consumers equate 'organic' with 'clean and green.' At present in Australia there are seven private organisations that can provide 'organic' certification under the National Standard for Organic and Biodynamic Produce (Department of Agriculture 2015). All certifying organisations need to ensure that their members comply with the national standard, but apply variations to this standard that generally are extra requirements beyond the minimum national standard, such as biodynamic production methods. Some but not all of these organisations are internationally recognised, and meet various other standards such as the US National Organic Program, the EU organic standard, and the Japanese Agricultural Standard, hence permitting export to those markets. Many consumers take 'organic' to equate to other categories such as locally- or Australian-produced or fair trade products, which may or may not be part of a particular certification regime.

Labelling is an active area of public discourse and policy deliberations and has been so for many years. Meeting the needs of Australian and overseas consumers for clear, unambiguous information while balancing the needs of industry to source ingredients from across the world to meet market demands for reliable year-round supply is not easy.

Parker *et al.* (2013) have argued that labelling categories are often not reflective of key consumer values but instead are terms constructed and utilised by producers, retailers, and others in the supply chain to influence consumer understandings according to commercial realities. Many consumers are concerned about the prevalence of 'greenwashing' and of the false sense of control over the broader systems of production that such

labels give consumers (e.g., Guthman 2007; Roff 2007; Kahn 2010). Many consumers also find food labels confusing and inadequate for their needs when attempting to buy products associated with various 'ethical' categories, including 'clean and green' (Bray & Ankeny 2015).

5.4.5 Need for standards

Thus consumer understanding of 'clean' or 'green' may be problematic because:

- it sets high, and sometimes mistaken, expectations about what is not being used in agriculture or in food production, notably that a variety of inputs have not been used when in fact they are the norms within our system of production (for example ripening agents for various types of fruit)
- the terms are largely unregulated and have no nationally agreed standards or definitions.

Our current 'clean and green' comparative advantage may not be sustained into the future as our trading partners improve their production systems. Australia's ability to compete internationally on these terms of 'clean and green' may also be threatened by increased international harmonisation by the World Trade Organization and other bodies. This is seen by some as having the potential to affect our relatively strict quarantine and other biosecurity restrictions, perhaps leading to damage to our 'clean and green' reputation inasmuch as crop- and other food-related threats may be present to a greater extent due to the importation of 'risky' foods (Dibden, *et al.* 2011). Operating in the opposite direction are the standards being developed increasingly by retailer-led private regulatory structures such as GlobalGAP that include standards around values-based concerns that are outside the purview of the WTO, such as labour standards and animal welfare.

Even with our 'clean and green' image, Australia has experienced negative sanctions or campaigns against our produce by foreign governments, non-government organisations, and consumers. The most recent cases relate to animal welfare issues, with the sudden cessation of live animal

exports from northern Australia in 2011 and the campaign in the United States and Europe against mulesing of sheep.

5.4.6 Genetically modified food ingredients—responding to consumers

Although food containing genetically modified (GM) ingredients has been available on Australian shelves for many years, the topic of GM foods and the use of GM techniques in agriculture remains contested in Australia. Australians are not as strongly opposed to GM foodstuffs as people in the European Union, but are not as broadly accepting as people in the United States (Biotechnology Australia 2005). Two Australian states, South Australia and Tasmania, continue to have moratoria on commercial growth of GM crops (despite the presence of extensive GM research within some of these locales), while others have revoked similar moratoria in recent years.

In Australia, most food containing GM ingredients must be labelled under the Australia New Zealand Food Standards Code but there are notable exceptions including: highly-refined foods, processing aids, or food additives where the genetic modifications are removed during processing (e.g. canola oil from GM plants); low concentrations of GM in the final food due to intentional (0.1 per cent) or unintentional (1 per cent) presence; and any foods consumed at the point-of-sale (e.g. in restaurants).

The key to the Australian legislated labelling regime is that the method of production is not labelled, only the final product. In addition, the principle of 'substantial equivalence' utilised by FSANZ holds that products deemed to have similar physical and chemical properties as their conventional counterparts are treated in the same manner with regard to health and safety and subjected to little, if any, additional testing (Lockie, *et al.* 2005).

Hence, various issues associated with GM foods represent both opportunities and risks for the Australian food industry, and it is undeniable that those in the food supply chain play increasingly critical roles in how food products come to be valued by consumers (Dixon 2003). Some consumers domestically and in several key international markets (e.g. Japan and parts of the EU) tend to seek out GM-free products. Their motivations for seeking these products differ considerably: some fear that GM foods are a risk to health or well-being, especially to children; others do not want to support global biotechnology companies associated with GM, including those perceived as placing pressures on smaller farmers particularly in the developing world; some do not perceive any real benefits of GM and hence avoid GM foods, a situation that could alter with the development of 'environmentally friendly' or medically important GM crops or products; and still others perceive GM as harmful to the environment or to other systems of agriculture, notably 'organic' production.

Current Australian legislation does not provide guidance or limitations on what can be labelled as GM-free. This means that some Australian products can be labelled 'GM-free' where GM ingredients have in fact been used in the process. This fails to address those consumer concerns not solely associated with products containing GM ingredients but with GM as a process. To add to the labelling confusion, many Australian products carry a 'GM-free' or similar label where there are no equivalent GM ingredients or products available in Australia or globally. Many consumers may consider such labelling to be deceptive, particularly where a price premium is attached to those explicitly labelled as GM-free, or at the least that labelling is not particularly helpful in ensuring that they are not ingesting GM foods (Lea 2005).

Given that the technological interventions associated with GM, and other uses of biotechnology in food, are difficult to understand (Eden 2011), consumers often construct their own meanings and fit information provided on food labels and similar into frameworks that are more familiar to them. In the case of GM, many consumers do this by reconceptualising GM ingredients as a form of 'additive,' and avoiding anything with additives as a way to avoid GM; this trend is particularly apparent among mothers with young children who may have behavioural or medical problems thought to result from or be exacerbated by 'additives' (Bray & Ankeny 2015).

Industry groups generally maintain that current labelling standards are adequate. However, many Australian consumers believe that labelling associated with GM does not allow them to make well-informed purchasing choices (Bray & Ankeny 2015), and has led to the development of food guides by activist groups to allow consumers to make these choices. Both producers and retailers face issues associated with GM as a result: voluntary labelling of products as 'GM free' may well increase popularity of products but there must be caution about the meaning of this terminology given its lack of legal definition and implicit tie-in to what some perceive as the misleading legal definition of what counts as 'containing' GM.

5.5 Policy challenges

Agricultural business viability is necessary but not sufficient to address the social issues identified in this report. Indeed strategies aimed at addressing business viability may exacerbate social issues. Transformative technologies that reduce labour demand, for example, may simultaneously reduce employment opportunities and deepen the isolation experienced by many working in agriculture.

Key challenges for government and the community relate to:

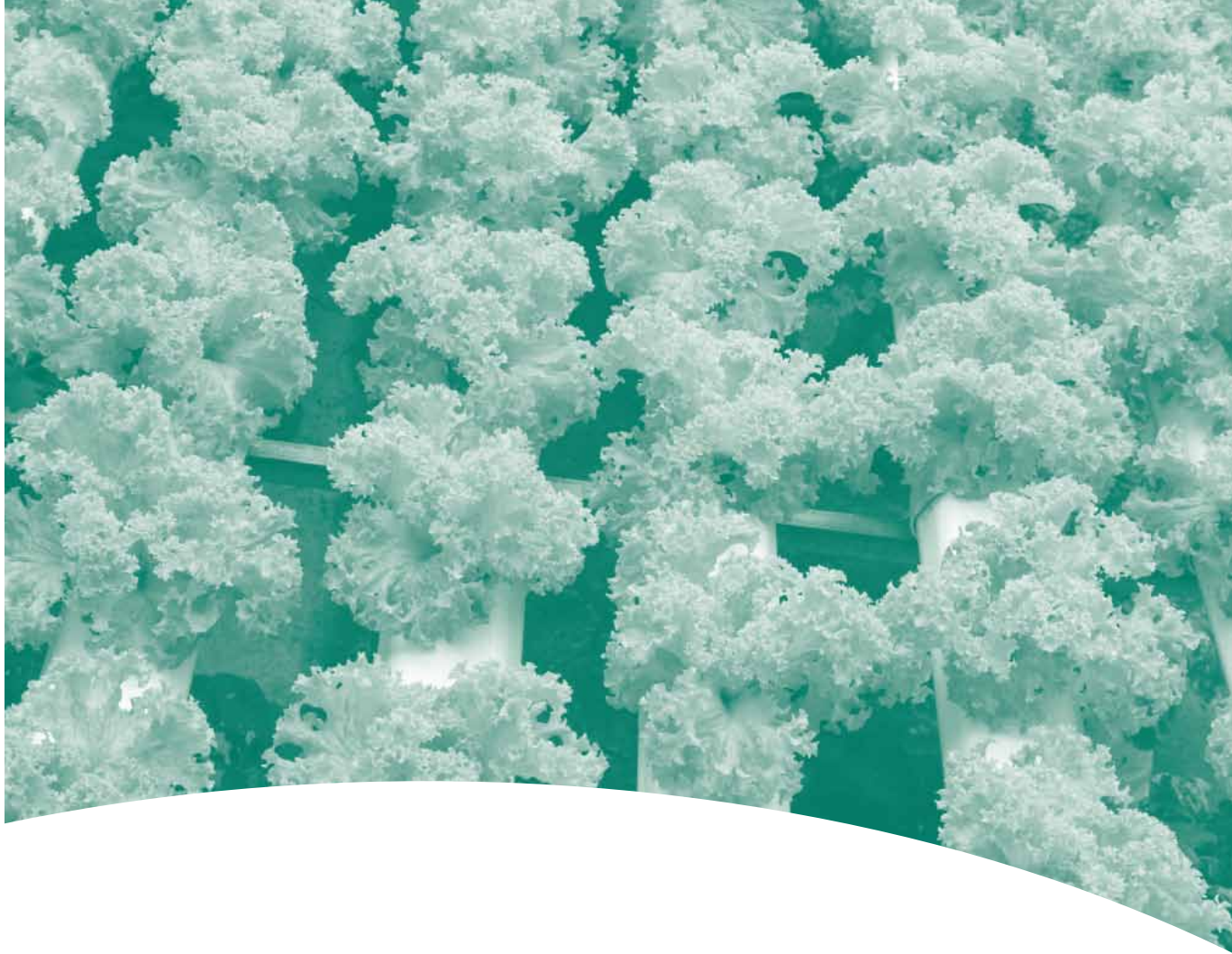
- a. recognising the social and cultural importance of farming and rural communities in Australian society
- b. recognising the changing face of employment in rural areas, both in terms of the nature of the workforce and the increasing need to employ people with non-traditional skillsets in response to technological change
- c. providing access to services in rural communities, particularly in response to changing demographics
- d. exploring improved forms of finance to ensure farm businesses have access to the capital necessary to take advantage of the opportunities of the future
- e. respecting and responding to consumer preferences, including for ethically produced foodstuffs
- f. ensuring consumers are provided with sound evidence-based information to inform their choices.

6

Farms of the future— transformative technology

6.1 Findings

1. Future agricultural enterprises will rely more on automation, robotics and sophisticated data analysis, causing employment opportunities to shift towards more specialised knowledge, skills and training.
2. The food value chain is increasingly utilising modern information systems.
3. Technological requirements of future farming may drive farmers to specialise in production whereas risk-reduction and sustainability drivers could push some farms to be more diverse.
4. Agriculture and food industries will need access to reliable, real-time information about markets, consumer preferences, and the conditions of the resource base.
5. Profitable agricultural industries will support those farmers and their communities that are innovative and well connected.



6. Contemporary agricultural industries with strong participation in export markets have innovative partnerships between farmers, information providers and researchers and have more farmer-initiated innovation.
7. Agricultural production and marketing are increasingly knowledge-intensive activities, drawing on technological developments in computing, engineering and data analysis.

6.2 Advanced technology and knowledge systems

Chapter 4 showed that agricultural production systems in Australia would need to adopt transformative changes in technology if future farms are to adapt to climate change, particularly from the middle of the century. Productivity increases are also needed to respond to terms of trade, competition from low cost competitors, and competition for workforce skills with other sectors.

Such changes will not be unique to Australia but will be required globally if we are to feed the world's rapidly growing population within the sustainability constraints of available land and fresh water.

A number of transformative technologies will build on information technology and rapidly expanding biological knowledge (e.g. in genomics). The next agricultural revolution will see the transition from using analogue to digital information. This will enable farmers to harness information at a large scale and make informed decisions to improve:

- *productivity*—increasing the yield and resilience of crops
- *profitability*—increasing the quality and quantity of produce per unit of energy, water and labour
- *sustainability*—minimising environmental impact by using resources more efficiently.

Since the 1960s, agriculture has benefited from increased use of agrochemicals, advances in crop and animal genetics, agricultural mechanisation and improved management practices. These technologies have driven productivity increases and will continue to provide future incremental improvements (Chapter 4).

Automation during the mid-20th century enabled increases in total factor productivity, through maintaining outputs with reduced labour inputs. New technologies and information systems will enable farming in a different way through enhanced knowledge coupled with targeted interventions.

6.2.1 Integrating knowledge and technology

Integrating deep agricultural knowledge with cutting-edge technologies (including sensor networks, robotics, autonomous systems, innovative mathematical and statistical models for big data sets and ICT) will be central to the next agricultural revolution. Agri-intelligence research is a springboard for agriculture into the second machine age, in which computer systems augment human perception and decision making in complex situations.

Agri-intelligence is the collection of tools and techniques—from robots, unmanned airborne vehicles (UAVs) and sensor networks to sophisticated mathematical models and

algorithms—that help a farmer make sense of large amounts of data (agronomic, environmental and economic) to make risk-informed decisions and run their farms more profitably and sustainably.

6.2.2 Robotic technology is a key component of agri-intelligent systems

Robotic technology is transforming practices in industries such as mining, manufacturing and health. Following this trend, this technology will also soon have a significant impact on agricultural practices (see Box 6.1).

Robots can be used for tasks related to field and crop management, enabling new practices and data collection leading to further advances in precision agriculture. As with the internet and mobile phone technologies just a decade ago, it is difficult to foresee the full potential of these technologies.

Weed and pest management in crops is becoming a serious problem for farmers, even jeopardising the sustainability of the current yield in crop production. Replacing large machinery with smaller cooperative autonomous ground robots can have significant advantages. The reduced soil compaction produced by lighter robots can lead to increased yields. Most importantly, small robots equipped with sophisticated computer vision systems can not only detect weeds but also classify them and decide upon a specific treatment, whether chemical (with appropriate herbicide mixtures and droplet sizes to improve absorption and reduce waste), mechanical or even microwave. Economic analyses have shown that agricultural robots or AgBots could reduce the cost of weed management—through savings in energy, labour and chemicals—by up to 40 per cent, and at the same time increase the effectiveness of weed control (Berry 2015).

Because of their ability to carry various sensors and operate in groups, AgBots can also play a key role in increasing farmer adoption of variable rate application of fertiliser. This type of operation can enable data to be collected at a faster rate

Box 6.1: Advanced field robotics and sensor systems in Australian agriculture

By Salah Sukkarieh, University of Sydney.

Field robotics are becoming an integral part of many farming systems, reducing labour and input costs and increasing output quality and productivity. Field robotics have the potential to: automate repetitive tasks; collect and process high resolution information to provide unprecedented knowledge about the state of the farm; form part of the wider farm management system to coordinate and control tasks based on intelligent data analytics and optimisation; and provide information and capabilities that benefit the wider supply chain and agricultural researchers.

Intelligent farming systems using sophisticated data analytics to support decision-making are set to revolutionise Australian agriculture. Field robots form a critical component of these kinds of systems, such as automated ground and air vehicles.

Field robots have a proud history in Australia, including the automation of a cargo berthing terminal by Patrick Stevedores, Rio Tinto's "Mine of the Future" program, and BAE Systems' development of intelligent robotic aircraft for environmental surveillance. The introduction of field robotics means that many physical tasks can be done more efficiently and continuously. These robots also carry various sensors—such as laser, video, radar, hyperspectral, temperature and moisture probes—that can measure specific environmental properties and process this information in real time to support decisions and enable greater autonomy.

Australian agriculture has many operational and commercial drivers that will benefit from field robotics, such as the need to monitor large outdoor areas, to collect real-time precision information and conduct precision activities, the need to reduce labour and input costs as well as minimising energy use. With the drive to continuously improve quality and safety, Australian agricultural industries are becoming more knowledge intensive. Information is becoming a valuable asset that needs to be collected and harnessed.

Self-guided robotic tractors are already providing farmers with information to better support and even automate decision making, such as variable seeding and the real-time application of fertiliser and pesticide. With added functionality such as collision avoidance these vehicles will become complete field robots for the broad-acre industry. Examples of such systems are being demonstrated nationally and internationally, with a drive towards robots that minimise operational costs and environmental footprint.

The Ladybird Robot™, developed for the Australian vegetable row crop industry, is battery operated and solar powered, providing continuous operation. It collects crop and soil information in real-time providing a 3D map of crop vigour and yield over time. It uses a robotic arm to automatically remove weeds and provide precision application of pesticide or fertiliser.

The dairy industry is trialling field robotics to correlate observed pasture quality with milk quality in individual cows, as well as robotic milking technology which drastically reduces labour requirements.

The "Big Bird" drone has been trialled by the cattle industry to monitor large areas for information such as weed detection, fence-line integrity and cattle location. Using stereoscopic vision techniques and machine learning algorithms the drone could identify and georeference woody weeds on the site and send a second robotic aircraft to dispense granular herbicide on each identified weed.

In addition to supporting better farm management and optimisation, field robotics have the potential to open the farm gate to the rest of the food value chain. Precise on-farm information can be shared down the chain to logistics and processing facilities, which will in turn feed decisions back up the chain to the farm. This might enable selective harvesting across farms to regulate the quality and quantity of produce delivered day-to-day.

The impact will also be felt within the research community. Agricultural science currently relies on data-poor but model-rich methods, but soon data driven models enabled by field robotics will surpass current methods and provide much more robust models.

There remain significant challenges in field robotics for agriculture, including affordability, system maintenance, and access to an appropriate support network. Communication technologies and infrastructure that underpin field robotics applications will be a major limiting factor. If the research and industry community are supported to tackle these challenges, Australian agriculture will be an international leader in the adoption of field robotics and associated technologies.

and, in combination with remote-sensing data from unpiloted aircraft, could lead to novel decision-support systems and strategies for robot autonomous decision-making in relation to site-specific crop management.

In some cases, the rapid adoption of these technologies may be hindered by current regulatory systems, such as in the use of airborne drones. Domestic regulatory agencies, in this case the Civil Aviation and Safety Authority, need the support to be able to adapt to rapidly changing technology and practices in order not to stifle emerging practices which promise to contribute significantly to improved productivity in agriculture. This situation is illustrated in the recent exemption granted by the US Federal Aviation Administration to allow farmers to use airborne drones for spraying operations in vineyards (Association for Unmanned Vehicle Systems International 2015).

6.3 The “Necessity of Strangers”

The opportunity presented in today’s burgeoning digital economy is having the knowledge and information about agro-ecosystems in a format that sees data of different types combined in ways previously impossible; this will give access to “agri-environmental intelligence” and empower collaboration along the value chain. This new era will see research efforts entwining different disciplines to create new practices and technologies that integrate and move beyond discipline-specific approaches (Basford & Harch 2014).

Growth and enhanced competitiveness in the agricultural sector will be characterised by ‘stranger catalysed’ innovation. As highlighted by Gregerman in *The Necessity of Strangers* (Gregerman 2013) new players investing in agriculture (i.e. strangers to traditional agricultural communities) will help agriculture innovate in ways not yet imagined, particularly in diversifying income on farm and creating new agricultural consulting businesses. For example, mechatronics engineers, big data analysts and human-computer interaction technologists are collaborating with the broadacre cropping and

horticultural industries to have robots deployed for activities such as spraying weeds and estimating crop yields, and discussions abound on breeding some horticultural crops to enable robotic harvesting.

In essence, fostering greater innovation and collaboration is central to accessing more new ideas and insights, which fuels competitiveness and growth. This “collaboration economy” (Deloitte Access Economics 2014) will also see stakeholders along agricultural value chains using this intelligence to develop new technologies and associated businesses, new markets, and build stronger intelligence and responsiveness along the value chain; all with the intent of achieving a balance across productivity, profitability and sustainability (Beddington, *et al.* 2012a; Beddington, *et al.* 2012b; FAO 2012; Neufeldt, *et al.* 2013).

This approach is consistent with the analysis of Sheng *et al.* (2014) who have shown that differences in rates of returns between small and large farms may not be just from economies of scale, as is often assumed, but from access to and application of advanced technology in these larger farms.

6.4 Knowledge systems: the need for interoperability

A characteristic of future farms and indeed of the whole agribusiness food chain is the availability of data about the system. While some of this data will be proprietary (see section 6.4.1), publicly available national databases will need to be expanded to provide a shared resource about the state of the environment from the national level to a regional and farm scale.

Nationally significant databases are not new. Historically, ABARES and its predecessors, as well as the Australian Bureau of Statistics and other government agencies such as Geosciences Australia, have released periodic reports containing important statistics about the nation.

However, the heterogeneous formats used for these databases, often released in print copy,

made it difficult to combine related data from different sources or to analyse data of multiple types. This is particularly so because data were often collected at a State or regional level and the format of data was not harmonised among the collections. In the past, data collections of many variables were not normally made with the view they would be combined with data from other regions or from other governments.

An example of this difficulty is illustrated in CSIRO's *Sustainable Yields Project* (2007 onwards) that modelled water yield in all the major catchments in Australia under a number of future climate scenarios (CSIRO 2015; Department of the Environment 2015). When these assessments are complete the project will provide Australia with a comprehensive scientific assessment to underpin water planning and policy decisions. One of the biggest challenges in these projects was combining data from different water authorities. Before national databases can be established there needs to be discussion and agreement on standards; even so the problem remains for existing records. The Bureau of Meteorology's real-time water tools (Box 4.3) are one example of a tool for planners, policy makers and farmers. Other examples of nationally significant databases are available for soil (ASRIS 2014), and biodiversity (ALA 2015).

COAG agreed in November 2008 to develop the *National Water Knowledge and Research Strategy* (Department of the Environment 2012) to establish priority research areas, promote coordinated research effort, and ensure the best returns from investment.

Tasmania is exploring the use of a state-wide data collection in the *Sense-T* project (Sense-T 2015) that is building an economy-wide sensor network and data resource for the state. Early project activities include the beef, dairy, viticulture, and aquaculture industries. In the beef and dairy industries it will enable farmers to optimise the use of inputs such as grain and fertilisers, minimise run-off and waste, support decisions on cattle movement and culling, substantiate provenance and sustainable practices and enhance understanding of animal behaviour.

6.4.1 Networks and partnerships

A recurrent theme through much of the literature and community discourse is the emergence of knowledge systems and partnerships as vital to resilient and profitable farming systems. The agricultural industry is becoming more knowledge intensive, with greater complexity in managing investments, changing production technologies, volatile markets, social challenges, and increased regulation (Grafton, *et al.* 2015, p. 95).

Knowledge generation and network interactions that allow for knowledge exchange are key processes of farmer-driven innovation. Yet these processes are not well understood at farm level, nor are they well-reflected in policy approaches for agricultural innovation. Intensive management systems will be an integral part of farm business as will farmer-driven innovation and the construction of farmer-to-farmer knowledge exchange networks via farmer groups (Grafton, *et al.* 2015, p. 106).

Strengthening whole industries through knowledge exchange to drive a strong export focus is also occurring in diverse industries, including the citrus export industry (Box 6.2), the wine industry (Box 2.2) and the cotton industry. These networks allow farmers to collectively set aspirational goals for exports, agree on standards for export, and engage in marketing campaigns. They also provide a structured arrangement for collaborative efforts with the research community that can better respond to strategic needs of an industry.

There are important emerging means of engaging in which the line between landholder and professional expert are becoming blurred (McKenzie & Williams 2014). The need for new ways to manage knowledge in agriculture should be seen as an opportunity to rebuild extension services in new and novel forms and not as a cost shifting exercise.

Examples of how networks and partnerships can improve agriculture in Australia include:

- the Commonwealth Government's *Agricultural Competitiveness Green Paper* (Commonwealth of Australia 2014) suggests that new entrants into farming can be better supported through mentoring, networking and training opportunities

Box 6.2: The Australian citrus export industry

By Tania Chapman, Citrus Australia.

Australia's citrus industry has adopted a coordinated, industry-wide approach through the peak body Citrus Australia to successfully target export markets for fresh fruit. By providing comprehensive support for the industry's export focus as well as connecting and coordinating across industry sectors, Citrus Australia is helping producers meet emerging challenges and opportunities.

The citrus industry is a leader in fresh produce exports from Australia, with \$202 million worth exported in 2014. Exports make up around 25 per cent of total citrus production in Australia, but account for around 45 per cent of overall industry farm gate returns.

Citrus is a long-term crop investment, with new orchards taking seven to eight years to reach full production. The production base cannot be adjusted quickly. Appropriate year to year export volumes are therefore essential for preventing short to medium term oversupply in the domestic market.

Export values for key destinations are shown in Figure 1 for the main product, oranges. Red columns indicate reduced value from the previous year, green columns indicate increased value, and the percentage change is shown for each destination.

With exporting playing such a crucial role in citrus farm viability, the industry as a whole has focused heavily on gaining, maintaining and improving market access into export destinations. Import conditions have been negotiated with more than 30 countries, with varying degrees of complexity. The peak industry body Citrus Australia employs a market development manager and a market access manager to coordinate trade conditions and processes between government, researchers and the industry.

Citrus Australia also has an export market sub-committee, comprising the largest citrus producers and marketers, that recommends priorities for market access activities, research and development to overcome phytosanitary trade barriers and, more recently, selected export market promotions.

For developing markets such as China, Citrus Australia has organised out-bound and in-bound trade missions, trade fair promotions, and training workshops to get the industry 'China ready'. Constant communication with the exporter, packer and grower sectors of the industry is a vital role of Citrus Australia.

The citrus industry in Australia faces a range of challenges, many of which are common across the agricultural sector. These include high labour costs in a labour-intensive industry, high compliance costs of phytosanitary protocols and export inspections, managing complex food safety requirements for multiple export markets, freight of product from growing regions to ports both in terms of costs and adequate infrastructure, biosecurity—particularly management of fruit fly disinfestation—and invasive organisms, and climatic issues such as drought and extreme weather.

- Australia's agricultural sector will need to equip itself with knowledge and understanding of how water extraction adversely affects catchment, estuary and near-shore ecological environmental function and assets. There is a need to evaluate the amount of water available for agriculture to ensure a secure future (Grafton, *et al.* 2015, p. 104)
- over the past decade, Australia has moved to a regional model for natural resource management that can be an effective means to secure the foundation of sustainable agriculture as this kind of model is small enough to take advantage of the local knowledge of farmers and landholders (Grafton, *et al.* 2015, p. 106).

Ironically, the drive for knowledge may lead to reduced diversity of land uses on farm, and the challenge is to ensure that this specialisation does not threaten wider landscape sustainability. Better understanding of diverse agro-ecological systems is required, rather than a focus on single component systems. For example, Australian industry has neglected the interaction between cropping and livestock, including in how R&D is funded (Grafton, *et al.* 2015, p. 97)

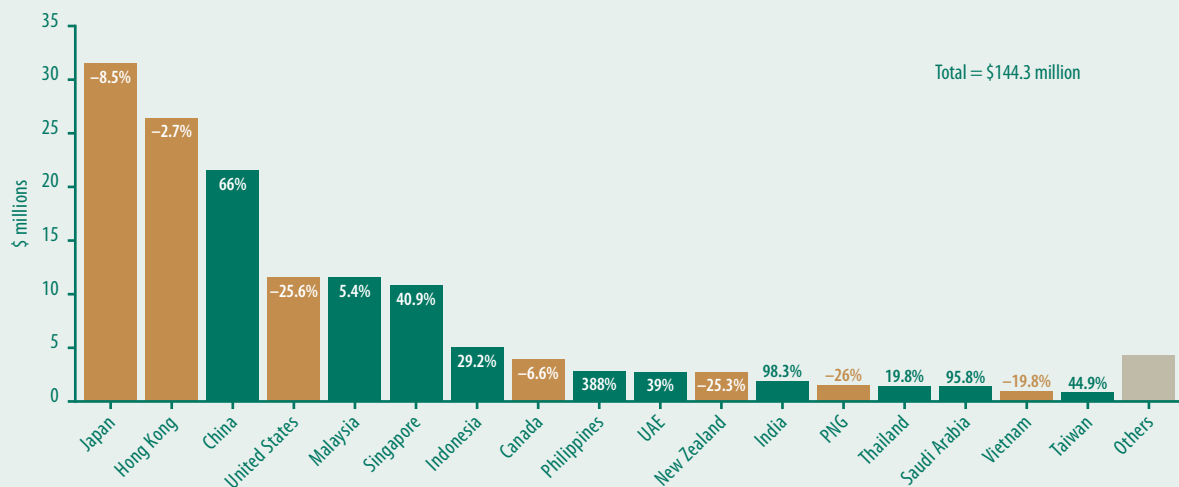
Middle income countries will become a more important source of new technologies and capturing and adapting spill-over technologies from middle income as well as high income countries will be worthwhile but may be difficult under existing levels of R&D funding in Australia (Grafton, *et al.* 2015, p. 46).

Transitioning from an industry traditionally composed of smaller, family-operated units to one increasingly dominated by larger corporate units has also posed challenges. The move to larger units to gain economies of scale will continue, and accessing skilled management staff is becoming an issue. Training and upskilling of personnel is both a challenge but also an opportunity for those seeking a career in primary industry.

The citrus export sector also has significant emerging opportunities common to much of Australia's agricultural sector. These include the burgeoning Asian middle class expanding the premium customer base, new varieties now moving from experimental to mainstream products, favourable exchange rates returning more to the farm gate, reduced interest rates lowering business costs for producers, lower fuel costs reducing freight charges, and improving orchard and packing shed productivity through schemes such as the Seasonal Worker Program.

Overall, the Australian citrus industry is now in a buoyant phase, and many foreseeable indicators are favourable—market strength, product mix and overall farm viability. Through the peak industry body, industry coordination in key activities is continually improving, and beginning to pay dividends.

Figure 1: Australian orange export values and destinations, 2014



Source: Citrus Australia.

6.5 Policy challenges

Key public policy challenges to ensuring that the technological change critical to Australia's agricultural future takes place are:

- to manage the ongoing restructuring pressures in agriculture and the flow-through impacts to regional Australia
- to limit and manage the major risks that agriculture is likely to face
- to develop the appropriate institutional framework, human capital resources and policy settings that will allow agricultural producers to be innovative and resilient
- to enable regulatory systems to evolve appropriately so that emerging technologies and practices are not unduly hindered
- to support R&D into appropriate technologies and provide education and skill development to facilitate their uptake
- to ensure that rural communities have the necessary IT and broadband infrastructure to support adoption of these technologies.

7

Concluding remarks and key policy areas

This report has indicated that agricultural industries in Australia have great opportunities to respond to increased demand for food and other agricultural products and has the following major conclusions:

1. **Australia's agricultural sector has a bright future with continuing comparative advantage in the export of bulk commodities and increasing opportunities to respond to the growth in demand for high-value products domestically and in Asia.** Imports of low-cost standard processed foods will continue to increase. Collaboration among all the players affecting agriculture and the food value chain is essential to reinforce growth in the sector. Nuanced information about consumers and markets will be increasingly important to match production to increasingly differentiated demands.
2. **Australia's reputation for 'safe, clean and green' food is a major comparative advantage that needs to be sustained and underpinned by internationally recognised standards and certification.** Brand Australia will continue to be important but will face increasing challenges from competitors who will seek to match our standards of production and processing. Niche markets will also be under continuing challenge.



3. **In order to meet increased demand, the sector will need to efficiently manage its soil and water resources, including the risks associated with climate change and climate variability.** The sector will experience competition from other industries, such as unconventional gas and tourism, and from the environment for water resources. Improved natural resource management will require the support of reliable and timely information through integrated databases, improved information technology infrastructure and ongoing R&D into decision support and other knowledge systems.
4. **The sector will need to attract capital and skilled labour in competition with other sectors of the Australian economy.** While unique in some ways, agriculture shares these common challenges with other sectors. Attention is needed on financial instruments that attract capital to agriculture taking into account its special characteristics.
5. **Accelerating the uptake of advanced technologies, communications and knowledge systems, and integrated workflows for decision making and planning, are critical for success along the whole value chain.** This includes advanced breeding technologies, ICT, robotics, sensors, knowledge systems, integrated workflows for decision-making and planning and the creation of nationally consistent databases about the environment. Ongoing investment in research and development, both private and public, is vital to underpin this uptake.

6. **Ongoing investment in research and development, both private and public, is vital to underpin this uptake.** Challenges in the future such as climate change and the need for transformational changes in productivity both require considerable investment in R&D.
7. **A range of community concerns with regulatory, social and political implications important to the future development of agriculture need to be acknowledged and managed sensitively. These include issues such as food safety, labelling, gene technology in plant and animal breeding, foreign investment and foreign workers, alternative land-use on pastoral leases and farm ownership.** These may all impact on the options available for the adaptation and growth of agricultural industries and their social licence to operate.

However, to realise this potential, the sector will need to address a range of constraints and barriers, including:

- *environmental and physical barriers*, such as access and availability of water, effects of climate change, possible shortfalls in availability of fertilisers and other inputs, degradation of soils and biodiversity
- *economic barriers*, such as cost and availability of labour, strong competition for new skills in IT and engineering from other sectors, lack of investment capital, and pastoral leases that restrict use of the land for alternative activities
- *technical barriers*, such as levels of investment in R&D, poor engagement of young people in agricultural sciences, lack of access to high-speed internet connections, lack of services to utilise new information and information technologies, and poor or inadequate infrastructure.

All of these barriers will need to be addressed within a social and political context that continues to value farming and farmers and, at least in the short-term, supports family farming as the preferred form of agricultural business

structure. Similarly, moves into technologies that may confront consumer opposition, such as the use of GM, need to be considered carefully.

7.1 Policy implications

Government policy towards agriculture needs to facilitate the farms of the future, and not entrench outmoded systems and practices. Foundation policies to strengthen agriculture are similar to other parts of the economy, and provide a recurrent theme in the range of ACOLA studies on *Securing Australia's Future* (Bell, *et al.* 2014; Withers, *et al.* 2015). This has the potential to produce competition for resources and investment, particularly in provision of infrastructure, or could result in potential synergies if investment proceeds intelligently. This commonality across the economy lends weight to certain types of government investment that will assist Australia to adapt to the future opportunities on a number of fronts.

Common policy areas identified by these different studies are:

1. *Skills and Productivity*: Technological change that focuses on improving labour productivity can have perverse social consequences in rural areas (Lockie 2015), namely that it can reduce employment opportunities, particularly in traditional farming occupations. However, new technologies also require new skills in IT, robotics and engineering—skills in strong demand in other parts of the economy (Bell, *et al.* 2014)—as discussed in section 6.3. The challenge for agriculture is to engender excitement and interest in career opportunities—to move from a reputation of ‘woeful to wonderful’ (ACIL Allen Consulting 2014). A decline in scientific and technical capacity into the future, when knowledge and innovation will be critical to increase both productivity and environmental sustainability, appears to be a significant risk facing Australian agriculture.

2. *Access to High-speed Broadband*: While some of these new skills will be attracted to rural and regional Australia, much of the work activities may be done remotely with skilled workers residing in urban or large regional centres. Access to these skills by farmers will require better access to appropriate and reliable, high speed internet connections.
3. *Infrastructure*: Provision of adequate infrastructure in regional Australia is required to sustain increases in agricultural production. Expansion of agriculture in the north and intensification in the southern regions will require difficult decisions on where to invest in roads, rail links, storage facilities, processing plants, etc. (Lockie 2015, p. 40).
4. *Adapting to Climate Change*: Shifting trends in rainfall and temperatures and increases in extreme weather events will impact on all parts of Australian society. The National Farmers Federation in their 'Blueprint for Australian Agriculture' (NFF 2013) highlights the need for investment in adaptation. However, Australian governments have not invested significantly in R&D that would enable the agricultural sector to transform its capacity to adapt. Greenhouse gas emissions from agriculture are difficult to monitor. However foreign markets may penalise production systems that cannot demonstrate best practice, presenting even greater risks to the sector.

What is particular to the agricultural sector is the public acceptance of new technology. The sections above described how new technologies can disrupt people's perception of what is 'clean and green' or 'pure and natural', as has been the case with GM technology (see section 5.4.4). Food is deeply embedded in our emotional, social and cultural experience in a way that other commodities are not. Institutional frameworks 'must engage positively with the concerns and preferences of consumers if transformational technologies are to be perceived as a benefit and not a threat' (Lockie 2015).

7.1.1 The family farm

The family farm has been very resilient, despite predictions of its demise (Lockie 2015), with 95 per cent of farms covering 77 per cent farmland being family owned (Commonwealth of Australia 2014). Indeed as seen above, current policy deliberations in agriculture remained focused on the viability of the family farm. It is also true that larger farms are more profitable and have better access to finance and specialised management expertise. However the *Agricultural Competitiveness Green Paper* saw advantages in fostering the family farm as a business enterprise and working towards more collaborative business models in the supply chain because of the knock-on advantages on social cohesion in rural areas, the enhanced capacity to enable new entries into farming by lowering the asset requirements and more stable supply chain relationships (Commonwealth of Australia 2014).

Lockie (2015) warns of the dangers of policies or programs that make assumptions about the typical farm or reduce diversity of business models; diversity and flexibility in the sector can assist it to adapt to changing conditions, including climate change and variability, and changing economic drivers. Enabling change requires collaboration and planning across the sector, across and between governments, and across agricultural industries and indigenous landowners.

7.1.2 Governance arrangements

Farming of the future will need to manage its social licence to operate, not only with respect to new technologies and food safety but also animal welfare (e.g. mulesing, live animal exports), biodiversity conservation, and water management. Issues such as community vitality, and the health and welfare of rural communities all need to be addressed if Australia is to benefit from the opportunities of rising demand for agricultural products and food.

Lockie (2015) has proposed that social and political issues associated with agriculture can only be resolved through social and political

means. He outlines three areas in which mechanisms and processes exist, and can be used to continue the dialogue between different players in the agricultural sector and the broader community:

1. standards and codes of practice
2. collaborative arrangements for natural resource management
3. legal arrangements for tenure and property rights.

Resolving community concerns or perceptions about new technology in the food chain needs further consideration. This will require widespread participation and deliberation if Australia is to benefit fully from new technologies (Renn & Klinke 2012). While this may not fully resolve opposition, it may indicate ways that technology can be deployed or modified to meet community concerns.

Upscaling production research to support continued productivity gains in Australian agriculture is critical but not sufficient.

(Lockie 2015, p. 49)

Agriculture will need to exploit not only new research and innovation in the sciences and technology domain, but access to research and innovation in the social sciences and humanities—a conclusion reached by Withers *et al.* in their evaluation of Australia's comparative advantage across all sectors (Withers, *et al.* 2015).

Australia's agricultural sector has a strong track record of innovation, adaptation and resilience, which suggests that the sector is willing and capable of responding to challenges and opportunities.

Changes over the past three decades that signal the sector is continuing to adapt include, among others:

- mergers of farms to achieve economies of scale and access to investment and technology

- responsiveness to the development of water markets to enable market-driven solutions to the allocation of water across the sector
- catchment management groups that draw communities together to manage the environment at landscape scale and to assist farmers to exchange knowledge
- innovative farmer networks that undertake experimentation and best practice
- creation of national databases on water, biodiversity and soils to complement weather data
- widespread uptake of tractors that are remotely controlled and gather real time data on yield, soil moisture and other parameters enabling farmers to better control inputs
- introduction of new crops such as oilseeds, an expansion of horticultural products in response to changing dietary preferences
- introduction of traceability of livestock from 'paddock to plate' to meet consumer demand for quality and reliability
- increasing use of decision making tools to assist farm management.

What is apparent is that technical solutions alone are not sufficient to overcome the above barriers. Technical and non-technical experts will need to work together to support the community and industry sector rise to the challenge of increasing productivity and profitability. Social issues including ongoing problems in accessing local services such as health and education in rural communities will only make it harder to attract the skilled labour force that the agriculture sector needs to thrive. Attitudes to farming as a 'sunset industry' must change and Australia must be willing to invest to secure the future of the agricultural sector.

7.2 Agriculture is an industry sector

While this report has focused on agricultural activity, other *Securing Australia's Future* reports have examined a range of other matters that bear on agriculture. There is a consistency of message throughout these reports. Economic development relies on: an innovative and skilled workforce, capital investment, partnerships, access to broadband internet, access to knowledge, and harmonised regulations across sectors. To this we add the need to address community concerns about change in technology, ownership of land and the safety of food.

Agriculture must also grapple with unique issues that reflect its special place in the national identity (see Chapter 5).

The *Australia's Comparative Advantage* Report (Withers, *et al.* 2015) concluded that agriculture is part of the post-mining boom economy. It also identified a range of issues and challenges that the agricultural sector shares with other parts of the economy. It identifies a range of foundational policy areas that need attending to across the economy:

- Infrastructure
- Skills
- Innovation and R&D
- Investment
- Partnerships
- Access to IT

This report also recognises these areas as critical to the agricultural sector.

7.3 What next

This report has canvassed the issues and key drivers that are likely to be important for agriculture to 2050, focusing on the most important factors that are likely to be relevant to the agricultural sector and policy makers. Agricultural policy is a crowded space; what distinguishes this report is a focus on identifying the key factors and trends that are expected over the longer time horizon. It was not possible to examine all the issues pertaining to the future of agriculture in Australia, and there are a number of areas worthy of further exploration and further research. Some of these include:

1. the scope for increased investment in corporate farms and by corporate investors in agricultural development in Australia in a way that is sensitive to the cultural context of rural Australia
2. investment models that could enable Australian superannuation funds and other institutional investors to invest in agriculture for long-term gain while managing risks and uncertainties in the short-term
3. business enterprise models that enable younger farmers to enter farming with access to equity
4. policy settings that stimulate intergenerational transfer of ownership to younger generations that may be more amenable to advanced technologies
5. educational training that attracts a diverse range of skills into agriculture.

This report's findings provide a broad summary of key directions to provide a useful reference and sounding guide for more specific initiatives. By helping to affirm and frame the broad directions of government policy, these findings provide some principles to underpin policy development, and in some cases provide a counterpoint to perceptions and ideas about agriculture that may deserve reassessment. Finally, this report gives a sense of the breadth of issues facing Australia's agricultural future, and the corresponding need for a systematic, evidence-based approach to policy development and reform.

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Appendix 1

Summary of key social and political trends shaping the future of Australian agriculture

Current trends and issues	Immediate consequences	Short to medium-term implications and possibilities	Long-term implications and possibilities	Alternative trajectories
Concentration of farm sector	Depopulation and aging of inland Australia	Widening gap between need for social and health services by remaining residents and availability of services	Widening health gap between rural and urban Australians	Cooperative and other business models increase economies of scale
				Productivity enhancement achieved through sustainable intensification of land use rather than expansion of landholdings
		Reduced viability of non-agricultural rural businesses and thus opportunities for off-farm employment and income	Collapse of non-agricultural economy in rural areas unsuitable for tourism or residential development	Diversification of non-agricultural business and employment opportunities including professional services
		Declining support base for traditional rural political parties	Diminished political support for agricultural policies inconsistent with views of urban electorate	Convergence of support for social, cultural and environmental values of agricultural landscapes
	Reduced amenity and services in rural areas	Reduced quality of life for remaining residents	Acceleration of depopulation and associated trends	Acceleration of return migration and associated transfer of skills and capital
	Reduced recruitment of young farmers and farm workers, including disproportionate impact on recruitment of women to farming	Increasing dependence on international labour migration to supply temporary workers	Increasing dependence on international labour migration to supply management expertise	Growing employment in management and professional services provides training and experience

Current trends and issues	Immediate consequences	Short to medium-term implications and possibilities	Long-term implications and possibilities	Alternative trajectories
Low and volatile farm incomes for much of sector	Lack of investment capital and pressure for concentration	Failure to invest in productivity enhancing and/or resource conserving technology	Corporatisation and increased reliance on foreign capital	Increased economies of scale provide platform for more investment including through joint ventures with off-farm investors
	Contribution to comparatively poor health and wellbeing status of farm and rural residents	As above	As above	Improved incomes and income stability reduce health gap between rural and urban, and Indigenous and non-Indigenous, Australians
Expansion of Indigenous landholdings	Aspiration of many Aboriginal and Torres Strait Islander Australians to live on, care for, and derive livelihoods from traditional lands	Slow expansion of Indigenous agricultural enterprises	Development of more economically viable agricultural enterprises on Indigenous land	Better integration of natural resource management activities across Indigenous and other landholdings to deliver ecosystem services at landscape scale
		Continued interest in Indigenous Ranger and other conservation programs	Improved land condition	
Reduced public-sector research and development	Narrowing of research focus and avoidance of cross-sectoral and high risk 'blue sky' research	Slowing rate of productivity growth	Decline in absolute levels of productivity due to climate impacts	Cross-sectoral research supports increased productivity, land use intensification and enhancement of ecosystem processes
		Missed opportunities for transformational research	Reduced capacity to adapt to high levels of environmental change	Climate resilience and adaptability enhanced
		Missed opportunities to address social and environmental concerns	Reduced market access	Market access enhanced

Current trends and issues	Immediate consequences	Short to medium-term implications and possibilities	Long-term implications and possibilities	Alternative trajectories
Consumer resistance to agricultural products perceived as unnatural, unsustainable and/or cruel	'Buycotts' and campaigns to ban controversial technologies and practices	Processor and retailer preference for products produced using alternative practices	Loss of Australia's reputation for 'clean and green' agriculture	Australian produce perceived as natural and sustainable
		Government intervention to ban practices	Reorientation of global supply chains, bypassing Australia	Reorientation of global supply chains to include Australia
	Growth in 'alternative' food markets including certified organic produce, farmers' markets, community supported agriculture etc.	Diversification of market opportunities for those producers capable of supplying them	Mainstreaming of 'alternative' produce through involvement of more and larger producers, agribusiness firms and retailers	Synergies between so-called 'conventional' and 'alternative' production systems improve consumer acceptance of new technologies
		Short supply chains increasing producer-consumer contact	Short supply chains provide viable livelihood option for more members of small farm sector	
Vertical coordination of supply chains	Highly concentrated retail sector	Concern over impact of retail concentration on farm-gate prices	Retail-coordinated supply chains achieve economies of scale by favouring large suppliers	Diversification of retail outlets ranging from competing large format supermarkets to direct farmer-consumer relationships
	Reduced importance of spot/wholesale markets to large retailers	Spot/wholesale markets become repositories for produce surplus to major supply chains and/or not certified as compliant with quality standards	Bifurcation of 'food system' into high and low value segments based on level of quality assurance and compliance with buyer expectations	Diversification of retail outlets accompanied by diversification of supply chains
	Dependence on quality standards to manage risk	Extension of standards to incorporate more types of risk including reputational risks associated with social and environmental issues	Exclusion of small producers unable to afford costs of certification and/or of changed management practices	Standards harmonised to reduce costs More stable and secure income streams for those farmers able to pre-empt concerns and meet market demands
	Increased foreign ownership of processing facilities	Vulnerability of producers to offshoring of processing facilities and reorientation of supply network		Increased investment and more competitive value chains

Current trends and issues	Immediate consequences	Short to medium-term implications and possibilities	Long-term implications and possibilities	Alternative trajectories
Politics of global environmental change	Opportunities to secure payments for ecosystem services (carbon sequestration)	Increased scrutiny of greenhouse gas emissions from agriculture	Trade restrictions and/or imposition of best-practice standards	Use of precision agriculture, ICT, biotechnologies and robotics to maximise input-use efficiency in intensive production systems
			Rising fuel and input costs	
			Imposition of taxes or other pricing mechanisms of GHG emissions from agriculture	Where this is not possible or viable, re-extensification of agriculture
			Systemic change in enterprise mixes and relocation of people and infrastructure	Substitution wherever possible of fossil fuel derived inputs with cultural practices, biologically derived inputs etc.
Geopolitical and economic transitions	Rising economic and political influence of Asia	Increased consumption and trade in the Asia Pacific	Shift of demand to quality, higher-value products by new middle classes	Global political instability and increased use of trade for political leverage
	New aspirants to regional leadership in Asia, South America and Africa			National food security concerns lead to reversal of liberalisation and reassertion of trade barriers to protect domestic production

Source: Lockie 2015.

Appendix 2

Findings arising from the early to mid-career agricultural producers and researchers workshop

1. Consumers and students need to be encouraged to engage with agriculture, including technology and science, including to promote the benefits of the diverse career opportunities available. School/ community visits, roadshows, cadetships/ internships, online educational courses, etc.
2. Many important issues are regional, and require community-level solutions.
3. Short-term funding cycles stifle innovation and lead to the loss of human capital in researchers.
4. There needs to be an appropriate economic value placed on a healthy environment (pricing externalities?).
5. Agriculture is a system, not a collection of independent disciplines.
6. 'Spill-ins' from international engagement on agriculture and research are valuable, and these linkages should be supported and encouraged.
7. National information systems that are consistent, relevant and accessible would aid farmers to improve productivity and manage risk.
8. Building relationships within and across segments of production is important—through facilitation and connectedness.
9. Australia's agriculture system isn't the only one that is evolving and developing—there is potential to learn from other countries, but change and improvement is required to at least maintain our current position.
10. Existing systems are not allowing answers and solutions to emerge naturally. Interdisciplinary interactions between different industries and researchers need to be rewarded and facilitated.
11. "If it isn't measured it isn't managed." There is a need to underpin Australia's 'green' image via robust environmental accounting systems that only government can provide.
12. We have to learn from the failures of the Murray Darling Basin.
13. A strong agriculture sectors needs more strategic infrastructure development.
14. Agriculture needs to reform and rebrand itself as ecological/environmental managers.
15. Australia needs a set of clearly defined national goals around agriculture that are specific in terms of deliverables. The government's role is to bring together all parts of new value chains that can solve these challenges in a step-change manner.

16. We need new integrated value chains from R&D through production, processing/value add, to end users for a step-change increase in productivity and efficiency.
17. Greater diversity increases resilience.
18. There is a need for a vision/narrative of agriculture in Australia—what is its place in society, the business of agriculture, a discussion about regionalism and farming identity. How does agriculture interact with health, IT, education, development, poverty, etc.?
19. We need to improve our process of exchange—connecting rural/regional/remote people with each other, with urban and global populations.
20. Agriculture needs a new model of engagement—for perception, governance, innovation, economic participation.
21. Land is a communal asset for all Australians—we need a holistic plan for land use, that also takes into account potential competing uses.
22. Community and grower organisations need support to engage with others and be outward looking.
23. Government can foster businesses to come together, work cooperatively to grow the industry and seek markets etc.
24. Agriculture needs to be recognised as a business, not a lifestyle.
25. More research is needed in how farmers and agriculture in general can take better advantage of new forms of social media to improve connectedness, knowledge exchange, etc.
26. Infrastructure issues are a major cost burden on agriculture—transport, irrigation, communication and information infrastructure.
27. Current models and structures of family farm ownership can tend to vest capital ownership in older family members, that can constrain the use of the capital to grow the business. Better ways to encourage productive use of capital and different investment models may improve the need for finance.
28. Producers, consumers, and retailers all drive trends in food together.

Expert Working Group

Dr Joanne Daly PSM FTSE

Joanne Daly is a CSIRO Strategic Advisor and a former Group Executive of Agribusiness and Chief of Division. Her activities focus on strategy for national research collections and in agricultural sciences, and assisting with the developing science precinct in Canberra with the ANU in the area of transformational agriculture. She has worked in CSIRO for over 30 years originally as a researcher in entomology. She is an ACIAR Commissioner and has held a number of senior roles including Chair of the international body, GBIF, and was a member of the Biosecurity Advisory Council and the Australian e-Research Infrastructure Council. She was head of the Secretariat that assisted Government in the setting of National Research Priorities in 2002, during her 2-year secondment to the Federal Public Service.

Professor Kym Anderson AC FASSA

Kym Anderson is a Professor of Economics at the University of Adelaide and at the Australian National University's Crawford School of Public Policy. He was on extended leave at the research division of the GATT (now WTO) Secretariat in Geneva during 1990–92 and at the World Bank's Research Group in Washington DC as Lead Economist during 2004–07. He is a Fellow of the AAEA, AARES, AAWE, ASSA, APPS and CEPR. He is also Chair of the Board of Trustees of the Washington DC-based International Food Policy Research Institute, and President of the Policy Advisory Council of the Australian Centre for International Agricultural Research.

Professor Rachel Ankeny

Rachel A. Ankeny is a professor in the School of Humanities at the University of Adelaide, and Associate Dean Research for the Faculty of Arts. She is an interdisciplinary teacher and scholar whose areas of expertise cross three fields: history/philosophy of science, bioethics and science policy, and food studies. She has major research projects on food ethics, animal welfare, and the history and public understanding of genetic modification, among other topics. She previously was a member of the Gene Technology Ethics and Community Consultative Committee for the Commonwealth Office of the Gene Technology Regulator, and the chair of the National Committee for History and Philosophy of Science of the Australian Academy of Sciences.

Professor Graham Farquhar AO FAA FRS NAS

Distinguished Professor Graham Farquhar has undertaken and led research across a broad range of fields and scales, from integration of photosynthesis with nitrogen and water use of plants, stomatal physiology, isotopic composition of plants and global change. He is a fellow of The Australian Academy of Science and of the Royal Society and a Foreign Associate of the National Academy of Sciences. He has over 300 research publications and is a leading Australian Citation Laureate.

Professor Bronwyn Harch FTSE

Professor Bronwyn Harch has a dual role at Queensland University of Technology as Science and Engineering Assistant Dean—Research and Deputy Director, Institute of Future Environment. Her focus is on research and development across STEM and with industry and government. She has developed multi-disciplinary research, engagement and commercialisation strategies with state and federal government and their agencies, Australian and global multi-national companies and partnerships with research organisations. Previously Professor Harch was Chief of the CSIRO division of Computational Informatics and Deputy Director of CSIRO's Sustainable Agriculture Flagship. She is a Fellow of the Australian Academy of Technological Sciences and Engineering.

Professor John Rolfe

John Rolfe is Professor of Regional Economic Development and the Deputy Dean Research in the School of Business and Law at CQ University at Rockhampton. He is a resource economist, and has extensive experience with environmental, resource and development issues across Queensland and Australia. Professor Rolfe has led a number of major research projects (> 30) over the past 10 years and is currently the Editor-in-Chief for a major applied economics journal, the *Australian Journal of Agricultural and Resource Economics*. He has a background in agriculture and operated a cattle property in the Central Queensland region for a number of years.

Professor Richard Waterhouse FAHA FASSA

Richard Waterhouse is Emeritus Professor of History at the University of Sydney. He was previously Bicentennial Professor of History and Head of the School of Philosophical and historical Inquiry at the same institution. He is the author of five books and more than 70 chapters and articles on aspects of the social, political and cultural history of Australia and the United States. His book, *The Vision Splendid: a social and cultural history of rural Australia*, mapped the critical role that rural Australia played in shaping the Australian economy, social life and a sense of identity. He is a Fellow of the Australian Academy of Humanities and the Australian Academy of Social Sciences.

All EWG members have declared any relevant interests.

Project Managers

Dr Andrew Hastings

Senior Research & Policy Officer
Australian Academy of Technological
Sciences and Engineering

Dr Matt Wenham

Executive Manager, Policy & Projects
Australian Academy of Technological
Sciences and Engineering

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The contributions of all of the attendees at the early to mid-career agricultural producers and researchers workshop (as listed under Evidence Gathering) is also gratefully acknowledged, along with the valuable facilitation provided by Mike Williams.

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Australia's agricultural sector has a bright future with continuing comparative advantage in the export of bulk commodities and increasing opportunities to respond to the growth in demand for high-value products domestically and in Asia.

Evidence gathering

1. Consultancy reports

The following work was commissioned for the project, and is available on the ACOLA website:

The CIE (Centre for International Economics) 2015, *Drivers of demand for Australian agricultural products. A report for the Australian Council of Learned Academies*, ACOLA, Melbourne.

Grafton, RQ, Mullen, J, Williams, J 2015, *Australia's Agricultural Future: Returns, Resources and Risks. A report for the Australian Council of Learned Academies*, ACOLA, Melbourne.

Lockie, S 2015, *Australia's agricultural future: the social and political context. A report for the Australian Council of Learned Academies*, ACOLA, Melbourne.

All reports are available online at <<http://acola.org.au/index.php/saf07-contributing-reports>>.

2. Early to mid-career agricultural producers and researchers workshop

On 2nd February 2015 the EWG hosted a one day, facilitated workshop with approximately 40 early to mid-career agricultural producers and researchers, from diverse backgrounds covering science, technology, social sciences and the humanities. The workshop participants reviewed the material contained within the three consultants' reports and, using their own perspectives on the future of Australia's agriculture sector, developed what they thought were the most important findings arising from these reports.

The EWG wishes to acknowledge the participants for their contributions:

Dr Alisha Anderson, CSIRO

Professor Kym Anderson, University of Adelaide and Australian National University

Professor Rachel Ankeny, University of Adelaide

Dr Michael Bange, CSIRO Agriculture Flagship

Dr Douglas Bardsley, University of Adelaide

Dr Robyn Bartel, University of New England

Dr Karl Behrendt, Charles Sturt University

Dr Heather Bray, University of Adelaide

Dr Anna Carr, ABARES Department of Agriculture Fisheries & Forestry

Associate Professor Timothy Cavagnaro, University of Adelaide

Mrs Tania Chapman, Nuffield

Ms Prudence Cook, Grains Research and Development Corporation

Dr Saul Cunningham, CSIRO

Dr Joanne Daly, CSIRO Environment Group

Dr Lauren Du Fall, GRDC

Associate Professor Ros Gleadow, Monash University

Professor Bronwyn Harch, Queensland University of Technology

Dr Will Howard, Office of the Chief Scientist

Dr Andrew Jacobs, ITEK Ventures

Dr Alexander Johnson, University of Melbourne

Mr Tomas Langley, Grains Research and Development Corporation

Dr Bennett Macdonald,
CSIRO—Division of Land & Water

Dr Julie McIntyre, University of Newcastle

Mr Jay Mohr-Bell, Pancho Beef

Ms Imogen Montgomery,
Southern Tablelands Produce

Dr Andrew Moore, CSIRO—Agriculture Flagship

Miss Alexandra Murray, GRDC

Dr James Petrie, CSIRO—Food Futures Flagship

Professor Stephen Powles,
University of Western Australia

Professor John Rolfe,
Central Queensland University

Dr Carly Rosewarne,
CSIRO—Division of Food & Nutritional Sciences

Mrs Sarah Sammon, Simply Rose Petals

Ms Rebecca Skinner, ACOLA Secretariat Ltd

Dr Kirrilly Thompson, CQUniversity

Mr Neil Thompson, ABARES

Dr Ernesto Valenzuela, Federation University

Dr Claudia Vickers, University of Queensland

Dr Michelle Watt,
CSIRO—Division of Plant Industry

Dr Matt Wenham, ATSE

Associate Professor Sarah Wheeler,
University of South Australia

Associate Professor Kerry Wilkinson,
University of Adelaide

Mr Mike Williams,
Michael Williams & Associates Pty Ltd

3. Break-out boxes

The EWG acknowledges the contribution of the authors of this report's break-out boxes on various subjects:

Productivity Growth in Australian Agriculture:
adapted from *Australia's Agricultural Future: Returns, Resources and Risks*: (Grafton et al., 2015)
Professor John Rolfe

Lessons from the wine industry's export-led growth: Professor Kym Anderson

Australia's northern beef industry:
Professor John Rolfe

Market access: is agricultural protectionism rising or falling?: Professor Kym Anderson

Beyond Food—the rise of the bioeconomy:
Dr Susan Pond

Soil security for a competitive agricultural future:
Andrea Koch

Riverina Rice: some characteristics of opportunistic diversification and sustainable intensification: adapted from *Australia's Agricultural Future: Returns, Resources and Risks* (Grafton et al., 2015)

New water information services assist Australian industries: Dr Rob Vertessy

Are Farmers Aging and is this a problem?: adapted from *New Entrants to Australian Agricultural Industries? Where are the young farmers?* (Barr, 2014) by Dr Joanne Daly

The potential for income contingent loans in the management of farm financial risks: Professor Linda Botterill and Professor Bruce Chapman

Advanced field robotics and sensor systems in Australian agriculture: Professor Salah Sukkarieh

The Australian Citrus Export Industry:
Tania Chapman

Review Panel

This report has been reviewed by an independent panel of experts. Members of this Review Panel were not asked to endorse the Report's conclusions and findings. The Review Panel members acted in a personal, not organisational, capacity and were asked to declare any conflicts of interest. ACOLA gratefully acknowledges their contribution.

Professor Kate Darian-Smith

Kate Darian-Smith is Professor of Australian Studies and History, Faculty of Arts and Professor of Cultural Heritage, Faculty of Architecture, Building and Planning at the University of Melbourne. Her cross-disciplinary expertise spans history and cultural heritage, and she has led major research projects and published widely in these fields, including on the history of rural Australia and cultural sustainability in country towns. She sits on the Council, Museum of Australian Democracy at Old Parliament House, recently completed two terms on the Board, Australia-Japan Foundation and is a Fellow of the Academy of the Social Sciences in Australia.

Dr Tony Fischer

Tony Fischer came from a wheat–sheep farm in southern New South Wales (NSW). He completed degrees in Agricultural Science at the University of Melbourne and a PhD at the University of California, Davis, USA. He worked as a crop agronomist and physiologist for the NSW Department of Agriculture and at CSIRO, and in the same capacity at CIMMYT, Mexico, where later he was Wheat Program Director (1988–95). Finally he was program manager for crops and soils at ACIAR and is now an Honorary Fellow at CSIRO Agriculture, also in Canberra. He has published widely and served on several International Center Boards of Trustees as well as the Board of GRDC. Recipient of many awards for contributions to crop science, including Fellowships of the Agriculture Institute of Australia, the Australian Academy of Technological Sciences and Engineering, and the American Crop Science and Agronomy Societies, in 2007 he was elected a Member of the Order of Australia.

Professor Deirdre Lemerle

Professor Lemerle is an agricultural weed scientist who has published over 150 scientific papers. She has research awards, including, the NSW Agriculture 'Outstanding Achievement', the Council of Australian Weed Science Societies Excellence Medal, and was a New Inventors Grand Finalist with 'Stubble Star' in 2005. She led the Cropping Program of the CRC for Australian Weed Management, and was appointed in 2005 inaugural Director of the Graham Centre for Agricultural Innovation at Charles Sturt University. She represented Australia in the "10 Sisters" exhibit at the World Expo in China. She has served on various advisory and editorial boards.

Douglas John Rathbone AM

Douglas John Rathbone studied Chemical Engineering at RMIT and Commerce at Melbourne University. In his early career he was a maths & science teacher, then an engineer in downstream petrochemicals. Douglas joined Nufarm as contract Engineer in 1973, continued in various roles and for the past 16 years has been the Managing Director and CEO. During this period Nufarm enjoyed significant growth from a small Australian supplier, then as a subsidiary of FERNZ (NZ) through to an Australian public company in 2000, forming part of ASX 100 for much of that time. Today Nufarm is a world leading crop protection and seed company employing 3500 people and total turnover of \$A3 billion. Doug is a former CSIRO Board Member, Director of the Burnett centre for Medical Research, Board Member of Cotton Seed Distributors, Board Member of the CANN Group and Chairman of Rathbone Wine Group.

About Securing Australia's Future

In June 2012 the Australian Government announced *Securing Australia's Future*, a \$10 million investment funded by the Australian Research Council in a series of strategic research projects. Projects are delivered to the Commonwealth Science Council by the Australian Council of Learned Academies (ACOLA) via the Office of the Chief Scientist and the Australian Chief Scientist.

Securing Australia's Future is a response to global and national changes and the opportunities and challenges of an economy in transition. Productivity and economic growth will result from: an increased understanding in how to best stimulate and support creativity, innovation and adaptability; an education system that values the pursuit of knowledge across all domains, including science, technology, engineering and mathematics; and an increased willingness to support change through effective risk management.

Six initial research topics were identified:

- i. Australia's comparative advantage
- ii. STEM: Country comparisons
- iii. Smart engagement with Asia: Leveraging language, research and culture
- iv. The role of science, research and technology in lifting Australian productivity
- v. New technologies and their role in our security, cultural, democratic, social and economic systems
- vi. Engineering energy: unconventional gas production

Two further research topics have been identified:

- vii. Australia's agricultural future
- viii. Sustainable urban mobility

The Program Steering Committee responsible for the overall quality of the program, including selection of the Expert Working Groups and the peer review process, is comprised of three Fellows from each of the four Learned Academies:

Professor Michael Barber FAA FTSE
(Chair)

Mr Dennis Trewin AO FASSA
(Deputy Chair—Research)

Professor James Angus AO FAA

Dr John Burgess FTSE

Professor Bruce Chapman AO FASSA

Professor Ruth Fincher FASSA

Professor Paul Greenfield AO FTSE

Professor Lesley Head FAHA

Professor Peter McPhee AM FAHA FASSA

Professor Stephen Powles FAA FTSE

Dr Susan Pond AM FTSE

Professor Graeme Turner FAHA

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