
The Parliament of the Commonwealth of Australia

Smart farming

Inquiry into agricultural innovation

House of Representatives
Standing Committee on Agriculture and Industry

May 2016
Canberra

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ISBN 978-1-74366-514-5 (Printed version)

ISBN 978-1-74366-515-2 (HTML version)

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Foreword

Australia has always been a world leader in agricultural innovation. Our farmers, supported by researchers, industry groups and other stakeholders, remain at the global forefront of the invention and adoption of technologies. This enthusiasm for change and innovation has helped Australian agriculture to retain its competitive edge over other producers.

Technological advances will be even more important to the future of Australian agriculture. The sector is a part of the broader boom in innovation across the Australian economy. Meanwhile, new technologies will support farm businesses to tackle heightened regional competition, growing resource scarcity, and other challenges.

The agriculture sector must be able to make the most of the innovation boom in order to support productivity growth and to maintain its competitiveness. At the core of the agricultural innovation boom are individual farm businesses that make decisions to adopt new technologies. If the Government wishes to support innovation and growth, it must support these businesses in technology adoption.

In this light, the Committee agreed to conduct an inquiry into emerging agricultural technologies, key barriers to their adoption, and what the Government may do to remove or reduce these barriers.

The Committee was pleased to hear of the vast scope and potential of emerging technologies in agriculture. These technologies will be different from those that have come before. They will perform ever more complex and varied tasks; they will collect and share greater volumes of data; and they will be more integrated across farms and along supply chains.

It became clear that these complex new technologies will bring their own challenges to farm businesses seeking to adopt them. Some of these barriers to successful adoption stem from the demands on internet, cloud and other physical infrastructure. In other cases, some regulations may unfairly impede the use of new technologies.

Another difficult set of barriers to adoption arise from the demand for more people with more advanced skills to shepherd technologies through the

innovation system and into the hands of the end user. There needs to be more collaboration between the organisations in the R&D process. There also needs to be a surge in the skilled researchers and workers supporting the sector.


The Government has already taken strong steps to support innovators in tackling the agriculture sector's challenges, such as through the ongoing rollout of the National Broadband Network.

In other cases, the Committee's recommendations have supported the tailoring of existing programs to the needs of the sector as it undergoes technological transformation. Regulation of technologies like unmanned aerial vehicles, and strategies in areas such as STEM education, may be helpfully adjusted to improve the capabilities of the agriculture sector to adopt new technologies.

These recommendations of the Committee have focussed on ensuring that the Government is responsive to the needs of farm businesses seeking to adopt innovation. The Committee has also recommended ways to support other players in the agricultural innovation system to do the same, for example through continued use of the successful Cooperative Research Centre program.

The Committee would like to express its appreciation to all who have contributed their valuable time and wisdom throughout the course of the inquiry.

Rowan Ramsey MP
Chair



Membership of the Committee

Chair Mr Rowan Ramsey MP


Deputy Chair Ms Clare O'Neil MP

Members

The Hon. Joel Fitzgibbon MP	Ms Melissa Price MP
Ms Michelle Landry MP	Mr Dan Tehan MP (to 11/2/2016)
Ms Nola Marino MP (from 11/2/2016)	Mr Rick Wilson MP
Ms Cathy McGowan AO MP	Mr Tony Zappia MP
Mr Tony Pasin MP	

Committee Secretariat

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Terms of reference

The Committee will inquire into and report on the role of technology in increasing agricultural productivity in Australia. The inquiry will have particular regard to:

- improvements in the efficiency of agricultural practices due to new technology, and the scope for further improvements;
- emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals; and
- barriers to the adoption of emerging technology.



List of abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ACFR	Australian Centre for Field Robotics
ACOLA	Australian Council of Learned Academies
ADF-DA	Australian Dairy Farmers and Dairy Australia
AIA	Ag Institute Australia
ATSE	Australian Academy of Technological Sciences and Engineering
APVMA	Australian Pesticides and Veterinary Medicines Authority
AusBiotech	Australia's Biotechnology Organisation
AWiA	Australian Women in Agriculture
CASA	Civil Aviation Safety Authority
CBA	Cotton Breeding Australia
CC-SC-ALFA	Cattle Council, Sheepmeat Council and Australian Lot Feeders Association
CRC	Cooperative Research Centre
CRDC	Cotton Research and Develop Corporation
CSIRO	Commonwealth Scientific and Industrial Research Organisation

DAWR	Department of Agriculture and Water Resources (Cth)
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
GM	genetically modified
GPS	Global Positioning System
GRDC	Grains Research and Development Corporation
GTR	Gene Technology Regulator
NBN	National Broadband Network
NHMRC	National Health and Medical Research Council
NRWC	National Rural Women's Coalition
PBCRC	Plant Biosecurity Cooperative Research Centre
PIRSA	Department of Primary Industries and Regions South Australia
R&D	research and development
RD&E	research, development and extension
RDC	Research and Development Corporation
RFID	Radio frequency identification
RIRDC	Rural Industries Research and Development Corporation
STEM	science, technology, engineering and mathematics
TAFE	Technical And Further Education institutions
TFP	total factor productivity: total output growth relative to the growth in traditionally measured inputs of labour and capital
UAV	unmanned aerial vehicle



List of recommendations

4 Telecommunications and data services

Recommendation 1

The Committee recommends that the Commonwealth Scientific and Industrial Research Organisation, in cooperation with industry, undertake a technical study to identify cost-effective approaches to using satellite services as backhaul for local wireless networks for agricultural applications.

Recommendation 2

The Committee recommends that the Australian Government commit to the continuation of the Mobile Black Spot Programme beyond the second round, and that the Department of Communications and the Arts consider changes or additions to the selection criteria to capture the telecommunications requirements of agricultural activity.

Recommendation 3

The Committee recommends that the Australian Government, in consultation with industry stakeholders, investigate incentives for mobile network operators to provide roaming services in rural and remote areas.

Recommendation 4

The Committee recommends that the Department of Agriculture of Water Resources, in conjunction with public and private infrastructure providers, publish consolidated information about the availability of telecommunications services in rural and remote agricultural areas.

Recommendation 5

The Committee recommends that the Council of Rural Research and Development Corporations, in conjunction with research and training providers and producer groups, coordinate the development and delivery of educational resources to raise awareness of innovative applications of telecommunications services across the agricultural industry.

5 Human capital

Recommendation 6

The Committee recommends that the Australian Government ensure that rural women's groups are included in future government-led policy-building activities and inquiries.

Recommendation 7

The Committee recommends that the Australian Government target funding for the development of innovative education strategies for agriculture, within the current science, technology, engineering and mathematics funding program.

Recommendation 8

The Committee recommends that the Australian Government provide assistance and support to farmers' groups to pursue farming benchmarking and support the development of national data sets.

6 A coordinated approach to research and development

Recommendation 9

The Committee recommends that the Department of Agriculture and Water Resources, in conjunction with the Department of Industry, Innovation and Science, investigate establishing appropriate incentives for the greater allocation of resources from rural Research and Development Corporations to relevant Cooperative Research Centres.

Recommendation 10

The Committee recommends that the Australian Research Council review its programs for funding research, with a view to increasing the duration of grants to be at least five years.

Recommendation 11

The Committee recommends that the Australian Government develop a national working group on agricultural innovation, focused on improved functionality of the agrifood/fibre innovation system. This working group should be developed as part of a wider strategy of cross-sectoral agricultural innovation, within the National Primary Industries RD&E Framework.

7 Regulation

Recommendation 12

The Committee recommends that the Department of Agriculture and Water Resources pursue legislative and regulatory changes to enable the

Australian Pesticides and Veterinary Medicines Authority to use the decisions of trusted and comparable international regulators as a basis for product registration.

Recommendation 13

The Committee recommends that the Australian Government, through the Council of Australian Governments, pursue reform options to ensure national consistency in the regulation of gene technology.

Recommendation 14

The Committee recommends that the Australian Government commission an independent review of the implementation and effectiveness of the Gene Technology Agreement with particular reference to the impact of moratoria invoked by state and territory governments under the Recognition of Designated Areas Principle.

Recommendation 15

The Committee recommends that the Department of Agriculture and Water Resources, in cooperation with Standards Australia, update the National Standard for Organic and Bio-Dynamic Produce to introduce a threshold for approved genetically-modified material consistent with comparable international standards.

Recommendation 16

The Committee recommends that the Department of Agriculture and Water Resources and the Civil Aviation Safety Authority develop appropriate extension materials promoting the appropriate use of unmanned aerial vehicles in the Australian agricultural sector.

Recommendation 17

The Committee recommends that the Civil Aviation Safety Authority investigate regulations requiring unmanned aerial vehicles to be flown within visual line of sight, with a view to amending the regulations to enable agricultural producers to use such vehicles for monitoring purposes beyond line of sight on or over their own properties.

Introduction

Background to the inquiry

- 1.1 On 11 August 2015, the Minister for Agriculture, the Hon. Barnaby Joyce MP, wrote to the Committee requesting that it inquire into and report on the role of technology in increasing agricultural productivity in Australia.
- 1.2 On 13 August 2015, the Committee adopted the terms of reference referred by the Minister and commenced its inquiry into agricultural innovation. In accordance with the terms of reference, particular regard was given to:
 - improvements in the efficiency of agricultural practices due to new technology, and the scope for further improvements;
 - emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals; and
 - barriers to the adoption of emerging technology.

Conduct of the inquiry

- 1.3 The inquiry was advertised on 13 August 2015. Submissions were invited from state governments, a range of Australian Government departments, researchers and research bodies, and industry groups.
- 1.4 The Committee received 116 submissions and 16 supplementary submissions. A full list of submissions can be found in Appendix A. In addition, 12 exhibits were presented to the committee, which are listed in Appendix B.
- 1.5 The Committee held 15 public hearings, 11 of which were conducted in Canberra, two in Victoria (Wodonga and Melbourne), and two in

New South Wales (Armidale and Sydney). A wide range of witnesses gave evidence to this inquiry, and their names and organisations are listed in Appendix C.

- 1.6 Three site inspections were also conducted during the inquiry. In January, the Committee visited the Alpine Valleys Dairy Pathways Project in the Kiewa Valley where it met with the representatives of the Project and members of the local community. In April, the Committee visited the University of New England's Kirby SMART Farm in Armidale, and the Australian Centre for Field Robotics at the University of Sydney.
- 1.7 The Committee wishes to thank to all those who facilitated its site inspections. Having the opportunity to visit these hubs of agricultural innovation in person made a valuable contribution to the Committee's inquiry.
- 1.8 The Committee also expresses its appreciation to all stakeholders who made written submissions to the inquiry or who took the time to meet with the Committee. The Committee acknowledges their significant contribution to the inquiry overall.

Structure of the report

- 1.9 The report consists of six chapters and four appendices.
- 1.10 Chapter 2 provides an overview of the structure of the Australian agriculture industry, including a brief summary of the roles of government and industry bodies. The chapter also addresses the first term of reference, providing some background information and case studies in relation to agricultural productivity improvements made in the past, and describes the current state of the agriculture sector in relation to productivity.
- 1.11 Chapter 3 addresses the second term of reference, by describing emerging technologies the Committee had heard about, and highlighting their potential to improve agricultural productivity into the future.
- 1.12 The remainder of the report – Chapters 4 to 7 – addresses the inquiry's final term of reference: barriers to the adoption of emerging technology. Each chapter focuses on a different set of barriers identified by evidence to the inquiry, and makes recommendations for government action targeted at overcoming these barriers.
- 1.13 Chapter 4 focuses on the role of telecommunications and data infrastructure in the agriculture of the future, and addresses issues

- relating to access to mobile and internet services, and factors impeding the adoption of data services in agriculture.
- 1.14 Chapter 5 addresses a range of barriers to innovation as they pertain to human capital, including workforce issues in agriculture, access to appropriate education for future members of the sector, and ensuring the industry is able to attract and retain the expertise required to drive research in agricultural innovation.
- 1.15 Chapter 6 focuses on the relationships between different stakeholders in the sector, and industry collaboration with government. It establishes the need for better cooperation and partnerships across the sector, and looks at the establishment of national priorities for research, development and extension in agriculture.
- 1.16 The final chapter of this report addresses the regulatory framework within which agricultural innovation takes place. Specifically, Chapter 7 considers some of the regulatory barriers to the development and adoption of innovation in agriculture, and makes recommendations for changes.
- 1.17 Throughout the report, readers will find references to a range of inter-related terms used to denote the process of innovation, encompassing education, research, development, extension and adoption. For example, while the term 'research and development' (R&D) has been used traditionally, more recently the trend has been to use alternatives which specifically acknowledge other important parts of the innovation process, such as 'research, development and extension' (RD&E).
- 1.18 In this report, such terms are used interchangeably, in acknowledgment of the fact that, while different stakeholders will wish to emphasise different parts of the innovation process, the entire process is relevant to the Committee's consideration of agricultural innovation.
- 1.19 Where references are made to evidence received by the Committee, the report will generally use the terminology offered by each witness. Otherwise, for the sake of simplicity and brevity, the report gives preference to 'R&D' being used to refer to the innovation process, while acknowledging that this process encompasses much more than simply 'research' or 'development'.
- 1.20 The majority of submissions to the inquiry focused on land-based food and fibre production. Deakin University considered agriculture to include fishing and aquaculture,¹ as did the National Rural Women's Coalition.²

1 Deakin University, *Submission 28*, p. 2.

2 Dr Patricia Hamilton, President, National Rural Women's Coalition, *Committee Hansard*, Canberra, 3 March 2016, p. 10.

Australian agriculture and productivity

- 2.1 This chapter of the report briefly outlines the structure of the Australian agriculture industry and examines efficiency improvements in Australian agricultural practices due to new technology, with reference to several case studies.
- 2.2 The chapter then discusses slowdown of productivity growth in recent years in the agriculture sector. The chapter concludes with discussion on the scope for further productivity growth in the industry.

The Australian agricultural sector

- 2.3 This section of the chapter outlines the existing policy and research structures within the Australian agricultural sector. First, Commonwealth contributions are outlined, including those of the Department of Agriculture and Water Resources; the *Agricultural Competitiveness White Paper*; the National Primary Industries Research, Development and Extension Framework; and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Contributions by state governments, industry and research bodies are also discussed.

Department of Agriculture and Water Resources

- 2.4 The Australian Government Department of Agriculture and Water Resources (DAWR) develops policy and provides services to improve the productivity, competitiveness and sustainability of Australian agriculture, fisheries, forestry and related industries. DAWR also supports farmers in times of hardship and assists with risk management and planning.¹

1 Department of Agriculture and Water Resources, 'Agriculture, farming and food' <www.agriculture.gov.au/ag-farm-food> viewed 13 April 2016.

- 2.5 Several submissions touched on the role that government should play in providing funding for agricultural research, development and extension.²
- 2.6 Submissions to the inquiry suggested that DAWR should have:
- a clear role in setting research priorities and supporting research that underpins discovery.³
 - a consultative role in facilitating collaborations.⁴
 - a role in promoting leadership within the sector by implementing research priorities through the Rural Research and Development (R&D) for Profit Programme.⁵

Agricultural Competitiveness White Paper

- 2.7 The *Agricultural Competitiveness White Paper* (the White Paper), released in 2015, outlines the Australian Government's five key priorities for the agricultural sector.⁶
- 2.8 These priorities include: ensuring a fairer go for farm businesses; building the infrastructure of the 21st century; strengthening the approach to drought and risk management; and promoting access to premium markets. The final area of focus, 'farming smarter', is the priority area most relevant to the present inquiry.⁷ In particular, the farming smarter chapter of the White Paper emphasises the need for access to advanced technologies and practices, including better research and development and access to skilled workers.⁸

2 Council of Rural Research and Development Corporations, *Submission 90*, p. 5; Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders Association, *Submission 84*, pp. 10, 17; The University of Queensland, *Submission 2*, p. 1; AusBiotech, *Submission 33*, pp. 3, 6, 16.

3 Grain Trade Australia, *Submission 21*, p. 2; Murdoch University, *Submission 37*, p. 3.

4 Murdoch University, *Submission 37*, p. 3.

5 Mr Paul Morris, Acting Deputy Secretary, Department of Agriculture and Water Resources, *Committee Hansard*, Canberra, 17 March 2016, p. 1.

6 DAWR, *Submission 88*, p. 4; Council of Rural Research and Development Corporations, *Submission 90*, p. 10.

7 DAWR, 'Agricultural Competitiveness White Paper: at a glance 2015' <agwhitepaper.agriculture.gov.au/white-paper/white-paper-at-a-glance> viewed 1 April 2016.

8 DAWR, 'Agricultural Competitiveness White Paper 2015' <agwhitepaper.agriculture.gov.au/> viewed 1 April 2016.

The National Primary Industries Research, Development and Extension Framework

- 2.9 The National Primary Industries Research, Development and Extension Framework was created in 2005, through the then Primary Industries Ministerial Council. The framework was endorsed by primary industries ministers and brings together Commonwealth, state and territory governments, the rural research and development corporations (RDCs), CSIRO, the Bureau of Meteorology, and the university sector through the Australian Council of Deans of Agriculture. The Framework seeks to deliver a more coordinated and collaborative approach to research, development and extension (RD&E) for rural industries in Australia.⁹
- 2.10 The framework has facilitated a process through which national RD&E capacity can be more effectively focused and efficiently deployed through strategies for 14 primary industry sectors, and addressing eight cross-sectoral issues. The process allows RDCs to work with research providers to identify potentially useful emerging technologies and then to strategically invest as and where needed along the pathway to adoption.¹⁰

CSIRO

- 2.11 CSIRO is Australia's leading agricultural research entity, and aims to help Australian farming businesses and industry improve productivity and sustainability across the agriculture sector.
- 2.12 CSIRO's agricultural research arm concentrates on animal science, aquaculture, plant science, digital agriculture, food security and sustainable farm management.¹¹

State government agencies

- 2.13 State government agriculture departments play a key role in the Australian agriculture industry. However, there has been a significant reduction in funding support and extension delivery in the past decade. This is discussed further in Chapter 5.
- 2.14 The South Australian Government's lead agency, Primary Industries and Regions South Australia (PIRSA), is involved in many activities which accelerate the adoption of new and more efficient agricultural practices.¹²

9 Council of Rural RDCs, *Submission 80*, p. 8. See also, National Primary Industries RD&E Framework <www.npirdef.org> viewed 16 April 2016.

10 Council of Rural RDCs, *Submission 80*, p. 8. See also, National Primary Industries RD&E Framework <www.npirdef.org> viewed 16 April 2016.

11 CSIRO, 'Agriculture research' <www.csiro.au/en/Research/AF> viewed 13 April 2016.

12 Primary Industries and Regions South Australia, *Submission 19*, p. 3.

- 2.15 The research and development arm of PIRSA seeks to deliver robust scientific solutions to support sustainable and internationally competitive primary industries.¹³
- 2.16 The PIRSA submission to the inquiry noted that these activities are usually conducted through partnerships with South Australian industry, the Australian Government and other research organisations such as universities or CSIRO.¹⁴
- 2.17 The Tasmanian Government also recognises the importance of investing in agricultural research, development and extension at the state level, which it does in partnership with the University of Tasmania.¹⁵
- 2.18 The Tasmanian Government's *Cultivating Prosperity in Agriculture* policy sets out its vision to increase the annual farm gate value of Tasmanian agriculture tenfold to \$10 billion per year by 2050.¹⁶
- 2.19 The Tasmanian Government is setting out to achieve this vision through co-investment in irrigation infrastructure, strategic investment in research, development and extension activities and supporting better skills pathways.¹⁷

Research and development corporations

- 2.20 The 15 rural research and development corporations, which are established partnerships between government and industry, play a key role in the agricultural innovation system.¹⁸
- 2.21 The RDCs were created with the objective of sharing funding and setting the strategic direction for investment in R&D. The RDCs also have a role in extension; that is, ensuring new technologies are able to be implemented by farming businesses.
- 2.22 The roles of the RDCs include prioritising and funding the research, development and extension of new technologies that can improve the economic, environmental and social performance of Australia's rural industries.¹⁹
- 2.23 The Council of Rural Research and Development Corporations (Council of Rural RDCs) represents all of the 15 rural RDCs, and exists to support and

13 PIRSA, *Submission 19*, p. 3.

14 PIRSA, *Submission 19*, p. 3.

15 Tasmanian Government, *Submission 58*, p. 2.

16 Tasmanian Government, *Submission 58*, p. 1.

17 Tasmanian Government, *Submission 58*, p. 1.

18 Dr Daniel Walker, Research Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 1.

19 Council of Rural RDCs, *Submission 90*, p. 2.

facilitate the RDCs to fulfil their broad purpose where action by any of the individual organisations would be impossible, impractical, inefficient or ineffective.²⁰ The Council of Rural RDCs provides a mechanism for RDCs to combine their resources and networks to share information, amplify and disseminate messages, and engage with common stakeholders.²¹

- 2.24 The Council of Rural RDCs explained that RDCs ensure industry has sufficient and appropriate levels of information to determine whether a technology is suitable and under what circumstances, what benefits it offers, and what risks may need to be managed should it be adopted.²²
- 2.25 The R&D innovation structure and associated issues related to the operation of RDCs are further examined in Chapter 6 of this report.

Levy system

- 2.26 Contributions to research and development investment from the agricultural industry are made through levies on production. The Australian Government collects levies on behalf of the industries, and also provides a matching contribution on a dollar-for-dollar basis, up to a capped limit.²³
- 2.27 Agricultural levies are an important source of funding for agricultural R&D for many commodities.²⁴ The levy system ensures that both industries and the Commonwealth contribute to research with public and private benefits.²⁵ It also ensures adequate investment in industry initiatives, as individual farmers and producers acting in isolation may not obtain a return on individual investments.²⁶
- 2.28 The establishment of a new levy would generally come about through an industry body identifying the need for a levy to address an issue requiring collective industry funding. The organisation would then put a levy proposal to its members, possibly in consultation with DAWR.²⁷
- 2.29 The availability of ‘matched industry money’ as a result of levies gives confidence to investors – including state governments and universities – to

20 Council of Rural RDCs, *Submission 90*, p. 3.

21 Council of Rural RDCs, *Submission 90*, p. 3.

22 Council of Rural RDCs, *Submission 90*, p. 2.

23 Council of Rural RDCs, ‘The Rural RDC Model – funding arrangements’ <www.ruralrdc.com.au/rural-innovation-in-australia/#rural-rdc-model> viewed 13 April 2016.

24 Council of Veterinary Deans of Australia and New Zealand, *Submission 46*, p. 1; Mr Anthony Battaglione, Winemakers’ Federation of Australia, *Committee Hansard*, Canberra, 4 February 2016, p. 1.

25 Council of Veterinary Deans of Australia and New Zealand, *Submission 46*, p. 1.

26 Australian Pork Limited, *Submission 70*, p. 4.

27 DAWR, ‘Levies’ <www.agriculture.gov.au/ag-farm-food/levies> viewed 11 April 2016.

invest in the most significant areas of RD&E.²⁸ Money, effort and confidence are leveraged into the priority innovation areas.²⁹

Rural Research and Development for Profit Programme

- 2.30 The Rural R&D for Profit Programme is a \$200 million competitive grants program which encourages RDC collaboration for innovation. Grants are provided to RDCs and partners for collaborative research which enhances farm-gate profitability and supports the continued innovation of Australia's primary industries.³⁰
- 2.31 One of the conditions of grants under the program is that applicants must be RDCs collaborating with other RDCs.³¹
- 2.32 The program began in 2014–15 as a four year program and was due to conclude in 2017–18. However, the Australian Government has committed to extend the programme by a further four years, with additional funding.³² This program is discussed further in Chapter 6.

Cooperative Research Centres

- 2.33 Cooperative Research Centres (CRCs) are structures through which participants within the research system, particularly at the provider end, come together to work on a specific problem within a defined period.³³
- 2.34 Mr Tim Lester, from the Council of Rural RDCs, suggested that CRCs are important mechanisms to drive collaboration, however their role is different to that of RDCs, being both time bound and limited in scope.³⁴
- 2.35 The Committee was told that one of the jobs of RDCs was to position the role of a particular CRC within the strategic priorities of the industry with which they work, and the broader context of the rural innovation system.³⁵
- 2.36 Professor James Rowe, Chief Executive of the CRC for Sheep Industry Innovation, noted that RDCs were research investors, in contrast to CRCs, which were 'research doers'.³⁶

28 Council of Veterinary Deans of Australia and New Zealand, *Submission 46*, p. 1.

29 Council of Veterinary Deans of Australia and New Zealand, *Submission 46*, p. 1.

30 DAWR, *Submission 88*, p. 5.

31 DAWR, 'Rural Research and Development for Profit' <www.agriculture.gov.au/ag-farm-food/innovation/rural-research-development-for-profit> viewed 6 April 2015.

32 DAWR, *Submission 88*, p. 5.

33 Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 2.

34 Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 2.

35 Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 2.

History of innovation and productivity performance

- 2.37 Submissions to the inquiry discussed at length the growth in productivity in the Australian agricultural industry over the last several decades. Each of those submissions explained that productivity growth has been underpinned by advances in technology.
- 2.38 PIRSA argued that agriculture is one of the most efficient industries in Australia due to a long history of adopting new technological innovation.³⁷ PIRSA stated that, from 1989–90 to 2013–14, multifactor productivity in agriculture had been increasing annually at 2.7 per cent, which is considerably higher than the market sector average.³⁸
- 2.39 Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) research reports support the commonly held notion that past growth has been underpinned by adoption of technology.³⁹ In particular, adoption of new technologies has been responsible for such growth over and above changes in the scale of farms.
- 2.40 The Ag Institute Australia (AIA) stated that productivity and efficiency gains have been derived from a mix of transformational and incremental innovations, with the source of these innovations being varied and unpredictable.⁴⁰
- 2.41 The AIA submission explained that all productivity and efficiency gains have depended on strong strategic investment in public sector and private sector research, effective collaboration between the sectors and close engagement with producers.⁴¹
- 2.42 The submission added that, in many cases, the transformational technologies have been created in the public sector – often at universities, CSIRO and state government agriculture departments – and have subsequently been developed and commercialised by the private sector and embraced by primary producers.⁴²

36 Professor James Rowe, CEO, CRC for Sheep Industry Innovation, *Committee Hansard*, Armidale, 13 April 2016, p. 30.

37 PIRSA, *Submission 19*, p. 3.

38 PIRSA, *Submission 19*, p. 3.

39 Sheng, Y., Gray, E.M., Mullen, J.D. and Davidson, A. (2011) *Public investment in agricultural R&D and extension: an analysis of the static and dynamic effects on Australian broadacre productivity*. ABARES research report 11.7, Canberra; Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra.

40 Ag Institute Australia, *Submission 73*, p. 2.

41 Ag Institute Australia, *Submission 73*, p. 2.

42 Ag Institute Australia, *Submission 73*, p. 2.

- 2.43 The submission from Southern Farming Systems and the Australian Controlled Traffic Farming Association discussed increased productivity performance and a key reason behind that improvement:
- Australian agricultural productivity has increased steadily by about two per cent per year since the 1950s and much of this can be attributed to improvements in cultivars, agronomy, farming systems and technologies brought about through structured research and development conducted either directly or indirectly through Australia's Rural Research and Development Corporations.⁴³
- 2.44 A 2011 research report produced by ABARES provided evidence of the important contribution of public research and development to broadacre total factor productivity in Australia.⁴⁴ The report found that:
- ... over the past 50 years, knowledge and technology accumulated from past public investments in [research, development and extension] in Australia and overseas have accounted for almost two thirds of average annual broadacre productivity growth.⁴⁵
- 2.45 ABARES, in its analysis for the report, calculated that every \$1 in public investment in research, development and extension produces \$12 in benefits to farmers in the long term.⁴⁶

Trends and variability

- 2.46 Several inquiry stakeholders noted that there is variability in productivity growth across different sectors of the agricultural industry, and across different periods of time. Furthermore, productivity growth can be driven by different factors in different sectors.
- 2.47 For example, the AIA noted that cotton industry productivity gains have exceeded 1.5 per cent per annum, while productivity gains in grains and sugar have been less than one per cent per annum over the same period.⁴⁷

43 Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*, p. 2.

44 Sheng, Y., Gray, E.M., Mullen, J.D. and Davidson, A. (2011) *Public investment in agricultural R&D and extension: an analysis of the static and dynamic effects on Australian broadacre productivity*. ABARES research report 11.7, Canberra.

45 DAWR, *Submission 88*, p. 10.

46 DAWR, *Submission 88*, p. 10.
Sheng, Y., Gray, E.M., Mullen, J.D. and Davidson, A. (2011) *Public investment in agricultural R&D and extension: an analysis of the static and dynamic effects on Australian broadacre productivity*. ABARES research report 11.7, Canberra.

47 Ag Institute Australia, *Submission 73*, p. 1.

- 2.48 Similarly, the Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders Association stated that, over the long term, beef enterprises were maintaining productivity growth at 0.9 per cent per annum, while sheep enterprises grew at 0.5 per cent per annum.⁴⁸
- 2.49 A 2014 research report produced by ABARES stated that average productivity growth across all broadacre agriculture (non-irrigated cropping and extensive livestock industries) has been around one per cent per annum for more than three decades. The report explained that this has largely been due to reduced input use rather than output growth.⁴⁹
- 2.50 The AIA added that, in the grains, sugar and animal production industries, gains in the efficiency of water use and labour efficiency have been substantial, relating these gains directly to innovation.⁵⁰
- 2.51 The ABARES report explained that trends among individual broadacre industries varied markedly over time:
- Productivity growth of cropping specialists averaged 1.5 per cent a year between 1977-78 and 2010-11, higher than the rate observed over the same period on farms in the beef (0.9 per cent) and sheep (0.0 per cent) industries. However, following the dismantling of the wool reserve price scheme in 1991, sheep industry productivity has increased at an average rate of 1.4 per cent a year since the mid-1990s ... The dairy industry has realised average annual productivity growth of around 1.6 per cent since the late 1970s.⁵¹
- 2.52 The report also stated that productivity growth varies considerably across farms, industries and regions.⁵²

Technological advances in agriculture

- 2.53 The Warren Centre for Advanced Engineering explained that agriculture has historically benefitted from technology adoption, with the industrial age bringing mechanisation and synthetic fertilisers, and the technology

48 Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders Association, *Submission 84*, p. 7.

49 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 9.

50 Ag Institute Australia, *Submission 73*, p. 1.

51 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 10.

52 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 10.

age delivering genetic engineering and automation.⁵³ The Warren Centre added that the information age brings the potential for integrating technology advances into a precision agriculture that drives growth and productivity.⁵⁴

2.54 The University of Sydney considers that new technologies encompass new physical instruments and products along with new knowledge, skills and management techniques. Its submission explained that the latter are essential for the former to succeed.⁵⁵

2.55 The Rural Industries Research and Development Corporation (RIRDC) submission stated that agricultural productivity gains have been driven by technology:

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.⁵⁶

2.56 The Charles Sturt University submission provided examples of large-step changes and incremental changes that have contributed to productivity growth in agriculture:

Notable examples of large step-changes include the introduction of no-till farming (facilitated by the availability of new herbicides), which greatly reduced input costs, retained more soil moisture and improved crop yields; and the introduction of subterranean clover in southern Australian livestock systems which improved soil fertility and increased livestock growth rates and carrying capacity. Incremental improvements (through plant and animal breeding, improved management practices) have built on these large changes to result in further production gains through improved water use efficiency, stress tolerance (e.g. disease and frost), feed conversion efficiency and product quality.⁵⁷

53 Warren Centre for Advanced Engineering, *Submission 43*, p. 2, referencing Whelan, B. M. (1997). *The Impact of Precision Agriculture. Proceedings of the ABARE Outlook Conference, 'The Future of Cropping in NW NSW'*, p. 5. Moree, UK.

54 Warren Centre for Advanced Engineering, *Submission 43*, p. 2, referencing Zhang, N. M. (2002). Precision agriculture - a worldwide overview. *Computers and Electronics in Agriculture*, 113-132.

55 University of Sydney, *Submission 40*, p. 4.

56 Rural Industries Research and Development Corporation, *Submission 74*, p. 3.

57 Charles Sturt University, *Submission 17*, p. 2.

- 2.57 Submissions to the inquiry provided examples of advances in technology that have benefited agriculture in Australia. The examples were extensive and quite comprehensive. A list of examples can be found in Appendix D.

Productivity growth and improvement: case studies

Wheat

- 2.58 The CSIRO submission to the inquiry provided details on the historical improvement in wheat yields in Australia:

... yield progress has been characterised by phases of gain interspersed with 'plateau periods' where progress slows. The intermittent periods of rapid yield improvement occurred where packages of improved management combined to allow the underlying improvements in genetic yield potential to be realised.⁵⁸

- 2.59 The submission further explained that, according to the history of progress in wheat yields, there is no single technology that has contributed to jumps in yield.⁵⁹

Cotton

- 2.60 The Committee heard that the Australian cotton industry is an exemplar for productivity growth in Australian agriculture. The CSIRO submission stated that the Australian cotton industry is worth \$2.5 billion per annum in exports, supports up to 10,000 jobs,⁶⁰ and relies heavily on science-based innovation.⁶¹

- 2.61 Cotton Australia explained that the Australian cotton industry is recognised internationally as innovative and dynamic, largely due to industry investment in RD&E:

Australian cotton is world leading for yield and quality and is underpinned by a world-class best management practice system that aligns with global initiatives for delivery of responsibly produced cotton. This success is due to industry investment in world-class research and rapid adoption of emerging science, innovations and technology to drive profitability.⁶²

58 CSIRO, *Submission 55*, p. 8.

59 CSIRO, *Submission 55*, p. 8.

60 Cotton Australia, *Submission 72*, p. 1.

61 CSIRO, *Submission 55*, p. 14.

62 Cotton Australia, *Submission 72*, p. 1.

2.62 Mr Adam Kay, Chief Executive Officer of Cotton Australia, described the rise of the Australian cotton industry over the last two or three decades:

... we are now the number one country for yield around the world, so we produce about three times the global average in yield of cotton, and we are up there as the highest quality of cotton out there, which means that Australian cotton is in demand.⁶³

2.63 Mr Kay explained that the cotton industry is recognised for innovation, being open to change and being prepared to take risks with technology.⁶⁴ He discussed some of the reductions in water and pesticide use in the cotton industry, due to the adoption of new technologies:

... we have been able in the last 20 years to reduce the amount of pesticide we use in the Australian cotton industry by 92 per cent. That is moving from back in the days of a dozen insecticide sprays onto a crop down to sometimes one these days – there are a lot of growers with none. We have been able to increase our water use efficiency in the last decade by 40 per cent.⁶⁵

2.64 Mr Kay also explained that a key development has been a significant improvement in land use efficiency, producing twice the amount of fibre from the same area of land.⁶⁶

2.65 The Cotton Research and Development Corporation (CRDC) outlined benefits of the introduction of biotechnology to the cotton industry, the environment, and society more broadly:

- increased populations of beneficial insects and wildlife in cotton fields;
- reduced pesticide run off;
- improved farm worker and neighbour safety;
- a decrease in labour and fuel usage;
- improved soil quality;
- reduced production costs;
- increased yield;
- reduced risks; and
- further opportunities to grow cotton in areas of high pest infestation.⁶⁷

63 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 7.

64 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 7.

65 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 7.

66 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 7.

- 2.66 The CSIRO submission stated that productivity growth in the Australian cotton industry has continued, with yields improving at two per cent per annum, which is greater than in any other agricultural sector in Australia.⁶⁸ CSIRO added that 45 per cent of the improvement is due to better cotton varieties, and 55 per cent due to better management.⁶⁹
- 2.67 When asked if the significant reduction in pesticide use was solely down to genetically modified cotton breeds, Mr Kay explained that integrated pest management programs play a significant role:
- Yes, the Bt cotton handles a couple of the pests, but there are still other pests there and our growers are using integrated pest management as well as some area-wide management techniques. It is all part of a package.⁷⁰
- 2.68 Similarly, when asked about water use efficiency improvements being a result of the genetics of the crop, Mr Kay explained that it is a part of a better farming system:
- With water-use efficiency, part of it is the genetics but part of it is a whole lot of infrastructure things like the scheduling and the delivery to the farm. There were a lot of losses, so I think a lot of the infrastructure upgrades and the like have been critical there. It is a combination, and some of it is genetics. There is ongoing work in getting more water-use efficient varieties.⁷¹
- 2.69 Mr Kay emphasised the role of the research and development system in taking the Australian cotton industry to world leader status.
- I do not think we can highlight enough how the R&D system has helped this industry move to a world-leading industry. It is all on the back of R&D. Yes, we have innovative farmers who are prepared to pick up the R&D and run with it, but it has been the R&D that has allowed us to address some of these key issues: the pesticide-use issues and the water-use issues were things that were impacting on our social licence in our own communities, let alone state and nationally. We have been able to address them effectively, and doing that has given us global recognition.⁷²

67 Cotton Research and Development Corporation, *Submission 49*, p. 1.

68 CSIRO, *Submission 55*, p. 14.

69 CSIRO, *Submission 55*, p. 14.

70 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 8.

71 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 8.

72 Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 8.

Dairy

- 2.70 Submissions from Australian Dairy Farmers and Dairy Australia (ADF-DA) and DAWR summarised an ABARES publication that examined productivity in the Australian dairy industry.
- 2.71 ABARES conducted a comprehensive assessment of Australian dairy farm performance.⁷³ The research report found that, on average, productivity growth in the Australian dairy industry has been 1.6 per cent per annum, for the period 1978–79 to 2010–11.⁷⁴
- 2.72 The report noted that rates of productivity growth differ across regions, reflecting relative differences in regional industry structures, the extent of uptake of new technologies, and the characteristics of each region that affect the types of farming systems used.⁷⁵
- 2.73 The report explains that two key drivers of the observed growth in dairy farm productivity have been the exit of relatively less efficient farms from the industry, and the widespread adoption of new technologies and management practices that have allowed dairy farmers to reduce the quantity of inputs required to produce a given quantity of output.⁷⁶
- 2.74 A 2011 report commissioned by Dairy Australia and the Victorian Department of Primary Industries also provided a comprehensive assessment of the impact of innovation for dairy.⁷⁷
- 2.75 ADF-DA provided details from the 2011 report, explaining that major increases in on-farm production are estimated to have increased Victorian dairy farm profitability by around \$10 billion over the three decades from 1980 to 2010.⁷⁸
- 2.76 The report found that nearly half of the increase could be attributed to on-farm innovation; it was estimated to have increased farmers' profitability by around \$7.7 billion in net present value terms, whilst only costing approximately \$2.3 billion in net present value terms. That represents an estimated cost-benefit ratio of \$3.30 economic benefit for each dollar invested in R&D.⁷⁹

73 Ashton, D., Cuevas-Cubria, C., Leith, R. and Jackson, T. (2014) *Productivity in the Australian dairy industry: pursuing new sources of growth*. ABARES research report 14.11, Canberra.

74 Australian Dairy Farmers and Dairy Australia, *Submission 65*, p. 2; DAWR, *Submission 88*, p. 12.

75 DAWR, *Submission 88*, p. 12.

76 DAWR, *Submission 88*, p. 12.

77 Centre for International Economics (2011) *The impact of innovation on the dairy industry over the last 30 years Evaluating the contribution of industry and government investment in pre farm gate RD&E*. Prepared for Dairy Australia and the Victorian Department of Primary Industries.

78 ADF-DA, *Submission 65*, p. 2; DAWR, *Submission 88*, p. 12.

79 ADF-DA, *Submission 65*, p. 2; DAWR, *Submission 88*, p. 12.

- 2.77 The report discusses some of the factors that drove the recorded increases in productivity:
- ... increased pasture production and utilisation, increased supplementary feeding, and more efficient cows, all of which have been – and remain – key areas of focus for the dairy industry’s RD&E program.⁸⁰
- 2.78 The report explains that milk production in Victoria more than doubled despite cow numbers remaining the same, and with a 35 per cent reduction in effective grazing area. Milk yield per cow almost doubled and production per hectare increased by 192 per cent.⁸¹

Slowdown of productivity growth

- 2.79 Several submissions to the inquiry stated that agricultural productivity growth has stalled in recent years.
- 2.80 CSIRO stated that rates of productivity increase for broadacre agriculture, as a whole, have stalled in the last 20 years. It did acknowledge notable exceptions, including cotton, dairy and large grain farms.⁸²
- 2.81 CSIRO discussed some of the possible reasons for the stalling productivity growth, including declining investment in R&D (in absolute and research intensity terms); the relatively low contribution of private sector R&D; the notable lack of public-private partnerships compared to countries such as Israel, the Netherlands, and Denmark; and the inability of various industries to adapt to a drying and warming climate, reduced irrigation supplies, and soil management issues.⁸³
- 2.82 The Australian Farm Institute stated that broadacre agriculture has experienced a marked slowdown in annual productivity growth rates since 1997.⁸⁴ Further, the Institute concurred that the slowdown is due to a number of different factors, with an important one being the level of investment in agricultural R&D in Australia.⁸⁵
- 2.83 Similarly, the ABARES research report from 2014 also suggested that growth has slowed in the broadacre industries, particularly the cropping and mixed crop livestock industries, and the agriculture sector more

80 ADF-DA, *Submission 65*, p. 2; DAWR, *Submission 88*, p. 12.

81 ADF-DA, *Submission 65*, p. 2; DAWR, *Submission 88*, p. 12.

82 CSIRO, *Submission 55*, p. 7.

83 CSIRO, *Submission 55*, p. 7.

84 Australian Farm Institute, *Submission 85*, p. 3.

85 Australian Farm Institute, *Submission 85*, p. 3.

broadly. The report stated that slower growth has been largely attributed to a combination of adverse seasonal conditions and stagnating investment in public agricultural R&D.⁸⁶

2.84 The Charles Sturt University submission reflected on the ABARES 2014 report, providing thoughts on total factor productivity (TFP) gains and the more recent slowdown:

It can be argued that much of the large TFP gains in cropping in the 1977-1988 period cited in this report were attributable to the R&D investment that allowed no-till cropping to become widespread, combined with largely good seasonal conditions allowing crops to approach their yield potentials. Much slower TFP growth in the 1999-2010 period coincided with the millennium drought and reduced public expenditure on R&D ...⁸⁷

2.85 The Charles Sturt University submission added that slower growth in the most recent decade has refocused R&D efforts towards breeding more drought tolerant varieties, conservation of soil moisture, and practices to improve risk management.⁸⁸

2.86 The ADF-DA submission noted that, despite favourable productivity increases, in the last decade productivity growth has slowed and the dairy industry has struggled to compete with the productivity gains of its major international competitor, New Zealand.⁸⁹

2.87 The DAWR submission referred to workshops conducted by ABARES and the Grains Research and Development Corporation (GRDC), where productivity slowdown in the grains industry was discussed. The main causes of productivity slowdown were considered to be:

- drought;
- slower spread and adoption of new technologies;
- smaller advances in farming systems and technologies;
- knowledge constraints; and
- shifts in research priorities away from productivity.⁹⁰

2.88 R&D funding issues are discussed in Chapter 5 of this report.

86 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 10.

87 Charles Sturt University, *Submission 17*, p. 2.

88 Charles Sturt University, *Submission 17*, p. 2.

89 ADF-DA, *Submission 65*, p. 2; DAWR, *Submission 88*, p. 12.

90 DAWR, *Submission 88*, pp. 11-12.

Scope for future improvements

- 2.89 This section of the chapter examines the uptake of the current technology, transformational change in technology and innovation, and predicted productivity growth for the agricultural sector.

Reaching full potential of existing technology

- 2.90 CSIRO suggested that there is scope for improvements in farm production through better application or wider adoption of existing technology.⁹¹ The Tasmanian Institute of Agriculture also suggested that there are many technologies to which farming businesses have access, however little adoption has occurred in many instances.⁹²
- 2.91 Deakin University pointed out that most innovation does not result from a new invention, but rather from the adoption of existing technology applied differently.⁹³ Consistent with this view, Soil Science Australia suggested that the present inquiry focus not only on the potential of emerging and new technologies, but also the need to raise the adoption rate of proven technologies.⁹⁴
- 2.92 The GRDC noted that adoption is hampered by the fact that:
- ... we only truly understand benefits and costs at the regional level whereas growers require data and exposure to technology at the sub-regional and local levels to make an informed decision on adoption.⁹⁵
- 2.93 CSIRO stated that there are considerable opportunities for productivity gains through better adoption of current technology:
- Recent work by CSIRO and GRDC has shown that current national average yields for grain crops are at about 50 per cent of what is potentially possible with current technology. We know that potential yields are possible because studies with elite farmers show that they are at this frontier now.⁹⁶
- 2.94 Deakin University also noted opportunities presented by high performing farmers who use existing technology with excellent results:
- Such farmers are often significantly more productive than their peers. The obvious opportunity is to identify who they are,
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91 CSIRO, *Submission 55*, p. 5.

92 Tasmanian Institute of Agriculture, *Submission 44*, p. 2.

93 Deakin University, *Submission 28*, p. 3.

94 Soil Science Australia, *Submission 41*, p. 1.

95 GRDC, *Submission 87*, p. 15.

96 CSIRO, *Submission 55*, p. 15.

understand what makes their enterprises so productive, and replicate their practice into the broader industry.⁹⁷

- 2.95 The CSIRO submission explained that the adoption of new technology is influenced by its complexity, ease of use, and readily identifiable benefits.⁹⁸
- 2.96 The CSIRO submission noted the variability in the adoption of technologies across the grain growing sector, with some technologies being widely adopted (for example, 90 per cent adoption of autosteer and guidance on farm vehicles) while other technologies are less widespread (for example, 10 per cent adoption of the use of decision support systems for risk management). CSIRO also noted that a 'significant cluster of technologies', currently with an adoption rate of approximately 30 per cent, could have their adoption rate increased to 70 per cent or more.⁹⁹
- 2.97 CSIRO added that there is a distinct lack of yield gap studies for many industries and a greater focus on this would highlight the scope for improvement.¹⁰⁰
- 2.98 The Australian Academy of Technological Sciences and Engineering (ATSE), however, explained that simply improving the uptake of best practice and current technologies is an insufficient strategy for ongoing progress, and that sound investment in new research was also required to produce the next generation of improvements.¹⁰¹ Indeed, the ATSE stated that investment in the fundamental research which enables new technologies must be recognised as the key to future growth in Australia's agricultural sector.¹⁰²

Transformational change

- 2.99 The University of Queensland stated that the majority of Australian farmers are operating close to the limits of technical efficiency.¹⁰³ It added that the next step-change of improvement will come from longer term transformational research, which is usually a very long term investment, with higher risk but producing very high returns.¹⁰⁴

97 Deakin University, *Submission 28*, p. 2.

98 CSIRO, *Submission 55*, p. 8.

99 CSIRO, *Submission 55*, p. 8.

100 CSIRO, *Submission 55*, p. 15.

101 Australian Academy of Technological Sciences and Engineering, *Submission 56*, p. 6.

102 ATSE, *Submission 56*, p. 6.

103 University of Queensland, *Submission 2*, p. 1.

104 University of Queensland, *Submission 2*, p. 1.

- 2.100 Similarly, the University of Sydney stated that technology will bring about innovation-driven increases in efficiency and productivity and the development of new and more attractive markets.¹⁰⁵
- 2.101 Professor Stewart Lockie suggested that the complexity of agricultural systems will ensure no single technology holds the key to transformative change.¹⁰⁶ Professor Lockie added that technologies must be embedded within a holistic understanding of the landscape-scale ecological and hydrological processes in which agriculture is situated.¹⁰⁷ Professor Lockie concluded that innovation in ‘systems management’ at higher scales is as important as – and must be integrated with – innovation at the genetic, field, and enterprise scales.¹⁰⁸
- 2.102 Transformative technologies are examined in further detail in Chapter 3 of this report.

Outlook and predicted growth

- 2.103 The CSIRO submission to the inquiry stated that Australia’s agricultural food and fibre sector is poised for significant growth, with a doubling in demand in key export markets and significant domestic market growth over the next 30 years.¹⁰⁹
- 2.104 The ABARES Outlook 2016 Conference¹¹⁰ reported complex facts and figures, revealing mostly good news for the Australian agricultural industry. Some of the key findings include:
- farm production will be worth \$60.3 billion in 2016–17, a three per cent increase on this financial year;
 - farm export earnings will be steady at around \$45 billion for 2016–17;
 - domestic prices for livestock will keep growing as conditions improve;
 - gross value of all Australian crop production will increase four per cent next year, as long as seasonal conditions continue to improve; and
 - Australian milk production is expected to increase by two per cent to 9.8 billion litres next year, reversing a one per cent decline in

105 University of Sydney, *Submission 40*, p. 1.

106 Professor Stewart Lockie, *Submission 100*, p. 3.

107 Professor Stewart Lockie, *Submission 100*, p. 3.

108 Professor Stewart Lockie, *Submission 100*, p. 3.

109 CSIRO, *Submission 55*, p. 5.

110 DAWR, ‘ABARES Outlook 2016 Conference – Programs and Presentations’ <www.agriculture.gov.au/abares/outlook-2016/Pages/Conference-Program.aspx> viewed 4 April 2016.

production for 2015–16 due to dry conditions in the major milk producing states of Tasmania, Victoria and South Australia.¹¹¹

- 2.105 A 2015 report from the Australian Council of Learned Academies (ACOLA), entitled *Australia's Agricultural Future*, suggested that the outlook for Australian agriculture is very positive.¹¹² It highlighted some of the circumstances that will support agricultural productivity growth, including the end of the mining boom, more favourable exchange rates, fewer rural labour shortages, and rising demand for food exports. The report added that improvements in productivity growth through increasing technological inputs and technical efficiency are necessary to increase production and profitability.¹¹³
- 2.106 The ACOLA report's major conclusions for Australia's agricultural future included:
- Australia's agricultural sector has a comparative advantage in the export of bulk commodities and opportunities presented by the growth in demand for high-value products domestically and in Asia;
 - Australia's reputation for 'safe, clean and green' food is a major comparative advantage;
 - to meet increased demand, the sector will need to efficiently manage its soil and water resources;
 - the sector will need to attract capital and skilled labour in competition with other sectors of the Australian economy;
 - 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;
 - ongoing investment in R&D, both private and public, is vital to underpin this uptake; and
 - 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.¹¹⁴

111 ABC Rural News, 'Value of Australian agricultural production tipped to pass \$60 billion for the first time next year: ABARES' <www.abc.net.au/news/2016-03-01/abares-outlook-2016/7209506> viewed 4 April 2016.

112 Daly, J., Anderson, K., Ankeny, R., Harch, B., Hastings, A., Rolfe, J. and Waterhouse, R (2015) *Australia's Agricultural Future*. Report for the Australian Council of Learned Academies, www.acola.org.au.

113 Daly, J., Anderson, K., Ankeny, R., Harch, B., Hastings, A., Rolfe, J. and Waterhouse, R (2015) *Australia's Agricultural Future*. Report for the Australian Council of Learned Academies, p. 18.

114 Daly, J., Anderson, K., Ankeny, R., Harch, B., Hastings, A., Rolfe, J. and Waterhouse, R (2015) *Australia's Agricultural Future*. Report for the Australian Council of Learned Academies, p. 16.

2.107 One of the paths to reinvigorating productivity growth in agriculture is clearly through the development and adoption of existing and emerging technologies. A range of key emerging technologies are canvassed in the following chapter.

Emerging technologies in agriculture

- 3.1 As discussed in the previous chapter, the need for technology to drive advances in agricultural productivity is well understood by governments, researchers, industry, and farmers.¹
- 3.2 The Committee heard that emerging technologies, such as those driven by the biological revolution, the digital revolution, materials science and seasonal climate forecasting, would all have a role to play in promoting ongoing productivity in agriculture.²
- 3.3 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) noted, however, that no one technology would be a 'silver bullet'. Rather, each technology would need to be progressed as part of a broader effort to innovate across value chains and commodities, and in concert with other enabling technologies.³
- 3.4 For farmers to capitalise on potential productivity gains arising from these technologies, an enabling environment, including suitable infrastructure, systems, regulatory structure and market operating environment, must be in place.⁴
- 3.5 This chapter discusses some of the technologies emerging in the above areas, relevant to the agricultural sector. Barriers to the further development and adoption of these technologies will be discussed in later chapters.

1 Rural Industries Research and Development Corporation, *Submission 74*, p. 2.

2 Dr Michael Robertson, Science Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 1.

3 Dr Michael Robertson, Science Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 1.

4 RIRDC, *Submission 74*, p. 6.

Trends

- 3.6 The Rural Industries Research and Development Corporation (RIRDC), in partnership with CSIRO, reported into the five megatrends that are envisaged to impact Australian agriculture over the next 15 to 20 years, one of which is transformative technologies.⁵
- 3.7 Transformative technologies – defined as advances in digital technology, genetic science and synthetics – have the potential to change the way food and fibre products are made and transported, such as in the following ways:
- farming and fishing enterprises would increasingly have sophisticated tools to assist with decision-making;
 - farming would be a more transparent activity;
 - many new business models would develop; and
 - the concept of farming would be expanded to non-food land use as new markets and opportunities for land-based products emerge.⁶
- 3.8 The Committee was told that technologies relevant to the sector were emerging in areas beyond those captured in the terms of reference – that is, beyond the areas of telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals.⁷
- 3.9 Adjunct Professor Tony Sorensen, of the University of New England, submitted:
- ... we are on the verge of a huge and accelerating surge in technological capacity that will rewrite dramatically nearly every aspect of economy and society within as little as ten or twenty years: products and services; their production methods; machinery and equipment; range of inputs and their sources, including especially energy; downstream processing; market destinations; and logistics.⁸
- 3.10 Professor Sorensen considered that under these conditions, just about every aspect of farm production could experience radical transformation

5 See RIRDC, *Rural Industries Futures*, July 2015, p. 6.

6 RIRDC, *Submission 74*, p. 3.

7 See CSIRO, *Submission 55*, p. 9. See also, Adjunct Professor Tony Sorensen, School of Behavioural and Cognitive and Social Sciences (BCSS), University of New England, *Submission 114*, p. 1; Entrevators Pty Ltd, *Submission 62*, pp. 2-4.

8 Professor Tony Sorensen, School of Behavioural and Cognitive and Social Sciences (BCSS), University of New England, *Submission 114*, p. 1.

over the medium to longer term – from inputs to production management, harvesting and delivery to end use.⁹

- 3.11 While recognising the need to identify and support the development and adoption of emerging technologies, CSIRO cautioned against restricting the view of ‘innovation’ to the invention of single component technologies by farmers. Rather, CSIRO advocated for the adoption of a broader view of innovation, noting that much of the productivity gains in Australian agriculture over the past 30 years had come about through increasing scale and mechanisation and evolving business models.¹⁰
- 3.12 The University of Melbourne similarly submitted that agricultural innovation needed to be understood as a combination of systems:
- Put simply, innovation requires a focus not just on the “hardware” (that is, the new idea or technology), but also on the “software” (the skills and knowledge required to use and derive benefits from the technology) and the “orgware” (the formal and informal relationships and arrangements between stakeholders that are required to support the successful and sustained deployment of the technology).¹¹
- 3.13 Areas where technologies are emerging with implications for the agricultural sector include (but are not limited to):
- biological science;
 - materials science;
 - seasonal forecasting; and
 - digital science.¹²

Biological science

- 3.14 CSIRO noted that the biological revolution in the past 30 to 40 years had already delivered value in production systems, evidenced in developments such as pest resistant cotton and herbicide tolerant crops.¹³
- 3.15 However, a new surge was emerging in crops, pastures and potentially animals, which would deliver higher value products – for example, cereals

9 Professor Tony Sorensen, School of Behavioural and Cognitive and Social Sciences (BCSS), University of New England, *Submission 114*, p. 4.

10 CSIRO, *Submission 55*, p. 11.

11 University of Melbourne, Faculty of Veterinary and Agricultural Sciences, *Submission 4*, p. 1.

12 See CSIRO, *Submission 55*, pp. 5-6.

13 See CSIRO, *Submission 55*, pp. 5, 9.

with enhanced health attributes, novel aquaculture breeds and feeds, and designed plants with bio-industrial applications.¹⁴

3.16 Australia's Biotechnology Organisation (AusBiotech) submitted that biotechnology offered a set of innovative tools that would create new and improved food and fibre products, and more efficient and resilient farming systems with far-reaching agronomic, environmental, nutritional, human health and economic benefits.¹⁵

3.17 The Australian Academy of Technological Sciences and Engineering (ATSE) considered that the suite of technologies and techniques available through modern biotechnology offered enormous potential for improving the efficiency and productivity of Australian agriculture. As referenced in a recent ATSE position statement on enabling growth in agriculture:

Biotechnology, integrated with modern genetics, breeding, and other techniques, offers opportunities to improve agricultural productivity, natural resource management, and consumer demand, while offering new opportunities for bio-industries across the agricultural value chain.¹⁶

3.18 The Australian Genome Research Facility and the University of Adelaide jointly submitted that the next revolution in genomic technology could see potential benefits including the development of sustainable and productive farming methods for the dry tropics in northern Australia; shifting crop and animal production systems into new climatic zones; and improved resource-use efficiency across all agricultural systems.¹⁷

3.19 However, the Committee heard evidence that the widespread adoption of genetic technologies in Australian agriculture had been slow and patchy.¹⁸ It was noted that new techniques for gene transfer or expression that were coming on-stream were beyond current regulations.¹⁹ To access the potential benefits of such technologies, the ATSE submitted that adoption of new technologies had to be simpler and faster, while also maintaining appropriate regulatory oversight and addressing public concerns.²⁰

14 See CSIRO, *Submission 55*, p. 5.

15 AusBiotech, *Submission 33*, p. 4. See also, for example, Australian Plant Phenomics Facility, *Submission 42*; Tasmanian Institute of Agriculture, *Submission 44*; NSW Farmers' Association, *Submission 45*; CSIRO, *Submission 55*; ATSE, *Submission 56*; RIRDC, *Submission 74*.

16 ATSE, *Submission 56*, p. 8. See also, ATSE, *Enabling growth in agriculture: Position statement*, Melbourne, 2014.

17 Australian Genome Research Facility and University of Adelaide, *Submission 18*, p. 1.

18 ATSE, *Submission 56*, p. 8.

19 Dr Lindsay Campbell, *Submission 31*, p. 4.

20 ATSE, *Submission 56*, p. 8.

- 3.20 The regulation of genetic technology and other barriers to the adoption of emerging biotechnologies are discussed in later chapters.

Materials science

- 3.21 Demand for resource efficiency, including new materials that control and target the release of agricultural chemicals, provides many opportunities for the agricultural services sector.²¹
- 3.22 Recent advances in custom designing new materials with unique properties held promise for agricultural applications. Examples of such advances provided to the Committee include the development of biodegradable polymers for water control, based on CSIRO's Reversible Addition Fragmentation chain Transfer (RAFT) technology; materials that could be used to trigger the release of fertiliser formulations; and seed coatings for germination control.²²
- 3.23 Dr Lindsay Campbell submitted that a major innovation for the Australian and agricultural economy was 3-D printing, a technology still in its infancy yet already achieving amazing things. To make full use of this technology, Dr Campbell argued that Australia would require experts in material science, design and computer-aided design, computer programming, and engineering, among others.²³

Seasonal forecasting

- 3.24 CSIRO submitted that increases in the physical understanding of climate, together with improvements in observations, modelling techniques and computer speed, would lead to an increase in seasonal forecast skill. It was noted that the advent of seasonal climate forecasting in the last 20 years had been an important development to aid risk management by farmers, and would have an important role to play in the future in maximising the benefits of improved fertiliser management practices, weed management practices, decisions about timely sowing, and feed forecasts.²⁴
- 3.25 The Council of Rural Research and Development Corporations (Council of Rural RDCs) highlighted a project led by the RIRDC, which aimed to improve on the productivity and profitability of Australian farmers by bridging the gap between seasonal climate forecasts and on-farm business

21 CSIRO, *Submission 55*, p. 5.

22 CSIRO, *Submission 55*, pp. 5, 9, 10.

23 Dr Lindsay Campbell, *Submission 31*, p. 4.

24 CSIRO, *Submission 55*, p. 10.

decisions, with new tools to be developed, and training and information to be provided to farmers.²⁵

- 3.26 The South Australian Government advised that it was investigating the use of automatic weather station networks and submitted that the Australian Government should give consideration to supporting CSIRO and the Bureau of Meteorology to research and deliver information on seasonal climate variability and climate change across Australia.²⁶

Digital science

- 3.27 The rapid growth of information and communications technology in recent decades is expected to drive new directions for agriculture, in areas such as automation, and developments in infrastructure and platforms that will allow farmers to store, access, re-use and market their own data.²⁷
- 3.28 The University of Sydney told the Committee that emerging technologies in this area included all aspects of automation and robotics ranging from automated aerial and ground vehicles, drones, and associated intelligent software and data analytics for crops; automated milking, herding and sampling and animal production systems such as dairying; to cultivating sampling, applying treatments, and harvesting in agriculture and horticulture.²⁸
- 3.29 Entrevators Pty Ltd explained the practical applications and potential impact of digital science on Australian farms:
- We do not need people to sit in tractors or any other farming vehicle. Autonomous driven vehicles are here to stay and the labour and labour cost saving will have ramifications for farmers and their traditional workforce ...
- ... Drones will check the water troughs, feeders and tanks and the conditions of livestock with direct feed back to the home computer ...²⁹
- 3.30 The Department of Agriculture and Water Resources (DAWR) submitted that the future of precision agriculture – where integrated data from various sources could be used to achieve desired outputs and minimise the incidence of pests and diseases – could lie in decision agriculture,

25 Council of Rural Research and Development Corporations, *Submission 90*, p. 14.

26 Department of Primary Industries and Regions South Australia, *Submission 19*, p. 8.

27 CSIRO, *Submission 55*, pp. 10-11. See also, Australian Centre for Field Robotics, *Submission 94*.

28 University of Sydney, *Submission 40*, p. 5. See also, CSIRO, *Submission 55*, p. 10.

29 Entrevators Pty Ltd, *Submission 62*, p. 3.

which integrates spatial and seasonal data at a site-specific level for producer decision-making.³⁰

- 3.31 Dr Campbell noted that ‘big data’ – that is, ‘lots of small data that has been aggregated together in a compatible format’³¹ – was generated in most emerging digital technologies, from global positioning system (GPS) data collected in the field, to remote sensing from satellites.³²
- 3.32 Emerging technologies with the potential to improve agricultural productivity include technologies within the Internet of Things ecosystem, such as connectivity to ensure efficient collection of data from sensors; and data storage and management techniques that could be used to transform data from many sources into information, projections and suggested actions for individuals and the sector.³³
- 3.33 Entrevators Pty Ltd submitted:
- Agriculture can and will collect huge amounts of data in the future. The volume of data will exponentially grow and the analytics tools will be developed to provide useable information. It is happening now and the demand is huge.³⁴
- 3.34 The Committee was told that remote sensing drones had the potential to ascertain a wide range of helpful data, including movement of stock, state of fencing, remote control of gates or electric fences, dam levels, water flows, crop monitoring for weeds, pests and diseases, pasture assessment to optimise livestock numbers, and early detection of stress or drought.³⁵
- 3.35 SST Software Australia submitted that to evolve the ability to apply findings in a decision support context:
- ... we need to have the ability to reference that data to a farmer’s management regime and practices, so as to connect it to documented decision making. This requires compatibility with on farm data applications and systems.³⁶
- 3.36 CSIRO submitted that farm-scale data would need to be ‘fused’ with broader scale national and regional data streams covering issues such as climate, soils, water and biodiversity.³⁷

30 Department of Agriculture and Water Resources, *Submission 88*, pp. 7-8.

31 Mr Mark Pawsey, General Manager, SST Software Australia Pty Ltd, *Submission 13*, p. 9.

32 Dr Lindsay Campbell, *Submission 31*, p. 5.

33 National Narrowband Network Co., *Submission 34*, pp. 4-5.

34 Entrevators Pty Ltd, *Submission 62*, p. 2.

35 Dr Lindsay Campbell, *Submission 31*, p. 3.

36 SST Software Australia Pty Ltd, *Submission 13*, p. 9.

37 CSIRO, *Submission 55*, p. 11.

- 3.37 The University of Sydney submitted that the key to achieving gains in the development and application of digital technologies lay in the integration of multidisciplinary science and collaboration among national and international organisations.³⁸
- 3.38 CSIRO noted that the key social challenge in the digital revolution was to provide platforms for farmers to store, access, re-use and market their own data, while maintaining protections of ownership and privacy.³⁹
- 3.39 Dr Campbell asked the Committee to consider the important questions of who owned this data; to whom the information should be made available; what protections could be placed on the data; and for what purpose the data could and should be utilised.⁴⁰
- 3.40 Issues of collaboration and the adoption of research and development are discussed in Chapter 6.

Adoption of emerging technologies

- 3.41 The University of Melbourne considered that there were many factors that influenced individual farmers' decisions to adopt emerging technologies. The university identified four key factors that have affected the level of adoption of a technology or practice by farmers, and the time taken for adoption:
- characteristics of the technology or practice (for example, cost, difficulty of implementation);
 - characteristics of the target population (for example, social norms, financial capacity, education levels);
 - relative advantages of using the technology or practice (for example, profitability); and
 - capacity to learn or adapt to generate a relative advantage (for example, support networks to aid decision-making and learning).⁴¹
- 3.42 As noted earlier, CSIRO considered that no one technology or technologies would be transformational, and progress on technologies would be incremental, because of the nature of innovation and adoption.⁴²

38 University of Sydney, *Submission 40*, p. 5.

39 CSIRO, *Submission 55*, p. 11.

40 Dr Lindsay Campbell, *Submission 31*, p. 5.

41 University of Melbourne, Faculty of Veterinary and Agricultural Sciences, *Submission 4*, p. 1.

42 CSIRO, *Submission 55*, p. 9.

- 3.43 The RIRDC submitted that for emerging technologies to deliver ‘game changers’ for agricultural industries, those technologies must be adopted by the agricultural industry. In this way, it was hoped that the Rice Industry Extension Coordination Project, aimed at improving the uptake of rice industry best management practices and adoption of new technologies, would become a sustainable model for other industry extension and innovation dissemination.⁴³

The enabling environment

- 3.44 The Committee was told that an enabling environment must be in place to capitalise on potential productivity gains of new technologies at the farm gate. That is, the right infrastructure, systems, and regulatory and market operating environment must be in place. The RIRDC considered that some of these enablers were within the domain of governments, while other enablers were outside government remit.⁴⁴
- 3.45 Accordingly, the challenge for governments was to create an attractive policy environment for private sector investment in agriculture, while also maintaining public sector investment.
- 3.46 A 2014 RIRDC report considered that better recognising and exploiting the spill-over benefits of R&D outcomes through a more organised approach to the sharing of R&D outcomes may help deliver greater efficiencies, less duplication and wider uptake of innovation.⁴⁵
- 3.47 The current R&D environment and barriers to R&D are discussed in detail in Chapter 6.

Infrastructure

- 3.48 Reliable access to telephone and internet coverage has been identified as a key enabler for adapting and adopting technological advances in agricultural industries.⁴⁶ Access to such communications infrastructure allows farmers to optimise their production systems in terms of inputs and outputs, and allows them to remain competitive in global markets.⁴⁷
- 3.49 Professor David Lamb, of the University of New England, submitted that achieving nationwide, reliable on-ground telecommunications, including

43 RIRDC, *Submission 74*, p. 5.

44 RIRDC, *Submission 74*, p. 5.

45 RIRDC, *Submission 74*, p. 5.

46 RIRDC, *Submission 74*, p. 6. See also, for example, CSIRO, *Submission 55*, p. 11; Telstra, *Submission 81*, p. 1.

47 Adjunct Professor John Hamblin, *Submission 3*, p. 6.

access to high speed internet, is crucial to realising e-business and technology opportunities on Australian farms.⁴⁸

- 3.50 The United States Studies Centre at the University of Sydney submitted that providing sufficient broadband and telecommunications would allow the market to innovate around emerging the Internet of Things and big data technology.⁴⁹
- 3.51 Professor Lamb contended that a critical impediment to Australian farmers adopting technology and innovation on farms, and realising the benefits of emerging technology, was a lack of nationwide ‘whole of farm’ communications infrastructure and multipoint access models that allowed farmers to connect to high speed internet from anywhere on their farms.⁵⁰
- 3.52 Telecommunications infrastructure and digital connectivity, as barriers to innovation, are discussed further in Chapter 4.

Investment in people and capacity building

- 3.53 As part of an enabling environment, investment in people and capacity building may also be seen as a key driver of agricultural innovation.
- 3.54 The RIRDC considered that young people were important to include in conversations around the opportunities for agricultural innovation, given that they are not only the current adopters of new technology and innovations, but also the future adopters.⁵¹
- 3.55 For this reason, the RIRDC initiated the Horizon Scholarship Program, in partnership with industry sponsors, which supports undergraduates studying agriculture at university. The program aims to support the next generation of agricultural leaders.⁵²
- 3.56 Programs such as the Horizon Scholarship Program have also highlighted how multi-disciplinary agriculture has become, and how occupations outside of the traditional agricultural sector, including engineers,

48 Professor David Lamb, *Submission 11*, p. 1. See also, for example, Alun Davies, *Submission 1*; National Rural Women’s Coalition, *Submission 5*; Pastoralists and Graziers Association of Western Australia, *Submission 16*; Precision Cropping Technologies, *Submission 24*; National Narrowband Network Co., *Submission 34*; United States Studies Centre, *Submission 39*; NSW Farmers’ Association, *Submission 45*; Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*; Entrevators Pty Ltd, *Submission 62*; Australian Women in Agriculture, *Submission 63*; ADF-DA, *Submission 65*; Australian Sugar Milling Council, *Submission 68*; RIRDC, *Submission 74*; Telstra, *Submission 81*; South East Premium Wheat Growers’ Association, *Submission 83*; CCA-SCA-ALFA, *Submission 84*.

49 United States Studies Centre, *Submission 39*, p. 2. See also, Entrevators Pty Ltd, *Submission 62*; RIRDC, *Submission 74*; Grain Growers Limited, *Submission 82*.

50 Professor David Lamb, *Submission 11*, p. 1.

51 RIRDC, *Submission 74*, p. 7.

52 RIRDC, *Submission 74*, p. 6.

biochemists and physicists, are now playing a critical role in driving agricultural technological innovations.⁵³

- 3.57 Dr Campbell submitted that agriculture no longer operated as a silo, but was highly dependent on a very wide range of expertise outside its traditional boundaries:

Agricultural technologies must be underpinned by a strong, vibrant research and development (R&D) sector to maintain competitiveness. New technologies arise from many different disciplines, frequently from basic research, and these technologies are applied into agricultural situations.⁵⁴

- 3.58 The investment in people and capacity building is discussed in more detail in Chapter 5.

Committee comment

- 3.59 In this chapter, the Committee has identified some of the key areas where technologies are emerging, with implications for the agricultural sector.
- 3.60 It should be noted, however, that the technologies discussed in this chapter do not represent an attempt to cover the vast field of separate technologies that are emerging in Australia, with potential application in agriculture over the coming years.
- 3.61 Instead, in this chapter the Committee has sought to illustrate how dynamic the area of agricultural innovation has become, to identify factors that contribute to the development and adoption of these technologies, and to identify barriers that prohibit the adoption of these technologies onto Australian farms.
- 3.62 These barriers to innovation are considered throughout the remaining chapters of this report.

53 RIRDC, *Submission 74*, p. 7.

54 Dr Lindsay Campbell, *Submission 31*, p. 1.

Telecommunications and data services

- 4.1 As discussed in the previous chapter, the Committee heard about a range of emerging technologies with the potential to increase productivity in the agricultural sector.
- 4.2 However, consistent with the terms of reference of this inquiry, the Committee also received evidence about impediments to timely and widespread adoption of technology in the sector.
- 4.3 This chapter discusses barriers to the adoption of emerging technology associated with access to telecommunications infrastructure and the collection and analysis of agricultural data.
- 4.4 Further barriers to innovation in the agricultural sector are discussed in subsequent chapters.

Role of telecommunications and data

- 4.5 Throughout the inquiry, the Committee was told about the essential role of telecommunications and data in the application of new and emerging agricultural technology and, more generally, in the day-to-day operation of a modern farming business.
- 4.6 Several areas of agricultural technology were identified in evidence as having a critical dependence on reliable access to telecommunications services and/or the capability to collect and analyse large quantities of agricultural data:
 - **Remote control and automation of farm equipment:** Using global positioning systems and wireless connectivity, farm equipment can be operated semi-autonomously and farm activities – such as irrigation,

livestock management, and feed allocation – can be controlled from remote sites.¹

- **Precision or spatially-enabled agriculture:** The availability of accurate positioning data enables automation of the rate and position of crop inputs, such as seed, pesticide, and fertiliser. Similarly, electronic identification allows animals to be monitored and managed at the individual level.²
- **Monitoring and remote sensing:** Networks of compact, cost-effective sensors and probes enable real time monitoring of soil moisture, soil pH, light absorption, water supply, gas emissions, and other agricultural and atmospheric variables. This information can be integrated with high-resolution images and other data collected from satellites and drones.³
- **Data services:** Building on the collection of data at the paddock level, agricultural data can be aggregated on an industry or regional scale and combined with external information such as weather or price forecasts.⁴

4.7 The Committee heard how the adoption and integration of these and other technologies has the potential to increase productivity (through better management of inputs and yields), improve environmental outcomes, and enable farmers and consultants to manage risk and make better management decisions (see previous chapter).

4.8 However, the Australian Academy of Technological Sciences and Engineering (ATSE) cautioned that only with reliable access to fit-for-purpose telecommunications services would farmers be able to take advantage of the opportunities presented by emerging technologies.⁵

4.9 Stakeholders also emphasised the importance of particular telecommunications services. For example, Cotton Australia submitted that innovation based on the analysis of agricultural data relies on upload capacity.⁶

1 Dr Lindsay Campbell, University of Sydney, *Submission 31*, pp. 1–2.

2 University of New England, *Submission 11*, pp. 2–3; Vanderfield Pty Ltd, *Submission 79*, pp. 3–7; Australian Farm Institute, *Submission 85*, pp. 3–4.

3 University of New England, *Submission 11*, p. 7; Professor Brian Orr, Macquarie University, *Submission 30*, p. 3; Dr Lindsay Campbell, University of Sydney, *Submission 31*, p. 2; Vanderfield Pty Ltd, *Submission 79*, p. 10; Telstra, *Submission 81*, p. 6.

4 NNNCo Pty Ltd, *Submission 34*, pp. 4–5; CSIRO, *Submission 55*, p. 11; Tasmanian Government, *Submission 58*, pp. 2–3; RIRDC, *Submission 74*, p. 4; Australian Centre for Field Robotics, *Submission 94*, p. 7.

5 Academy of Technological Sciences and Engineering, *Submission 56*, pp. 6–7, 11.

6 Cotton Australia, *Submission 72*, p. 10.

- 4.10 Similarly, the University of New England submitted that the adoption of precision agriculture would be assisted by the availability of centimetre-accurate positioning systems across Australia.⁷
- 4.11 However, the University also emphasised the importance of reliable whole-of-farm communications infrastructure that would enable farmers to connect to high-speed internet from anywhere on the farm:
- Increasingly, farm technology and innovation is reliant on two-way data transfer enabled by reliable mobile phone coverage and concomitant access to high speed internet, not just in the homestead but also in the paddock where sensors and machinery are deployed.⁸
- 4.12 The Committee was also told about the increasing importance of basic telecommunications services in the day-to-day management of a farm, such as accessing information in the field using mobile devices or communicating with financial, veterinary, and agricultural advisory services.⁹
- 4.13 More broadly, the Committee received evidence about how access to telecommunications services is critical to the ability of rural communities and the agricultural sector to develop and retain a skilled workforce.¹⁰ Evidence relating to labour, skills, and training is discussed in further detail in the following chapter.

Access to telecommunications infrastructure

- 4.14 The Committee notes and applauds Australian farmers' demonstrated ability to adapt to existing innovative technologies. One clear example of this is the adoption of mobile phone or 'smart phone' technology.
- 4.15 Limited access to telecommunications services was frequently cited as being a fundamental barrier to agricultural innovation and the adoption of emerging technology.¹¹

7 University of New England, *Submission 11*, pp. 3–4.

8 University of New England, *Submission 11*, p. 7.

9 NSW Farmers' Association, *Submission 45*, p. 15; Victorian Farmers Federation, *Submission 57*, p. 2; Grain Growers Limited, *Submission 82*, p. 7; South East Premium Wheat Growers' Association, *Submission 83*, p. 2.

10 Victorian Farmers Federation, *Submission 57*, p. 2; Australian Women in Agriculture, *Submission 63*, p. 5; South East Premium Wheat Growers' Association, *Submission 83*, p. 2.

11 For example, see: Alpine Valleys Dairy Pathways Project, *Submission 10*, p. 2; Gwydir Shire Council, *Submission 14*, p. 1; Plant Biosecurity Cooperative Research Centre, *Submission 36*, pp. 7–8; United States Studies Centre, University of Sydney, *Submission 39*, p. 2; Rabobank Australia, *Submission 48*, p. 5; Tractor and Machinery Association of Australia, *Submission 54*,

- 4.16 The Victorian Farmers Federation submitted that inadequate telecommunications services are currently limiting the uptake of emerging technology and, as a result, limiting the productivity of farm businesses.¹²
- 4.17 Similarly, the NSW Farmers' Association submitted that there is a 'digital divide' facing farm businesses, putting many at a competitive disadvantage. The Association argued that the highest priority in agricultural innovation is improving connectivity to information and communication technology.¹³
- 4.18 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) submitted that a lack of access to high-speed internet would continue to limit the adoption of digital technologies by many Australian farm businesses as telecommunications networks evolve.¹⁴
- 4.19 However, the Committee also heard that the uptake of digital technologies and the application of 'big data' to farming have been strong within Australia, to the extent that existing infrastructure has allowed.¹⁵
- 4.20 The NSW Farmers' Association submitted that farmers are motivated to adopt digital technology and engage with the digital economy, although many are 'blocked at the first step'.¹⁶
- 4.21 The Victorian Farmers Federation identified inadequate bandwidth and intermittent coverage and connectivity as barriers limiting the ability of farm businesses to embrace new technology.¹⁷
- 4.22 However, a wide range of concerns were raised in evidence in relation to telecommunications, including basic connectivity and coverage, service reliability, upload and download bandwidth, download limits, and the cost of services.
- 4.23 Evidence related to both fixed-line (and fixed-wireless and satellite) internet services and mobile networks, reflecting the variety of ways in which regional and rural communities access the internet.

p. 1; Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*, p. 9; Entrevators Pty Ltd, *Submission 62*, p. 2; Australian Women in Agriculture, *Submission 63*, pp. 2-3; Growcom, *Submission 67*, p. 5; Australian Sugar Milling Council, *Submission 68*, p. 2; Australian Pork Limited, *Submission 70*, p. 4; Cotton Australia, *Submission 72*, p. 10; Ag Institute Australia, *Submission 73*, p. 3; Cattle Council of Australia, Sheepmeat Council of Australia, and Australian Lot Feeders Association, *Submission 84*, p. 12; DAWR, *Submission 88*, p. 16.

12 Victorian Farmers Federation, *Submission 57*, p. 1.

13 NSW Farmers' Association, *Submission 45*, p. 15.

14 CSIRO, *Submission 55*, p. 11.

15 Grain Growers Limited, *Submission 82*, p. 6.

16 NSW Farmers' Association, *Submission 45*, p. 18.

17 Victorian Farmers Federation, *Submission 57*, p. 6.

- 4.24 Stakeholders also noted that new technologies strengthen the dependence on reliable cost-effective power supply and emphasised the importance of maintaining a viable electricity market.¹⁸
- 4.25 Further evidence related to access to telecommunications services is discussed in the remainder of this section as follows:
- internet access and the National Broadband Network;
 - mobile networks; and
 - satellite services.

Internet access and the National Broadband Network

- 4.26 The Committee heard that in many rural and remote areas, fixed-line internet services such as ADSL, which operates over relatively short distances of copper-based telephone line, are unavailable to farm businesses.¹⁹
- 4.27 Mr Mark Swift illustrated the difficulty of adopting new technology – in this case, multispectral imaging – without access to high-speed internet:
- Large high resolution images are very large data files. In many rural areas the fastest way to transfer these files is via Australia Post ...²⁰
- 4.28 Telstra explained the ad-hoc nature of the fixed-line network in rural and remote areas:
- ... large amounts of the fixed line network in regional and rural Australia have been there for a long period of time, and the original network was configured to support voice services. Over time, broadband has been added as a new feature in the network, using copper based services. But there are large parts of regional Australia where in fact their fixed line service is provided via radio concentrator services and the like, which were never envisaged to provide broadband services.²¹
- 4.29 The Committee heard that there were practical and commercial limitations to comprehensive high-speed internet access. However, stakeholders were

18 ADF-DA, *Submission 65*, p. 7; Cotton Australia, *Submission 72*, pp. 4–5.

19 NSW Farmers' Association, *Submission 45*, p. 13; South East Premium Wheat Growers' Association, *Submission 83*, att. B: 'Regional data access: Connection to our economic future', p. 5.

20 Mr Mark Swift, *Submission 76*, p. 2.

21 Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, pp. 3–4.

- optimistic that the ongoing rollout of the National Broadband Network (NBN) would improve access to high-speed broadband in regional areas.²²
- 4.30 Telstra submitted that the NBN, which is being built and operated by a government-owned corporation, is designed to address the perceived market failure in the provision of fixed-line broadband services.²³
- 4.31 The NBN is planned to provide fixed-line connections (optical fibre or hybrid fibre-coaxial cable) in some areas, fixed-wireless connections in other areas, and satellite access where fixed-line or fixed-wireless technologies are impractical.²⁴
- 4.32 Results of recent telecommunications surveys undertaken by the NSW Farmers' Association and the Victorian Farmers Federation indicated that fixed-wireless and satellite-based services delivered as part of the NBN rollout are beginning to be adopted by some farmers.²⁵
- 4.33 Further evidence in relation to access to satellite services is discussed later in this chapter.

Mobile networks

- 4.34 Given the limited availability of fixed-line internet services in rural and remote areas of Australia, the Committee heard that farm businesses are increasingly accessing the internet using mobile networks.
- 4.35 The Victoria Farmers Federation submitted that more than 50 per cent of respondents to its recent telecommunications survey reported connecting to the internet using mobile networks.²⁶ Representatives of the Federation explained:

... increasingly, our members are connecting to the internet through portable devices and portable machinery ...²⁷

22 Victorian Farmers Federation, *Submission 57*, p. 2; Cotton Australia, *Submission 72*, p. 10; Telstra, *Submission 81*, p. 4.

23 Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, pp. 2–4.

24 Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, p. 4. See also: NBN, 'What is the nbn™ Multi Technology Mix?', <www.nbnco.com.au/blog/the-nbn-project/what-is-the-nbn-multi-technology-mix.html> viewed 5 April 2016.

25 NSW Farmers' Association, *Submission 45*, pp. 12–13; Victorian Farmers Federation, *Submission 57*, p. 7.

26 Victorian Farmers Federation, *Submission 57*, p. 7.

27 Mr Peter Hunt, Executive Policy Manager, Victorian Farmers Federation, *Committee Hansard*, Melbourne, 29 January 2016, p. 7.

- 4.36 Similarly, the South East Premium Wheat Growers' Association submitted that the Telstra mobile network is now the most common means for people in regional Western Australia to connect to the internet.²⁸
- 4.37 Vanderfield Pty Ltd, an agricultural product and service supply company, noted the potential of mobile networks to support innovation in remote areas, but also highlighted the lack of adequate coverage:
- The benefits of being able to offer support to farm businesses without being on site is obviously the greatest in geographically remote regions. However, the irony is that these are often the regions that do not have adequate network coverage to deliver technology enabled benefits ...²⁹
- 4.38 Other stakeholders identified network reliability, bandwidth, and the limited availability of fourth-generation (4G) connectivity as barriers to the adoption of mobile technology in the agricultural industry.³⁰
- 4.39 The South East Premium Wheat Growers' Association noted that mobile networks are prone to overload and, as a result, demand is often managed by limiting data allowances. The Association also submitted that data charges on mobile networks are expensive relative to the equivalent charges on fixed-line networks.³¹
- 4.40 Telstra submitted that a relatively light regulatory approach had assisted in the development of the mobile sector in Australia, and that coverage in regional Australia was continuing to expand due to competition in the sector.³² Mr James Shaw, representing Telstra, explained:
- The robust competition that exists today, especially in the mobile sector, has been brought about by a regulatory environment that has rewarded those who are prepared to invest.³³
- 4.41 Mr Shaw indicated that Telstra had recently invested \$190 million to purchase additional spectrum to meet its commitment of providing 4G network coverage to 99 per cent of the Australian population by June 2017.³⁴

28 South East Premium Wheat Growers' Association, *Submission 83*, p. 1.

29 Vanderfield Pty Ltd, *Submission 79*, p. 15.

30 NSW Farmers' Association, *Submission 45*, pp. 12-13; Grain Growers Limited, *Submission 82*, p. 7.

31 South East Premium Wheat Growers' Association, *Submission 83*, p. 1.

32 Telstra, *Submission 81*, p.2; Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, pp. 1-2.

33 Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, p. 1.

34 Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, p. 1.

- 4.42 However, the University of New England noted that current coverage across all mobile network operators extended to approximately 31 per cent of the Australian landmass.³⁵
- 4.43 The University submitted that in open, sparsely populated agricultural areas, there is insufficient demand to justify commercial investment in mobile network infrastructure.³⁶
- 4.44 The University went on to suggest that the introduction of roaming arrangements between mobile network providers would increase the effective coverage available to customers in agricultural areas. It also suggested that a requirement for mobile network operators to provide roaming could be attached to public funding, or that in 'non-commercial areas' the NBN could offer fixed-wireless services on a wholesale basis to other mobile network operators, such as Telstra.³⁷
- 4.45 The Committee also heard evidence about several technologies that had the potential to expand access to mobile devices in rural and remote Australia in place of traditional mobile networks.
- 4.46 For example, Telstra explained how 'small cell' technology is being developed to increase connectivity in communities where there is no commercial case to establish a mobile network tower. Small cells provide 4G data connectivity to mobile devices in a radius of up to 200 metres and are intended to service towns of 100 to 200 people.³⁸
- 4.47 Similarly, CSIRO highlighted its 'Ngara' technology, which is designed to efficiently use spectrum to service geographical areas with low population density and limited telecommunications infrastructure.³⁹
- 4.48 Telstra also noted that sensors and devices deployed in the paddock may not send large amounts of data, which may ease network requirements.⁴⁰

Mobile Black Spot Programme

- 4.49 In May 2014, to improve mobile services in regional and remote Australia, and to stimulate further competition in the mobile sector, the Australian

35 University of New England, *Submission 11*, p. 7.

36 University of New England, *Submission 11*, p. 7.

37 University of New England, *Submission 11*, pp. 7–8. See also: Victorian Farmers Federation, *Submission 57*, p. 9; Mr Peter Hunt, Executive Policy Manager, Victorian Farmers Federation, *Committee Hansard*, Melbourne, 29 January 2016, p. 7; Mr Maxwell Eastcott, General Manager, Gwydir Shire Council, *Committee Hansard*, Armidale, 13 April 2016, p. 16.

38 Telstra, *Submission 81*, pp. 3–4.

39 CSIRO, *Submission 55*, p. 11. See also: CSIRO, 'Ngara: Next gen wireless' <www.csiro.au/en/Research/DPF/Areas/Wireless/Wireless-technologies/Ngara> viewed 5 April 2016.

40 Mr Channa Seneviratne, Director, Wireless Network Engineering, Telstra, *Committee Hansard*, Canberra, 11 February 2016, p. 2.

- Government committed \$100 million to the Mobile Black Spot Programme. The program provides funding to mobile network operators to build or upgrade mobile base stations in locations with inadequate coverage.⁴¹
- 4.50 In the first round of the program, Telstra and Vodafone committed \$185 million over three years to deliver 499 new or upgraded base stations around Australia. Further funding was committed by state and local governments, businesses, and community organisations.⁴²
- 4.51 Telstra explained to the Committee that its \$165 million investment in the program would deliver 429 mobile base stations and 250 small cells over three years in communities that currently have no coverage.⁴³
- 4.52 In June 2015, the Australian Government committed a further \$60 million to the second round of the program. The selection process for this round is due to be finalised in June 2016.⁴⁴
- 4.53 While welcoming the government's investment in the program, Grain Growers Limited noted that the new infrastructure proposed under the program is largely not located in the grain belts of Australia.⁴⁵
- 4.54 Similarly, the University of New England submitted that selection criteria used to prioritise investment in new infrastructure are weighted towards areas of high population (or transportation corridors) rather than areas that support broadacre or outdoor horticultural activity.⁴⁶
- 4.55 However, Cotton Australia submitted that the program, along with the ongoing rollout of the NBN, would significantly improve the capacity of regional industries to capitalise on emerging technologies.⁴⁷

Satellite services

- 4.56 The Committee heard how farmers in areas of Australia beyond the scope of fixed-line, fixed-wireless, and mobile networks rely on satellite-based services to access the internet.⁴⁸

41 The Hon. Malcolm Turnbull MP, Minister for Communications, 'Investing in Australia's communications infrastructure', *Media Release*, 13 May 2014.

42 The Hon. Malcolm Turnbull MP, Minister for Communications, 'Mobile Black Spot Programme to deliver almost 500 new or upgraded base stations with total investment of \$385 million', *Media Release*, 25 June 2015.

43 Telstra, *Submission 81*, p. 3; Mr James Shaw, Director, Government Relations, Telstra, *Committee Hansard*, Canberra, 11 February 2016, pp. 1-2.

44 The Hon. Paul Fletcher MP, Parliamentary Secretary to the Minister for Communications, 'Abbott Government commits \$60 million to Round 2 of Mobile Black Spot Programme', *Media Release*, 25 June 2015.

45 Grain Growers Limited, *Submission 82*, p. 8.

46 University of New England, *Submission 11*, p. 7.

47 Cotton Australia, *Submission 72*, p. 10.

- 4.57 The University of New England submitted that satellites have the potential to be an ideal telecommunications backbone for connectivity over open areas of farming land. However, the University also noted that existing satellite services are struggling to meet larger-than-expected demand in rural and remote areas of Australia.⁴⁹
- 4.58 The Committee received a range of evidence about the limitations of existing satellite services, such as the Interim Satellite Service introduced as part of the NBN in 2011.⁵⁰
- 4.59 The Victorian Farmers Federation submitted that, while many of its members have access to satellite services, the quality of the connection is highly variable.⁵¹ Similarly, the NSW Farmers' Association noted capacity constraints associated with satellite and other shared-spectrum services.⁵² Grain Growers Limited submitted that, in some cases, the Interim Satellite Service provided a poorer service than what was previously available.⁵³
- 4.60 As part the ongoing rollout of the NBN, two purpose-built satellites are being launched to deliver broadband services to over 200,000 homes and businesses in rural and remote Australia. The first of the satellites was launched in October 2015, and the new services are expected to be available in the second quarter of 2016.⁵⁴
- 4.61 The Committee heard from several stakeholders who were anticipating the introduction of additional satellite services.⁵⁵ However, those stakeholders also noted that changes in user behaviour in response to improved services, combined with already increasing demand for internet services in regional areas, may eventually exhaust the capacity provided by the new satellites.⁵⁶

48 NSW Farmers' Association, *Submission 45*, pp. 12–13.

49 University of New England, *Submission 11*, p. 9.

50 NBN, 'NBN Co launches Interim Satellite Service for remote Australians' <www.nbnco.com.au/corporate-information/media-centre/media-releases/nbnco-launches-interim-satellite-service-for-remote-australians.html> viewed 5 April 2016.

51 Victorian Farmers Federation, *Submission 57*, p. 16.

52 NSW Farmers' Association, *Submission 45*, p. 12.

53 Grain Growers Limited, *Submission 82*, pp. 7–8.

54 NBN, 'Sky Muster™ service', <www.nbnco.com.au/connect-home-or-business/information-for-home/satellite.html> viewed 5 April 2016.

55 South East Premium Wheat Growers' Association, *Submission 83*, p. 1; Mr David McKeon, General Manager – Advocacy and Policy, Grain Growers Limited, *Committee Hansard*, Canberra, 22 February 2016, p. 8.

56 Grain Growers Limited, *Submission 82*, pp. 7–8; South East Premium Wheat Growers' Association, *Submission 83*, pp. 1–2.

- 4.62 In addition to using satellites to provide connectivity to households, Telstra noted the organisation was investigating options for satellites to provide economical backhaul for wireless networks in rural areas.⁵⁷
- 4.63 Lastly, the University of New England noted the importance of flexible service plans to support an increasing number of connected devices across agricultural land.⁵⁸

Adoption of data services

- 4.64 In addition to issues related to access to telecommunications infrastructure, the Committee heard evidence about a range of impediments to the adoption of data services for agriculture.
- 4.65 The Committee was pleased to observe the best practice efforts of the University of New England SMART Farm and the Australian Centre for Field Robotics. They are important examples of successful practical application of data technology services. The Committee also commends these organisations for the inclusion of farm businesses in the R&D process.
- 4.66 At a fundamental level, the Committee heard that a barrier to the adoption of data services was the cost and effort of generating sufficient data to support analysis and decision making.⁵⁹
- 4.67 More broadly, CSIRO outlined the capability required to support the widespread collection and analysis of agricultural data:
- The key social challenge in the digital revolution will be to provide platforms for farmers to store, access, re-use and even market their own data with appropriate protections of ownership and privacy. These farm-scale data will need to be ‘fused’ with broader scale national and regional data streams covering issues such as climate, soils, water, and biodiversity.⁶⁰
- 4.68 Further evidence related to the adoption of data services is discussed in the remainder of this section as follows:
- data standards;
 - data ownership and access; and

57 Mr Channa Seneviratne, Director, Wireless Network Engineering, Telstra, *Committee Hansard*, Canberra, 11 February 2016, p. 5.

58 University of New England, *Submission 11*, p. 9.

59 NNNCo Pty Ltd, *Submission 34*, p. 3; Mrs Jennifer Medway, Manager Investing in People, RIRDC, *Committee Hansard*, Canberra, 22 October 2015, p. 3.

60 CSIRO, *Submission 55*, p. 11.

- security and privacy.

Data standards

- 4.69 The Committee heard that, while the use of data services in agricultural production is already emerging, there may be a risk of fragmentation and dysfunction due to a lack of coordination between existing initiatives or the use of local or proprietary data standards.⁶¹
- 4.70 The Australian Centre for Field Robotics submitted that a lack of coordinated data and safety standards for robotic systems is preventing their incorporation onto the farm, and that such standards would enable interoperability between hardware and software providers and the adoption of open source software.⁶²
- 4.71 Other issues raised in evidence include the challenge of ensuring that connected devices adhere to a commonly accepted standard and that data generated by such devices is machine-readable, reliable, and accurate.⁶³
- 4.72 CSIRO submitted that there is growing evidence of market failure in Australia in the provision of fit-for-purpose data services and suggested that there may be a role for government to participate in the development of a data platform to address both public and private interests.⁶⁴
- 4.73 CSIRO noted that the organisation is currently investigating the feasibility of a network service – potentially via a co-operative or not-for-profit business model – to support data services in rural industries.⁶⁵

Data ownership and access

- 4.74 The Committee heard that as increasing amounts of data are generated in the agricultural industry, uncertainty in relation to data ownership and appropriate access to data may pose a barrier to the adoption of data services.⁶⁶
- 4.75 Southern Farming Systems and the Australian Controlled Traffic Farming Association submitted that farmers might only participate in the collection

61 NNNCo Pty Ltd, *Submission 34*, p. 5; CSIRO, *Submission 55*, p. 11.

62 Australian Centre for Field Robotics, *Submission 94*, p. 8.

63 NNNCo Pty Ltd, *Submission 34*, p. 7; Entrevators Pty Ltd, *Submission 62*, pp. 2-3; Mrs Jennifer Medway, Manager Investing in People, RIRDC, *Committee Hansard*, Canberra, 22 October 2015, p. 3.

64 CSIRO, *Submission 55*, pp. 6, 11; See also: Grain Growers Limited, *Submission 82*, p. 8; United States Studies Centre, University of Sydney, *Submission 39*, pp. 4-5.

65 CSIRO, *Submission 55*, p. 11.

66 Dr Lindsay Campbell, University of Sydney, *Submission 31*, p. 5; DAWR, *Submission 88*, Appendix B: 'Example of barriers to adoption – ownership and use of big data', p. 15.

and storage of agricultural data if they trust that the information is used for the benefit of the farmer who supplied it.⁶⁷

- 4.76 The Department of Agriculture and Water Resources (DAWR) noted that, in cases where data is collected from farming equipment, there needs to be agreement between the producer and the equipment manufacturer regarding ownership of, and rights to, the data. For example, DAWR suggested that manufacturers could be restricted from selling producer data to third parties without prior agreement.⁶⁸
- 4.77 The Committee also heard about initiatives underway to make more agricultural data openly available.⁶⁹
- 4.78 The Rural Industries Research and Development Corporation (RIRDC) suggested that there was recognition by government, but also in the private sector, of the increases in productivity that greater access to data may enable. However, it also suggested that there may be less incentive in the private sector to release data, and that intellectual property restrictions could prevent some data from being disclosed.⁷⁰

Security and privacy

- 4.79 Lastly, as increasing numbers of sensors and devices are connecting to the internet and transmitting information from the paddock, the Committee heard that network security is becoming an important consideration.⁷¹
- 4.80 The DAWR submitted that businesses may be reluctant to invest in mapping, data analysis or cloud-based technologies that offer inadequate protection or de-identification of sensitive data.⁷²
- 4.81 Similarly, Australian Pork Limited submitted that, in the pork industry, confidence in the privacy and security of agricultural data throughout the supply chain is essential.⁷³

67 SFS-ACTFA, *Submission 61*, p. 10.

68 DAWR, *Submission 88*, Appendix B: 'Example of barriers to adoption - ownership and use of big data', p. 15.

69 Mrs Jennifer Medway, Manager Investing in People, RIRDC, *Committee Hansard*, Canberra, 22 October 2015, p. 3; Global Open Data for Agriculture and Nutrition <www.godan.info/> viewed 6 April 2016.

70 Mrs Jennifer Medway, Manager Investing in People, RIRDC, *Committee Hansard*, Canberra, 22 October 2015, p. 3.

71 Mr Channa Seneviratne, Director, Wireless Network Engineering, Telstra, *Committee Hansard*, Canberra, 11 February 2016, p. 2.

72 DAWR, *Submission 88*, Appendix B: 'Example of barriers to adoption - ownership and use of big data', p. 15.

73 Australian Pork Limited, *Submission 70*, pp. 3-4.

- 4.82 The Plant Biosecurity Cooperative Research Centre (CRC) submitted that internet security is a ‘non-negotiable’ requirement for the adoption of many of the advances that are available to better protect Australian agriculture from biosecurity threats.⁷⁴
- 4.83 The CRC also submitted that internationally-agreed regulatory frameworks for data management were essential to the process of capturing data that informs biosecurity management.⁷⁵
- 4.84 However, the Committee heard that issues related to data confidentiality are beginning to be resolved as information and security technologies are becoming integrated into governance, risk management, and planning for government and businesses.⁷⁶

Committee comment

- 4.85 It is clear from evidence received by the Committee that limited access to reliable and affordable telecommunications services poses an ongoing barrier to the adoption of emerging technology in the agricultural sector.
- 4.86 Lack of access to telecommunications services compromises the ability of farmers and farming businesses to embrace innovative technology and increase productivity. More generally, such services are increasingly becoming essential to maintaining lively and prosperous communities in rural and remote Australia.
- 4.87 The Committee acknowledges the significant practical and commercial impediments to achieving comprehensive coverage in rural and remote Australia.
- 4.88 As such, the Committee supports an ongoing role for government in ensuring that agricultural businesses have access to reliable, affordable telecommunications services to serve as a platform for new and emerging agricultural technology.
- 4.89 The Committee strongly supports the ongoing rollout of the National Broadband Network across rural and remote Australia.
- 4.90 As fixed-wireless coverage expands, and as new satellite-based services become available later this year, the Committee is confident that the NBN will significantly improve access to modern, high-speed internet in homes and businesses across the country.

74 Plant Biosecurity Cooperative Research Centre, *Submission 36*, p. 7.

75 Plant Biosecurity Cooperative Research Centre, *Submission 36*, p. 7.

76 DAWR, *Submission 88*, Appendix B: ‘Example of barriers to adoption – ownership and use of big data’, p. 15.

- 4.91 However, the Committee also acknowledges the importance of connectivity in the paddock, which enables farmers to work more productively and adopt a range of new and emerging agricultural technologies.
- 4.92 The Committee has identified a need for further improvement in the provision of on-farm wireless networks that are compatible with the internet services available in remote areas.
- 4.93 Given its expertise in this area, the Committee considers that CSIRO is best placed to investigate cost-effective approaches to using the NBN as backhaul for on-farm wireless networks.

Recommendation 1

The Committee recommends that the Commonwealth Scientific and Industrial Research Organisation, in cooperation with industry, undertake a technical study to identify cost-effective approaches to using satellite services as backhaul for local wireless networks for agricultural applications.

- 4.94 The Committee is also of the view that there is scope for further expansion of mobile networks in rural and remote Australia.
- 4.95 The Committee supports the rollout of mobile network infrastructure under the Mobile Black Spot Programme, and notes the strong industry engagement in the initial rounds of the program.
- 4.96 The Committee strongly encourages the Australian Government to make an ongoing commitment to the program beyond the second round.
- 4.97 Under any expansion of the program, the Committee would support changes to the criteria used to select black spot locations in order to more accurately capture the telecommunications requirements and usage patterns associated with new and emerging agricultural practices.
- 4.98 For example, the Committee envisages the selection criteria could have reference to the number of connected devices, which would capture the deployment of numerous low-bandwidth sensors across the agricultural landscape.

Recommendation 2

The Committee recommends that the Australian Government commit to the continuation of the Mobile Black Spot Programme beyond the second round, and that the Department of Communications and the Arts consider changes or additions to the selection criteria to capture the telecommunications requirements of agricultural activity.

- 4.99 In addition, the Committee considers there is scope for the more effective use of existing mobile network infrastructure, as well as infrastructure to be delivered under the Mobile Black Spot Programme. In particular, in areas where only one network offers coverage, or where there is partial overlap between networks, roaming arrangements between network operators could significantly improve the effective coverage available to farmers in the paddock.
- 4.100 As such, the Committee would support additional measures that encourage mobile network operators to offer cost-effective roaming services to customers in these areas.

Recommendation 3

The Committee recommends that the Australian Government, in consultation with industry stakeholders, investigate incentives for mobile network operators to provide roaming services in rural and remote areas.

- 4.101 The Committee notes the importance of access to adequate telecommunications infrastructure in agricultural areas, and is therefore keen to monitor the rollout of telecommunications services and their impact on innovation and the uptake of emerging technology in the agricultural sector over the coming years.
- 4.102 The Committee notes that there may be a period of transition as services in some communities are improved before others, and as new services become available to farm businesses.
- 4.103 To assist in this transition, the Committee considers there is a need for timely and accurate information to be provided to farm businesses about the availability of the range of telecommunications services available in

their particular area, or about the anticipated timeframe for improved services.

- 4.104 Such information would assist farm businesses in planning for the adoption of new technology and making informed investment decisions.

Recommendation 4

The Committee recommends that the Department of Agriculture of Water Resources, in conjunction with public and private infrastructure providers, publish consolidated information about the availability of telecommunications services in rural and remote agricultural areas.

- 4.105 The Committee expects that information published by the Department would include existing and planned internet and mobile network services, including services provided through the ongoing rollout of the NBN and the Mobile Black Spot Programme. The Committee expects that this information would be consolidated and made easily accessible.
- 4.106 Further to this recommendation, the Committee supports the provision of education to ensure that farmers have sufficient information to determine how and under which circumstances they may benefit from emerging telecommunications-based technology.
- 4.107 Specifically, the Committee considers that practical information about the application of telecommunications and data services should be delivered by producer groups, in conjunction with TAFEs, training providers, and local leaders on the ground. The Committee is of the view that the Council of Rural Research and Development Corporations, in conjunction with universities and other research providers, is best placed to coordinate the development and delivery of educational material to assist in this process.

Recommendation 5

The Committee recommends that the Council of Rural Research and Development Corporations, in conjunction with research and training providers and producer groups, coordinate the development and delivery of educational resources to raise awareness of innovative applications of telecommunications services across the agricultural industry.

- 4.108 The Committee considers that, taken together, these recommendations will assist agricultural businesses in adopting new technologies and services as the appropriate infrastructure becomes available.
- 4.109 The Committee also notes the potential positive impact of data services on productivity in the agricultural sector. The Committee is of the view that some barriers to the adoption of these services will be resolved as technology matures and the associated industry develops.
- 4.110 However, the Committee acknowledges that there may be role for government in the development of appropriate standards to facilitate a greater adoption of data services in the agricultural industry. The Committee notes evidence that CSIRO is currently investigating initiatives in this area.

Human capital

- 5.1 This chapter examines barriers to technology adoption which arise from the human capital side of the innovation system. These barriers arise firstly through workforce issues such as access to leaders, labour and skills; and secondly through the extension and adoption processes.

Workforce

- 5.2 This section of the chapter considers the adoption barriers caused by limited access to leadership, and skilled and unskilled labour. This section also examines the development and retention of university research professionals in agricultural fields.

Access to leaders

- 5.3 Mr Tyran Jones, Chair of the Policy Committee and Director of Australian Dairy Farmers, was among those to identify the role of local leaders in driving community buy-in to innovation and adoption of technology.¹
- 5.4 Evidence to the inquiry also noted that local leadership potential is limited by factors such as the ageing farmer demographic. The Australasia-Pacific Extension Network noted that since 1976, the number of farmers under the age of 35 has fallen by more than 75 per cent.²
- 5.5 Submissions suggested that local leaders could be developed from three segments of agricultural communities: women, young people, and farmers' groups. The first two are discussed here and the third is considered throughout the chapter.

1 Mr Tyran Jones, Chair, Policy Committee and Director, Australian Dairy Farmers, *Committee Hansard*, Melbourne, 29 January 2016, p. 35.

2 Australasia-Pacific Extension Network, *Submission 95*, p. 8.

Women as leaders

- 5.6 The Rural Industries Research and Development Corporation (RIRDC), Australian Women in Agriculture (AWiA) and the National Rural Women's Coalition (NRWC) emphasised that women can make valuable contributions as local leaders of agricultural innovation.³
- 5.7 Ms Rachel Hay and Mr Philip Pearce's research has found that rural women are ready adopters of innovation and are more likely to use some technologies than men are. They noted that women are becoming local leaders as attitudes towards women's use of technology change.⁴
- 5.8 Meanwhile, the NRWC, Ms Hay and Mr Harrington recommended targeting women with flexible and tailored training in technology and business skills to enable them to take up leadership roles in encouraging the adoption of emerging technologies.
- 5.9 The NRWC submission commented that:
- Rural women would like to expand their knowledge and skills in using emerging digital technologies as and when they become available if they are to become digital disruptors that will lead to strong business innovation in agriculture.⁵

Young people as leaders

- 5.10 The Alpine Valleys Dairy Pathways (Alpine Valleys) project, RIRDC, and the Winemakers' Federation of Australia identified young people as a source of leadership in agricultural innovation.⁶
- 5.11 The Australasia-Pacific Extension Network, Rabobank and the RIRDC Horizon Scholars elaborated on the value of young people as local leaders of innovation through their familiarity with technology, their focus on future thinking, and their readiness to accept change.⁷

3 RIRDC, *Submission 74*, p. 7; Mrs Sarah Parker, Director, Australian Women in Agriculture, *Committee Hansard*, Canberra, 3 March 2016, p. 8; Dr Patricia Hamilton, President, National Rural Women's Coalition Ltd, *Committee Hansard*, Canberra, 3 March 2016, p. 8; Ms Rachel Hay and Mr William Harrington, *Submission 91*, p. 4, att. 1, p. 319.

4 Ms Rachel Hay and Mr William Harrington, *Submission 91*, att. 1, R Hay and P Pearce, 'Technology adoption by rural women in Queensland, Australia: Women driving technology from the homestead for the paddock', *Journal of Rural Studies*, vol. 36, 2014, p. 326.

5 NRWC, *Submission 5*, p. 4.

6 Mr Patten Bridge, Project Consultant, Alpine Valleys Dairy Pathways project, *Committee Hansard*, Wodonga, 28 January 2016, p. 24; RIRDC, *Submission 74*, p. 7; Mr Anthony Battaglione, General Manager, Strategy and International Affairs, Winemakers' Federation of Australia, *Committee Hansard*, Canberra, 4 February 2016, p. 2.

7 Australasia-Pacific Extension Network, *Submission 95*, p. 8; Rabobank, *Submission 48*, p. 8; RIRDC, *Submission 74*, p. 11.

- 5.12 However, Ms Hay and Mr Pearce cited research that fewer young people are entering agriculture.⁸ The Primary Industries Education Foundation Australia attributed this trend to negative perceptions of farming and particularly a failure to connect agriculture with innovation.⁹
- 5.13 Mr Ian Haggerty, Manager of Prospect Pastoral Company, and Mr Stuart Crosthwaite, Chair of the Project Steering Committee of the Alpine Valleys project, explained that young people often have inaccurate perceptions of agriculture as hard and risky work with few rewards and a poor lifestyle.¹⁰
- 5.14 Evidence to the inquiry proposed several options to improve attitudes towards agriculture and attract young people into agricultural careers.
- 5.15 Ms Jenny Anderson, Production Manager of Rutherglen Lamb, and the Primary Industries Education Foundation Australia recommended the introduction of agricultural science and the promotion of agricultural careers throughout school curricula.¹¹
- 5.16 The RIRDC recommended leadership programs to excite students about the prospects for innovation and growth in agriculture. It gave the example of its Horizon Scholars program which supports university students studying agriculture or related degrees.¹²

Access to skilled labour

- 5.17 The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) predicted that demand for skilled labour will increase to help farm businesses adopt sophisticated technology and become more innovative.¹³
- 5.18 However, submissions to the inquiry established that skilled labour is difficult to access. Some of the causes of this shortage, such as the ageing workforce, are felt across the economy. Other causes which are more particular to the agricultural sector are discussed below.

8 Ms Rachel Hay and Mr William Harrington, *Submission 91*, att. 1, R Hay and P Pearce, 'Technology adoption by rural women in Queensland, Australia', p. 320.

9 Primary Industries Education Foundation Australia, *Submission 111*, p. 1.

10 Mr Ian Haggerty, Manager, Prospect Pastoral Company, *Committee Hansard*, Wodonga, 28 January 2016, p. 14; Mr Stuart Crosthwaite, Chair, Project Steering Committee, Alpine Valleys Dairy Pathways project, *Committee Hansard*, Wodonga, 28 January 2016, p. 25.

11 Ms Jenny Anderson, Production Manager, Rutherglen Premium Lamb, *Committee Hansard*, Wodonga, 28 January 2016, pp. 30-32; Primary Industries Education Foundation Australia, *Submission 111*, p. 2.

12 RIRDC, *Submission 74*, p. 7.

13 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 37, cited in DAWR, *Submission 88*, p. 10.

Geography

- 5.19 The inquiry heard of the scarcity of skilled labour in regional, rural and remote agricultural communities. For example, Deakin University noted the trend of skilled workers moving from agricultural areas to cities.¹⁴
- 5.20 Ms Deborah Kerr, General Manager for Policy at Australian Pork Limited, noted that it is difficult to reverse the trend and attract labour from cities:
- There are not a lot of people who would like to move to small rural towns where they are away from family and friends and the enjoyment that they would have in a capital city.¹⁵
- 5.21 The Australian Controlled Traffic Farming Association and Southern Farming Systems recommended a partial waiver of student fees to attract graduates to agricultural communities.¹⁶ Other submissions also proposed incentives to retain skilled labour in agricultural communities.¹⁷

Telecommunications

- 5.22 Chapter 4 considered the impact of telecommunications access on the adoption of innovative technologies. The Australian Academy of Technological Sciences and Engineering (ATSE) made particular note of its impact on access to skilled labour.¹⁸
- 5.23 Likewise, the Victorian Farmers Federation submitted that:
- ... without adequate mobile and internet services [rural] communities are limited in their ability to attract and retain the increasingly skilled labour force they demand.¹⁹

Succession

- 5.24 Rabobank's submission identified succession in farm ownership to younger generations as a key enabler of the adoption of innovative technologies. It also acknowledged that succession is dependent upon proper planning by current owners and the successful identification of new owners.²⁰

14 Deakin University, *Submission 28*, p. 1.

15 Ms Deborah Kerr, General Manager for Policy, Australian Pork Limited, *Committee Hansard*, Canberra, 29 February 2016, p. 3.

16 Australian Controlled Traffic Farming Association and Southern Farming Systems, *Submission 61*, p. 9.

17 Dr David John Halliwell, Director, Centre for Regional and Rural Futures, Deakin University, *Committee Hansard*, Melbourne, 29 January 2016, pp. 13-14; Plant Biosecurity Cooperative Research Centre, *Submission 36*, p. 8.

18 Australian Academy of Technological Sciences and Engineering, *Submission 56*, p. 11.

19 Victorian Farmers Federation, *Submission 57*, p. 2.

20 Rabobank, *Submission 48*, p. 8.

- 5.25 Evidence from the Alpine Valleys project, Cotton Australia and Ms Hay and Mr Pearce held that succession planning is critical to identifying new farm owners and prosecuting effective generational change.²¹
- 5.26 The Alpine Valleys project found that few of its members had clear succession plans and some had retired without successfully transferring ownership to younger dairy farmers. The project's trial to support succession planning may prove a useful model for other farmers' groups.²²
- 5.27 Meanwhile, the barriers to entry into farming for the next generation are considered above in the access to leaders section.

Access to unskilled labour

- 5.28 The agricultural sector also struggles with access to unskilled labour. Agromillora Australia explained that the cost and scarcity of unskilled workers has made robotics and automation a focus for agricultural innovation, particularly in labour-intensive areas such as horticulture.²³
- 5.29 The Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders' Association concurred and noted that labour saving technologies are already reducing labour costs and workplace injuries in their industries.²⁴
- 5.30 During the inquiry's site inspection with the Alpine Valleys Project, the Committee heard that increased mechanisation can make farm work more interesting, more profitable, and less labour-intensive. All of these factors encourage young and skilled workers to consider the industry for their careers.
- 5.31 The University of Sydney concurred that robotics and automation technology is likely to replace repetitive tasks and to increase the variety and interest of agricultural work, in turn aiding the retention of skilled labour.²⁵
- 5.32 However, the University of Melbourne and Professor Stewart Lockie identified the potential for increased unemployment among particularly

21 Alpine Valleys project, *Submission 10*, p. 3; Cotton Australia, *Submission 72*, p. 11; Ms Rachel Hay and Mr William Harrington, *Submission 91*, att. 1, p. 320.

22 Alpine Valleys project, *Submission 10*, p. 3.

23 Agromillora Australia, *Submission 38*, p. 2.

24 Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders' Association, *Submission 84*, p. 7; Growcom, *Submission 67*, p. 3; Grains Research and Development Corporation, *Submission 87*, p. 10; Australian Centre for Field Robotics, *Submission 94*, p. 8.

25 University of Sydney, *Submission 40*, p. 4.

unskilled workers if robotics and automation technology is adopted more broadly.²⁶

- 5.33 Robotics and automation may improve workers' conditions if they have the skills required to operate the new technology. Addressing the skills requirements of agricultural labour, as addressed below, will be key to maximising the positive impacts of these technologies.

Access to skills

- 5.34 Just as employers struggle to access skilled labour in the agricultural sector, workers struggle to access the skills they need to support the adoption of new technologies. Access to skills is limited by the content and delivery of training in the sector.

Training content

- 5.35 The RIRDC Horizon Scholars identified the need for skills development for all agricultural occupations to allow the sector to understand and exploit opportunities to adopt innovation.²⁷
- 5.36 AWiA and the NRWC submitted that this demand for skills is not being met due to the limited training content available in the agricultural sector.²⁸
- 5.37 ABARES noted that inadequate training content stems from the sector's historical lack of emphasis on formal training.²⁹ Some submissions suggested ways to overcome this trend. For example, AWiA proposed that agricultural training could be made a priority of the Industry Skills Fund.³⁰
- 5.38 A further barrier to supplying training is that the skills demanded to support the adoption of innovation are very broad. The inquiry heard of the importance of skills in fields as varied as biology, chemistry, engineering, data science, information technology, finance, and change management.
- 5.39 The University of Melbourne recommended enhancing the content of agricultural training. Mr Michael Santhanam-Martin, Lecturer in Agricultural Production Systems, gave the example of the University's

26 The University of Melbourne, *Submission 4*, p. 4; Professor Stewart Lockie, *Submission 100*, p. 2.

27 RIRDC, *Submission 74*, p. 13.

28 NRWC, *Submission 5*, pp. 4-5; AWiA, *Submission 63*, pp. 4-7.

29 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 37, cited in DAWR, *Submission 88*, p. 10.

30 AWiA, *Submission 63*, p. 6.

own Bachelor of Agriculture degree which has been relaunched to include interdisciplinary material on topics such as sustainability, ethics, and commerce.³¹

- 5.40 Dr Matt Wenham, Executive Manager of Policy and Projects at the ATSE, suggested that agricultural stakeholders should also pursue non-agricultural courses:

The people who are going to work in agriculture in the digital age are not necessarily just ag science graduates; they are mechanical and robotics engineers, computer scientists and hydraulic engineers. We need to expand the definition of what a career in agriculture involves and make sure we are training people in the right areas.³²

- 5.41 An on-farm training barrier identified by the University of Melbourne was that farmers require specific technical skills to implement and use individual technologies.³³ Deakin University commented that such training usually requires only modest investment to be provided by technology suppliers, industry groups or the like.³⁴
- 5.42 Finally, AusBiotech, Entrevators Pty Ltd and the NSW Farmers' Association recommended that farm owners be offered skills in cost-benefit analysis, entrepreneurship, and general technological skills.³⁵

Training delivery

- 5.43 ABARES noted that workers struggle to access skills because traditional, face-to-face training programs require a substantial time commitment and involve travelling significant distances to reach training facilities.³⁶
- 5.44 The NRWC submission recommended the use of webinars and gave the example of its 'E-Leaders Programs'. It noted that webinars are of particular benefit to women because these courses are flexible and can accommodate caring and business responsibilities.³⁷

31 Mr Michael Santhanam-Martin, Lecturer in Agricultural Production Systems, University of Melbourne, *Committee Hansard*, Melbourne, 29 January 2016, p. 49.

32 Dr Matt Wenham, Executive Manager, Policy and Projects, ATSE, *Committee Hansard*, Melbourne, 29 January 2016, p. 23.

33 The University of Melbourne, *Submission 4*, p. 3.

34 Deakin University, *Submission 28*, p. 5.

35 AusBiotech Ltd, *Submission 33*, p. 5; Entrevators Pty Ltd, *Submission 62*, p. 4; NSW Farmers' Association, *Submission 45*, p. 16.

36 Gray, E.M., Oss-Emer, M. and Sheng, Y. (2014) *Australian agricultural productivity growth: past reforms and future opportunities*. ABARES research report 14.2, Canberra, p. 38, cited in DAWR, *Submission 88*, p. 10.

37 NRWC, *Submission 5*, p. 5.

- 5.45 The Australasia-Pacific Extension Network also supported the use of information technology for interactive remote learning.³⁸
- 5.46 Professor Andrew Reeves, Senior Research Advisor to the Vice-Chancellor of Deakin University, proposed a method to reduce the burden of traditional training programs. The University partners with the Riverina Technical and Further Education (TAFE) college to offer the first years of some degrees in the Riverina area to reduce students' costs and travel.³⁹

Researchers

Career paths and retention

- 5.47 The Committee received consistent evidence that it is generally difficult to attract and retain people with expertise in fields relevant to agriculture.⁴⁰
- 5.48 For agricultural researchers, three year contracts are the norm – what Professor Banks describes as a 'three-yearly internship model' – rather than secure, long-term career paths. This makes comparable work in other sectors or countries relatively more attractive.⁴¹
- 5.49 Greater continuity of research funding would help to attract and retain the highest calibre of researchers in the agricultural field.⁴² Reducing the prevalence of short-duration projects, especially in the public service agencies, would preserve relevant expertise in those agencies.⁴³
- 5.50 The Ag Institute of Australia suggested that one possible solution would be to support longer-term projects, through a model similar to that adopted by the National Health and Medical Research Council (NHMRC).⁴⁴
- 5.51 The NHMRC supports broad-based, multi-disciplinary and collaborative research projects. Significantly, these grants are typically five years in duration.⁴⁵ Increasing the length of research projects in agriculture to five years, as commented on by the Committee in Chapter 6, may help to retain talented research staff.

38 Australasia-Pacific Extension Network, *Submission 95*, p. 6.

39 Professor Andrew Reeves, Senior Research Advisor to the Vice-Chancellor, Deakin University, *Committee Hansard*, Melbourne, 29 January 2016, pp. 13-14.

40 Ag Institute Australia, *Submission 73*, p. 17.

41 Professor Robert Banks, *Submission 115*, p. 1.

42 The University of Queensland, *Submission 2*, p. 1.

43 Ag Institute Australia, *Submission 73*, p. 17.

44 Ag Institute Australia, *Submission 73*, p. 17.

45 National Health and Medical Research Council, 'Program Grants' <www.nhmrc.gov.au/grants-funding/apply-funding/program-grants> viewed 16 April 2015.

- 5.52 Chapter 6 also examines Cooperative Research Centres (CRCs), noting that the Committee heard evidence supporting the CRC model as an effective means of driving innovation and supporting longer-term research.
- 5.53 However, this model could be improved to address structural career issues for researchers. The ATSE made a number of important recommendations in its submission to the CRC Review.⁴⁶ Among these, two stand out: first, providing greater flexibility as to the duration of a particular CRC may assist; second, implementing a simpler, cheaper and quicker process for processing CRC proposals should also be implemented, reducing the resources required to be allocated to the bidding process.

STEM and agriculture education

- 5.54 Dr Mark Trotter, of the University of New England, identified the need to educate the next generation of agricultural workers and graduates, which is particularly important given the increasing complexity of technological advancements in the field.⁴⁷
- 5.55 According to Professor Roseanne Taylor, Dean of the Faculty of Veterinary Science at the University of Sydney:
- World-leading innovation in our food and land management sectors requires us, as universities, to attract and educate highly skilled, multidisciplinary, multicultural, diverse student groups who will then be ready to approach jobs and create jobs and to work in jobs that do not exist right now. That is the future we face.⁴⁸
- 5.56 AusBiotech stated in its submission that the prosperity of Australian agriculture relies on a steady stream of specialist science, technology, engineering and mathematics (STEM) skills in the workforce, and general science and mathematical literacy in the community.⁴⁹ There is an undersupply of graduates suitably qualified to do much of the available work in agriculture.⁵⁰

46 ATSE, *Submission to the Cooperative Research Centres Programme Review* (2014) <www.atse.org.au/Documents/submissions/cooperative-research-centres-programme-review.pdf> viewed 16 April 2016.

47 Dr Mark Trotter, Senior Lecturer, Precision Agriculture, University of New England, *Committee Hansard*, Armidale, 14 April 2016, p. 28.

48 Professor Roseanne Taylor, Dean of the Faculty of Veterinary Science, the University of Sydney, *Committee Hansard*, Sydney, 14 April 2016, p. 20.

49 AusBiotech, *Submission* 33, p. 5.

50 Mr Andrew Smart, Managing Director, Precision Cropping Technologies, *Committee Hansard*, Armidale, 13 April 2016, p. 14.

- 5.57 A number of stakeholders suggested that there is a need to engage students in agriculture from primary school age.⁵¹
- 5.58 Mr Jones argued that there is a need to promote agriculture as an exciting career path attracting a ‘young, passionate and new skill base to the industry’.⁵²
- 5.59 A large component of the strategy for attracting young students to explore careers with agricultural applications is to dispel outdated preconceptions about agriculture. Dr Trotter cited a 2012 survey by the Primary Industries Education Foundation Australia, which found that 55 per cent of students and teachers did not associate innovation with agriculture and that 43 per cent of students did not associate science with agriculture.⁵³
- 5.60 Mr Christopher Russell, Chairman of the Ethics Committee at the ATSE, suggested that agriculture is often viewed as an unsophisticated career path with limited prospects, particularly for talented students. He said that it was particularly important to challenge this kind of ingrained thinking in the parents of promising students.⁵⁴
- 5.61 Professor Alex McBratney, Dean of the Faculty of Agriculture and Environment at the University of Sydney, suggested that innovation is required in the development of educational resources that attract the brightest students to careers in the field.⁵⁵
- 5.62 Dr Trotter described the successful ‘Smart Farm Learning Hub’ as an example of a strategy that links universities and leading agriculture industry technology developers to reach students at secondary and tertiary levels.⁵⁶ In the program, students across Australia will be able to log in and watch the video footage or access data from farms across Australia to gain a better understanding of the intersection between agriculture and technology.⁵⁷
- 5.63 Professor Friend described the ‘enrichment days’ run by Charles Sturt University, where students from different schools are able to witness

51 Ag Institute of Australia, *Submission 73*, p. 17; Australian Centre for Field Robotics, *Submission 94*, p. 8; Primary Industries Education Foundation Australia, *Submission 111*, p. 1.

52 Mr Tyran Jones, Chair, Policy Committee and Director, Australian Dairy Farmers Ltd, *Committee Hansard*, Melbourne, 29 January 2016, p. 29.

53 Dr Mark Trotter, Senior Lecturer Precision Agriculture, University of New England, *Committee Hansard*, Armidale, 14 April 2016, p. 28.

54 Mr Christopher Russell, Chairman, Ethics Committee, Australian Institute of Agricultural Science and Technology, *Committee Hansard*, Sydney, 14 April 2016, p. 10.

55 Professor Alex McBratney, Dean, Faculty of Agriculture and Environment, University of Sydney, *Committee Hansard*, Sydney, 14 April 2016, pp. 19-20.

56 University of New England, *Submission 11.2*, p. 1.

57 University of New England, ‘SMART Farm Data’ <www.une.edu.au/research/research-centres-institutes/smart-farm/smart-farm-data> viewed 16 April 2016.

agricultural science applications first-hand. Professor Friend also noted programs, such as AgVision, which have similar objectives although they are targeted at metropolitan schools in Sydney.⁵⁸ With respect to the science curriculum in schools, he recommended incorporating examples of the agricultural applications.⁵⁹

5.64 The Primary Industries Education Foundation Australia suggested that using examples of innovation in agriculture would provide a way of engaging students of STEM subjects, and to incorporate food and fibre production systems within the mainstream curriculum.⁶⁰

5.65 The Australian Centre for Field Robotics noted that it had an 'extremely positive' experience when running STEM-based robotics courses with young students, noting:

... a growing awareness by the younger generation that agriculture can be a rewarding experience when coupled with the digital experience.⁶¹

Universities, teaching and the publication imperative

5.66 Professor McBratney suggested that university education in agriculture would need to reflect a growing multidisciplinary, with a focus on technology and engineering.⁶²

5.67 Professor Paul Wood, representing AusBiotech, suggested that even those graduates with relevant PhDs still needed guidance on how to effectively interact with industry.⁶³

5.68 Universities focus more on their publication rate rather than outcomes for industry.⁶⁴ Professor Taylor suggested that it is particularly difficult to

58 Professor Michael Friend, Director, Graham Centre for Agricultural Innovation, Charles Sturt University and NSW Department of Primary Industries, *Committee Hansard*, Wodonga, 28 January 2016, p. 35.

59 Professor Michael Friend, Director, Graham Centre for Agricultural Innovation, Charles Sturt University and NSW Department of Primary Industries, *Committee Hansard*, Wodonga, 28 January 2016, p. 35.

60 Primary Industries Education Foundation Australia, *Submission 111*, p. 1.

61 Australian Centre for Field Robotics, *Submission 94*, p. 8.

62 Professor Alex McBratney, Dean, Faculty of Agriculture and Environment, University of Sydney, *Committee Hansard*, Sydney, 14 April 2016, pp. 19-20.

63 Professor Paul Wood, Chair of the Ag and FoodTech Committee at AusBiotech Ltd, *Committee Hansard*, Melbourne, 29 January 2016, p. 6.

64 Professor Roseanne Taylor, Dean of the Faculty of Veterinary Science, the University of Sydney, *Committee Hansard*, Sydney, 14 April 2016, p. 23; Ag Institute of Australia, *Submission 73*, pp. 11-12.

capture funding for industry-specific research because it has generally not been seen as sufficiently 'blue-sky'.⁶⁵

- 5.69 The push for university publications is compounded by the fact that universities derive a substantial amount of their revenues from overseas students. From the perspective of the majority of international students, the attractiveness of a particular university depends on its international ranking;⁶⁶ the majority of international rankings systems operate on publications metrics.⁶⁷
- 5.70 In addition, the limited prospect of publications in agricultural research is probably deterring talent from pursuing careers in the field.⁶⁸
- 5.71 AusBiotech praised the ATSE proposal to measure outcomes in agricultural R&D, noting the need to 'focus on outcomes, not just publications'.⁶⁹
- 5.72 Mr Richard Webb from the Department of Agriculture and Water Resources (DAWR) noted the work undertaken, as a part of the National Innovation and Science Agenda, to alter the model by which universities receive research funding. The new model provides incentives for universities to undertake research in partnership with industry or for industry outcomes.⁷⁰

Extension and adoption

- 5.73 This section of the chapter considers barriers to adoption which arise from the human capital elements of the extension and adoption processes. Extension is the process of linking newly developed technologies with end users. Adoption is the process where end users select, implement and use technologies on-farm.

65 Professor Roseanne Taylor, Dean of the Faculty of Veterinary Science, the University of Sydney, *Committee Hansard*, Sydney, 14 April 2016, p. 23.

66 Professor Paul Wood, Chair of the Ag and FoodTech Committee at AusBiotech Ltd, *Committee Hansard*, Melbourne, 29 January 2016, p. 6.

67 Mr Michael Keogh, Executive Director, Australian Farm Institute, *Committee Hansard*, Sydney, 14 April 2016, p. 5.

68 Ag Institute Australia, *Submission 73*, pp. 3-4; Dr Matt Wenham, ATSE, *Committee Hansard*, Canberra, 29 January 2016, p. 20.

69 Mr Michael Blake, DAWR, *Committee Hansard*, Canberra, 17 March 2016, p. 4.

70 Mr Richard Webb, DAWR, *Committee Hansard*, Canberra, 17 March 2016, p. 4.

Extension

- 5.74 Many submissions named extension issues as barriers to the adoption of innovation. The key extension issues identified are discussed below.

Educating farmers

- 5.75 For adoption to be effective, farmers must understand a particular technology; this includes its strengths and weaknesses, how to dovetail that technology into existing operations, and also how that technology might be developed further.⁷¹
- 5.76 The Committee heard that farmers are used to the imperative to innovate.⁷² However, often the absence of on-farm skills necessary to adopt new technology is one barrier to innovation.⁷³
- 5.77 Precision Agriculture Pty Ltd suggested in its submission that complexity is one of the key factors influencing successful adoption.⁷⁴
- 5.78 In particular, the Committee heard that there is a need to educate current growers about advances in technology pathways and the rapid growth of various sub-technologies (for example, 3D printing, computing, robotics and sensing).⁷⁵
- 5.79 The average age of Australian farmers is 52 years old, which is 12 years above the average for other occupations. This may pose a unique barrier to adoption. Many older farmers have not grown up in the digital era, making it more difficult for them to participate in online education even if the infrastructure existed.⁷⁶
- 5.80 There are examples of industry groups collaborating to educate producers. For instance, the red meat industry has collaborated through programs such as ProGraze, Grain&Graze and EverGraze to develop new pastures and to educate producers on pasture and animal assessment, as well as climate risk management and environmental benefits.⁷⁷
- 5.81 Professor Robert Banks, of the University of New England, noted the need for public and private support and training:

71 Professor Tony Sorensen, *Submission 114*, pp. 4-5.

72 Mr Kim Russell, Chairman, Southern Farming Systems, *Committee Hansard*, Canberra, 22 February 2016, p. 2.

73 DAWR, *Submission 88*, p. 9.

74 Precision Agriculture Pty Ltd, *Submission 106*, p. 1.

75 Australian Centre for Field Robotics, *Submission 94*, p. 8.

76 AWiA, *Submission 63*, p. 6.

77 CCA-SCA-ALFA, *Submission 84*, p. 8.

... to ensure that farmers and others in agricultural value chains and communities have the skills and confidence to make use of the information tools and knowledge.⁷⁸

- 5.82 The Australian Food Sovereignty Alliance recommended that the Committee support local agricultural extension services for small farmers, to enable them to access information in order to educate themselves on best practice models.⁷⁹

Provision of services

- 5.83 Extension services were previously largely provided by state governments. Over the past decade, the states have significantly reduced their commitments and other players have been moving in to fill the void. The Council of Rural Research and Development Corporations (Council of Rural RDCs) noted that the transition has caused some uneven provision of services.⁸⁰
- 5.84 Australian Dairy Farmers and Dairy Australia (ADF-DA) commented that the future of extension should involve a balance of private and public sector support to make the most of available resources.⁸¹
- 5.85 FarmLink and the Cattle Council of Australia supported the continued expansion of private sector extension, in part because the private sector can be more flexible and responsive.⁸²
- 5.86 The Ag Institute of Australia (AIA) submission recommended that the public sector continue to significantly support extension.⁸³ Grain Growers Ltd and the University of Melbourne recommended an inquiry into the future of extension services to determine the appropriate level of public sector support.⁸⁴
- 5.87 Various RDCs and industry groups indicated that they have been providing extension in the gap between public and private services.⁸⁵ The Australasia-Pacific Extension Network recommended that extension

78 Professor Robert Banks, *Submission 115*, p. 1.

79 Australian Food Sovereignty Alliance, *Submission 99*, p. 5.

80 Council of Rural RDCs, *Submission 90*, p. 9.

81 ADF and Dairy Australia, *Submission 65*, p. 7.

82 FarmLink, *Submission 101*, p. 4; CCA-SCA-ALFA, *Submission 84*, pp. 17-18.

83 Ag Institute of Australia, *Submission 73*, p. 12.

84 Grain Growers Ltd, *Submission 82*, p. 4-5; University of Melbourne, *Submission 4*, pp. 4-5.

85 Council of Rural RDCs, *Submission 90*, pp. 6, 10; RIRDC, *Submission 74*, p. 6; Mr Selwyn Snell, Chairman, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 4; Mr Jed Matz, Chief Executive Officer, Cattle Council of Australia, *Committee Hansard*, Canberra, 3 December 2015, p. 2.

should be permanently integrated into research and development bodies.⁸⁶

- 5.88 Finally, FarmLink identified farmers' groups as a useful means for providing extension which would not be profitable for the private sector. Because these groups support members and regional agriculture, they can complement the activities of other players.⁸⁷

Coordination of services

- 5.89 The University of Melbourne commented that the fragmentation of extension services has reduced the level of coordination between the various providers.⁸⁸
- 5.90 The University of Sydney recommended industry and multi-disciplinary programs to improve collaboration and coordination.⁸⁹ The RIRDC named the Rice Industry Extension Coordination Project as a successful example of such a project.⁹⁰
- 5.91 The Council of Rural RDCs, the Sheepmeat Council of Australia and the NSW Farmers' Association noted that technology could be used to improve the coordination and provision of extension to rural and remote end users.⁹¹

Quality of services

- 5.92 Dr Jane Weatherley, of Meat and Livestock Australia, noted the variable quality of extension services from the private sector, and that farmers are unwilling to pay for [poor quality] services.⁹²
- 5.93 Mr Paul Morris, Acting Deputy Secretary of the DAWR, concurred that farm businesses must adjust their expectations from the free services offered by the States to the commercial model of private sector extension.⁹³
- 5.94 The AIA noted that the withdrawal of the states from extension has compounded issues of private sector service quality. Private extension

86 Australasia-Pacific Extension Network, *Submission 95*, p. 4.

87 FarmLink, *Submission 101*, p. 5.

88 University of Melbourne, *Submission 4*, p. 3.

89 University of Sydney, *Submission 40*, p. 6.

90 RIRDC, *Submission 74*, p. 6.

91 Mr Mark Harvey-Sutton, Acting Chief Executive Officer, Sheepmeat Council of Australia, *Committee Hansard*, Canberra, 3 December 2015, p. 7; Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 5.

92 Dr Jane Weatherley, Meat and Livestock Australia, *Committee Hansard*, Canberra, 3 December 2015, p. 7.

93 Mr Paul Morris, Acting Deputy Secretary, DAWR, *Committee Hansard*, Canberra, 17 March 2016, p. 5.

consultants often served in public sector positions first but this source of capacity building is no longer available.⁹⁴

- 5.95 FarmLink and the Australasia–Pacific Extension Network recommended the expansion of opportunities for formal tertiary and vocational training in extension to improve the quality and sustainability of private services.⁹⁵

Adoption

- 5.96 Evidence to the inquiry indicated that human capital matters affect the final adoption processes where end users take up new technologies.

Selection

- 5.97 The first phase of end users' adoption of innovation involves the selection of technologies which are appropriate to their business context.
- 5.98 The University of Melbourne and others identified a range of demographic, business, and social factors driving individual adoption decisions.⁹⁶ The Council of Rural RDCs recommended that extension services be tailored to the different needs and objectives of farmers.⁹⁷
- 5.99 However, submissions identified some circumstances that can unnecessarily impede the selection of new technologies for farmers.
- 5.100 Growcom, the Grains Research and Development Corporation (GRDC), and ADF-DA noted that farmers are deterred from choosing technologies by the time cost of evaluating the plethora of options available.⁹⁸
- 5.101 Some of the business and technological skills discussed earlier in this chapter would help farmers manage this process more efficiently. Additionally, Deakin University identified a role for extension agents and advisors to help match end users' needs with technological solutions.⁹⁹
- 5.102 A further adoption barrier is the lack of performance data available to inform the selection of technologies. The University of Melbourne, Charles Sturt University and ADF-DA noted that performance data from suppliers

94 Ag Institute of Australia, *Submission 73*, p. 12.

95 FarmLink, *Submission 101*, p. 6; Australasia-Pacific Extension Network, *Submission 95*, p. 8.

96 The University of Melbourne, *Submission 4*, pp. 2-3; CCA-SCA-ALFA, *Submission 84*, p. 16; Ms Hay and Mr Harrington, *Submission 91*, pp. 4-5; AWiA, *Submission 63*, p. 6.

97 Council of Rural RDCs, *Submission 90*, p. 9.

98 Growcom, *Submission 67*, p. 5; GRDC, *Submission 87*, pp. 13-14; ADF-DA, *Submission 65*, pp. 8-9.

99 Deakin University, *Submission 28*, p. 2.

is often limited or based on inapplicable field conditions and is not fully trusted by farmers.¹⁰⁰

- 5.103 Charles Sturt University, the GRDC, and the Council of Rural RDCs all recommended grower participatory approaches. These approaches make farmers partners in the evaluation process while providing the trusted local data needed to support informed decision making.¹⁰¹

Integration and use

- 5.104 The second phase of the end user adoption process involves the technology being integrated and actually used on-farm.
- 5.105 Deakin University explained that the process of integrating technologies into a farm system context adds complexity, a time cost, and a delay before the benefits of adoption are realised.¹⁰²
- 5.106 ADF-DA described the integration challenge using the example of technology 'lock out' through the incompatibility of data formats.¹⁰³ SST Software Australia noted that this problem will worsen as technologies proliferate.¹⁰⁴
- 5.107 Beyond integration, the inquiry heard that useability is key to the ongoing adoption of technologies to drive productivity improvements and growth.
- 5.108 Professor Friend described the risk that technologies are only temporarily adopted but then discontinued because benefits have not been realised to offset the cost of using the technology.¹⁰⁵
- 5.109 The GRDC explained that complexity is a defining factor in useability. It noted that complexity is a time cost for both management and labour in farm businesses. As such, simplicity, ease of use and convenience are all highly desirable factors for emerging technologies.¹⁰⁶
- 5.110 Finally, Deakin University recommended that additional effort be spent on providing useable interfaces for new technologies to promote adoption. It considered that interfaces are an often overlooked part of the development process but pose a significant adoption barrier.¹⁰⁷

100 University of Melbourne, *Submission 4*, p. 2; Charles Sturt University, *Submission 17*, p. 5; ADF-DA, *Submission 65*, p. 9.

101 Charles Sturt University, *Submission 17*, p. 5; GRDC, *Submission 87*, pp. 11-13; Council of Rural RDCs, *Submission 90*, p. 9.

102 Deakin University, *Submission 28*, p. 4.

103 ADF-DA, *Submission 65*, p. 9.

104 SST Software Australia Ltd, *Submission 13*, p. 4.

105 Professor Michael Friend, Charles Sturt University, *Committee Hansard*, Wodonga, 28 January 2016, p. 9.

106 GRDC, *Submission 87*, p. 13.

107 Deakin University, *Submission 28*, p. 5.

Support

- 5.111 A final human capital feature overlaying the adoption process is the support networks available to farm businesses. A number of submissions identified these networks as mechanisms to overcome adoption barriers.
- 5.112 The University of Melbourne identified support networks such as grower groups as drivers of adoption.¹⁰⁸ The Australasia-Pacific Extension Network expanded on their benefits:
- In addition to the research value, it appears that ... these groups provide the 'like-minded' people that farmers identify as helping to maintain motivation, provide access to other innovative farmers, and function as an effective network for information exchange and moral support.¹⁰⁹
- 5.113 The Alpine Valleys project was presented to the inquiry as a useful example of a farmers' group in action.¹¹⁰ Its membership encompasses farmers, their communities, peak bodies, milk processors, and government, all working towards increasing the sustainability of the local dairy industry.
- 5.114 One of the project's functions is accelerating the uptake of technologies and practices that will increase profitability. To this end, the project coordinators have developed a culture of information-sharing so that farmers can support one another to adopt technology. Mr Crosthwaite identified this as one of the most attractive features of the project:
- I would say that the overall response has been incredibly positive. People just want to climb on board, because the model that we have developed has been an attractive and inclusive way of people sitting around the table.¹¹¹
- 5.115 Farmers' groups may also offer benchmarking or demonstration farms where members can observe the implementation of a new technology. The Committee's site inspection of the Alpine Valleys project canvassed the sharing of experiences with technologies between farmers. Professor John Hamblin also provided examples of farming benchmarking.¹¹²
- 5.116 Mr Ian Haggerty, Manager of Prospect Pastoral Company, described the value of demonstration farms to socialising new technologies:

108 The University of Melbourne, *Submission 4*, pp. 2-3; Dr Jane Weatherley, Meat and Livestock Australia, *Committee Hansard*, Canberra, 3 December 2015, p. 7.

109 Australasia-Pacific Extension Network, *Submission 95*, p. 7.

110 Alpine Valleys project, *Submission 10*, p. 1.

111 Mr Stuart Crosthwaite, Chair, Project Steering Committee, Alpine Valleys project, *Committee Hansard*, Wodonga, 28 January 2016, p. 27.

112 Adjunct Professor John Hamblin, *Submission 3*, p. 6.

How you get that example out there is probably more demonstrations – farm examples – so people can actually see, because a lot of farmers, when they are doing something unique, do not do a lot of talking over the fence. The way agriculture is run at the moment is like the Titanic: it will take a bit to turn.¹¹³

Committee comment

- 5.117 The evidence received by the inquiry emphasised that the people of the agricultural sector are essential to converting innovation into the meaningful adoption of new technologies on farm.
- 5.118 The Committee notes the importance of ensuring that the agricultural industry can attract and retain appropriately trained and qualified people to enable the transformation of the industry through the adoption of emerging technologies. Coincidentally, it would appear that these same technologies will be the key to attracting the right people to the farm businesses of the future.
- 5.119 Access to labour is a longstanding challenge for the sector. The Committee notes that skilled labour will be particularly important to enabling increasingly sophisticated technologies. Securing the range of skills required will be a complex task, particularly as they will be in high demand in other parts of the economy.
- 5.120 The Committee commends the development of a range of creative solutions to the skills problem, from online training to multidisciplinary university courses. Future efforts should continue to make use of local leaders among women, young people and farmers' groups.
- 5.121 Another facet of the skills challenge is ensuring that the sector can access the full human capital resources available. In particular, the Committee recognises the significant contribution of women in agriculture. The Committee notes evidence that women feel they are not able to participate sufficiently in the policy- and decision-making processes of the sector.
- 5.122 It is the Committee's opinion that the Australian Government should include rural women's groups, such as Australian Women in Agriculture and the National Rural Women's Coalition, in future government-led inquiries and policy-building activities.
- 5.123 The Committee will also ensure that rural women's groups are invited to make submissions to all of its inquiries.

113 Mr Ian Haggerty, Manager, Prospect Pastoral Company, *Committee Hansard*, Wodonga, 28 January 2016, p. 17.

Recommendation 6

The Committee recommends that the Australian Government ensure that rural women's groups are included in future government-led policy-building activities and inquiries.

- 5.124 The Committee notes the challenge of securing the successful transition of farm business ownership to younger people. It commends the work of the Alpine Valleys Dairy Pathways Project to support succession planning. The Committee is also of the opinion that the Australian Government should support CSIRO research into improving succession planning.
- 5.125 The Committee notes the challenge of retaining researchers within the agricultural sector. The Committee considers this issue further in Chapter 6 and makes a recommendation which will assist in increasing the job security for researchers.
- 5.126 The Committee notes that there are Australian Government initiatives such as the Industry Skills Fund and the 457 visa scheme for skilled labour migration.
- 5.127 A shortage of unskilled labour has led to an increase in robotics and automation technology in the agricultural sector. The Committee notes the advantages that such technologies present to employers in reducing costs, improving workplace safety and the like.
- 5.128 However, the Committee acknowledges the potential impact on the unskilled, seasonal, and working holiday workforces. It encourages agricultural communities to contemplate the labour outcomes of new technology as part of regional development strategies and programs.
- 5.129 The Committee acknowledges the benefits associated with engaging school students – particularly those in rural areas – on STEM subjects, especially when taught in conjunction with agricultural applications. The Committee was encouraged by the Australian Centre of Field Robotics' 'Wallabot' project, which seeks to make low-cost robots and an associated programming interface available to rural school students to demonstrate the potential of the interface between technology and agriculture, while also teaching valuable STEM skills.
- 5.130 The Committee sees considerable scope for enhancing STEM education for future members of the agricultural industry, and sees some role for government in facilitating this.

Recommendation 7

The Committee recommends that the Australian Government target funding for the development of innovative education strategies for agriculture, within the current science, technology, engineering and mathematics funding program.

- 5.131 Evidence to the inquiry highlighted the significant shift in the provision of extension services over the past decade and its impact upon the adoption processes of farm businesses. The private sector, industry bodies and farmers' groups have stepped in to fill much of the void left by the withdrawal of state government services.
- 5.132 The Committee supports a vibrant and varied extension industry within the agricultural sector comprising a blend of private, industry and community providers as appropriate to the particular circumstances. Of particular interest is the role for RDCs and industry groups to increase coordination of extension as discussed in Chapter 6.
- 5.133 Finally, the Committee notes evidence to the inquiry which discussed the complexity of selecting, integrating and using new technologies for farmers. It supports an increased focus on useability throughout the research and development process.
- 5.134 The Committee also commends the role of farmers' groups in supporting farmers through the adoption process. In particular, it notes the value of farmers' groups as a mechanism for providing benchmarking or demonstration farms for new technologies. Such benchmarking can be difficult to establish without some external support.

Recommendation 8

The Committee recommends that the Australian Government provide assistance and support to farmers' groups to pursue farming benchmarking and support the development of national data sets.

A coordinated approach to research and development

- 6.1 Professor Mark Dodgson, of the University of Queensland, told the Committee:

Just like every other productive sector in Australia, the fundamental issue confronting innovation is how well the various parts of the chain are connected.¹

- 6.2 It was proposed that agricultural innovation be thought of as more than the adoption of new technology, but also as a 'systematic process grounded in functioning and well-orchestrated relationships between multiple stakeholders'.² Such stakeholders include farmers and communities; developers and suppliers of technology; people and organisations who educate and advise farmers; participants in the product supply chain; and policy-makers and regulators.³
- 6.3 The Committee heard evidence that some features of the current agricultural innovation system, which facilitates important relationships between industry, government and knowledge providers (universities), can be prohibitive to agricultural innovation and collaboration. The Committee also heard that innovation is being stymied by competing incentives across these key players.
- 6.4 This chapter considers the current agricultural innovation system in Australia, and the barriers this model may create in furthering agricultural innovation and adopting emerging technologies across the sector. The chapter also considers current issues that affect investment in agricultural research and development (R&D) by universities and the private sector,

1 Professor Mark Dodgson, University of Queensland, *Submission 86*, p. 1.

2 University of Melbourne, *Submission 4*, p. 1.

3 University of Melbourne, *Submission 4*, p. 1.

and the role that effective partnerships and collaboration will play in the future of agricultural innovation.

Collaboration in research and development

- 6.5 Mr Tim Lester, from the Council of Rural Research and Development Corporations (Council of Rural RDCs), stated that effective collaboration must be driven by shared purpose, as collaboration is a resource intensive exercise:

Collaborations work best when there is strategic alignment, rather than saying, 'Well, we should collaborate for the sake of it.'

Collaborating for the sake of it is just a drain on resources.

Collaboration is actually resource intensive. If you are driving purely for efficiency of outcome, then that is not necessarily going to drive a lot of collaborative behaviour either. However, there are points of strategic alignment, and we are working on those.⁴

- 6.6 Inquiry participants raised the need to facilitate and encourage more collaboration across the agricultural industry to drive further innovation. In particular, evidence suggested that more cross-sectoral collaboration was required to harness emerging technologies and boost productivity across agriculture.
- 6.7 Before considering how government might further encourage and facilitate collaboration and cooperation throughout the agricultural sector, it is first prudent to consider the collaboration on agricultural innovation currently taking place between the government, industry, and knowledge providers.

Industry collaboration

- 6.8 As outlined in Chapter 2, federal Research and Development Corporations (RDCs) and Cooperative Research Centres (CRCs) each have an important role to play in agricultural innovation.
- 6.9 RDCs are service providers to industry, creating partnerships between government and industry, and setting the direction for investment in and adoption of R&D.⁵ CRCs have a narrower role, and operate to facilitate researchers working on a specific issue within a defined period of time.⁶

4 Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 1.

5 See Council of Rural RDCs, *Submission 90*, p. 4.

6 Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 2.

In this way, each has a distinct role in driving collaboration in the agricultural sector.

- 6.10 As discussed in Chapter 2, contributions to R&D investment from industry are made through levies on production, where the Australian Government matches contributions made by industry (through RDCs) to a capped limit.⁷ As discussed below, this levy system is said to affect the levels of collaboration across the sector.

Cooperative Research Centres

- 6.11 The Committee heard evidence supporting the CRC model as an effective means of driving innovation within the agricultural sector, and facilitating collaboration across and outside the sector.

- 6.12 Professor James Rowe, Chief Executive of the CRC for Sheep Industry Innovation, considered that CRCs were an effective and transparent model that advanced innovation:

Right now, you have to explain very clearly what you will do at the end of the CRC before you start and update it every year. I really believe that it is a model that keeps everything evolving, that keeps getting better, that stays focussed on that industry-researcher partnership driven by industry.⁸

- 6.13 Professor David Lamb, Project Leader of the University of New England SMART Farm, told the Committee of his experience with a number of CRCs over 18 years:

We are cherry-picked for our specific capacity to deliver on a specific industry problem. I have found myself working with people I would never have dreamt that I would ever work with, in a collaborative environment and with an industry footprint that I would never have expected to have ...

... I would have no hesitation in suggesting that that has been a very significant set of innovations in terms of investing in R&D.⁹

- 6.14 The University of Queensland noted that CRCs are a critical source of funding for agricultural research, and that these should be fostered to enable 'longer term[,] more transformational research'.¹⁰

7 Council of Rural RDCs, 'The Rural RDC Model - funding arrangements' <www.ruralrdc.com.au/rural-innovation-in-australia/#rural-rdc-model> viewed 13 April 2016.

8 Professor James Rowe, Chief Executive Officer, CRC for Sheep Industry Innovation, *Committee Hansard*, Armidale, 13 April 2016, pp. 29, 30.

9 Professor David Lamb, Project Leader, University of New England SMART Farm, *Committee Hansard*, Armidale, 13 April 2016, p. 30.

10 University of Queensland, *Submission 2*, p. 1.

- 6.15 CRCs are considered to be an effective vehicle for generating new technologies and new knowledge.¹¹
- 6.16 Australian Pork Limited submitted that collaboration was part of the pork industry's culture, through its involvement with the CRC program (through two iterations of the Pork CRC), as well as the RDC and Rural R&D for Profit Programme – the latter of which are discussed further below.¹²
- 6.17 Mr Darryl D'Souza, of Australian Pork Limited, explained that the biggest areas of learning flowing from the two CRCs had been the industry collaboration with Australian Pork Limited and the CRCs themselves:
- The proof in the pudding for us, at the end of this CRC, which is 2018–19, is the industry partners have come out and said, 'This is a pretty good model, in terms of you having pretty competitive research being undertaken.'¹³
- 6.18 Mr Michael Keogh, Executive Director of the Australian Farm Institute, submitted that the finite life of CRCs was one of the weaknesses of the CRC model, noting that setting up a CRC was resource intensive:
- ... it lasts perhaps seven years and then the tent folds up and the circus moves on.¹⁴
- 6.19 Professor Lamb stated that, as CRCs had a finite life, gaps left by a CRC's conclusion needed to be addressed.¹⁵

Research and Development Corporations

- 6.20 Much of the evidence regarding how innovation is facilitated within the agricultural sector has been focussed around the operation of RDCs.
- 6.21 It was submitted that the current system of agricultural innovation operates in a traditional, linear way that discourages innovation outside the RDC structure, and encourages the creation of silos throughout the sector based on industry groups.

11 Professor Anthony Sorensen, *Committee Hansard*, Armidale, 13 April 2016, p. 30.

12 Australian Pork Limited, *Submission 70*, p. 4.

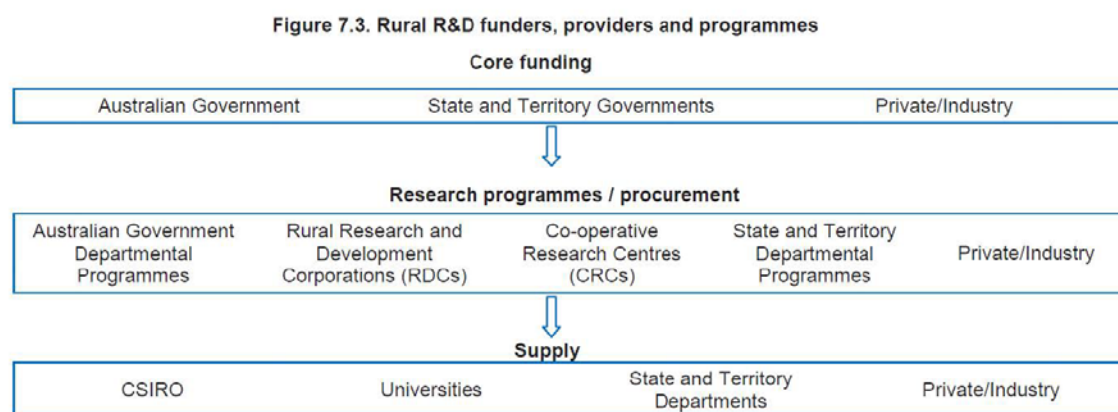
13 Mr Darryl D'Souza, General Manager, Research and Innovation, Australian Pork Limited, *Committee Hansard*, Canberra, 29 February 2016, p. 2.

14 Mr Michael Keogh, Executive Director, Australian Farm Institute, *Committee Hansard*, Sydney, 14 April 2016, p. 5.

15 Professor David Lamb, Project Leader, University of New England SMART Farm, *Committee Hansard*, Armidale, 13 April 2016, p. 30. See also, Mr Darryl D'Souza, General Manager, Research and Innovation, Australian Pork Limited, *Committee Hansard*, Canberra, 29 February 2016, p. 6.

6.22 The Commonwealth Scientific and Industrial Research Organisation (CSIRO) illustrated the linear model of innovation R&D, through a table which is replicated in Figure 1.

Figure 1 Rural research and development funders, providers and programmes



CSIRO: Commonwealth Scientific and Industrial Research Organisation.

Source: Productivity Commission (2011), *Rural Research and Development Corporations*,

<http://www.pc.gov.au/projects/inquiry/rural-research>.

Source CSIRO, *Submission 55*, p. 12, Figure 2.

6.23 Several submissions suggested that the adoption of innovation is being impeded by the RDC model, whereby RDCs are funded by levies on a specific commodity. This barrier is discussed below.

6.24 While accepting the value of the RDC system in providing important links between government and individual industry groups, CSIRO explained that the need to provide general outputs for all levy payers meant that tailored solutions for farming were limited, as research was only as specific or general as the commodity being served. In this way, levy-funded research would generally not address niche or cross-sectoral problems or wider system improvement.¹⁶

6.25 Southern Farming Systems and the Australian Controlled Traffic Farming Association suggested that the RDC structure:

... is an impediment to farming systems groups banding together, identifying priorities, monitoring and controlling the research and commercialising the outcomes.¹⁷

6.26 This point was illustrated by Professor Michael Friend, of Charles Sturt University, who told the Committee that the current system struggled to cope with cross-industry, integration, and sustainability issues:

16 CSIRO, *Submission 55*, p. 13; Dr Graham Bonnet, Research Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 9.

17 Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61.1*, p. 4.

If you try to work with GRDC [Grains Research and Development Corporation] to get a project up, they are interested in the grain outcome. If you are working with MLA [Meat and Livestock Australia], they are interested in the meat outcome and so on, whereas the majority of farmers we deal with have mixed farms. You can pull one lever in terms of grain or you can pull another lever for meat, but often the biggest outcomes at the farm financial performance level can come from the integration of the different bits of the system. Quite often it is not in the interests of the RDCs to look at that sort of integration approach, although they are starting to recognise that.¹⁸

- 6.27 CSIRO noted that under the current system, one levy payer's dollar could effectively leverage multiple additional dollars into the RDC system, in matching government funding, through publicly funded RDCs, entities like CSIRO, the university sector and CRCs. While advantageous for RDC-led innovation, this leveraging effect could pull resources away from other parts of the sector, making it difficult to promote innovation through any projects outside the RDC system.¹⁹

Cross-sectoral collaboration

- 6.28 The Committee was told that the current agricultural innovation system favours short-term, sector-specific research.²⁰ However, inquiry participants submitted that addressing cross-sectoral priorities through collaboration could increase the efficiency and effectiveness of R&D investments.²¹
- 6.29 Examples of important cross-sectoral priorities that have been identified include issues of climate change, soils, and water.²²
- 6.30 AusBiotech suggested that initiatives that support consolidation, cooperation and collaboration between sectors would help to reduce duplication. Further, they could enhance synergies where familiar challenges and barriers to adoption exist across the industry.²³

18 Professor Michael Friend, Charles Sturt University, *Committee Hansard*, Wodonga, 28 January 2016, pp. 35-36, 37.

19 Dr Daniel Walker, Research Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, pp. 1-2.

20 See, for example, the University of Melbourne, *Submission 4*, p. 5; Australian Academy of Science as cited by Grain Trade Australia, *Submission 21*, p. 2; The University of Queensland, *Submission 2*, pp. 1-2.

21 See, for example, Council of Rural RDCs, *Submission 90*, p. 8.

22 Mr Phillip Glyde, DAWR, *Committee Hansard*, Canberra, 12 November 2015, p. 4.

23 AusBiotech, *Submission 33*, p. 6.

- 6.31 The model for collaboration between key players in the agricultural innovation system – for example, CSIRO, the RDCs, and the private sector – has evolved over time. Dr Graham Bonnet from CSIRO argued that where collaboration was previously organic, and players sought outside assistance on an as-needed basis, this was no longer viable in many cases, as resources were already leveraged into other activities.²⁴ Dr Bonnet explained:
- I think there is a tightness in the system that is not allowing that organic collaboration, and so the concentration, rather than being on the outcome, comes onto the resources to further the outcome.²⁵
- 6.32 The University of Melbourne raised the need to support the use of multi-disciplinary and trans-disciplinary R&D teams to address the adaptation challenge of agricultural technologies and their interaction with sectors outside agriculture.²⁶
- 6.33 The University submitted that, as a result of not supporting such systems, important issues such as farmer interfaces, useability of new technologies, and ‘system integration’ between the paddock and the value chain were not being included in research designs, and were considered too late in the innovation process.²⁷
- 6.34 Mr Kim Russell, from Southern Farming Systems, stated that there were many opportunities to work with cross-sectoral groups, as a means of sharing and adopting innovations. Mr Russell gave the example of their recent adoption of new methods for composting, which resulted in significant improvements in productivity. Mr Russell considered that involving farming systems groups in managing and commercialising innovation or directing research projects would be helpful.²⁸
- 6.35 Murdoch University contended that national governments retain a pivotal role in nurturing collaborations between higher education institutions, industry, and international partners.²⁹ Specifically, it was argued that a national government’s facilitative role should not be restricted to investment in scientific research, but that it should include helping to

24 Dr Graham Bonnet, Research Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 2.

25 Dr Graham Bonnet, Research Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 2.

26 University of Melbourne, *Submission 4*, p. 4.

27 University of Melbourne, *Submission 4*, p. 4.

28 Mr Kim Russell, Southern Farming Systems, *Committee Hansard*, Canberra, 22 February 2016, pp. 3–4.

29 Murdoch University, *Submission 37*, p. 1.

facilitate intellectual property, growers' rights, and commercialisation as well as knowledge transfer between sectors and between countries.³⁰

Rural Research and Development for Profit Programme

- 6.36 A number of inquiry participants identified the Rural Research and Development for Profit Programme, outlined in Chapter 2, as a current example of cross-sectoral collaboration on innovation.³¹
- 6.37 The Council of Rural RDCs submitted that the program allowed RDCs to collaborate with one another, as RDCs were working together on project bids in precision agriculture, transformative technologies, digital agriculture, and automation. The Council advised that 12 projects were approved under the first round of the program, with most projects directly pursuing the implementation of new technologies for improved industry efficiency and productivity. More than 35 project partner organisations, in addition to the RDCs, are expected to be involved in the delivery of the projects.³²
- 6.38 Dr Stephen Thomas, of the Grains Research and Development Corporation (GRDC), was in favour of the program as a means of providing incentives for cooperation, and to identify gaps that require further R&D.³³
- 6.39 Dr Alex Ball, from Meat and Livestock Australia, considered that the Rural R&D for Profit Programme facilitated collaboration between RDCs that would normally not collaborate. Dr Ball provided the example of the customer and consumer insights program, a collaborative program across several RDCs, which also involved about eight private providers. Dr Ball highlighted the potential benefits of this type of model:
- ... the technology we develop today has a real-time impact tomorrow because the people who are investing in the program in the R&D are actually going to see the outcomes coming straight out. We would not have had that opportunity if we had not had that type of structure.³⁴

30 Murdoch University, *Submission 37*, p. 1.

31 See, for example, Mr Darryl D'Souza, General Manager, Research and Innovation, Australian Pork Limited, *Committee Hansard*, Canberra, 29 February 2016, p. 5; Dr Nicola Cottee, Policy Officer, Research Direction and Stewardship, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 8.

32 Council of Rural RDCs, *Submission 90*, p. 8.

33 Dr Stephen Thomas, Chief Operating Officer, Grains Research and Development Corporation, *Committee Hansard*, Canberra, 29 February 2016, p. 14.

34 Dr Alex Ball, General Manager, Red Meat Innovation, Meat and Livestock Australia, *Committee Hansard*, Canberra, 3 December 2015, p. 8.

Committee comment

- 6.40 The Committee notes evidence suggesting that the current agricultural innovation system, centred on the operation of RDCs, can stymie innovation by encouraging a silo mentality among industry groups, and creating a disjointed and disconnected sector, at the cost of broader, cross-sectoral innovation.
- 6.41 The Committee also notes calls for further cross-sectoral collaboration within and beyond the agricultural sector, to seize opportunities relating to emerging technologies with application across the sector.
- 6.42 For example, the Committee heard evidence relating to emerging technology relevant to the agricultural sector, in the area of soil management. Specifically, the United States Studies Centre at the University of Sydney considered that ‘improved soil management provides the biggest single opportunity to dramatically increase agricultural productivity’, and yet was a ‘forgotten resource’ in agricultural research and development.³⁵
- 6.43 The Committee considers soil management to be an example of an important issue with relevance across the agricultural sector, and thus an area with opportunities for cross-sectoral innovation.
- 6.44 The Committee further acknowledges the examples provided of successful models for facilitating cross-sectoral collaboration and innovation, including the CRC Programme and the Rural R&D for Profit Programme.
- 6.45 The Committee considers that RDCs have a pivotal role in facilitating collaboration within industry sectors, and notes their ongoing importance in linking industry to government and knowledge providers in the innovation process. RDCs ensure that innovation is industry-led, and assist in facilitating the adoption of emerging technologies, by working to provide industry with information and education on the application of new technologies at the farm gate.
- 6.46 However, the Committee notes that due to the nature of RDCs, there appears to be a focus on RDC-driven research, related to a particular commodity or industry, at the expense of cross-sectoral innovation.
- 6.47 The Council of Rural RDCs, in representing the 15 RDCs, indicated that it is currently undertaking work to harness the combined resources of the RDCs and find areas of common interest where collective effort will achieve gains for the whole sector. The Committee encourages continuation of the Council’s work in this area.

35 The United States Studies Centre at the University of Sydney, *Submission 39*, p. 3.

- 6.48 The Committee also notes that CRCs, as part of the CRC Programme within the Australian Government's National Innovation and Science Agenda and the Rural R&D for Profit Programme, have also played a significant role in harnessing cross-sectoral collaboration and driving the development of new technologies for the benefit of the agricultural sector.
- 6.49 On evidence provided to the Committee, the CRC model has been proven to facilitate industry-led collaboration between researchers, industry and communities for the benefit of the agricultural sector as a whole. The Committee is confident that further investment in the CRC model will strengthen its capacity to contribute to cross-sectoral, collaborative research on agricultural innovation.
- 6.50 Evidence throughout the inquiry revealed broad support for the outcomes of CRCs and for the continuation of the CRC model. The Committee notes that the CRC Programme was established in 1990 and that, at the time of writing, the selection process for the 18th round of CRCs is underway. However, in evidence to the inquiry, there appeared to be some apprehension among stakeholders that the future of the CRC model was not certain. Therefore, some reassurance about the intended future of the CRC model would be beneficial.
- 6.51 The Committee recognises the significant benefits of the CRC model and its ability to attract cross-sectoral support and investment, including from RDCs. The Committee also supports the development of incentives to ensure that CRCs are well resourced, including through industry, and sees a role for government in facilitating this.

Recommendation 9

The Committee recommends that the Department of Agriculture and Water Resources, in conjunction with the Department of Industry, Innovation and Science, investigate establishing appropriate incentives for the greater allocation of resources from rural Research and Development Corporations to relevant Cooperative Research Centres.

- 6.52 The Committee expects that this recommendation will enhance contributions from the private sector, enabling CRCs to maximise the outcomes of available funding and create longer-term revenue streams. This may assist in effectively lengthening the funding cycle and providing longer-term focus to research priorities.

- 6.53 Evidence to the inquiry also addressed the relatively short funding cycles for research grants, including those through the Australian Research Council. The Committee considers that three year grants are too short to effectively support innovation in agriculture, and instead favours four to five year cycles. Longer funding cycles would also help to address concerns about career paths for researchers and retention of talent, discussed in Chapter 5.

Recommendation 10

The Committee recommends that the Australian Research Council review its programs for funding research, with a view to increasing the duration of grants to be at least five years.

A partnership approach

- 6.54 The Committee heard evidence that a stronger partnership approach to agricultural innovation is fundamental to improving innovation performance.³⁶
- 6.55 CSIRO stated it had observed a general degradation of effective partnerships in the agricultural sector, in an environment where activities are short-term, project-based, and transactional. CSIRO submitted that this has produced a purchaser-provider relationship, rather than a more dynamic partnering culture.³⁷
- 6.56 Professor Friend advised that industry partnerships are important to Charles Sturt University's work in agricultural innovation – whether that be with farmers' groups or multinational companies – because those partnerships are important for increasing their chance of research outcomes being adopted.³⁸
- 6.57 Mr Tim Neale, Manager of Precision Agriculture Pty Ltd, argued that successful public-private agreements must engage private companies as 'true partners' from the beginning of the innovation process.³⁹

36 CSIRO, *Submission 55*, p. 14.

37 CSIRO, *Submission 55*, p. 14.

38 Professor Michael Friend, Director, Graham Centre for Agricultural Innovation, Charles Sturt University and NSW Department of Primary Industries, *Committee Hansard*, Wodonga, 28 January 2016, p. 33.

39 Mr Tim Neale, Manager, Precision Agriculture Pty Ltd, *Committee Hansard*, Armidale, 13 April 2016, pp. 6-7.

- 6.58 Charles Sturt University noted that one-third of its external research funding comes from partnerships with industry (double the sectoral average), and includes ongoing research collaborations through RDCs, farming systems groups, multinationals, peak bodies, and state governments.⁴⁰
- 6.59 CSIRO called for a reframing of partnerships with research providers, where ‘participation is priced on value and outputs (and not on inputs), with shared income streams from the value that is created.’⁴¹
- 6.60 CSIRO detailed the example of innovation within the Australian cotton industry, where there was a ‘virtuous circle between public and private interests’.⁴² Similarly, several inquiry participants praised the partnership between GRDC and Bayer CropScience as a further example of a successful public-private partnership where individual groups see a common goal and work together to achieve an outcome of mutual benefit.⁴³
- 6.61 Both of these case studies are discussed below.

A case study: Cotton

- 6.62 Cotton variety breeding is carried out by a private-public partnership – Cotton Breeding Australia (CBA) – between Cotton Seed Distributors and CSIRO.⁴⁴
- 6.63 CSIRO outlined some of the positive features of the partnership, which include:
- value-based pricing of technology innovations is reinvested by CSIRO and CBA in long-term R&D;
 - the Cotton RDC adds value, without seeking to dominate and control the innovation ecosystem;
 - the industry has a strong leadership with coherent common interests; and
 - the partnership takes a value chain approach that focusses on a differentiated high value quality end product, achieved via multi-

40 See Charles Sturt University, *Submission 17*, p. 1.

41 CSIRO, *Submission 55*, p. 14.

42 CSIRO, *Submission 55*, p. 14.

43 Associate Professor Daniel Tan, Director, Australian Institute of Agricultural Science and Technology, The University of Sydney, *Committee Hansard*, Sydney, 14 April 2016, p. 9; Dr Broughton Boydell, *Committee Hansard*, Sydney, 14 April 2016, p. 41; Mr Matthew Cossey, Chief Executive Officer, Croplife Australia, *Committee Hansard*, Canberra, 22 February 2016, p. 14.

44 CSIRO, *Submission 55*, p. 14.

disciplinary teams extending from plant breeding to farm management to textile science.⁴⁵

A case study: GRDC and Bayer partnership

6.64 The GRDC recently collaborated with Bayer CropScience in the 'Herbicide Innovation Partnership', whereby the GRDC committed \$45 million over five years, and Bayer CropScience committed to increase its herbicide discovery and optimisation program with a focus on Australian cereal farming systems, Australian weeds and early testing of promising new chemistries in Australian field trials.⁴⁶

6.65 The GRDC said of the partnership:

It is expected that the collaboration will yield new chemistries for Australian conditions and released in Australia at least at the same time as our international competitors. Given the extremely high cost of weed control in Australian cropping systems, any new chemistry delivered even one or two years earlier to Australia will have significant production efficiency outcomes for Australian growers.⁴⁷

6.66 This model was praised as an example of a public-private partnership that would result in productivity gains for Australian agriculture.⁴⁸

6.67 Mr Richard Dickmann, Chief Executive of Bayer CropScience, suggested that partnering in global consortia 'is now an indispensable route to accessing global technologies', however noted that recent reports suggested that Australian was lagging in these areas:

We are last amongst OECD countries in terms of collaboration between universities and business, and we are third-last in terms of global collaborations amongst the OECD. I think you have seen the figures: we are 10th in R&D investment, we are 81st in terms of innovation efficiency, and recently The Economist indicated that only one to two per cent of Australian companies – and this is broadly across the economy – are said to be innovating.⁴⁹

45 CSIRO, *Submission 55*, p. 14.

46 GRDC, *Submission 87*, pp. 12-13.

47 GRDC, *Submission 87*, pp. 12-13.

48 Mr David McKeon, General Manager, Advocacy and Policy, Grain Growers Ltd, *Committee Hansard*, Canberra, 22 February 2016, p. 6. See also, ABC, 'Grains Research and Development Corporation teams up with global chemical giant to fight weeds and herbicide resistance' <www.abc.net.au/news/2015-06-02/grdc-bayer-sign-deal-to-tackle-herbicide-resistance/6515536> viewed 15 April 2016.

49 Mr Richard Dickmann, Head, New Business Development, Bayer Crop Science Pty Ltd, *Committee Hansard*, Canberra, 29 February 2016, p. 17.

- 6.68 Mr Dickmann submitted that for Australia to attract investment from global companies requires Australia to establish and maintain itself as a world leader in agricultural research. This requires consistency of investment in CSIRO and systems that support university research; strengthening policy settings around the commercialisation of research; sending consistent messages around international collaboration; removing regulatory barriers to innovation; and adhering strictly to the science based approach to assessing new technologies.⁵⁰

Committee comment

- 6.69 The Committee heard about a number of successful partnerships that have developed between industry, private sector, knowledge providers, government, farming groups, and communities.
- 6.70 The Committee supports the continued development of public-private partnerships, and partnerships between knowledge providers and industry groups. It is clear that with a common goal in mind, partnerships can drive innovation and achieve enormous gains for the Australian agricultural sector.
- 6.71 Where possible, the Committee encourages government to continue to support such partnerships, through programs and initiatives such as the CRCs, the Rural R&D for Profit Programme, and through RDCs.
- 6.72 The Committee is of the view that establishing clear national leadership on agricultural innovation will go some way to facilitating further successful public-private partnerships in the future.

National research and development priorities

- 6.73 Professor Edward Barlow, of the Australian Academy of Technological Sciences and Engineering (ATSE), told the Committee that the agricultural innovation system is diverging, because three of the key players – the university sector, CSIRO, and the state agriculture departments – are all headed in different directions.⁵¹
- 6.74 CSIRO agreed there was a lack of connectedness between the key players, and an over-emphasis on on-farm production at the expense of value

50 Mr Richard Dickmann, Head, New Business Development, Bayer Crop Science Pty Ltd, *Committee Hansard*, Canberra, 29 February 2016, p. 17.

51 Professor Edward (Snow) Barlow, Deputy Chair, Agriculture Forum, Australian Academy of Technological Sciences and Engineering, *Committee Hansard*, Canberra, 29 January 2016, p. 19.

- chains, business innovation, cross commodity issues, and farming systems.⁵²
- 6.75 Associate Professor Ruth Nettle, of the University of Melbourne, suggested that leadership around managing the innovation process and the sectors, by 'directing traffic and shaping', was important in achieving productivity outcomes.⁵³
- 6.76 Referring to biosecurity, the Plant Biosecurity CRC submitted that national and coordinated leadership was needed to ensure strategic and efficient investment in innovation, infrastructure and capability, and to underpin the productivity of Australian agriculture for the future.⁵⁴
- 6.77 Professor Nettle outlined a New Zealand government-funded initiative with co-investment by most of the industry bodies in New Zealand (for example, horticulture, dairy and forestry). The objective of the initiative was to assess methods for innovation across all agricultural sectors, and to examine the whole innovation system for primary industries.⁵⁵
- 6.78 Professor Friend considered that some form of overarching government leadership may be necessary to link the different segments of the sector. For this to be successful, buy-in would be required from all of the peak bodies, the RDCs, and representatives of the different research organisations. However, achieving such buy-in would be challenging due to the many vested interests involved.⁵⁶
- 6.79 AusBiotech praised the development of long-term sector priorities, which could be seen in the development of the National Primary Industries RD&E Framework (the Framework) as outlined in Chapter 2. AusBiotech stated that the Framework has led to a national approach to developing sector priorities and has helped to align RD&E activities with these sector priorities.⁵⁷
- 6.80 Mr Tim Lester, of the Council of Rural RDCs, told the Committee that the Council actively engages with others within the Framework:
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52 Dr Michael Robertson, Science Director, Agriculture, CSIRO, *Committee Hansard*, Canberra, 26 November 2015, p. 1.

53 Associate Professor Ruth Nettle, Leader, Rural Innovation Research Group, Faculty of Veterinary and Agricultural Sciences, University of Melbourne, *Committee Hansard*, Canberra, 29 January 2016, p. 50.

54 Plant Biosecurity Cooperative Research Centre, *Submission 36*, p. 8.

55 Associate Professor Ruth Nettle, Leader, Rural Innovation Research Group, Faculty of Veterinary and Agricultural Sciences, University of Melbourne, *Committee Hansard*, Canberra, 29 January 2016, p. 49.

56 Professor Michael Friend, Charles Sturt University, *Committee Hansard*, Wodonga, 28 January 2016, p. 36.

57 AusBiotech, *Submission 33*, p. 6. See also, National Primary Industries RD&E Framework, <www.npirdef.org> viewed 16 April 2016.

We come together quite regularly with our state and territory colleagues to talk with the Commonwealth on how do we drive alignment, where are the opportunities and where we will take it. They are important questions. It is not an easy process, but I think we are getting better at it.⁵⁸

6.81 However, AusBiotech noted the Framework has had mixed success in enhancing cross-sector cooperation, despite this being a primary objective:

Whilst in general the Framework led to the development of good sector-specific strategies, the performance of some strategies was found by the Allan Consulting Group to be disappointing. Many of the sectors have not published updated strategies since their initial commissioning in 2010.⁵⁹

6.82 AusBiotech suggested that the limited success of cross-sectoral cooperation could be due to sector leaders' responsiveness to their stakeholders (that is, levy payers) and the inherent incentives for sector leaders to pursue activities directly benefiting their sector, rather than those cross-sectoral activities that may indirectly benefit their sector.⁶⁰

6.83 CSIRO raised concerns about the current performance of the agricultural innovation system. The organisation argued for a closer examination of the contemporary and future needs of the agri-food innovation system, having regard to a number of factors, including the national innovation agenda, emerging market opportunities, and changing patterns of competitive pressures in global agriculture.⁶¹

6.84 To address these concerns, CSIRO recommended the creation of a national leadership forum, or national working group on agricultural innovation, focussed on improving the functionality of the agri-food/fibre innovation system, with evidence-based leadership inputs from government, industry and knowledge institutes.⁶²

6.85 The proposed working group would conceive and describe one or more models of the agri-food innovation system to meet Australia's needs in 2030. CSIRO envisaged that the group would consist of a diverse set of perspectives, with representatives of institutions such as the National Farmers Federation, the Australian Food and Grocery Council, CSIRO, the

58 Mr Tim Lester, Operations Manager, Council of Rural RDCs, *Committee Hansard*, Canberra, 25 February 2016, p. 2.

59 AusBiotech, *Submission 33*, p. 6.

60 AusBiotech, *Submission 33*, p. 6.

61 CSIRO, *Submission 55.1*, p. 1.

62 CSIRO, *Submission 55.1*, p. 1.

Australian Farm Institute, and relevant Australian Government Departments.⁶³

- 6.86 Specifically, outputs of the proposed working group would be:
- overarching options for the future structure and function of Australia's agri-food innovation system with particular emphasis on innovative models for the interaction of RD&E with agriculture and on cross-sector, value chain and whole of system performance metrics;
 - description of the roles and responsibilities of the types of organisations expected to be involved in the proposed models; and
 - options for exploring the transition from the current state to the proposed future agri-food innovation system architecture.⁶⁴

Committee comment

- 6.87 The Committee heard evidence that there is a lack of clear leadership and connectedness between the key players within the agricultural innovation system, which was a barrier to whole-of-sector innovation.
- 6.88 While it is clear that there are successful links between key players across the different industry groups, the Committee notes the view that national leadership is needed to connect the industry groups and develop strategies for whole-of-sector innovation and reform.
- 6.89 The Committee notes evidence about the mixed success of attempts at establishing national priorities for RD&E, including the National Primary Industries RD&E Framework.
- 6.90 The Committee notes with interest CSIRO's proposals for the establishment of a national forum or working group, to consider longer-term and 'whole of system' performance issues across the agricultural sector, and to explore a future innovation system capable of maintaining Australia's competitive position in agricultural innovation, in an era of rapid global change.
- 6.91 The Committee considers the National Primary Industries RD&E Framework to be an important framework within which Commonwealth and state and territory governments can work with industry partners and knowledge providers to set national priorities and goals for agricultural innovation.
- 6.92 However, the Committee considers that there may be benefit in a detailed consideration of the agricultural innovation system. The Committee therefore supports CSIRO's proposal to develop a national working group

63 CSIRO, *Submission 55.1*, p. 2.

64 CSIRO, *Submission 55.1*, p. 2.

on agricultural innovation, with a view to addressing longer-term and whole of system issues.

- 6.93 The Committee is of the view that such a working group should form part of a strategy established through the National Primary Industries RD&E Framework, and should be supported by a secretariat within the Department of Agriculture and Water Resources.

Recommendation 11

The Committee recommends that the Australian Government develop a national working group on agricultural innovation, focused on improved functionality of the agrifood/fibre innovation system. This working group should be developed as part of a wider strategy of cross-sectoral agricultural innovation, within the National Primary Industries RD&E Framework.

Regulation

- 7.1 In addition to the barriers to agricultural innovation discussed in the previous chapters, the Committee also heard evidence about the role of regulation in supporting or inhibiting the adoption of innovative practices and new and emerging agricultural technology.
- 7.2 This chapter presents a brief overview of the existing regulatory framework as it applies the agricultural sector. Evidence is then presented in relation to the regulation of several key areas of agricultural technology.
- 7.3 This chapter also presents evidence in relation to community acceptance of emerging technology in the agricultural sector.

Overview of existing regulatory framework

- 7.4 In a previous review of government regulation in the agricultural sector, the Productivity Commission identified regulatory requirements at each stage of production.¹
- 7.5 These requirements related to the acquisition and preparation of land; on-farm operations such as cropping, animal husbandry, and processing; transportation; marketing; and the sale of agricultural goods.
- 7.6 The Commission also identified other regulations that apply across the economy but are nevertheless particularly relevant to agricultural production, such as regulations covering chemicals, water use, food, and temporary labour.
- 7.7 The Commission noted that, while state and territory governments are most closely involved with the sector due to their responsibility for land and natural resource management, federal regulation is responsible for

1 Productivity Commission, *Annual Review of Regulatory Burdens on Business: Primary Sector*, Research Report, 2007, pp. 29–32.

supporting the profitability and competitiveness of the sector, in addition to ensuring environmental and biosecurity protections.

- 7.8 In the current inquiry, a range of evidence was put to the Committee about the appropriateness of the existing regulatory environment.
- 7.9 However, there was general agreement among stakeholders about the important role of an effective regulatory environment in supporting innovation in the agricultural sector. AusBiotech told the Committee:

The application of good regulation is critical to build confidence and certainty and underpins public investment in agricultural innovation. Ambiguous or absent regulation elevates risk and is a strong barrier to innovation.²

Productivity Commission review into Regulation of Agriculture

- 7.10 In November 2015, the Australian Government requested that the Productivity Commission undertake a new inquiry into the regulatory burden imposed on farming businesses.³
- 7.11 The terms of reference of the Commission's inquiry have regard to regulation that has a material impact on domestic and international competitiveness of farm businesses and the productivity of Australian agriculture.
- 7.12 While the Commission is expected to consider regulatory arrangements affecting access to new technology, the terms of reference of its inquiry also encompass a wide range of regulation affecting investment, land tenure, environmental protection, and animal welfare, among other areas.
- 7.13 Consistent with the terms of reference of the present inquiry, the Committee will restrict its focus to particular areas of regulation identified in evidence as having the potential to impede the adoption of innovative agricultural practices and emerging agricultural technology.
- 7.14 As such, evidence presented in this chapter relates to the regulation of the following areas of agricultural activity:
- agricultural and veterinary chemicals;
 - gene technology; and
 - drones and robotics.

2 AusBiotech, *Submission 33*, p. 2.

3 Productivity Commission, 'Regulation of Agriculture' <www.pc.gov.au/inquiries/current/agriculture> viewed 7 April 2016.

Agricultural and veterinary chemicals

- 7.15 Agricultural and veterinary chemical products in Australia are regulated under an intergovernmental agreement to ensure that products are safe, effective, and labelled and packaged correctly.⁴
- 7.16 The Australian Pesticides and Veterinary Medicines Authority (APVMA) is an independent statutory authority within the Agriculture portfolio responsible for the registration and regulation of agricultural and veterinary chemical products up to the point of retail sale.⁵
- 7.17 State and territory governments regulate and control the use of these products in each jurisdiction.⁶
- 7.18 The Committee heard evidence about the role of agricultural and veterinary chemical products in increasing on-farm productivity. For example, Bayer CropScience submitted:
- ... crop protection and biotechnology solutions can assist farmers in producing high yields with fewer natural resources by reducing water consumption, increasing a crop's nutrient uptake, and reducing the need for other inputs.⁷
- 7.19 However, although there was strong support for the role of the APVMA, the Committee heard that a range of regulatory processes were impeding the timely availability and use of agricultural and veterinary chemical products in the Australian market.
- 7.20 Bayer submitted that excessive regulation increases the pre-market barrier for innovative new products, meaning that fewer products are ultimately registered and approved for use.⁸
- 7.21 Representatives of CropLife Australia outlined the consequences for the competitiveness of the Australian agricultural industry:
- We know from our research that [the unavailability of chemical products] stops [farmers] looking at growing alternative crops or products.

4 DAWR, 'The National Registration Scheme' <www.agriculture.gov.au/ag-farm-food/ag-vet-chemicals/regulation> viewed 8 April 2016.

5 Ms Kareena Arthy, Chief Executive Officer, APVMA, *Committee Hansard*, Canberra, 17 March 2016, p. 7.

6 Ms Kareena Arthy, Chief Executive Officer, APVMA, *Committee Hansard*, Canberra, 17 March 2016, p. 7.

7 Bayer CropScience, *Submission 78*, p. 3.

8 Bayer CropScience, *Submission 78*, p. 15.

It restricts Australian farmers from being able to make the same decisions about their businesses as American, European, or Brazilian farmers.⁹

- 7.22 Stakeholders emphasised that reducing inefficiencies and regulatory burdens was particularly important given the relatively small size of the Australian market for certain speciality products.¹⁰

Product registration

- 7.23 The Committee heard evidence about the length, cost, and complexity of the process for registering agricultural and veterinary chemical products in Australia.
- 7.24 Bayer submitted that the APVMA regularly missed prescribed deadlines for deciding upon applications for new crop protection products.¹¹ Bayer also noted that the Department of Health currently reviews the poison scheduling of products at the end of the APVMA registration process, rather than in parallel, adding a minimum of eight months to the process.¹²
- 7.25 CropLife submitted that the costs imposed by the regulation of chemical products in Australia were equal to the United States but relatively high compared with other countries, and high relative to the size of the Australian market.¹³ CropLife suggested that the cost of registration under the current system restricts the availability of products for specialty and minor uses, as the expected volume of sales of these products does not offset the cost of registration or of extending labels to include new uses for existing products.¹⁴
- 7.26 Other issues raised in evidence included a lack of flexibility to submit data during the review process, inconsistency in state and territory regulation of off-label uses of chemical products, and burdens imposed by other

9 Mr Matthew Cossey, Chief Executive Officer, CropLife Australia, *Committee Hansard*, Canberra, 22 February 2016, p. 14.

10 Adjunct Professor John Hamblin, *Submission 3*, p. 7; CCA-SCA-ALFA, *Submission 84*, p. 15; Mr Matthew Cossey, Chief Executive Officer, CropLife Australia, *Committee Hansard*, Canberra, 22 February 2016, pp. 12–13; Mr Richard Dickmann, Head, New Business Development, Bayer CropScience, *Committee Hansard*, Canberra, 29 February 2016, p. 19.

11 Bayer CropScience, *Submission 78*, p. 15.

12 Mr Richard Dickmann, Head, New Business Development, Bayer CropScience, *Committee Hansard*, Canberra, 29 February 2016, p. 19.

13 Mr Matthew Cossey, Chief Executive Officer, CropLife Australia, *Committee Hansard*, Canberra, 22 February 2016, p. 14.

14 CropLife Australia, *Submission 50*, p. 14.

government entities requesting data above and beyond what is requested by the APVMA.¹⁵

7.27 Several stakeholders recommended that the APVMA recognise assessments already undertaken by trusted international organisations in order to streamline the process of registering chemicals and pesticides for use in the Australian market.¹⁶

7.28 CropLife suggested that, while duplication between the APVMA and overseas regulators could be reduced, recognition of overseas decisions would not necessarily be automatic:

Farming practices are different and the environmental circumstances are different. That is where an Australia-specific assessment is required. But ... adopting the things that are common and not replicating that work is crucial to delivering efficiency.¹⁷

7.29 At a public hearing of the inquiry, representatives of the APVMA acknowledged that alternative or minor uses of products are potentially beneficial to farmers, but that these uses are often unavailable in Australia due to the cost of registration:

... sometimes we are in a situation where they are very close to access, but that final research and development that might be required locally to get it across the line, or the business case for the company, does not stack up.¹⁸

7.30 The representatives told the Committee that the APVMA was investigating options to streamline the product registration process:

We are currently doing a lot to work around how we can speed up the time it takes for registration – in particular, how we can use international assessments and reduce the time it takes for products of low regulatory risk.¹⁹

15 Larkman Nurseries Pty Ltd, *Submission 51*, p. 2; Bayer CropScience, *Submission 78*, p. 17; Council of Rural RDCs, *Submission 90*, p. 10; Mr Richard Dickmann, Head, New Business Development, Bayer CropScience, *Committee Hansard*, Canberra, 29 February 2016, p. 19.

16 Pastoralists and Graziers Association of WA Inc., *Submission 16*, p. 2; CCA-SCA-ALFA, *Submission 84*, p. 15.

17 Mr Matthew Cossey, Chief Executive Officer, CropLife Australia, *Committee Hansard*, Canberra, 22 February 2016, pp. 12–13.

18 Ms Kareena Arthy, Chief Executive Officer, APVMA, *Committee Hansard*, Canberra, 17 March 2016, p. 8; Mr Alan Norden, Executive Director, Registration Management and Evaluation Program, APVMA, *Committee Hansard*, Canberra, 17 March 2016, p. 8.

19 Ms Kareena Arthy, Chief Executive Officer, APVMA, *Committee Hansard*, Canberra, 17 March 2016, p. 7.

- 7.31 The representatives also referred to work underway to identify and use data from a representative commodity across an entire group, thereby minimising the amount of data required in an application.²⁰
- 7.32 However, the Committee heard that there is often a mismatch between the studies undertaken by research companies and the requirements of registration, or that existing data that may be available to support product registration is not provided to the regulator.²¹

Product labelling

- 7.33 Concerns were also raised about the introduction of additional regulation relating to the labelling of agricultural chemicals.²²
- 7.34 From 1 January 2017, work health and safety legislation requires that labels on agricultural chemicals used principally in workplaces include information relating to the intrinsic hazards of the product, based on the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), in addition to information already required by the APVMA.²³
- 7.35 Bayer submitted that generic hazard-based labelling is not appropriate given that hazards and risks are appropriately managed by the APVMA. Bayer also told the Committee that GHS information would not result in any improvements in work health and safety and may undermine measures already in place.²⁴
- 7.36 Bayer noted that pharmaceutical chemicals regulated by the Therapeutic Goods Administration were exempt from the requirement to include GHS information, and argued that APVMA-approved labels should similarly be recognised as being compliant with work health and safety laws.²⁵

Committee comment

- 7.37 Best-practice regulation of agricultural and veterinary chemical products is essential for ensuring Australia's biosecurity, protecting health and the environment, and maintaining the international reputation of Australia's agricultural industry.

20 Mr Alan Norden, Executive Director, Registration Management and Evaluation Program, APVMA, *Committee Hansard*, Canberra, 17 March 2016, pp. 8–9.

21 Ms Kareena Arthy, Chief Executive Officer, APVMA, *Committee Hansard*, Canberra, 17 March 2016, p. 9.

22 CropLife Australia, *Submission 50*, pp. 12–13; Bayer CropScience, *Submission 78*, pp. 13–14.

23 Safe Work Australia, 'Labelling requirements for agricultural and veterinary chemicals' <www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/labelling-agvet-chemicals> viewed 11 April 2016.

24 Bayer CropScience, *Submission 78*, p. 13.

25 Bayer CropScience, *Submission 78*, p. 14.

- 7.38 However, it is clear from the evidence received by the Committee that there remains scope for the regulation of these products to be more appropriately aligned with risk and more efficiently implemented by the APVMA.
- 7.39 In particular, the Committee acknowledges that the current regulatory framework creates a disincentive for the registration of new products (or for the registration of existing products for new uses), particularly given the relative size of the Australian market for some products.
- 7.40 In turn, this prevents local producers from accessing new chemicals to improve their competitiveness in the international market.
- 7.41 In July 2015, as part of the *Agricultural Competitiveness White Paper*, the Australian Government announced measures to streamline access to agricultural products, including reduced pre-market assessments of low- and medium-risk products and recognition of assessments by accredited third parties and trusted overseas regulators.²⁶
- 7.42 The Committee supports the proposition that, where the risks posed by a product are equivalent between jurisdictions, the APVMA should be empowered to register that product based partly or wholly on the assessment of trusted and comparable international regulators.
- 7.43 The Committee is of the view that this streamlined process should be implemented incrementally by the APVMA so as to ensure the continued integrity of Australia's regulatory system.
- 7.44 Nevertheless, the Committee considers that the necessary legislative and regulatory changes should be pursued as a priority.

Recommendation 12

The Committee recommends that the Department of Agriculture and Water Resources pursue legislative and regulatory changes to enable the Australian Pesticides and Veterinary Medicines Authority to use the decisions of trusted and comparable international regulators as a basis for product registration.

- 7.45 The Committee encourages the APVMA to continue working with industry to achieve further efficiencies in its registration processes. In particular, the Committee supports continued engagement between the APVMA, the Rural Research and Development Corporations, and other

26 Australian Government, *Agricultural Competitiveness White Paper*, 2015, pp. 37–38.

stakeholders to identify and address barriers to the registration of products for minor uses.

- 7.46 Lastly, the Committee notes that the Department has commissioned a review of the impact of chemical product compliance with both work health and safety legislation and agricultural chemical legislation.²⁷
- 7.47 The Committee supports this process and encourages the Australian Government to consider any recommendations of the review that would streamline the regulation of work health and safety in relation to agricultural chemical products.

Gene technology

- 7.48 Throughout the inquiry, the Committee heard evidence about the role of gene technology in increasing agricultural productivity and improving the sustainability of agricultural practices (see Chapter 3).
- 7.49 For example, the Committee was told that the availability of genetically modified (GM) cotton had facilitated changes in farming practices to reduce the use of water and crop protection products while improving productivity and profitability.²⁸
- 7.50 Gene technology is regulated in Australia under the Gene Technology Agreement, an intergovernmental agreement which commenced in 2001.²⁹
- 7.51 The Gene Technology Regulator (GTR) is an independent statutory office holder responsible for administering the Commonwealth gene technology legislation and corresponding state and territory laws.³⁰
- 7.52 The GTR has specific responsibility to protect the health and safety of people and to protect the environment by undertaking risk assessment, risk management, and monitoring of work with GM organisms to ensure compliance with legislation.³¹

27 DAWR, 'Review of duplication between agricultural and veterinary chemical and work health and safety legislation' <www.agriculture.gov.au/ag-farm-food/ag-vet-chemicals/review-of-duplication> viewed 15 April 2016.

28 Ag Institute Australia, *Submission 73*, p. 5; Bayer CropScience, *Submission 78*, p. 8; Mr Matthew Cossey, Chief Executive Officer, CropLife Australia, *Committee Hansard*, Canberra, 22 February 2016, p. 1; Mr Michael Keogh, Executive Director, Australian Farm Institute, *Committee Hansard*, Sydney, 14 April 2016, p. 1.

29 Department of Health, 'The Gene Technology Agreement' <www.health.gov.au/internet/main/publishing.nsf/Content/gene-tech-agreement> viewed 15 April 2016.

30 Office of the Gene Technology Regulator, *Submission 71*, p. 1.

31 Office of the Gene Technology Regulator, *Submission 71*, pp. 1–2.

- 7.53 The GTR assesses and regulates the development, trial, and commercial release of GM plants and animals that can be used in agriculture, among other sectors.³² Before a GM plant or animal is released for commercial use, the GTR must make a determination that it is safe and has no impact on the environment.³³
- 7.54 To avoid duplication, other regulators are responsible for the assessment of products derived from GM plants or animals. For example, Food Standards Australia New Zealand is responsible for the assessment and approval of GM food products.³⁴
- 7.55 Appearing at a public hearing, Dr Jane Cook, the Acting GTR, explained to the Committee that GM canola and cotton had been approved by the regulator for commercial-scale release, and that GM cotton accounts for 95 per cent of the Australian cotton crop.³⁵
- 7.56 The Committee also heard that research and development was underway on a range of other GM plants, including wheat, barley, sugar cane, and ryegrass, in addition to live GM veterinary vaccines and GM animals.³⁶
- 7.57 The Acting GTR noted the emergence of increasingly sophisticated uses of gene technology in the agricultural sector:
- What has also been noticed is that there is an expansion of the types of GM traits that are being trialled. Initially, they were about relatively simple herbicide tolerance. Now we are seeing efforts to enhance more complex environmental stress responses such as drought and salinity tolerance.³⁷
- 7.58 However, the Committee heard that, although Australian scientists have been at the forefront of researching and developing GM traits across a range of crops, the adoption of gene technology in Australian agriculture has been slow and uneven.³⁸
- 7.59 The Committee heard that the significant cost of developing a new GM trait necessitated a transparent and workable regulatory framework, but that aspects of the current framework present a significant barrier to the

32 Office of the Gene Technology Regulator, *Submission 71*, p. 3.

33 Dr Jane Cook, Acting Gene Technology Regulator, Office of the Gene Technology Regulator, *Committee Hansard*, Canberra, 3 March 2016, p. 2.

34 Office of the Gene Technology Regulator, *Submission 71*, p. 2.

35 Dr Jane Cook, Acting Gene Technology Regulator, Office of the Gene Technology Regulator, *Committee Hansard*, Canberra, 3 March 2016, p. 2.

36 Office of the Gene Technology Regulator, *Submission 71*, p. 3.

37 Dr Jane Cook, Acting Gene Technology Regulator, Office of the Gene Technology Regulator, *Committee Hansard*, Canberra, 3 March 2016, p. 2.

38 AusBiotech, *Submission 33*, pp. 13, 15; Australian Academy of Technological Sciences and Engineering, *Submission 56*, p. 8.

adoption of gene technology. This evidence is discussed throughout the remainder of this section.

Lack of national regulatory consistency

- 7.60 Evidence to the inquiry indicated that the principal impediment to the more widespread adoption of gene technology in Australia was the lack of a nationally consistent regulatory approach.
- 7.61 In particular, stakeholders expressed strong concern that state-based moratoria on the commercial cultivation of GM crops had discouraged private investment and inhibited research and development in the sector.³⁹
- 7.62 AusBiotech explained:
- It is unlikely that any single factor has a greater impact on public investment in agricultural biotechnology in Australia than the uncertainty created by indecisive state moratoria against GM crops.⁴⁰
- 7.63 Under the intergovernmental Gene Technology Agreement, the Recognition of Designated Areas Principle allows states and territories to designate geographical areas under state and territory law to preserve the identity of GM crops or non-GM crops for marketing purposes.⁴¹
- 7.64 The GTR submitted the principle was established in recognition of the fact that, at the inception of the intergovernmental agreement, some jurisdictions were concerned that the introduction of GM products might affect the marketing of agricultural products in those jurisdictions.⁴²
- 7.65 At the time of this inquiry, the cultivation of GM food crops is prohibited in South Australia until at least September 2019.⁴³ Similarly, the commercial release of GM organisms is prohibited in Tasmania until November 2019.⁴⁴

39 AusBiotech, *Submission 33*, pp. 10–11, 14; CropLife Australia, *Submission 50*, pp. 21–23; Ag Institute Australia, *Submission 73*, p. 8; Bayer CropScience, *Submission 78*, pp. 23–25; Grain Growers Limited, *Submission 82*, p. 9; Mr Adam Kay, Chief Executive Officer, Cotton Australia, *Committee Hansard*, Canberra, 29 February 2016, p. 9; Mr Shaun Coffey, Editor, *Journal of Agricultural Science*, Australian Institute of Agricultural Science and Technology, *Committee Hansard*, Sydney, 14 April 2016, p. 9.

40 AusBiotech, *Submission 33*, p. 11.

41 Office of the Gene Technology Regulator, *Submission 71*, p. 2.

42 Office of the Gene Technology Regulator, *Submission 71*, p. 2.

43 Primary Industries and Regions SA, 'Genetically modified crops', <www.pir.sa.gov.au/primary_industry/genetically_modified_gm_crops> viewed 16 April 2016.

44 Tasmanian Government, *Submission 58*, p. 3.

- 7.66 The Tasmanian Government submitted that the adoption of gene technology requires careful consideration to ensure there are no negative impacts on markets or on the State's brand.⁴⁵
- 7.67 However, other stakeholders gave evidence of the impact of inconsistent state and territory regulation, including state-based moratoria, on the adoption of gene technology.
- 7.68 AusBiotech explained that, although GM herbicide-tolerant canola was approved by federal regulators in 2004, it was not commercially released until 2008 in Victoria and New South Wales and until 2010 in Western Australia, and remains unavailable in South Australia and Tasmania.⁴⁶
- 7.69 Bayer CropScience submitted that, in some cases, state legislation is written such that a licence for the commercial production of a GM crop may not be granted even if the required conditions are met:
- ... there remains a very real possibility that a company would invest significantly in bringing a technology to market in Australia with data to address all the federal and state regulations and still be unable to sell its product commercially.⁴⁷
- 7.70 The Committee also heard that state-based moratoria have caused agronomic and on-farm financial losses, and that environmental benefits have been forgone.⁴⁸
- 7.71 An independent review of the implementation and effectiveness of the Gene Technology Agreement undertaken in 2011 identified scope to improve national consistency in order to fully achieve the aims of the agreement.⁴⁹
- 7.72 In particular, the review stated that:
- The moratoria create uncertainty leading to:
- a poor path-to-market for GM products, which acts as a disincentive for private investment; and
 - a potential to fall behind in developments and adoption of biotechnology innovations in its export competitor countries.⁵⁰
- 7.73 The review recommended that jurisdictions with GM moratoria that had not been reviewed in the last three years commit to reviewing them by the

45 Tasmanian Government, *Submission 58*, p. 3.

46 AusBiotech, *Submission 33*, p. 13.

47 Bayer CropScience, *Submission 78*, p. 24.

48 Mr Matthew Cossey, Chief Executive Officer, CropLife Australia, *Committee Hansard*, Canberra, 22 February 2016, pp. 14–15.

49 Department of Health and Ageing, *Review of the Gene Technology Act 2000*, 2011.

50 Department of Health and Ageing, *Review of the Gene Technology Act 2000*, 2011, p. 23.

end of 2014. However, in the all governments' response to the review, this recommendation was deemed to be outside the scope of review.⁵¹

Regulation of low-level presence

- 7.74 Lack of regulatory alignment in relation to the low-level presence of GM material was also raised as a concern, particularly due to the potential impact on international trade and national standards.
- 7.75 The Committee heard that, due to the practical limitations of supply chains, and as the global trade in GM crops increases, incidents of the unintended low-level presence of GM plant material in non-GM commodities will become more common.⁵²
- 7.76 Several stakeholders suggested that inconsistent and asynchronous approaches to the approval of GM products across different countries – including the diversity of policies in relation to the low-level presence of GM material – have the potential to negatively impact the international trade in GM products.⁵³
- 7.77 For example, Bayer CropScience submitted that grain shipments may be at risk of being turned back if importing countries have zero-tolerance import policies or do not have processes in place to manage occurrences of the low-level presence of GM material.⁵⁴
- 7.78 Stakeholders also submitted that the Australian National Standard for Organic and Bio-Dynamic Produce (the national organic standard) is inconsistent with other Australian Government policies and does not align with equivalent international standards.⁵⁵
- 7.79 AusBiotech explained that the national Food Standard Code allows for up to a one per cent threshold for the accidental presence of an approved GM ingredient, whereas the national organic standard states that GM products are not compatible with organic and bio-dynamic management practices and are not permitted under a parallel production system.⁵⁶
- 7.80 Bayer CropScience submitted that organic standards in Europe permit up to 0.9 per cent of approved GM material in organic food products, and

51 Department of Health, '2011 Review of the Gene Technology Act 2000', <www.health.gov.au/internet/main/publishing.nsf/Content/gene-techact-review> viewed 16 April 2016.

52 AusBiotech, *Submission 33*, p. 12; CropLife Australia, *Submission 50*, pp. 26–27.

53 Grain Trade Australia, *Submission 21*, p. 4; AusBiotech, *Submission 33*, pp. 11–12; CropLife Australia, *Submission 50*, p. 26.

54 Bayer CropScience, *Submission 78*, p. 28.

55 AusBiotech, *Submission 33*, pp. 12–13; CropLife Australia, *Submission 50*, pp. 24–25.

56 AusBiotech, *Submission 33*, pp. 12–13.

that products approved under these standards can be imported into Australia as organic products.⁵⁷

- 7.81 Stakeholders submitted that inconsistent standards disadvantage both organic and GM farmers and undermine confidence in the adoption of gene technology.⁵⁸

Public perception of gene technology

- 7.82 Lastly, the Committee heard evidence about the relationship between the perception of gene technology among the community and its adoption in the agricultural sector.

- 7.83 Research commissioned by the Office of the Gene Technology Regulator found that awareness in and support for gene technology had fallen between 2012 and 2015.⁵⁹

- 7.84 The research accorded with previous research that found that people with less knowledge of gene technologies were less likely to support the application of gene technologies.⁶⁰

- 7.85 The Acting GTR noted that the research indicated that people are more likely to support therapeutic or industrial applications of gene technology than the use of gene technology in food crops.⁶¹

- 7.86 However, the research also found that support for GM food products was likely to increase based on growing understanding of regulation and scientific evidence of safety.⁶²

- 7.87 The Committee heard that efforts to address public and consumer acceptance were an important element in the more widespread implementation of gene technology.⁶³

- 7.88 For example, the Australian Academy of Technological Sciences and Engineering submitted:

The concerns of some parts of the public in regards to the use of [gene technologies] must be reconciled, if Australia is to truly

57 Bayer CropScience, *Submission 78*, p. 26.

58 AusBiotech, *Submission 33*, p. 13; Bayer CropScience, *Submission 78*, pp. 26–27.

59 Office of the Gene Technology Regulator, *Community attitudes to gene technology*, 2015, p. 4.

60 Office of the Gene Technology Regulator, *Community attitudes to gene technology*, 2015, p. 4.

61 Dr Jane Cook, Acting Gene Technology Regulator, Office of the Gene Technology Regulator, *Committee Hansard*, Canberra, 3 March 2016, p. 4.

62 Office of the Gene Technology Regulator, *Community attitudes to gene technology*, 2015, p. 4.

63 ADF-DA, *Submission 65*, p. 8; Growcom, *Submission 67*, p. 3; Professor Stewart Lockie, *Submission 100*, p. 2.

benefit from the enormous potential benefits to our agriculture and food industries.⁶⁴

- 7.89 The Acting GTR advised that risk assessments, regulatory processes, and information on all GM approvals by and notified to the regulator are available to the public.⁶⁵
- 7.90 However, speaking to the Committee, the Acting GTR suggested that providing plain-language information about gene technology and GM organisms might lead to greater public awareness and acceptance of gene technology.⁶⁶

Committee comment

- 7.91 The Committee accepts that effective regulation has a critical role in supporting the adoption of gene technology in the agricultural sector and underpinning confidence at all levels of the supply chain.
- 7.92 However, the Committee has identified scope to address inconsistencies in the existing regulatory framework that are preventing the widespread adoption of gene technology.
- 7.93 While the Committee acknowledges that states and territories are operating within the scope of the national Gene Technology Agreement, the Committee considers that moratoria on the commercial cultivation of GM products undermine the purpose of the agreement.
- 7.94 The result of the moratoria is that, in practice, the regulation of gene technology is fragmented and inconsistent.
- 7.95 The Committee accepts the evidence that this inconsistency discourages private-sector investment in the development of gene technology suited to Australian conditions. In turn, this limits the ability of Australian producers to compete in the international market.
- 7.96 The Committee acknowledges that there are competing interests within the industry, which, to some extent, reflect the range of views in the community about gene technology.
- 7.97 However, the Committee considers that the industry as a whole would be best served by a harmonised regulatory environment across all states and territories to encourage further adoption of gene technology.

64 Australian Academy of Technological Sciences and Engineering, *Submission 56*, p. 8.

65 Office of the Gene Technology Regulator, *Submission 71*, p. 2; Office of the Gene Technology Regulator, 'Record of GMO Dealings', <www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/gmorec-index-1> viewed 16 April 2016.

66 Dr Jane Cook, Acting Gene Technology Regulator, Office of the Gene Technology Regulator, *Committee Hansard*, Canberra, 3 March 2016, pp. 4–5.

- 7.98 As such, the Committee strongly urges the Australian Government to pursue all available options to achieve a nationally consistent approach to the approval for commercial use of gene technology, including the phase out of state-based moratoria of the cultivation of GM products.

Recommendation 13

The Committee recommends that the Australian Government, through the Council of Australian Governments, pursue reform options to ensure national consistency in the regulation of gene technology.

- 7.99 Further to this recommendation, the Committee notes that an independent five-yearly review of the Gene Technology Agreement is required to be undertaken this year.
- 7.100 In commissioning the review, the Committee recommends that the Australian Government, through the Gene Technology Ministerial Council, seek terms of reference that empower the review to fully consider the impact of moratoria invoked by state and territory governments under the Recognition of Designated Areas Principle.
- 7.101 If this is considered to be outside the scope of the existing process, the Committee recommends that the Australian Government commission a separate, yet still independent, review to consider the issue.

Recommendation 14

The Committee recommends that the Australian Government commission an independent review of the implementation and effectiveness of the Gene Technology Agreement with particular reference to the impact of moratoria invoked by state and territory governments under the Recognition of Designated Areas Principle.

- 7.102 In addition to efforts to achieve consistency in the regulation of gene technology, the Committee encourages the Australian Government to resolve other inconsistencies in national and international approaches to the treatment of GM material.
- 7.103 In particular, the Committee supports an update to the National Standard for Organic and Bio-Dynamic Produce to accommodate the unintended

presence of approved GM material at low levels, in line with other national standards and international practice.

Recommendation 15

The Committee recommends that the Department of Agriculture and Water Resources, in cooperation with Standards Australia, update the National Standard for Organic and Bio-Dynamic Produce to introduce a threshold for approved genetically-modified material consistent with comparable international standards.

- 7.104 Lastly, in addition to overcoming the regulatory impediments outlined in this chapter, the Committee considers that efforts to increase public awareness in gene technology have an important role in increasing its adoption, particularly in the agricultural sector.
- 7.105 The Committee therefore encourages the Office of the Gene Technology Regulator to develop and publish educational resources on the process of assessment of gene technology and the role of the regulator in ensuring the safety of human health and the environment.
- 7.106 The Committee anticipates that such an initiative would contribute to increased awareness of gene technology and greater public trust in Australia's regulatory framework.

Drones

- 7.107 The development and increasing use of unmanned aerial vehicles (UAVs) – or drones – were raised in the digital science section of Chapter 3. UAVs, drones and other surveillance technologies offer agricultural producers the ability to monitor and track stock location, pasture conditions, and crop growth.⁶⁷
- 7.108 The submission from the Plant Biosecurity Cooperative Research Centre (CRC) stated that the use of small UAVs for biosecurity surveillance in wheat fields, vineyards and orchards is another example of technological advancement and potential.⁶⁸

⁶⁷ DAWR, *Submission 88*, p. 7.

⁶⁸ Plant Biosecurity Cooperative Research Centre, *Submission 36*, p. 6.

- 7.109 The Plant Biosecurity CRC submission explained the benefits of UAV use for agricultural surveillance:
- Drones generally provide increased operational flexibility and visibility over land-based detection methods. They can provide coverage over large areas and monitor remote, dangerous or difficult to access locations. They offer a non-invasive monitoring approach that can target site-specific threats, which in turn allows for directed treatment and management. By combining mature drone technology and advanced sensing systems, important disease and pest specific data can be collected in novel ways.⁶⁹
- 7.110 The submission from the Australian Centre for Field Robotics outlined some of its recent collaborative project work on UAVs, which includes capturing multi-spectral data of large-scale areas at high precision for detecting and classifying individual weed species.⁷⁰
- 7.111 The Department of Primary Industries and Regions South Australia (PIRSA) explained that drones with advanced sensor, web-based and wireless technologies are among the options being considered for early detection of crop pests and diseases in a new collaborative research project underway in South Australia.⁷¹
- 7.112 PIRSA stated that the research will look at UAVs fitted with near-infrared, laser, acoustic and biosensor detectors for grain and other crops, and also for fisheries and environmental management.⁷²
- 7.113 The PIRSA submission added that the research aims to significantly reduce crop losses and safeguard the biosecurity status of grains destined for export markets.⁷³
- 7.114 A Grains Research and Development Corporation (GRDC) news item, published in August 2015, discussed some of the uses of UAVs for agricultural monitoring. The news item examined data capture and uses, and discussed user experiences.⁷⁴ The item suggested that:
- uses for UAVs will evolve with experience and as sensors become cheaper and more robust; and

69 Plant Biosecurity Cooperative Research Centre, *Submission 36*, p. 6.

70 Australian Centre for Field Robotics, *Submission 94*, p. 2.

71 Department of Primary Industries and Regions South Australia, *Submission 19*, p. 7.

72 Department of Primary Industries and Regions South Australia, *Submission 19*, p. 7.

73 Department of Primary Industries and Regions South Australia, *Submission 19*, p. 7.

74 Grains Research and Development Corporation, 'Farming's new eyes in the sky' <grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-118-Sep-Oct-2015/Farmings-new-eyes-in-the-sky> viewed 15 April 2016.

- while there is plenty of enthusiasm for UAVs in broadacre agriculture their economic role in day-to-day or even season-to-season agronomy has yet to be established.⁷⁵

Regulatory issues

- 7.115 Several submissions to the inquiry pointed out that the use of UAVs has privacy and air safety implications. Some submissions suggested that farmers may not always be aware of the legal and regulatory issues associated with the use of UAVs.
- 7.116 Further, the University of Melbourne suggested that government policies, laws and regulations may not account well enough for the wider ramifications of the use of new technologies such as UAVs.⁷⁶
- 7.117 The Tasmanian Institute of Agriculture also suggested that challenges exist with the operation of UAV technology, particularly with respect to licencing and operation within the rules of the Civil Aviation Safety Authority (CASA).⁷⁷
- 7.118 Some evidence to the inquiry suggested that the technology is perhaps evolving faster than the regulations that govern its use.
- 7.119 Mr Bill Magee, from the Plant Biosecurity CRC, stated that the use of UAVs has regulatory implications, which has been presenting some problems:
- My only comment on that is that seems to be very much in its infancy. Because of the pace at which the technology is moving, the regulatory framework has not quite kept up with that, and it is not surprising.⁷⁸
- 7.120 A recent inquiry into the use of drones, conducted by the House of Representatives Standing Committee on Social Policy and Legal Affairs, identified a need for sustained attention on the privacy implications of the use of UAV technologies.⁷⁹

75 Grains Research and Development Corporation, 'Farming's new eyes in the sky' <grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-118-Sep-Oct-2015/Farmings-new-eyes-in-the-sky> viewed 15 April 2016.

76 University of Melbourne, *Submission 4*, p. 4.

77 Tasmanian Institute of Agriculture, *Submission 44*, p. 2.

78 Mr Bill Magee, Project Leader, Plant Biosecurity Cooperative Research Centre, *Committee Hansard*, Canberra, 22 February 2016, p. 19.

79 House of Representatives Standing Committee on Social Policy and Legal Affairs (2014) *Eyes in the Sky – Inquiry into drones and the regulation of air safety and privacy*.

- 7.121 Mr Magee called for the resolution of any regulatory impediments so that the benefit of new surveillance technologies can be realised.⁸⁰
- 7.122 Some submissions to the inquiry discussed the need for new and ongoing education regarding new surveillance technologies for agricultural producers. The ACFR submission stated that the organisation has:
- ... engaged with various government agencies and growers in undertaking the research and in conducting workshops/field days for demonstrating the technology, and in educating the agencies about the potential and limitations of the technology.⁸¹

Line of sight

- 7.123 Some submissions called for the extension of, or changes to, particular regulations to allow producers to use UAVs beyond line of sight.
- 7.124 Falcon UAV submitted that being able to fly beyond line of sight over a farmer's own property is essential, especially in vast rural areas. The submission added that the technology exists for this to be done easily and safely.⁸²
- 7.125 The submission from the Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders Association stated that remote monitoring applications can be limited by current legislative restrictions, which require UAVs to only be used within the line of sight of the operator.⁸³ The submission recommended that the Australian Government review relevant legislation regarding the use of UAVs and remove restrictions to better enable them to be used as tools for producers on-farm.⁸⁴
- 7.126 At the end of March 2016, CASA announced an easing of regulations that apply to UAVs.⁸⁵ The regulatory amendments are further detailed on the CASA website and will come into effect on 29 September 2016.⁸⁶ Although certain restrictions have been eased or lifted, the line of sight requirement is still in place.

80 Mr Bill Magee, Project Leader, Plant Biosecurity Cooperative Research Centre, *Committee Hansard*, Canberra, 22 February 2016, p. 19.

81 Australian Centre for Field Robotics, *Submission 94*, p. 2.

82 Falcon UAV, *Submission 103*, p. 1.

83 CCA-SCA-ALFA, *Submission 84*, p. 3.

84 CCA-SCA-ALFA, *Submission 84*, p. 3.

85 Civil Aviation Safety Authority, 'Red tape cut for remotely piloted aircraft' <www.casa.gov.au/publications-and-resources/media-release/red-tape-cut-remotely-piloted-aircraft> viewed 15 April 2016.

86 Civil Aviation Safety Authority, 'Part 101 Amendments - Cutting red tape for remotely piloted aircraft' <www.casa.gov.au/aircraft/standard-page/part-101-amendments-cutting-red-tape-remotely-piloted-aircraft> viewed 15 April 2016.

- 7.127 The CASA website states that autonomous flight is currently prohibited, however, suitable regulations are being developed. The website also states that there is scope for CASA to approve autonomous flight on a case-by-case basis.⁸⁷

Committee comment

- 7.128 The Committee notes evidence to the inquiry suggesting that UAV technology will become an extremely useful tool for agricultural producers. The Committee recognises the monitoring and surveillance potential of this technology for farm businesses.
- 7.129 The Committee considers that there is value in producers being made aware of the potential uses and limitations of UAV technology. Further, the Committee sees a need for regulations and restrictions pertaining to UAV technology being communicated to agricultural producers in an efficient and targeted manner.
- 7.130 The Committee is of the view that responsible use of UAVs is a matter for consideration by agencies involved in the agricultural research, development and extension process. This would include the Department of Agriculture and Water Resources, state and territory agriculture departments, Research and Development Corporations, and private and public extension services.
- 7.131 While acknowledging that UAVs are used beyond the agricultural industry, the Committee considers that there could be some benefit in having tailored educational material made available to stakeholders in the agricultural sector. Such materials might cover possible uses of UAVs and current regulatory implications of UAV use.

Recommendation 16

The Committee recommends that the Department of Agriculture and Water Resources and the Civil Aviation Safety Authority develop appropriate extension materials promoting the appropriate use of unmanned aerial vehicles in the Australian agricultural sector.

87 Civil Aviation Safety Authority, 'Part 101 Amendments - Cutting red tape for remotely piloted aircraft' <www.casa.gov.au/aircraft/standard-page/part-101-amendments-cutting-red-tape-remotely-piloted-aircraft> viewed 15 April 2016.

- 7.132 The Committee is mindful of the existing restrictions on the use of UAVs, however the easing of some of those restrictions in September 2016 will be of benefit to users of this new technology.
- 7.133 The Committee is of the view that there would be benefit in the line of sight issue being further examined by CASA. The Committee considers that CASA should investigate the safety implications of adjusting the regulation affecting line of sight, enabling landholders to use UAVs beyond line of sight, provided that it is still on or over their own property. The Committee recognises that this will be extremely useful for producers with very large and remote properties.

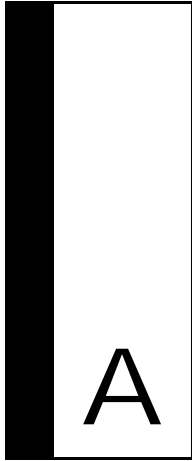
Recommendation 17

The Committee recommends that the Civil Aviation Safety Authority investigate regulations requiring unmanned aerial vehicles to be flown within visual line of sight, with a view to amending the regulations to enable agricultural producers to use such vehicles for monitoring purposes beyond line of sight on or over their own properties.

Rowan Ramsey MP

Chair

2 May 2016



Appendix A: List of submissions

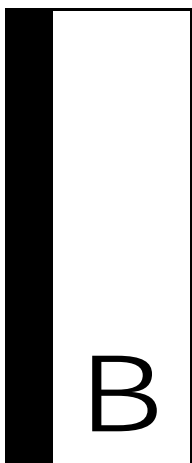
- 1 Mr Alun Davies
 - 1.1 Supplementary to Submission 1
- 2 The University of Queensland
- 3 Adjunct Professor John Hamblin
- 4 The University of Melbourne
 - 4.1 Supplementary to Submission 4
- 5 National Rural Women's Coalition
- 6 Mrs Margaret House
- 7 University of South Australia
- 8 Flinders University
- 9 Australian Nuclear Science and Technology Organisation
- 10 Alpine Valleys Dairy Pathways Project
- 11 University of New England
 - 11.1 Supplementary to Submission 11
 - 11.2 Supplementary to Submission 11
- 12 Winemakers' Federation of Australia
 - 12.1 Supplementary to Submission 12
- 13 SST Software Australia
- 14 Gwydir Shire Council
 - 14.1 Supplementary to Submission 14
- 15 Queensland Dairyfarmers' Organisation Ltd
- 16 Pastoralists & Graziers Association of Western Australia Inc.
- 17 Charles Sturt University
- 18 Australian Genome Research Facility and University of Adelaide

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- 19 Department of Primary Industries and Regions South Australia
20 Swamps Rivers & Ranges
21 Grain Trade Australia Ltd
22 Mr Peter Dixon
23 Mr Don Lawson OAM
24 Precision Cropping Technologies
25 NutriHealth International
25.1 Supplementary to Submission 25
26 Professor Michael D'Occhio
27 Geological Exploration Services Pty Ltd
28 Deakin University
29 Agribusiness Yarra Valley
30 Professor Brian Orr, Macquarie University
31 Dr Lindsay Campbell, University of Sydney
32 Rutherglen Premium Lamb
33 AusBiotech
34 NNNCo Pty Ltd
35 AgriWebb Pty Ltd
36 Plant Biosecurity Cooperative Research Centre
37 Murdoch University
38 Agromillora Australia JV Pty Ltd
39 The United States Studies Centre at the University of Sydney
40 The University of Sydney
40.1 Supplementary to Submission 40
41 Soil Science Australia
42 The Australian Plant Phenomics Facility
43 The Warren Centre for Advanced Engineering
44 Tasmanian Institute of Agriculture
45 NSW Farmers' Association
46 Council of Veterinary Deans of Australia and New Zealand
47 Australian Controlled Traffic Farming Association
48 Rabobank Australia
49 Cotton Research and Development Corporation
50 CropLife Australia
50.1 Supplementary to Submission 50

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- 51 Larkman Nurseries Pty Ltd
- 52 The Crawford Fund
- 53 North East Catchment Management Authority
- 54 Tractor and Machinery Association of Australia
- 55 CSIRO
- 55.1 Supplementary to Submission 55
- 56 Australian Academy of Technological Sciences and Engineering
- 57 Victorian Farmers Federation
- 58 Tasmanian Government
- 59 Riverina Local Land Services
- 60 Australian Centre for International Agricultural Research
- 61 Southern Farming Systems and the Australian Controlled Traffic Farming Association
- 61.1 Supplementary to Submission 61
- 62 Entrevators Pty Ltd
- 63 Australian Women in Agriculture
- 64 National Centre of Excellence in Desalination Australia
- 65 Australian Dairy Farmers
- 66 Department of Agriculture and Food, Western Australia
- 67 Growcom
- 68 Australian Sugar Milling Council
- 69 Macquarie University
- 70 Australian Pork Limited
- 70.1 Supplementary to Submission 70
- 71 Office of the Gene Technology Regulator, Department of Health
- 71.1 Supplementary to Submission 71
- 72 Cotton Australia
- 73 Ag Institute Australia
- 74 Rural Industries Research & Development Corporation
- 75 Ms Loretta Carroll
- 76 Mr Mark Swift
- 77 Mr Aharon Arakel
- 78 Bayer CropScience Pty Ltd
- 78.1 Supplementary to Submission 78
- 79 Vanderfield Pty Ltd

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- 80 Ms Susan Campbell OAM and Mr David Lord
- 81 Telstra
81.1 Supplementary to Submission 81
- 82 Grain Growers Limited
- 83 South East Premium Wheat Growers' Association
- 84 Cattle Council of Australia, Sheepmeat Council of Australia and Australian Lot Feeders' Association
- 85 Australian Farm Institute
- 86 Professor Mark Dodgson, Technology and Innovation Management Centre, University of Queensland
- 87 Grains Research & Development Corporation
- 88 Department of Agriculture and Water Resources
88.1 Supplementary to Submission 88
- 89 Australian Steel Institute
- 90 Council of Rural Research and Development Corporations
- 91 Ms Rachel Hay (James Cook University) and Mr William Harrington (Harrington Systems Electronics)
- 92 PodPlants
- 93 Mr Chris Wilkins
- 94 Australian Centre for Field Robotics
- 95 Australasia-Pacific Extension Network Inc.
- 96 Ms Alex Hodges and Mr Ray Linkevics
- 97 Mr and Mrs Jamie and Jo Fowler
- 98 Integrated Agri-Culture Pty Ltd
- 99 Australian Food Sovereignty Alliance
- 100 Professor Stewart Lockie
- 101 FarmLink
- 102 Mrs Sally Wylie
- 103 Falcon UAV
- 104 Connexion Pty Ltd
- 105 Ms Anne-Marie Copeland
- 106 Precision Agriculture Pty Ltd
- 107 Pesticide Action Group of Western Australia, Save Our Trees WA and the Alliance for a Clean Environment
- 108 Friends of the Earth

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- 109 Ms Emily Wallis
- 110 Mrs Meg Wilson
- 111 Primary Industries Education Foundation Australia
- 112 Gene Ethics
- 113 University of Newcastle
- 114 Adjunct Professor Anthony Sorensen
- 115 Dr Robert Banks, Animal Genetics and Breeding Unit, University of
New England
- 116 Associate Professor Nigel Andrew, Zoology, University of New England



Appendix B: List of exhibits

- 1 *The Peoples' Food Plan – Policy Directions*, August 2013.
Relates to Submission 99, Australian Food Sovereignty Alliance
- 2 Report by the Regional Australia Institute: *Pathfinder Initiative – Shaping the Future in the Namoi*, September 2015;
Report by the Great South Coast Group: *Food & Fibre Strategy & Action Plan – Document 2: Strategic Plan & Independent Analysis, 2015–2020*; and
Report by Deloitte Access Economics: *Food and Fibre Strategic Action Plan – situational analysis, Great South Coast Group – Victoria, Final Report, 2015*.
Relate to testimony given by the Australasia Pacific Extension Network at a public hearing held in Melbourne on 29 January 2016
- 3 Cotton Australia's final submission to the Productivity Commission's inquiry into Regulation of Agriculture (Issues Paper), 19 February 2015.
Relates to testimony given by Cotton Australia at a public hearing held in Canberra on 29 February 2016
- 4 Report by the Rural Industries Research & Development Corporation: *Managing Farming – How Farmers Learn*, August 1999.
Relates to testimony given by Australian Women in Agriculture at a public hearing held in Canberra on 3 March 2016
- 5 Report by Friends of the Earth: *GM 2.0 – Australian Regulators Engineering the Truth*.
Relates to Submission 108, Friends of the Earth
- 6 John Fagan, Michael Antoniou, and Claire Robinson: *GMO Myths and Truths*, published by Earth Open Source, 2014.
Relates to Submission 112, Gene Ethics
- 7 Pilot Report: *Research Engagement for Australia – Measuring research engagement between universities and end users*, March 2016.
Relates to testimony given by the Australian Academy of Technology and Engineering at a public hearing held in Melbourne on 29 January 2016

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- 8 Excel document containing data on wheat yields.
 Relates to testimony given by the Grains Research and Development Corporation at a public hearing held in Melbourne on 29 January 2016
 - 9 Report: *Community Attitudes to Gene Technology*, June 2015
 Relates to Submission 71.1, Office of the Gene Technology Regulator, Department of Health
 - 10 *Agriculture Technology Survey 2015*
 Grain Growers Limited
 - 11 Australian Egg Corporation Limited, Annual report 2005
 Relates to testimony given by Poultry CRC appearing with the University of New England at a public hearing held in Armidale on 13 April 2016
 - 12 Australian Egg Corporation Limited, Annual report 2015
 Relates to testimony given by Poultry CRC appearing with the University of New England at a public hearing held in Armidale on 13 April 2016



Appendix C: List of public hearings

Thursday, 22 October 2015 – Canberra

Rural Industries Research and Development Corporation

Mr Craig Burns, Managing Director

Mrs Jennifer Medway, Manager, Investing in People

Thursday, 12 November 2015 – Canberra

Department of Agriculture and Water Resources

Mr Phillip Glyde, Deputy Secretary

Mr Peter Gooday, Assistant Secretary, Farm Analysis and Biosecurity
Branch, Australian Bureau of Agricultural and Resource Economics and
Sciences

Mr Richard Webb, Director, Research and Innovation Policy, Rural
Research and Innovation Branch

Thursday, 26 November 2015 – Canberra

CSIRO

Dr Graham Bonnet, Research Director, Agriculture

Dr Michael Robertson, Science Director, Agriculture

Dr Daniel Walker, Research Director, Agriculture

Thursday, 3 December 2015 – Canberra

Cattle Council of Australia

Mr Jed Matz, Chief Executive Officer

Meat and Livestock Australia

Dr Alex Ball, General Manager, Red Meat Innovation

Dr Jane Weatherley, General Manager, Livestock Productivity
Sheepmeat Council of Australia

Mr Mark Harvey-Sutton, Acting Chief Executive Officer

Thursday, 28 January 2016 – Wodonga

Alpine Valleys Dairy Pathways Project

Mr Stuart Crosthwaite, Chair, Project Steering Committee

Mr Patten Bridge, Project Consultant

Charles Sturt University and NSW Department of Primary Industries

Professor Michael Friend, Director, Graham Centre for Agricultural
Innovation

North East Catchment Management Authority

Ms Jane Young, Executive Manager, Leadership and Strategy

Mr Adam Green, Manager, Strategy, Investment and Evaluation

NutriHealth International (trading as NutriSoil)

Mrs Rachelle Armstrong, Managing Director

Mrs Dianne Haggerty, Manager, Prospect Pastoral Company

Mr Ian Haggerty, Manager, Prospect Pastoral Company

Riverina Local Land Services

Mr William Auldish, Senior Land Services Officer, Native Vegetation

Mr Geoff Minchin, Senior Land Services Officer, Mixed Farming Systems

Rutherglen Premium Lamb

Mrs Jennifer Anderson, Production Manager

Appearing in a private capacity

Mr Don Lawson OAM

Friday, 29 January 2016 – Melbourne

AusBiotech

Professor Paul Wood, Chair, Ag and FoodTech Committee

Dr Michael Blake, National Programs Manager

Australasia-Pacific Extension Network

Mr Michael Weise, State Coordinator

Australian Academy of Technology and Engineering

Dr Matt Wenham, Executive Manager, Policy and Projects

Professor Edward Barlow, Deputy Chair, Agriculture Forum

Dr Mary Ann Augustin, Deputy Chair, Agriculture Forum

Australian Dairy Farmers

Mrs Simone Jolliffe, President

Mr Tyran Jones, Chair, Policy Committee and Director

Ms Irene Clarke, Senior Policy Manager

Australian Genome Research Facility

Dr Susan Forrest, Chief Executive Officer

Professor Robert Lewis, Board Chair

Dairy Australia

Ms Paula Fitzgerald, Manager, Biotechnology and Strategic Initiatives

Deakin University

Professor Andrew Reeves, Senior Research Advisor to the Vice-Chancellor

Dr David Halliwell, Director, Centre for Regional and Rural Futures

Soil Science Australia

Dr Vanessa Wong, President, Victorian Branch

University of Adelaide

Professor Andrew Lowe, Deputy Dean, Faculty of Sciences and Chair, Plant Conservation Biology

Professor Peter Langridge, Emeritus Professor

University of Melbourne

Associate Professor Ruth Nettle, Leader, Rural Innovation Research Group

Mr Michael Santhanam-Martin, Lecturer, Agricultural Production Systems

Dr Margaret Ayre, Senior Research Fellow

Victorian Farmers Federation

Mr Peter Tuohey, President

Mr Peter Hunt, Executive Policy Manager

Thursday, 4 February 2016 – Canberra

Winemakers' Federation of Australia

Mr Anthony Battaglione, General Manager, Strategy and International Affairs

Thursday, 11 February 2016 – Canberra

Telstra

Mrs Lavina Muscat, Industry Development Executive, Global Enterprise Services

Mr Channa Seneviratne, Director, Wireless Network Engineering

Mr James Shaw, Director, Government Relations

Monday, 22 February 2016 – Canberra

Australian Controlled Traffic Farming Association

Mr John McPhee, Chair

CropLife Australia

Mr Matthew Cossey, Chief Executive Officer

Ms Jaelle Bajada, Manager, Public Affairs and Research

Grain Growers Limited

Mr David McKeon, General Manager, Advocacy and Policy

Mr Michael Pengilley, Business Manager, Information Services

Plant Biosecurity Cooperative Research Centre

Dr Joanne Luck, Research Director

Mr Bill Magee, Project Leader

Southern Farming Systems

Mr Kim Russell, Chairman

Thursday, 25 February 2016 – Canberra

Council of Rural Research and Development Corporations

Mr Selwyn Snell, Chairman

Mr Tim Lester, Operations Manager

Monday, 29 February 2016 – Canberra

Australian Pork Limited

Ms Deborah Kerr, General Manager, Policy

Mr Darryl D'Souza, General Manager, Research and Innovation

Bayer CropScience

Dr Judy Patterman, Regulatory Affairs Manager, Seeds

Mr Richard Dickmann, Head of New Business Development

Cotton Australia

Mr Adam Kay, Chief Executive Officer

Dr Nicola Cottee, Policy Officer, Research Direction and Stewardship

Grains Research and Development Corporation

Dr Stephen Thomas, Chief Operating Officer

Thursday, 3 March 2016 – Canberra**Australian Women in Agriculture Ltd**

Mrs Sarah Parker, General Board Director

National Rural Women's Coalition Ltd

Dr Patricia Hamilton, President

Ms Leonie Noble, Vice President

Office of the Gene Technology Regulator, Department of Health

Dr Jane Cook, Acting Gene Technology Regulator

Dr Vidya Jagadish, Acting Assistant Secretary, Regulatory Practice and Compliance Branch

Dr Peter Thygesen, Director, Regulatory Practice and Secretariat Section, Regulatory Practice and Compliance Branch

Thursday, 17 March 2016 – Canberra**Australian Pesticides and Veterinary Medicines Authority**

Ms Kareena Arthy, Chief Executive Officer

Dr Phil Reeves, Chief Scientist

Dr Raj Bhula, Executive Director, Scientific Assessment and Chemical Review Program

Mr Alan Norden, Executive Director, Registration Management and Evaluation Program

Department of Agriculture and Water Resources

Mr Paul Morris, Acting Deputy Secretary

Mr Peter Gooday, Assistant Secretary, Farm Analysis & Biosecurity Branch, Australian Bureau of Agricultural and Resource Economics and Sciences

Mr Richard Webb, Director, Research and Innovation Policy Section, Rural Research and Innovation Branch, Agricultural Policy Division

Wednesday, 13 April 2016 – Armidale**Cotton Research and Development Corporation**

Mr Bruce Finney, Executive Director

Gwydir Shire Council

Mr Maxwell Eastcott, General Manager

Precision Agriculture Pty Ltd

Mr Tim Neale, Manager, Research and Innovation Team

Precision Cropping Technologies

Mr Andrew Smart, Managing Director

Mr Ian Gourley, Farmer

University of New England and UNE Smart Farm

Professor David Lamb, Project Leader, UNE SMART Farm

Dr Mark Trotter, Senior Lecturer in Precision Agriculture

Adjunct Professor Anthony Sorensen, School of Behavioural, Cognitive and Social Sciences

Professor James Rowe, Chief Executive Officer, Cooperative Research Centre for Sheep Industry Innovation

Mr Lloyd Thomson, Commercial Manager & Company Secretary, Poultry Cooperative Research Centre Ltd

Appearing in a private capacity

Dr Nigel Andrew, Associate Professor, School of Environmental and Rural Science, University of New England

Dr Robert Banks, Director, Animal Genetics and Breeding Unit, University of New England

Mr Alun Davies, Head of the Armidale Digital Economy Implementation Group and Regional Communications Advocate

Thursday, 14 April 2016 – Sydney**Ag Institute Australia (Australian Institute of Agricultural Science and Technology)**

Associate Professor Daniel Tan, Director

Mr Christopher Russell, Chairman, Ethics Committee

Mr Shaun Coffey, Editor, Journal of Agricultural Science, Australian Institute of Agricultural Science and Technology

Australian Centre for Field Robotics

Professor Salah Sukkarieh, Professor of Robotics and Intelligent Systems

Australian Farm Institute

Mr Michael Keogh, Executive Director

John Deere

Dr Broughton Boydell, Senior Staff Engineer, Intelligent Solutions Group

NNNCo Pty Ltd (National Narrowband Network Co.)

Mr Robert Zagarella, Founder and Chief Executive Officer

Dr Eric Hamilton, Chief Technology Officer

Ms Margaret Wright, Head of Strategy, Risk and People

NSW Farmers

Mr David Eyre, General Manager, Research & Development

University of Sydney

Professor Alexander McBratney, Dean and Professor of Soil Science,
Faculty of Agriculture and Environment

Professor Rosanne Taylor, Dean and Professor, Faculty of Veterinary
Science

Warren Centre for Advanced Engineering

Mr Jonathan (Ashley) Brinson, Executive Director

Appearing in a private capacity

Dr Aharon Arakel

Dr Lindsay Campbell, Senior Lecturer, Faculty of Agriculture and
Environment, University of Sydney

Ms Andrea Koch, Program Leader, Soil Carbon Initiative, United States
Studies Centre and Adjunct Associate Professor, School of Life and
Environmental Sciences, Faculty of Agriculture and Environment,
University of Sydney

Emeritus Professor Brian Orr, MQ Photonics Research Centre, Department
of Physics and Astronomy, Faculty of Science and Engineering, Macquarie
University



Appendix D: Examples of advances in technology in Australian agriculture

Submissions to the inquiry provided the following examples of advances in technology that have benefited agriculture in Australia:

- Mechanisation;¹
- Fertilisers² such as superphosphate³ and nitrogen,⁴ and broader plant nutrition;⁵
- Crop rotation⁶ and fallowing;⁷
- Nitrogen fixing;⁸
- Animal genetics and breeding;⁹
- Crop protection products such as fungicides, herbicides and insecticides¹⁰
- Plant genetics and breeding;¹¹
- Disease resistance;¹²

1 University of South Australia, *Submission 7*, p. 1; The Warren Centre for Advanced Engineering, *Submission 43*, p. 2; CSIRO, *Submission 55*, p. 11.

2 CSIRO, *Submission 55*, p. 9.

3 Mr David McKeon, General Manager Advocacy and Policy, Grain Growers Ltd, *Committee Hansard*, Canberra, 22 February 2016, p. 6.

4 ADF-DA, *Submission 65*, p. 5; GRDC, *Submission 87*, p. 9.

5 Warren Centre for Advanced Engineering, *Submission 43*, p. 2; GRDC, *Submission 87*, p. 9.

6 Professor John Hamblin, *Submission 3*, p. 3; Grain Trade Australia, *Submission 21*, p. 3.

7 GRDC, *Submission 87*, p. 8, p. 16.

8 GRDC, *Submission 87*, p. 9.

9 ADF-DA, *Submission 65*, p. 4; CCA-SCA-ALFA, *Submission 84*, p. 7.

10 CropLife Australia, *Submission 50*, p. 4; Bayer CropScience, *Submission 78*, p. 5.

11 The Australian Plant Genomics Facility, *Submission 42*, p. 2; Tasmanian Institute of Agriculture, *Submission 44*, p. 1; ACIAR, *Submission 60*, p. 4.

- Minimum or no tillage;¹³
- Genetically modified crops;¹⁴
- Integrated management practices¹⁵ and best practice programs;¹⁶
- Animal monitoring, including oestrus detection, temperature recording, body condition and weight measurements;¹⁷
- Carcass classification and traceability;¹⁸
- Animal tracking, using GPS, RFID,¹⁹ and UAVs;²⁰
- Controlled traffic farming;²¹
- Precision agriculture;²²
- Sterile insect technology;²³
- Remote sensing for yield mapping,²⁴ soil, water and pasture monitoring and measurement;²⁵
- Drone or UAV use for crop assessment,²⁶ weed detection and tree and vegetable crop analysis,²⁷ and pest management;²⁸
- Variable rate technology;²⁹

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- 12 Charles Sturt University, *Submission 17*, p. 4; Department of Primary Industries and Regions South Australia, *Submission 19*, pp. 3-4; GRDC, *Submission 87*, p. 9.
- 13 Grain Trade Australia, *Submission 21*, p. 3; CropLife Australia, *Submission 50*, p. 6; ATSE, *Submission 56*, p. 4; Ag Institute Australia, *Submission 73*, pp. 5-6.
- 14 Grain Trade Australia, *Submission 21*, p. 3; AusBiotech, *Submission 33*, p. 2; CropLife Australia, *Submission 50*, p. 2.
- 15 Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*, p. 3; Cotton Australia, *Submission 72*, p. 1.
- 16 GrowCom, *Submission 67*, p. 3; Cotton Australia, *Submission 72*, p. 1.
- 17 ADF-DA, *Submission 65*, p. 4; CCA-SCA-ALFA, *Submission 84*, p. 7.
- 18 Australian Pork Limited; *Submission 70.1*, p. 1.
- 19 ADF-DA, *Submission 65*, p. 4; CCA-SCA-ALFA, *Submission 84*, p. 7.
- 20 Australian Centre for Field Robotics, *Submission 94*, p. 4.
- 21 Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*, p. 2; GrowCom, *Submission 67*, p. 3; Australian Sugar Milling Council, *Submission 68*, p. 2.
- 22 Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*, p. 2; The Warren Centre for Advanced Engineering, *Submission 43*, p. 2; Tasmanian Institute of Agriculture, *Submission 44*, p. 1.
- 23 GrowCom, *Submission 67*, p. 3.
- 24 Australian Sugar Milling Council, *Submission 68*, p. 2.
- 25 ADF-DA, *Submission 65*, p. 4.
- 26 DAWR, *Submission 88*, p. 7; Falcon UAV, *Submission 103*, p. 1; Mr Kim Russell, Chairman, Southern Farming Systems, *Committee Hansard*, Canberra, 22 February 2016, p. 1; Dr Joanne Luck, Research Director, Plant Biosecurity Cooperative Research Centre, *Committee Hansard*, Canberra, 22 February 2016, p. 16.
- 27 Australian Centre for Field Robotics, *Submission 94*, p. 2.
- 28 Department of Primary Industries and Regions South Australia, *Submission 19*, p. 7.

- Robotics,³⁰ including robotic milking³¹ and robotic crop monitoring;³²
- Automation,³³ including harvesting,³⁴ planting,³⁵ irrigation³⁶ and spraying systems,³⁷ and automated livestock weighing and handling;³⁸
- Driverless or GPS guided vehicles;³⁹ and
- Use of big data.⁴⁰

29 Ag Institute Australia, *Submission 73*, p. 6; RIRDC, *Submission 74*, p. 3; Vanderfield Pty Ltd, *Submission 79*, p. 11.

30 Tasmanian Institute of Agriculture, *Submission 44*, p. 1.

31 ADF-DA, *Submission 65*, p. 4

32 University of Sydney, *Submission 40*, p. 4.

33 Tasmanian Institute of Agriculture, *Submission 44*, p. 1.

34 Agromillora Australia, *Submission 38*, p. 2; University of Sydney, *Submission 40*, p. 4; Southern Farming Systems and the Australian Controlled Traffic Farming Association, *Submission 61*, p. 2.

35 Australian Sugar Milling Council, *Submission 68*, p. 2.

36 ADF-DA, *Submission 65*, p. 4; Australian Sugar Milling Council, *Submission 68*, p. 2; CCA-SCA-ALFA, *Submission 84*, p. 7.

37 Australian Sugar Milling Council, *Submission 68*, p. 2.

38 University of Sydney, *Submission 40*, p. 4.

39 Tractor and Machinery Association of Australia, *Submission 54*, p. 2.

40 The majority of submissions to the inquiry discussed the use of big data.

