



# THE FUTURE OF AGRICULTURAL TECHNOLOGIES

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EXTRACT

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HORIZON  
SCANNING

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## EXPERT WORKING GROUP

Professor Stewart Lockie FASSA (Chair, September 2019 – December 2019)  
Dr Kate Fairley-Grenot FAICD FTSE (Chair, November 2018 – September 2019)  
Professor Rachel Ankeny  
Professor Linda Botterill FASSA  
Professor Barbara Howlett FAA  
Professor Alex McBratney FAA  
Professor Elspeth Probyn FAHA FASSA  
Professor Tania Sorrell AM FAHMS  
Professor Salah Sukkarieh FTSE  
Professor Ian Woodhead

## AUTHORS

Professor Stewart Lockie FASSA  
Dr Kate Fairley-Grenot FAICD FTSE (December 2018 – September 2019)  
Professor Rachel Ankeny  
Professor Linda Botterill FASSA  
Professor Barbara Howlett FAA  
Professor Alex McBratney FAA  
Professor Elspeth Probyn FAHA FASSA  
Professor Tania Sorrell AM FAHMS  
Professor Salah Sukkarieh FTSE  
Professor Ian Woodhead

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## PROJECT MANAGEMENT

Dr Lauren Palmer  
Ryan Winn

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Australian Council of Learned Academies  
Level 6, 436 St Kilda Road  
Melbourne Victoria 3004 Australia  
Telephone: +61 (0)3 9864 0923  
[www.acola.org](http://www.acola.org)

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## ACKNOWLEDGEMENT OF COUNTRY

ACOLA acknowledges the Traditional Owners and custodians of the lands on which our company is located and where we conduct our business. We pay our respects to Elders past, present and emerging.



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# HORIZON SCANNING SERIES

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We live in a time of rapid change; change that is driven by developments in science and technology and challenged by our capacity to adapt in the present and prepare for the future.

Commissioned by Australia's Chief Scientist, on behalf of the National Science and Technology Council, Horizon Scanning reports present independent and timely analyses to guide decision makers through the decade ahead.

Horizon Scanning reports by the Australian Council of Learned Academies (ACOLA) draw on the deep disciplinary expertise from within Australia's Learned Academies to analyse the future, navigate change and highlight opportunities for the nation. As interdisciplinary studies, ACOLA's reports include economic, social, cultural and environmental perspectives to provide well-considered findings that inform complete policy responses to significant scientific and technological change.

This project has been supported by the Australian Government through the Department of Agriculture, Water and the Environment.

ACOLA collaborates with the Australian Academy of Health and Medical Sciences and the New Zealand Royal Society Te Apārangi to deliver the interdisciplinary horizon scanning reports to Government.

## Also in the Horizon Scanning Series

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Published 2018

### **Synthetic biology in Australia: An outlook to 2030**

Published 2018

### **The effective and ethical development of artificial intelligence:**

#### **An opportunity to improve our wellbeing**

Published 2019

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# PROJECT AIMS

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The aim of this horizon scan is to examine and understand the impacts, opportunities and challenges associated with around ten highly prospective technologies likely to impact agriculture over the next ten years and consider how Australian agriculture is positioned to meet them. This will include consideration of the role these technologies can play in helping Australian agriculture address the broader trends and pressures facing it, including:

- climate variability and resilience
- changing consumer preferences
- workforce capacity
- environmental and landscape sustainability
- biosecurity
- industry disruption
- costs of production.

Each technology will be analysed within the following framework:

- What transformative role could the technology play in the agricultural sector?
- What are the social, cultural, economic, legal and regulatory implications of the technology?
- What is the role of 'big data' in the technology? Where relevant, examine issues of data integrity and standards and security and privacy.
- What is the role for government and industry in addressing challenges and facilitating uptake of opportunities, presented by the technology?





# NOTE FROM THE EXPERT GROUP CHAIR

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It is no accident most of the findings presented in this report speak to leadership and collaboration across the government, industry and research sectors if we are to realise the transformational potential of advanced technology.

We are confident that the future of agriculture in Australia will be one in which data analytics and artificial intelligence are as at home on the farm as they are in any other high-tech industry – a future in which the use of advanced sensing, automation, the internet of things and other emerging technologies is no more remarkable than tractors and quad bikes are today.

Advanced technologies open possibilities for Australian agriculture beyond incremental gains in production and labour productivity. These include genuinely transformational approaches to managing capital, plant and livestock, natural resources, biosecurity and supply chains to better deal with climatic and market variability. They include possibilities to commercialise new products, differentiate Australian produce in the global market, verify its provenance and quality, and lift the profitability of agriculture while protecting social, cultural, health and environmental values.

There is a great deal to be optimistic about but there are risks too that should be managed. Perhaps the most obvious of these are consumer resistance to products perceived as unethical. Farm businesses must always play the balancing act between rates of return on capital and investment into new technology and this is particularly difficult for less profitable industries.

Of more concern to the Expert Working Group is the risk that change in the Australian agriculture sector will not be quick enough, or substantial enough, to deal with climate-induced shocks and intensifying global competition.

Sustained engagement is needed with urban and rural communities alike to ensure agriculture maintains its 'licence to operate' and attracts skills and investment to service advanced technology.



**Professor Stewart Lockie FASSA**

# EXECUTIVE SUMMARY

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Australian agriculture is world-renowned for leadership in harvesting practices, water-efficient agronomy, crop and livestock breeding, conservation tillage and development of fit-for-purpose farm machinery. While Australia exports two-thirds of its produce, it is a relatively small exporter when compared to countries like the United States and the Netherlands (Howden & Zammit, 2019). Nonetheless, our primary producers (or farmers) are among the most efficient in the world, with a long history of productivity improvement and adaptation to external challenges, including environmental extremes, price fluctuations, variations in international trade conditions and changes in government policy. Farmers have embraced innovation and shown willingness to adopt technologies that lead to improvements in farm practices. Governments, research providers and a range of other stakeholders have been critical to ensuring that the appropriate resources, policies and institutional arrangements are in place to support research, development and extension.

However, new and transformational approaches will be needed for the agriculture sector to remain productive and competitive in a changing natural, social and economic environment. The development of advanced technologies is critical to this transformation, but it is not by itself sufficient. Ensuring the suitability and adoption of advanced technologies requires consideration of the broader economic, social and environmental context for technology use.

This Horizon Scanning report examines impacts, opportunities and challenges associated with nine technologies: sensors,

internet of things (IoT), robotics, machine learning, large scale optimisation and data fusion, biotechnology, nanotechnology, and distributed ledger technology.

These technologies present opportunities to improve the efficiency and profitability of agricultural production, to develop novel agricultural industries and markets, and to contribute to a range of social and environmental values. Transformational change of this nature will most likely occur when multiple technologies are applied together, and their integration is underwritten by the power of big data and skilful analysis.





## Methodology

A rigorous review process was conducted to explore key factors that could inform the adoption of future technologies, including the contextual and historical background of the Australian agriculture sector and the broader trends and pressures that the industry is facing. As a result of this review process, technologies were identified and examined against their potential to address broader trends and pressures over the next decade. Finally, the factors likely to determine and enable the uptake of agricultural technologies were investigated, including social, legal, regulatory and economic considerations. The outcomes of these investigations are summarised below.

## Broader trends and pressures

The current prevailing drought across much of Australia highlights the importance of technological innovation as one of a range of strategies for coping with climatic and market variability. Over the coming decade, the pace and direction of innovation are likely to be influenced by:

- increasing prevalence and intensity of extreme weather events including droughts, floods, hail and frost as a consequence of climate change



- intensifying global competition as the adoption of new technologies in other countries increases the relative productivity and quality of their agricultural sectors
- biosecurity risks including exotic diseases and pests increasing as a consequence of climate change, global travel and trade
- demands from domestic and international buyers for assurance concerning the quality and safety of agricultural products, and the social and environmental impacts of agricultural products
- perceptions of risk associated with non-traditional methods of food production, which will influence consumer preferences.

Responding to these trends while ensuring a profitable and sustainable agricultural sector will demand step-changes in the productivity of Australia's agricultural systems along with new business models and the development of new food and fibre industries.

## Technology opportunities

The identified technologies may result in novel products: including new traits in existing crops and animals; new forms of nutrient-rich products; and the use of microbes to produce high-value plant metabolites for food and medical purposes. The deployment of advanced biotechnology solutions and digital technologies and devices will provide opportunities to increase profitability and production, global competitiveness, environmental quality, economic growth, and community wellbeing.

The deployment of advanced technologies, such as robotics, coupled with artificial intelligence (AI) and IoT, has the potential to generate vast amounts of data that will be transformational for farming practices, complex decision making and environmental monitoring. Advanced capabilities such as data fusion and machine learning will benefit farming practices and create new markets for on-farm capital – for example, through better forecasting of weather and natural resource strategies. On-farm sensors, devices, robotics and automation will allow agricultural workers to devote more time to complex tasks rather than to activities requiring low levels of skill.

Data, AI and IoT, if properly harnessed, will underpin many future farming capabilities, including asset automation and optimisation, supply chain optimisation, rapid testing of localised crops, and robotics. This will be enabled and driven by a reduction in cost and the increasing capability of computational hardware, memory and communications, coupled with increasing investment and capacity in software and algorithm development.

Sensors and blockchain technologies employed by primary producers, processors and retailers will enable quality assurance programs to verify and communicate the quality and ethical attributes of products. This will lead to improved transparency of the environmental impacts, animal welfare and treatment of workers for consumers.

Biotechnologies have the potential to improve the resilience of crops and livestock to climate variability, pests and diseases. Gene editing provides opportunities to cultivate new and improved products in agriculture.







## Creating an enabling environment for transformational change

There will be a role for primary producers, government and industry to work together in establishing the environment that enables the development, uptake and success of new technologies.

The adoption of advanced agricultural technologies has the potential to provide the sector with new opportunities and to contribute to the economic wellbeing of regional and rural Australia. At the same time, the potential for negative impacts on, for example, rural labour markets, should be mitigated through provision of education and training opportunities.

Attitudes to technology and its adoption by primary producers are complex and multifactorial. Australian primary producers need a clear value proposition in order to be willing to adopt the new technologies. In addition, new and emerging technologies need to be viewed as fit for purpose in the Australian context, which will involve partnerships between technology developers, researchers, farmers and the broader community.

Consumer and broader community expectations and concerns are increasingly influencing the agricultural sector. These must be understood, especially for gene technologies. There is a need for greater

transparency and consultation between primary producers, governments, industry and consumers to understand and raise awareness of new technologies.

Creating a national approach to the use of agricultural data will be a key enabler underpinning many technologies. Relevant considerations include privacy, surveillance and ownership of data between technology users and providers. Farmers should be active participants in all discussions and decisions in this domain.

Telecommunications is a key enabler for many prospective technologies. While regional and rural telecommunication infrastructure has improved over the last decade with new technologies being developed, there remain significant areas where connectivity is unreliable or suboptimal for the needs of future technologies.

Farmers already use a diverse range of skills and expertise to manage their complex businesses, equipment and current technology solutions. However, additional skills will be needed to maximise the value of new technologies and ensure their reliability. For example, up skilling in data literacy and knowledge to maintain or repair sensors will be essential to ensure the reliability and value from on farm data streams.

## The future of Australia's agriculture sector

New and emerging technologies have the potential to assist the agriculture sector to overcome a number of challenges, generate new products and market opportunities, increase rural and regional population, as well as offer rural and regional communities economic and community benefits, including for Aboriginal and Torres Strait Islander businesses.

No single emerging technology will solve the challenges facing Australian agriculture. Supporting transformational change in agriculture requires both the creative combination of multiple technologies and provision of institutional, regulatory and communications infrastructure to enable collaboration and innovation. National leadership must:

- provide a platform for cross-sectoral and cross-disciplinary collaboration in research, development and innovation
- resolve regulatory and policy issues including the use of agricultural data
- prioritise construction of critical enabling infrastructure
- ensure sustained focus across the agricultural innovation system on long-term challenges and opportunities.

There is a role for all stakeholders, including the community, in the future prosperity of Australia's agricultural sector. Governments, academia and industry all have roles in assessing and responding to consumer

and public perceptions and attitudes; engagement with communities about their views and values relating to emerging technologies at all stages of the planning implementation cycle will be necessary.

Technology opens opportunities to explore new products and markets along with new or modified production systems. This is particularly important where agricultural businesses struggle with low profitability and return on investment.

Given the extent of landholdings now under Aboriginal and Torres Strait Islander control it is equally important that Indigenous landholders participate in technology development and adoption. Additional work involving, and preferably led by, Indigenous landholders, researchers and innovators will be critical to understanding this opportunity and its implications for the broader agricultural sector.

This report builds on two previous ACOLA reports on artificial intelligence and synthetic biology. The key findings identify cross-cutting themes, activities and actions to be considered in the development and application of new agricultural technologies, which address key challenges and opportunities, while mitigating risks. This will contribute to a thriving agriculture sector that meets domestic and international requirements over the coming decades and ensures profitability while considering and addressing social and environmental needs.

# KEY FINDINGS

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## 1

### **Addressing the opportunities and challenges facing Australian agriculture requires transformative application of emerging technologies.**

- Step-changes in productivity are required if Australian agriculture is to remain profitable and sustainable. Reviving productivity growth, which has slowed over the last two decades, will necessitate adoption of new technologies and practices along with the development of new products and business models.
- Agriculture industries must work together as a cohesive sector to determine how best to capture and integrate provenance, production and environmental information to enhance product value and enable diversification, taking into account trends in consumer values and preferences.
- Efforts are needed to increase the capacity to adopt and adapt advanced technologies. Increased adoption could help to ensure our agriculture sector can respond to particular nation specific challenges with more drought resilient crops, improved resource management, better understanding and prediction of climate variability, new and enhanced products, and improved on-farm decision-making.

## 2

### **Australia's agricultural technology and innovation ecosystem needs revitalisation to provide more opportunity for stakeholder involvement and to break down sectoral and disciplinary silos.**

- Future investment should more effectively leverage Australia's existing expertise in research and development, continuing a substantial legacy of innovation in agriculture. While more investment is always welcomed, the effectiveness of investment will be substantially enhanced by building more synergistic relationships across traditional sectoral boundaries and through multidisciplinary approaches to national issues.
- The inclusion of primary producers and other community members in the innovation ecosystem is critical to enable timely identification and respond to the needs and aspirations of end-users.





### 3

**The strength and resilience of Australia's agricultural sector will be enhanced by supporting adoption of agricultural technology by Indigenous landholders.**

- The size of Indigenous estate suggests there is significant potential to realise more economic value through the adoption of advanced technology by Indigenous landholders.
- Technology enabled enterprise diversification, improvement in land and water management, and supply chain development in rural and remote Australia will benefit both Indigenous and non-Indigenous businesses.

### 4

**Technology development and adoption across Australian agriculture should include explicit consideration of buyer preferences and expectations.**

- Advanced technologies offer new opportunities to address buyer concerns about the acceptability of some agricultural practices and to provide assurance, more broadly, that buyer expectations can be met in a robust and transparent manner.
- Opportunity also exists to foresee and avoid the perception of risk associated with technology itself by engaging with the public about new technologies at an early stage (i.e. as these technologies are being considered and integrated into agricultural practice) and address their concerns openly.

## 5

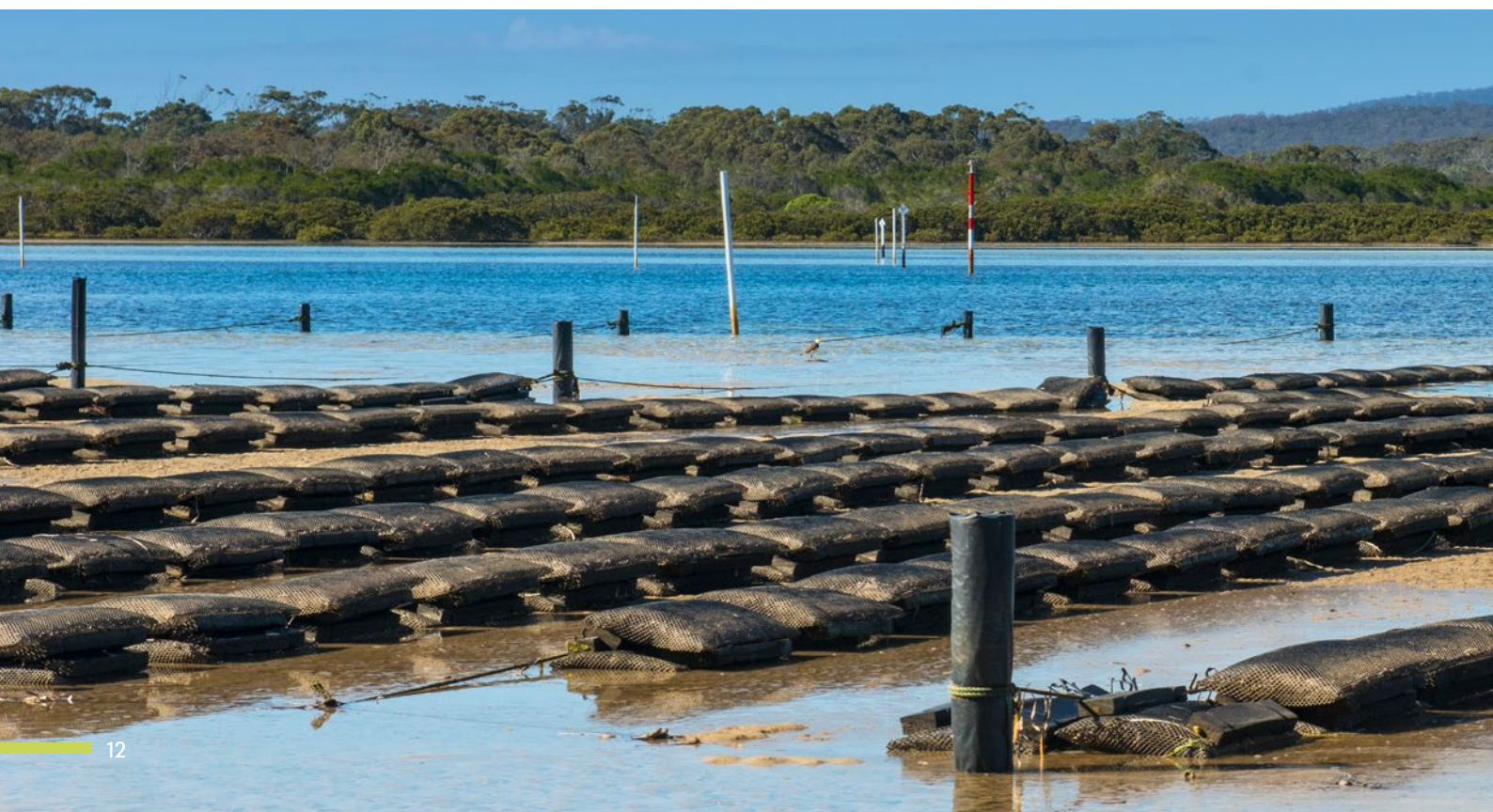
### **Appropriate policy settings are needed to enable technological implementation to move beyond incrementalism and support transformational change.**

- Transformational change will require investment by government, industry and farmers into enabling infrastructure. This includes both physical (e.g. farm connectivity and regional data hubs) and soft infrastructure (e.g. machine learning and artificial intelligence).
- Future regulation of advanced technologies will need to be more transparent, outcome focused, accessible, and sufficiently flexible to accommodate the development of further technologies and meet the needs and concerns of affected communities.

## 6

### **Data are a powerful asset but will require appropriate national leadership and regulation to ensure their potential value to agriculture is realised.**

- The collection of large amounts of farm-related data from sensors on equipment and robotics should be harnessed for better on-farm decision making and the creation of new products. National leadership is needed to ensure the equitable balance of privacy, surveillance and fair ownership of data between technology users and providers.
- The development of codes of practice and access to open source software, open data, and agricultural data codes of practice could assist in making many technological solutions more equitable and acceptable for Australian primary producers.
- Farmers should be active participants in all discussions and decisions in this domain.





# 7

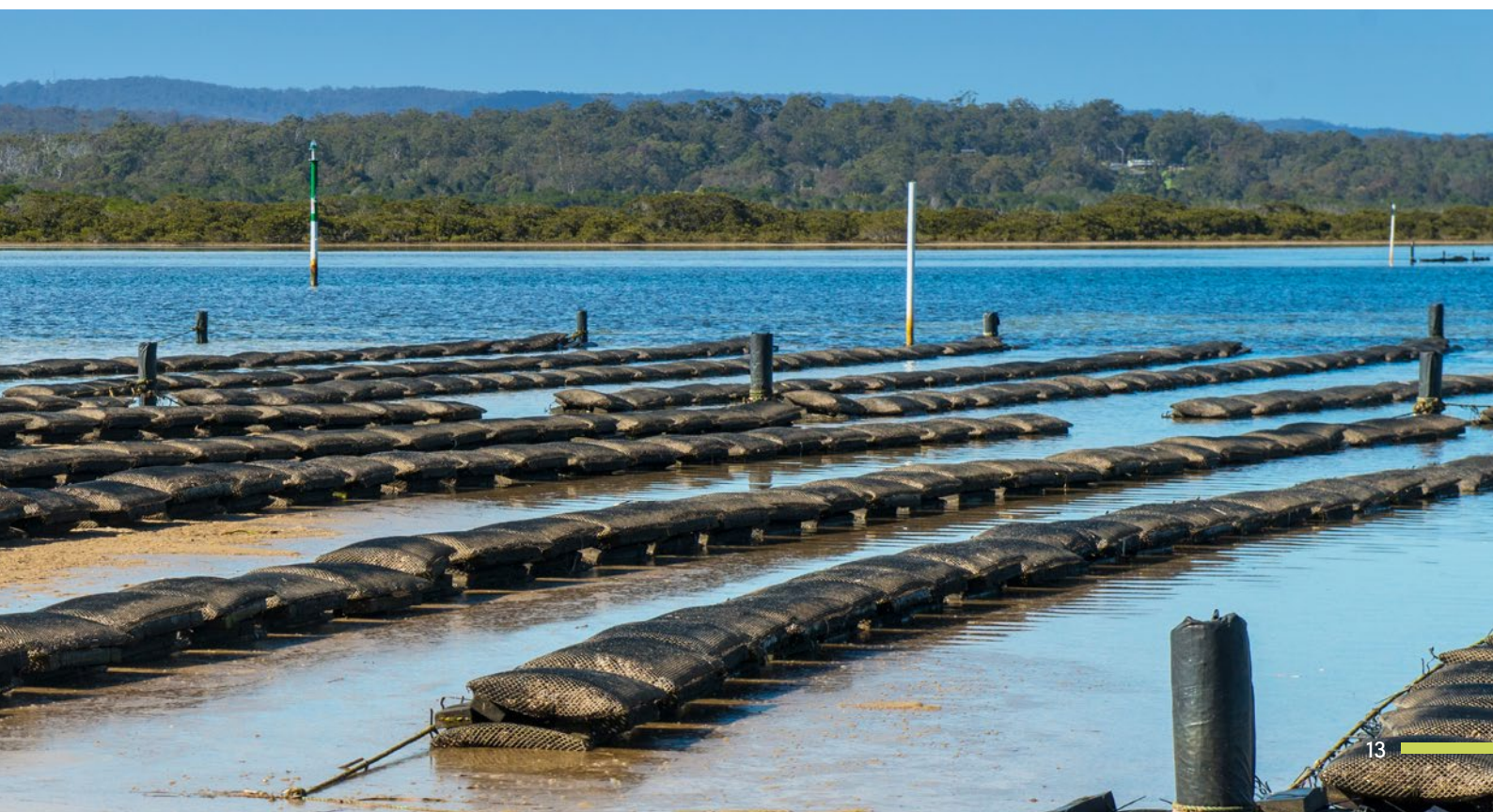
**Empowering Australia's regions through investment in local solutions and capacity will facilitate transformational change through agricultural technologies and will provide complementary social and economic benefits.**

- There are roles for all levels of government in facilitating the development of innovation ecosystems servicing agriculture and other regional industries. These will be characterised by virtuous cycles of education, locally-relevant research and development, industry application, and the establishment of technical service businesses.
- Place-based approaches are needed to ensure innovation is sensitive to the full range of economic, social, cultural and environmental values relevant to agriculture, and maximises opportunities for regional employment, business development and traditional owner engagement.

# 8

**Farmers and other agricultural workers need support to familiarise themselves with emerging technologies and to obtain the specialist skills required to maximise their use.**

- Providing the skills for farmers to use new technologies on farm is important, as is developing the broader rural workforce to work in support and service roles. Upskilling could be provided through accredited training, micro-credentialing and other professional development programs.
- Higher education, TAFE and other VET providers will be important in workforce development. Potential models could include innovation precincts anchored by regional universities or other research and development providers.













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