

Agricultural workforce digital capability framework

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RDC PARTNERS



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Abbreviations and Glossary of Terms

Abbreviation	Definition
AgTech	Agricultural Technology
AI	Artificial Intelligence
CAGR	Compound Annual Growth Rate
CALD	Culturally and Linguistically Diverse
FAO	Food and Agriculture Organisation (United Nations)
GIS	Geographic Information System
IoT	Internet of things
ML	Machine Learning
NCVER	National Centre for Vocational Educational Research
NFF	National Farmers Federation
RDC	Research and Development Corporation
RTO	Registered Training Organisation
SSO	Skills Service Organisation
VET	Vocational Education and Training

Technology	Definition
Artificial intelligence	In computer science, artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans. Colloquially, the term artificial intelligence is often used to describe machines (or computers) that mimic cognitive functions that humans associate with the human mind, such as learning and problem solving.□
Augmentation/ augmenting technologies	Augmentation is defined as the capability of technologies to supplement efficiency of a job and in doing so, enabling a worker to gain capacity to do higher value work. Augmenting technologies can be leveraged to enhance worker capacity, drive productivity and efficiency.
Automation/automating technologies	Automation refers to the capacity of technologies to complete tasks and activities, hence driving process efficiencies.
Big data	Any collection of datasets so large and complex that it becomes difficult to store, process and analyse using current technologies. Big data comes from many sources (e.g. text, image, audio, social media etc.) at an alarming velocity, volume and variety, which adds to this challenge. In the context of agriculture big data typically refers to farm machinery, sensors and digital technologies that generate large volumes of data about the status of soil, water, crops, animals and pasture.□
Data governance	The overall management of the availability, usability, integrity and security of data used in an enterprise.
Decision agriculture	Conclusion or action resulting from the application of knowledge and/or information that may be derived from digital agriculture.
Edge computing	The practice of processing data near the edge of your network, where the data is being generated, instead of in a centralised data-processing warehouse.□
Extended reality	Extended reality technologies create experiences that blur the boundaries of real and digital environments. □
Geographic information system	System designed to capture, store, manipulate, analyse, manage, and present spatial or geographic data. GIS applications are tools that allow users to create interactive queries (user-created searches), analyse spatial information, edit data in maps, and present the results of all these operations. □
Information and communication technologies	ICT is a broad term used to refer to technologies that involve the use of computers, computer networks, telephone networks and internet networks to manage data and information. □
Internet of things	Devices such as sensors, machine and other digital instruments which are connected to each other and the internet so that they are able to collect and exchange data with each other.□
Machine learning	An application of artificial intelligence that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves. □
Precision agriculture	Farming practices that involve precise spatial management through the use of Global Positioning System (GPS) or machine vision technologies. Involves the observation, impact assessment and timely strategic response to fine-scale variation in causative components of an agricultural production process. This can include variable rate seeding and fertiliser application, yield mapping, and animal location and analysis.
Quantum computing	Quantum computing is a model that uses a different kind of data unit and data handling to perform calculations and solve complex problems that are beyond the capabilities of a classical computer.
Smart sensor(s)	A device that takes input from the physical environment and uses built-in compute resources to perform predefined functions upon detection of specific input and then process data before passing it on.
Variable rate technology	Describes any technology which enables producers to vary the rate of crop inputs.□

Executive Summary

In an effort to respond to a rapidly changing agricultural environment and boost the industry's competitiveness entering a new age of digital farming, Cotton RDC and a group of Rural Research and Development Corporations have come together to fund the Agriculture workforce digital capability framework project, managed by Cotton RDC. The project will assist in understanding the digital capabilities required by agricultural workers in order to address any gaps in the ability to meet future demand. The project will also provide education providers with a framework to develop education pathways for up-skilling the agricultural workforce to better adopt technology.

With more than 220,000 people employed, the Australian agricultural industry is characterised by an ageing workforce, which one component of the workforce of particular concern are the farmers.¹ About 23 percent of the sector's current workforce is expected to retire over the next five years². In addition, the education system currently does not train enough people to enter the sector, as the industry identifies 800 agricultural graduates leaving tertiary institutions to meet an estimated annual demand of 2,000 people.³ Although it is acknowledged that is not the unique pathway for people to join the agricultural workforce (e.g. marketing and communication, engineering, business and finance), specific agricultural training programs were the focus of this study. Meanwhile, the future and existing agricultural workforce will have to embrace change and develop new skills to ensure the industry seize the opportunities presented by digital agriculture and remains competitive globally.

Realising these opportunities will require addressing the challenges of lifting the digital maturity of the industry. This will require considerations including but not limited to assessing key workforce digital characteristics through the lens of the **national digital capability framework, understanding the impact of digital technologies on workforce capabilities**, and taking into account **insights from the analysis of the current existing training providers and learning pathways**.

Further steps for the agricultural industry to consider in uplifting the digital maturity include:

- Looking into the specifics of which agricultural sectors and which particular technologies present the greatest augmentation and automation opportunities, in order to prioritise capability development focus;
- Driving the development of curricula and training pathways for both future and existing workers to address the gaps in digital skills;
- Developing a self-assessment tool for individuals to assess future capability requirements based on current digital skills; and
- Driving a campaign to develop benchmarks across the various sectors within the agricultural industry.

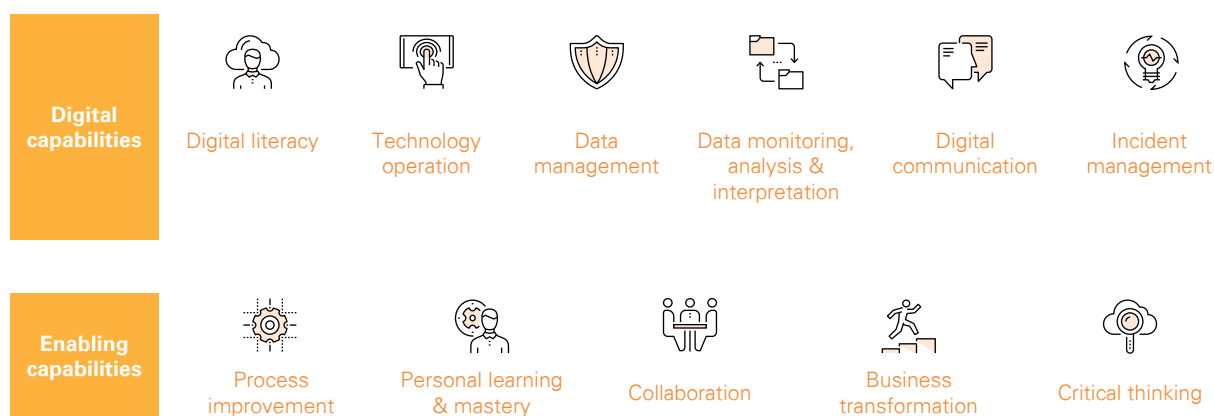
¹ Skills Impact, *IRC Skills Forecast and Proposed Schedule of Work 2019-2022*, p. 12.

² Queensland Farmers Federation, 2018, 2018 Agriculture Future Skills and Training Needs Research', p. 23.

³ Journal of economic and social policy, 2015, *Educating Australian High School Students in relation to the digital future of agriculture*, p.1.

Developing a national digital capability framework for the agricultural industry

There is currently no competency model available in the Australian agricultural industry to simply identify digital capabilities. As a result, a national framework has been created to map the digital capabilities of the agricultural workforce that will be required in enabling individuals to adapt to a rapidly changing technological environment. The digital capability framework identified a set of **six digital capabilities** and **five enabling capabilities** that will be required for the agriculture workforce to work and thrive in a digital environment:



In this study, agriculture-specific role categories were found to have low levels of digital maturity. More specifically, while the maturity of digital adoption varies between role categories across the supply chain, the study found that there is currently a consistent lack of proficiency in operating technologies and digital devices applicable to business activities and processes.

Whilst the full range of digital and enabling capabilities will be required in the future of the agricultural industry, the greatest level of expectation is set on data collection and analysis as well as data management. The analysis demonstrated that the workforce are aware of the value of data collection and the habit of data collection is increasing. However, significant barriers seem to remain in understanding what data is required and collecting data digitally to allow for analysis and decision making processes. Among the most influenced role categories within the agricultural industry, the study found that livestock farming and crop farming, currently representing the top employer sectors, hold the greatest potential for workers' capabilities to be augmented by leveraging technologies.

The industry is also likely to face an increasing need for other non-traditional agricultural skills in the workforce such as technological, scientific and management competencies, which are also identified to possess more mature digital capabilities. Areas such as business transformation skills, for example, represent a major gap in meeting future demand of agricultural operations, and will only continue to grow in importance. Additionally, collaboration and critical thinking are anticipated to be the most important enabling capabilities in the future digital environment, especially for stakeholders across the supply chain (for instance farmers, corporates, government, training and education providers) cooperate on agricultural innovation enabled by digital.

Further details on the national digital capability framework are available in the [Future state section](#). Extensive explanations of the key components for each maturity level associated with digital and enabling capabilities can be found in the standalone report **Agricultural workforce digital capability framework – Digital training and curricula handbook for education and training providers**. Further details on the assessment of the workforce digital capabilities are available in the [Gap analysis section](#).

Understanding the impact of digital technologies on workforce capabilities

The agricultural workforce is likely to be influenced by technologies and digital solutions in the future that will **augment** and **automate** the way people operate. In order to adapt to this new environment, the workforce will need to develop and up-skill their digital capabilities. Refer to definitions available in the [Glossary](#) section.

Over the next 10 years, Faethm modelling indicates 41% of jobs in the Agricultural Industry will be transformed through the impact of technology, of which 31% by automating technology and 10% by augmenting technology. Through the adoption of new AI and robotics technologies, the industry will be able to automate manual tasks and augment others, achieving a higher productivity rate. This imperative to leverage these technologies will also drive the need to hire for and create jobs that can own their implementation and operation.

Additionally, Faethm modelling predicts that in the next 10 years one in three new jobs created in Agriculture, Forestry and Fishing will be tech related. As a result, Software Developers, Data Engineers and Data Scientists are some of the new roles that will be needed to make the most of technologies such as Navigation Technology, Process Automation and Fixed Robotics amongst others.

Among the most influential technologies augmenting the workforce capabilities in the future, the study identified navigation robotics, process automation, and fixed robotics. Detailed definitions of these concepts will be further discussed in the [Future state section](#).

There are many technologies available in the market supporting the agricultural industry to address key challenges such as strengthening productivity yields, improving traceability or increasing efficiency and accuracy. However, there is on average a slow uptake of digital solutions due to various reasons including but not limited to poor digital literacy in regards to awareness of available technologies, difficulties to identify the right solution for the business, a lack of clear value propositions from technology providers, a lack of understanding of the value proposition of the available technologies, serviceability issues and connectivity barriers. Whilst there is evidence that the majority of farmers are progressing digitally in that they widely utilise technological devices such as computers and smartphones, it is clear that in the past connectivity and download speeds have presented a significant barrier to leveraging the opportunities digital technologies pose and strengthening digital capabilities. This is a reality acknowledged. However, the report also recognises that new and exciting communication protocols, digital devices and market players have emerged to provide solutions that can service the connectivity needs of nearly any farmer today. There is a parallel need of promoting awareness of the options available.⁴

Understanding the insight-analysis of existing training providers and learning pathways

This report also conducted a review of current training providers and curricula focusing on digital and technological training. The review found that digital skills training is available through the VET system, universities and, increasingly, informal training provided by equipment and service suppliers and unregistered training organisations.

Across relevant agricultural workforce qualifications in VET only five percent of the units of competency have a focus on digital capabilities and skills, or could be contextualised to do so during delivery.

The review highlights the range of training options and the difficulties for employers, workers and potential workforce entrants to identify specific options for digital skills training available to them. This is particularly so given the different sources and types of information for each type of training.

Another key challenge was that there is currently no mechanism within the VET systems to prescribe particular technologies within units of competency, thus allowing training providers to deliver and assess training in the context of technologies relevant to each group of learners.

A third critical issue identified was the difficulty in improving and increasing enrolment in digital skills training due to difficulties in providers attracting staff with suitable knowledge and experience, extensive equipment requirements and low demand from an industry that is lacking in digital technologies leadership and adoption.

⁴ KPMG, 2019, *Agri 4.0 Connectivity at our fingertips*, p. 5.

While there are various providers of digital capabilities training for precision agriculture (especially informally), the majority of training delivery is for generic digital capabilities.

Regarding the new workforce, this report details the need for a wider scope of the education landscape. Attracting students will rely on the ability to strengthen the appeal of agriculture-related studies by incorporating more cross-industry curricula and skills in disciplines such as science, technology, engineering and mathematics. Future education pathways should increase emphasis on decision agriculture and include training in connectivity options, data management, use and licensing.

On the other hand, many skills including the development of digital capabilities are best learnt on the job due to the variability in context requirements. A recent study by Swinburne University noted that 38 percent of Australian workers prefer learning on the job and that the more digitally disrupted an industry, the more workers prefer this form of education.⁵ There is currently an education gap in practical on-farm training to produce industry-ready skills and job candidates. Resulting issues of this include a lack of formal recognition of the value of on-the job competencies compared to formal education and training, and a reduction in viability for RTOs in promoting their own digital training.

Generally, industry possesses low levels of knowledge about existing training opportunities. To drive a national development agenda, there is need for increased industry involvement and a coordinated national plan to utilise and publicise digital capabilities standards across educational activities.

5 Swinburne University of Technology, 2019, *Peak Human Potential: Preparing Australia's workforce for the digital future*, p. 4

Introduction

1. Purpose of the report

Context

In 2017, the *Accelerating Precision Agriculture to Decision Agriculture (P2D)* project recommended to increase digital literacy and up-lift digital skills of the agriculture workforce.

Australian agriculture is on the brink of vast change, striving to meet the National Farmers' Federation's (NFF) vision of \$100 billion in farm gate output by 2030.⁶ To achieve this goal and remain globally competitive the industry needs to grow significantly in the next 11 years. The value of current agriculture revenue is expected to increase from its current level of \$59 billion to reach \$64 billion in 2023-24.⁷ In order to achieve the NFF's \$100 billion objective, growth needs to reach an estimated compound annual growth rate (CAGR) of 4.5 percent per annum by 2030. Among other enablers identified in the NFF's 2030 roadmap⁸, this growth will be facilitated by unlocking the opportunities of agricultural technology, estimated by the P2D project to be capable of delivering a \$20.3 billion gross value at the farmgate.⁹

The P2D project outlined, among several recommendations, that the 15 Research and Development Corporations (RDCs) and the university sector strategically invest in education and capacity building for the agricultural workforce to increase digital literacy and up-lift digital skills.

The Cotton RDC has led a working group made up of eleven RDCs to manage three projects aiming to uplift the digital capability of the agricultural industry:

- Digital capability framework and self-assessment approach
- Data governance framework
- Digital agricultural maturity index and self-assessment tool.

This report addresses the development of the Digital capability framework to identify the capabilities required by the agricultural workforce in the future.

Key objectives and achievements

Objectives

This report aims to provide the Cotton RDC, acting on behalf of the eleven RDCs representing the Australian agriculture, with a national digital capability framework for the agricultural workforce that resonates across the industry. The report includes a framework of training requirements to close the gap of current digital capabilities. The Cotton RDC intends to use this report to identify up-skilling pathways for the agricultural workforce to increase digital literacy of the industry and increasing the adoption of new technologies as part of the project *Australian Agriculture: Growing a Digital Future*.

6 KPMG and National Farmers Federation, 2018, *Talking 2030: Growing agriculture into a \$100 billion industry*, p. 3.

7 ABARES, 2019, *Agriculture overview March quarter 2019*. <http://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/mar-2019/agriculture-overview>

8 National Farmers Federation, 2018, *2030 Roadmap*, p. 24.

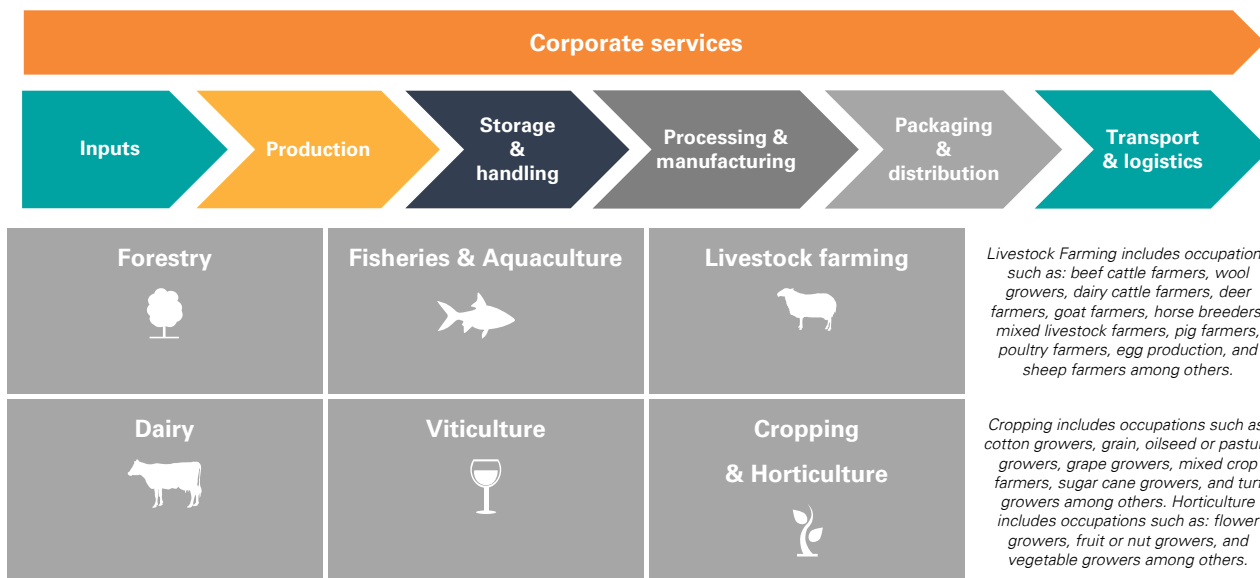
9 Australian Government Department of Agriculture and Water Resources, 2017, *Accelerating Precision to Decision Agriculture: Summary Report for Stakeholder Consultation*, p. 1.

Main achievements of this report

- 1** Definition of a national digital capability framework about the Australian agricultural workforce.
- 2** Identification of the influence of emerging technologies will have on agricultural workforce capabilities over the next 10 years.
- 3** Assessment of the current digital capabilities of the agricultural workforce.
- 4** Identification of digital and enabling capabilities gaps of the agricultural workforce compared to estimated future needs.
- 5** Review of current training providers and curricula in digital agriculture-related disciplines.

2. Scope, definitions and approach

Analysis of digital workforce capabilities across end-to-end supply chain among all sectors forming part of the Australian agricultural industry



Digital capabilities are defined as the skills and attitudes an individual, organisation or industry require to ensure they have the capability to actively participate in a current and future environment heavily reliant on digital resources and technologies.

In order to reflect the multi-faceted digital skill sets required to operate in the industry, the study considered a broad scope of roles currently contributing to farm gate output. The scope of this project includes the roles identified as agriculture in reference to ANZSCO data, Census data, and client consultations with industry research and development corporations across the end-to-end agricultural supply chain.

The list of roles in-scope of this report were grouped under meaningful, specific, and generic role categories used to analyse the maturity of digital and enabling capabilities in the current state and future state.

The role categories used were as follows and the sub-categories analysed within these categories can be found in [Appendix C](#).

Agriculture specific:	Fisheries & aquaculture farming	Livestock farming	Cropping & horticulture	Mixed crop farming	Product processing
Generic:	Science & engineering	Governance	Business management	Vehicle operation & maintenance	Building & property maintenance

Digital agriculture

Digital agriculture refers to the use of digital technology to complete activities focused on production leveraging on farm machinery, digital devices, software, data collection and information processing. Digital agriculture unlocks opportunities for the agricultural industry including but not limited to achieving better input efficiencies, improving farming productivity and profitability, making more informed decisions. The data created and captured through digital agriculture activities can be integrated into the food and fibre processing stages of the supply chain, and in some cases integrated through to the consumer via technology enabled solutions (such as food e-commerce platforms and blockchain). How it impacts the way the workforce operates will ultimately determine the workforce capabilities required.

The assessment of the impact of digital technologies on the agricultural workforce capabilities in the future is based on Faethm Technology Taxonomy which identifies 17 technology AI and robotics types, categorised in four broad divisions described below.

Programmed intelligence	Narrow artificial intelligence	Broad artificial intelligence	Reinforced artificial intelligence
<p>Pre-programmed technologies.</p> <p>Non-autonomous, depends entirely on human input. These technologies can perform highly structured and simple process tasks by employing rules-based logic, processes, instructions and simple robotics.</p> <p>The most mature and adopted category of AI and robotics types, yet has the most rudimentary capability of the four categories.</p>	<p>Semi-autonomous technologies.</p> <p>Acts semi-autonomously when prompted by humans (reactive). These technologies perform structured, familiar tasks in defined domains by using machine learning to interpret certain problems.</p>	<p>Pro-active technologies that require no prompt to act.</p> <p>Broad AI can self-initiate actions with no human input. These technologies perform unstructured tasks and engage with their environment using perception and sensory processing of external input data.</p>	<p>Self-improving technologies that can perform unfamiliar tasks.</p> <p>Reinforced AI can independently learn from experience to perceive and complete new tasks. They perform creative, unfamiliar actions across domains through using reinforced learning.</p> <p>The most capability-sophisticated category, yet immature as these technology types are in mainly in R&D stage.</p>
<p>Process automation</p> <p>Fixed robotics</p> <p>Mobile robotics</p>	<p>Predictive analysis</p> <p>Recognition vision</p> <p>Voice response</p> <p>Suggestion provision</p>	<p>Sensory perception</p> <p>Decision generation</p> <p>Conversation exchange</p> <p>Dexterous robotics</p>	<p>Navigation robotics</p> <p>Collaborative robotics</p> <p>Solution discovery</p> <p>Generative design</p> <p>Creative origination</p> <p>Assistive robotics</p>

According to the Faethm technology taxonomy (see [Appendix E: Detailed Technologies](#) for in-depth description of Faethm technology), there is also an infrastructure technology layer which categorises technology types that enable the application of AI/robotics. These technology types are not directly modelled to assess the impact of technologies on the agricultural workforce.

Agriculture-specific technologies have been mapped against the top five technology types identified with the greatest potential to augment or automate agricultural workforce capabilities, including navigation robotics, process automation, fixed robotics, conversation exchange and conversation exchange. The mapping of the technologies predicted to be most relevant to agriculture can be seen in the [Future state assessment](#).

Within these technology types and processes it is important to note the differences between those that are **automating technologies** and **augmenting technologies**. Automation refers to the capacity of technologies to complete tasks and activities, hence driving process efficiencies. It also prompts the need to redefine role description and ensure capability evolution for relevant workforce to fully capture the opportunities of automating technologies. Augmentation is defined as the capability of technologies to supplement efficiency of a job and in doing so, enabling a worker to gain capacity to do higher value work. Augmenting technologies can be leveraged to enhance worker capacity, drive productivity and efficiency. This would require the workforce to up-skill or build new digital and enabling capabilities to seize the opportunities offered by technologies in the future.

Approach

A range of methodologies were used to develop this report to ensure a number of perspectives were taken into account to provide the required insights to the Cotton RDC, including:

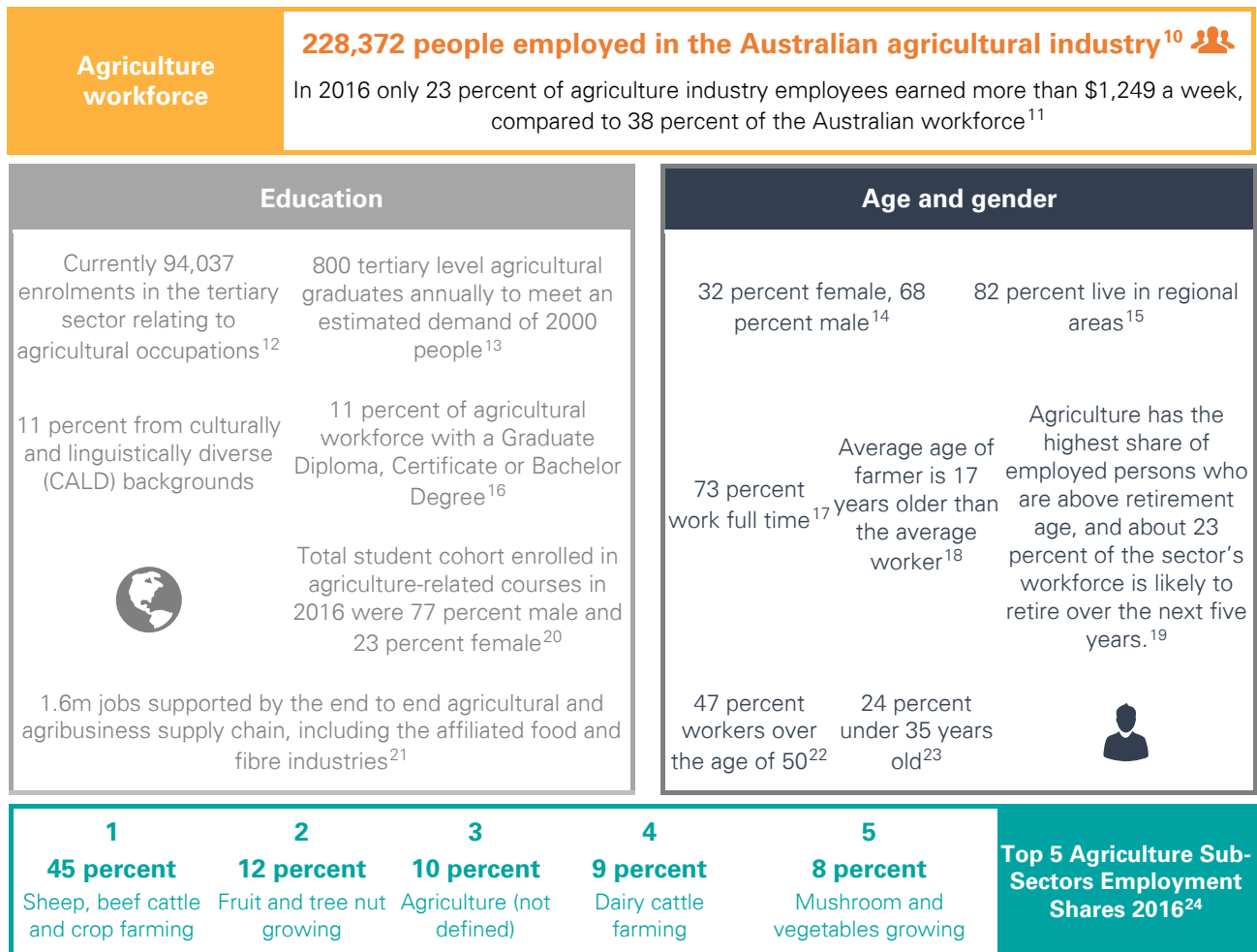
- Definition of the scope of the agricultural workforce;
- Desktop research;
- Collaboration with an industry cohort;
- Determining the current and future state of digital capabilities – powered by Faethm’s technology; and
- In-depth review of current training providers and curricula.

A detailed approach is available in [Appendices](#).

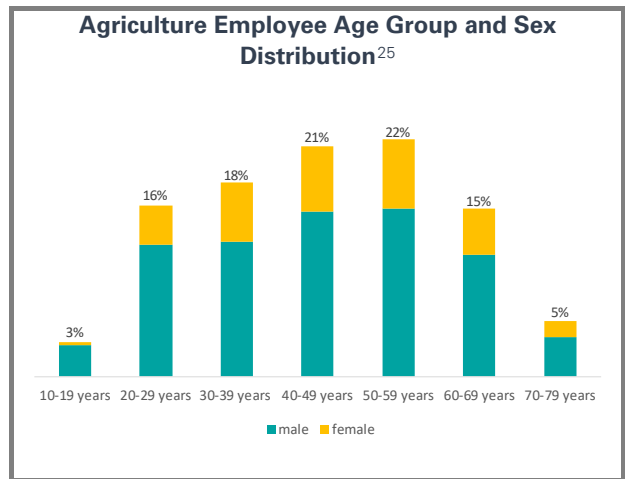
Current state assessment of the Australian agricultural workforce


1. Setting the scene

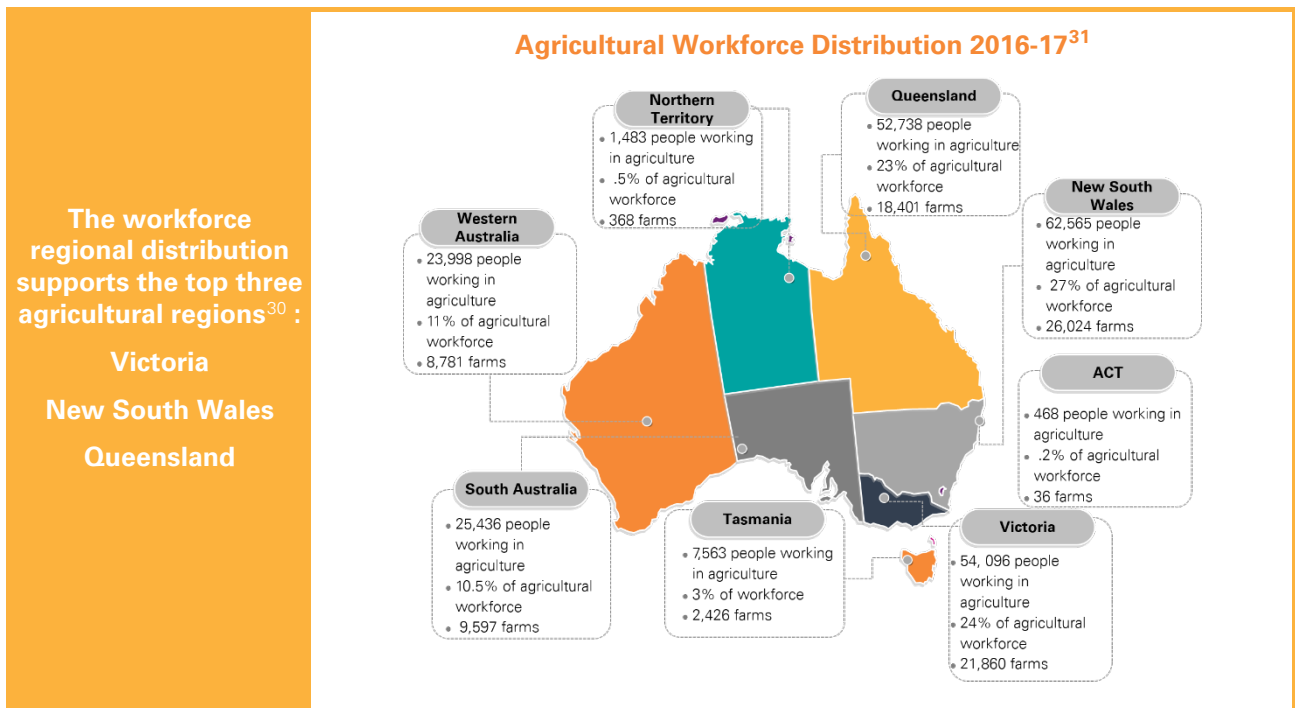
Snapshot of the current Australian agricultural workforce



10 ABARES Insights, 2018, Snapshot of Australia's Agricultural Workforce, p.2.
 11 ABARES Insights, 2018, Snapshot of Australia's Agricultural Workforce, p.4
 12 Skills Impact 2019, *Review of existing training providers and curricula*
 13 Journal of economic and social policy, 2015, *Educating Australian High School Students in relation to the digital future of agriculture*, p.1.
 14 ABARES Insights, 2018, Snapshot of Australia's Agricultural Workforce, p.2.
 15 Ibid
 16 ABARES Insights, 2018, Snapshot of Australia's Agricultural Workforce, p. 5.
 17 ABARES Insights, 2018, Snapshot of Australia's Agricultural Workforce, p.2.
 18 Ibid
 19 Queensland Farmers Federation, 2018, 2018 Agriculture Future Skills and Training Needs Research', p. 23.
 20 Skills forecast 2018-2021, p. 52.
 21 Graduate Careers Australia, *Agriculture*, <http://www.graduatecareers.com.au/agriculture/>
 22 ABARES Insights, 2018, Snapshot of Australia's Agricultural Workforce, p.2.
 23 Ibid
 24 IBID



<p>Approximately one-third of farmers reported that a lack of digital skills was a constraint on their uptake of new ICT tools²⁷</p>	<p>34 percent of respondents reported having mobile coverage across their entire property, 43 percent had no coverage at all²⁸</p>	<p>83 percent of producers in P2D survey who owned a smartphone, with over half using it more than five times per day²⁹</p>	<p>Digital Capability</p> 
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25 Queensland Farmers' Federation, 2018, *Final Report to Jobs Queensland, 2018 Agriculture Future Skills and Training Needs Research*, p. 23.

26 ABARES Insights, 2018, *Snapshot of Australia's Agricultural Workforce*, p.9.

27 ABARES, 2018, *Information and communication technology use in Australian agriculture*

28 Australian Government Department of Agriculture and Water Resources, 2017, *Accelerating Precision to Decision Agriculture: Summary Report for Stakeholder Consultation*

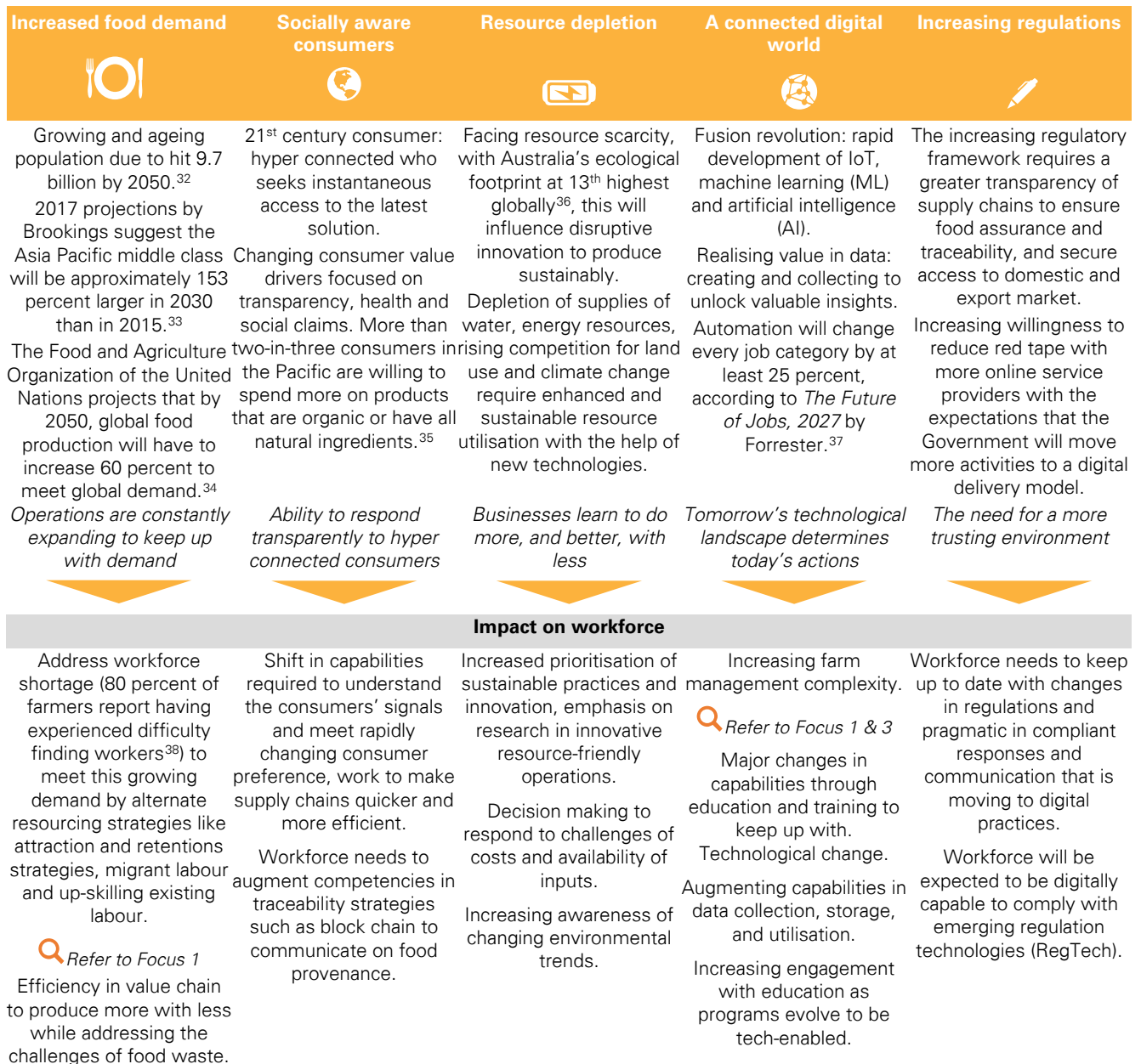
29 Australian Government Department of Agriculture and Water Resources, 2017, *Accelerating Precision to Decision Agriculture: Data connectivity for digital agriculture*, p.3

30 ABARES Insights, 2018, *Snapshot of Australia's Agricultural Workforce*, p.3.

31 ABARES Insights, 2018, *Snapshot of Australia's Agricultural Workforce*, p.2. / ABARES, 2018, *About my region: regional profiles*, <http://agriculture.gov.au/abares/research-topics/aboutmyregion/vic>

Megatrends in the agricultural sector and key impacts on the workforce

The pressure of global megatrends will reshape the market in which organisations in the agricultural industry compete for skills. The agricultural industry will keep competing with other industries to attract trained and digitally capable workforce. With rapidly changing global consumer demand, adoption of digital innovation will be a key aspect for Australian agriculture to remain competitive on a global scale.



32 United Nations, 2019, *Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100*, <https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html>

33 Farm Tender, 2018, *Ag Tech Sunday – Advancing digital agriculture from point solutions to platforms*, <https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html>

34 The United States Studies Centre at the University of Sydney, 2018, *Seeds of Success: Advancing Digital Agriculture from point solutions to platforms*, p. 4.

35 <https://www.nielsen.com/au/en/insights/article/2017/premium-potential-grocery-categories-pacific-consumers-are-willing-to-spend-more-on/>

36 State of the Environment Australia, 2016, *Consumption and extraction of natural resources*, <https://soe.environment.gov.au/theme/biodiversity/topic/2016/consumption-and-extraction-natural-resources>

37 Forrester, 2015, *Robots won’t steal all the jobs – but they’ll transform the way we work*, https://go.forrester.com/blogs/15-08-24-robots_wont_steal_all_the_jobs_but_theyll_transform_the_way_we_work/

38 National Farmers’ Federation, 2018, *A Greener Future*, p. 1.

Focus 1 – Workforce shortage

A significant barrier to the agricultural industry achieving an aggregate improvement to their capabilities is a serious workforce shortage for the farming and broader agribusiness workforce.

Specifically for farming workforce, 80 percent of farmers experience difficulty finding workers.³⁹ In particular there is a lack of educated workers, with a job market for graduates five times larger than the supply and only seven percent of the sector holding tertiary qualifications, compared with 25 percent of the national workforce.⁴⁰ The most disadvantageous effects of a workforce shortage are under-capacity production, with farmers noting they often have to leave crops to rot due to an insufficient amount of accessible labour.⁴¹

With 82 percent of the agricultural workforce living in regional areas⁴² where the job opportunities mostly exist, the workforce shortage in the industry must be directly linked to the causes attributed to a workforce shortage in rural areas, regardless of the industry and including:

- Lower access to telecommunications and connectivity;
- Poor access to doctors, health care, and education, as well as the trend for children to be sent away to school and not return; and
- A lack of childcare services.

Focus 2 – Increasing farm management complexity and skills requirements

As the Australian agricultural sector consistently consolidates, with a decreasing number and increasing size of farms⁴³, the repertoire of roles fulfilled by a single worker is becoming increasingly complex. A farmer may perform tasks in livestock and crop management, in addition to business management and supplier and stakeholder relationship management, requiring expertise in numerous disciplines.⁴⁴

The adjustments will also be impacted by technologies and in the future, the agricultural workforce including a combination of in-house and agri-consultants (e.g. agronomist) will need to up skill and also collaborate to address the future needs of the industry moving to a more digital environment.

Focus 3 – Rapid change of the capabilities required due to changing technological environment

With Australia's consistent progress in striving to become a digitally competent agricultural workforce, handling the increasing complexity of operations will require farmers and agribusinesses to adapt capabilities to a changing technological environment. By 2030 Australian workers will spend at least 60 percent more time using technological skills than they currently do; up-skilling to address a changing technological environment is crucial.⁴⁵ This environment in Australia is marked by the progressive use of automated machinery, smart sensors, big data, variable rate technology, unmanned aerial vehicles, and digital farm management platforms.⁴⁶ More specifically, applications such as edge computing, extended reality, and quantum computing are becoming more commonplace in the sector.⁴⁷ (See definitions in [Glossary](#)).

The uptake of technology has been stronger in some sectors than others, for example in the cotton sector 35 percent of growers use automation and 40 percent are considering adoption.⁴⁸ According to the P2D report the cotton sector was also found to have the highest number of average types of data collected on the farm (4.4), compared to less technologically mature sectors such as sugarcane and grains (2.7).⁴⁹

39 National Farmers' Federation, 2018, *A Greener Future*, p. 1.

40 Journal of economic and social policy, 2015, *Educating Australian High School Students in relation to the digital future of agriculture*, p.1.

41 National Farmers Federation, 2018, *Farmers asked to report worker shortages in campaign for Ag Visa* <https://www.nff.org.au/read/6204/farmers-asked-report-worker-shortages-in.html>

42 ABARES Insights, 2018, *Snapshot of Australia's Agricultural Workforce*, p.2

43 ABARES, 2018, *Disaggregating farm performance statistics by size, 2017-18*, <http://www.agriculture.gov.au/abares/research-topics/productivity/related-research/disaggregating-farm-size#farm-characteristics-and-performance>

44 Agricultural Appointments, 2019, *Agribusiness Trend and Salary Report 2019*, p. 14.

45 Swinburne University of Technology, 2019, *Peak Human Potential*, p. 18.

46 KPMG, 2019, *Agri 4.0 Connectivity at our fingertips*, p. 17.

47 AgriFutures Australia, 2018, *Horizon Scan 6*, p. 4.

48 Cotton Research Development Corporation, *2018 Grower Survey*, p. 7.

49 Australian Government Department of Agriculture and Water Resources, 2017, *Accelerating Precision to Decision Agriculture: Technical Report*

The implementation of such technologies can assist in replacing subjective human assessment and therefore decrease margin for error on farms, help farmers make more informed decisions, more efficiently monitor the activity and performance of agribusinesses, improve workplace health and safety, play a role in meeting regulatory and compliance requirements, and above all, vastly improve efficiency and reduce time needed for human labour⁵⁰, while improving health and safety for the workforce.

The capabilities required of workers to remain up-to-speed with this changing technological environment are constantly increasing and evolving. Updating one's skill set is more important than ever before, a reality epitomised by a Swinburne University study that found 56 percent of working Australians expect that work in five years will require new skills which they currently lack.⁵¹ It is becoming more imperative for workers to be competent in the STEM disciplines: namely science, technology, engineering and mathematics.⁵² A USDA report identified that 27 percent of professional employment opportunities within the food and agriculture related space will be in STEM capacities in the next five years.⁵³ The impact of technological capabilities on agricultural output is immediately tangible, for example digitising cropping systems report gains of 10-15 percent increases in production.⁵⁴

More specifically, the digital skills within STEM may involve anything from processing data, to working with robots, computer sciences, operating advanced machinery and auto-steered equipment, to complex phone and computer applications.⁵⁵ For example, according to a 2018 survey of cotton growers, 69 percent responded 'yes' to whether the implementation of automation has required workers to learn new technological skills to perform their jobs.⁵⁶

In addition to technology-based skills, interpersonal skills, identified as enabling capabilities in the future state assessment section, will be required as farmers perform tasks like improving their business. Communication and collaboration skills will continue to become increasingly important given an augmented level of collaboration between farmers and advisory businesses such as agronomists, suppliers and contractors. According to a research paper by the *Wageningen Journal of Life Sciences*, agricultural advisors will play a role in co-designing digital innovation on farms, offering a repertoire of outside expertise, networks and resources.⁵⁷

This report details the impact of technologies on the agricultural workforce using Faethm Technology Taxonomy which identifies 17 technology AI and robotics types. Refer to the [Introduction](#) and the [Appendix E](#) to understand Faethm Technology taxonomy in more details.

Refer to the [Future state assessment](#) section for more details on the impact of technologies.

50 Australian Government Department of Agriculture and Water Resources, 2017, *Accelerating Precision to Decision Agriculture: Summary Report for Stakeholder Consultation*, p. 5.

51 Swinburne University of Technology, 2019, *Peak Human Potential: Preparing Australia's workforce for the digital future*, p. 4.

52 Beef Central, 2019, Recruitment: Digital transformation broadens work roles in ag, <https://www.beefcentral.com/news/recruitment-news/recruitment-digital-transformation-broadens-work-roles-in-australian-ag/>

53 United States Department of Agriculture, 2015, *Employment Opportunities for College Graduates in Food, Agriculture, Renewable Natural Resources and the Environment*, <https://www.purdue.edu/usda/employment>

54 AFI, 2016, The implications of digital agriculture and big data for Australian agriculture, p. IV

55 Farm Policy Journal, 2017, *The Changing Agricultural Workforce Autumn Quarter 2017*, p. 4.

56 Cotton Research Development Corporation, 2018 *Grower Survey*, p. 7.

57 Wageningen Journal of Life Sciences, 2019, *Supporting Practising Digital Innovation with advisers in smart farming*.

2. High level insights of current digital capabilities of the agricultural workforce

Key insights

- 1 While digital literacy in some sectors may be growing in regards to awareness of available technologies, the maturity of most digital capabilities – as defined in the digital capability framework – remain low in the current state.

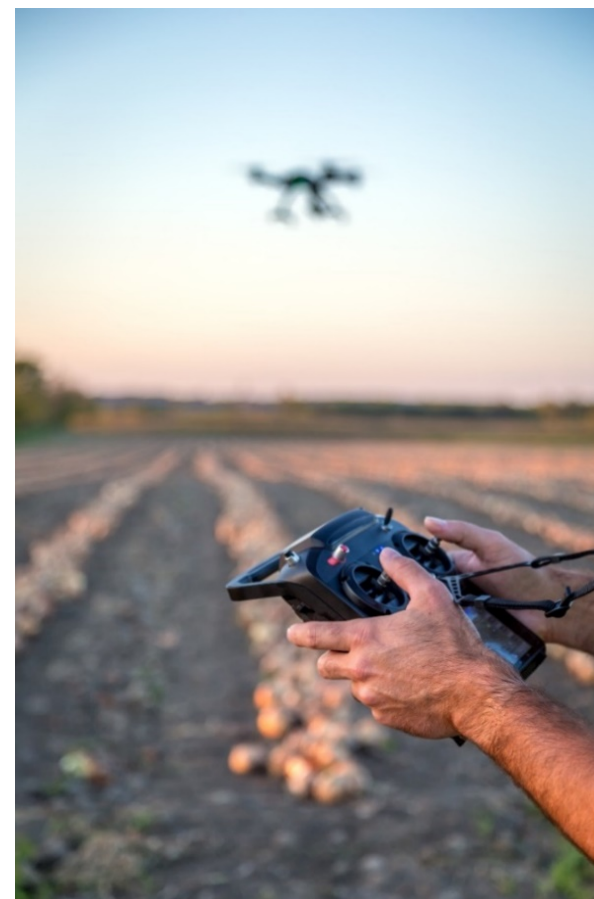
- 2 While many technologies currently exist, there is on average a slow uptake of digital solutions, that could be due to various reasons, including but not limited to, a lack of digital literacy among the industry, a lack of clear value propositions from technology providers, a lack of understanding of the value proposition of the available technologies, difficulties to identify the 'right' solution for the business, serviceability issues or connectivity barriers (regardless of available technology solutions industry needs to work around this limitation).

- 3 The ageing workforce is weakened by a shrinking labour supply, however numerous valuable opportunities are available to fill the gap.

- 4 There is an increasing need for non-traditional agricultural skills in the workforce such as technological, scientific and management competencies, also assessed to possess more mature digital capabilities.

- 5 The workforce are aware of the value of big data collection and while collection of data has been growing, significant barriers remain in understanding what data is required, collecting data digitally and interpreting this data to yield maximum use.

- 6 Education and training pathways are trapped in a trade-off between reflecting current industry conditions and incorporating future-focused digital and technological training.



Current assessment of the agricultural sector by digital capability

Key facts

Digital literacy



The ability to acquire and maintain a basic awareness and knowledge of current and emerging technologies impacting on the agricultural industry.

- Agricultural workforce are mostly operating from regional areas facing connectivity issues. Mobile coverage across farms and agribusinesses commonly reported as poor – 34 percent having most or full coverage and 43 percent having no coverage at all.⁵⁸ Solutions however exist to access new technologies in areas with poor coverage.
- A lack of understanding of agricultural technology pricing contracts (74 percent identified in P2D survey as knowing very little) in production implementation presents a significant barrier to strengthening this capability.⁵⁹
- An FAO report on blockchain for agriculture cites a study that identified farmers' reasons for resistance against integrating blockchain technology, with 48 percent citing regulatory uncertainty, 30 percent citing intellectual property concerns and 25 percent citing lack of trust as a barrier.⁶⁰
- Approximately one-third of farmers reported that a lack of skills was a constraint on their uptake of new ICT tools.⁶¹
- Data from ABARES (2018) survey revealed that farmers who are operating in sectors characterised by greater engagement with external providers appear to have augmented skills required to adoption of ICT.⁶²

Takeaways for the Australian agriculture workforce

- Low levels of digital literacy are one of the major factors preventing farmers from opting for digital solutions, as they struggle to identify what exists and see immediate value in implementation. A report by the United States Studies Centre comparing Australian and US agricultural digital literacy highlights the conundrum that Australian farmers resist going digital because the less farmers who use technology (for example big data software), the less useful it is. Low levels of digital literacy in the agricultural workforce exacerbates the situation.⁶³
- Awareness of existing and new technologies able to turnaround poor coverage issues is key to harnessing the existing and future technologies able to improve business operations. The KPMG Agri 4.0 report identifies a growing choice of connectivity options and AgTech solutions, presenting complexity for farmers to navigate the technology marketplace especially whilst there are few case studies to follow.⁶⁴
- Digital literacy is the first step for the agricultural workforce to be able to understand what exists, and how/if it can be used to improve the business.
- While some barriers are outside of farmers' and agribusinesses' control (for example regulatory uncertainty), others are the result of a lack of knowledge and understanding of existing technologies to then be able to decide which solutions are fit for purpose.⁶⁵
- Education is evolving as new practices enter the industry. In addition, the future workforce supported by training providers such as universities and VET, will have about 230,000 people operating in the agricultural industry who need to access knowledge and training to maintain and update their knowledge of best practices. There is a need to up skill digital capabilities to support day-to-day business operations. However, as identified in the review of existing training providers and curricula, learning pathways are flawed in their contradiction of reflecting current industry practices with teaching future-facing technology competences.

58 ABARES, 2018, *Information and communication technology use in Australian agriculture*,

59 Department of Agriculture and Water Resources, *Accelerating Precision to Decision Agriculture: Summary Report*, p. 13.

60 Food and Agriculture Organization of the United Nations, 2019, *E-Agriculture in Action: Blockchain for agriculture opportunities and challenges*, p.1, <http://www.fao.org/3/ca2906en/CA2906EN.pdf>

61 ABARES, 2018, *Information and communication technology use in Australian agriculture*, p.9.

62 ABARES, 2018, *Information and communication technology use in Australian agriculture*, p.9.

63 The United States Studies Centre at the University of Sydney, 2018, *Seeds of Success: Advancing Digital Agriculture from point solutions to platforms*, p. 3.

64 KPMG, 2019, *Agri 4.0 Connectivity at our fingertips*, p. 6.

65 Ibid

Technology operation



Proficiency in operating all relevant technologies and other digital devices applicable to business activities and processes. Anticipates the occurrence of digital problems including errors, issues and road blocks and proactively implements preventative actions.

Key facts

- 95 percent of Australian farmers are connected to the internet⁶⁶, however only a third are satisfied with their home office connectivity.⁶⁷
- The ecosystem of AgTech providers is disaggregated and includes a large number of small companies and start-ups. Such an ecosystem can be difficult to navigate for the agricultural workforce to identify the existing solutions and analyse those most relevant for the business.
- There is misalignment between farmers and AgTech providers (which are increasingly start-ups disconnected with on-farm operations).⁶⁸ For example software systems often require farmers to have all the same brands of machinery; this presents a barrier to adoption.
- A Rabobank study of 1,000 farmers across Australia found less than a quarter were using sensor technologies.⁶⁹
- Blockchain distribution systems are forecasted to be worth \$195.3 million USD by 2023⁷⁰, emphasising the importance of a workforce that can utilise the technologies involved in these systems.
- A global agribusiness survey found that price volatility is the number one voted challenge facing agribusiness in the next decade⁷¹, epitomising a need to prepare for commodity price fluctuations by tightening the efficiency of operations through technology to enhance output and protect against risk.

Takeaways for the Australian agriculture workforce

- New initiatives are aiming to facilitate the identification of existing solutions by gathering AgTech vendors and service providers on a platform accessible by agricultural businesses. This not only supports digital literacy but also the technology operations by providing a customised approach that enables farmers to find the right technology to suit the specific needs of their operations. Optimally, this platform will build sustainable relationships between AgTech vendors and farmers to augment digital capabilities.
- Farmers' procurement and maintenance of technology is sometimes hindered by a remoteness roadblock when service providers are often city-based and cannot be present at farms as much as farmers would prefer. This creates an issue in that if farmers experience difficulty with technology and do not receive adequate service, repeat investments are unlikely, reinforcing low adoption rates. However, some service providers do now offer remote services and technology can be provided by correspondence. Both scenarios present a significant need for technology operation capabilities.
- Serviceability in technology operation also indicates an opportunity for the development of the new role of agricultural consultants.
- Majority of farmers procure technology by word-of-mouth from other farmers or on advice from advisors. However, most advisors are not digitally trained and only provide high-level advice of the technology market.

⁶⁶ ABARES, 2018, *Information and communication technology use in Australian agriculture*

⁶⁷ Australian Department of Agriculture and Water Resources, 2018, *Accelerating Precision to Decision Agriculture: Producer Survey and Report*

⁶⁸ Agrifutures, 2018, *Accelerating the development of agtech solutions worth adopting*

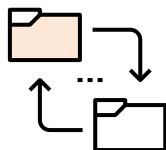
⁶⁹ Rabobank, 2019, *AgTech – does sensor adoption make 'cents'?* <https://www.rabobank.com.au/media-releases/2017/170801-agtech-does-sensor-adoption-make-cents/>

⁷⁰ Statista, 2019, *Forecasted value of blockchain in the agriculture and food market worldwide from 2017 to 2028.* <https://www.statista.com/statistics/947609/global-blockchain-in-agriculture-and-food-market-value/>

⁷¹ KPMG, 2017, *Global agribusiness survey*, p. 6.

Key facts

Data monitoring, analysis & interpretation



Critically monitors and analyses collected data from leveraged technologies. Selects and interprets data to identify opportunities, problems and trends to make informed decisions.

- There is an increasing popularity of using edge computing to process big data and develop insights from that data without a high-bandwidth internet connection.⁷²
- Access to insights resulting from real-time data allows farmers to respond at pace and make more informed decisions.
- Better use of big data also offers great potential in productivity, estimated at 13-26 percent for soil fertility improvements, 9-11 percent for better feed allocation, 4-9 percent for animal production monitoring and. 4-3 percent for animal health monitoring.⁷³
- Farmers' struggle to find relevance with data. For example, currently large stores of farm data in the form of yield maps are cluttering up hard drives of numerous farm computers but are not being used – essentially valueless.⁷⁴
- Workers are hindered by complex data platforms user interfaces that provide cryptic feedback and no clear management options.⁷⁵

Takeaways for the Australian agriculture workforce

- Capitalising on the full potential of data for agriculture in Australia will require the greatest maximum amount of people to become data-literate.
- In turn, improving data integration and utilisation across the board will only be enabled by the widespread combatting of misperceptions regarding data privacy, a situation amendable by a comprehensive data governance framework.
- With enhanced data monitoring and analysis capabilities, farmers will be able to make more informed business decisions through interrogation and interpretation skills. The sustainability of these skills will enable more efficient farm management in the long term as data analysis and application becomes habitual, and farmers are able to seamlessly leverage previous farm data as well as other farmers' data for reference when making important farm decisions.

72 Agrifutures, 2018, *Horizon Scan 6*.

73 AFI, 2016, The implications of digital agriculture and big data for Australian agriculture, p. 15.

74 AFI, 2016, The implications of digital agriculture and big data for Australian agriculture, p.49.

75 Agrifutures, 2018, *Accelerating the development of agtech solutions worth adopting*

Key facts

Takeaways for the Australian agriculture workforce

Digital communication



Effectively communicates and reports in digital spaces including within the organisation, with digital service providers, regulatory entities, digital communities and other identified stakeholders.

- Mutual understanding between farmers and service providers results in more efficient operations, better utilisation of agricultural technology, and more likeliness to invest in further technological knowledge and adoption.
- The P2D survey into telecommunications found that seven percent of monthly data on farms is used for social media activity.⁷⁶
- The ABARES ICT adoption study found that around five percent of farms in Australia had a social media presence.
- The use of apps is steadily increasing, primarily for weather and yield mapping.⁷⁷

- Communication of data know-how and benefits is also a critical reason to uplift digital communication capabilities, as the seamless sharing of ideas across the industry will be essential in strengthening the workforce at an aggregate level. Mutually-beneficial data communication between farmers will enable not only more informed decision making but also frequent collaborative innovation.
- Technologies will provide the industry’s stakeholders with the opportunity to participate in broader trade and supply chain ecosystems through an enhanced ability to communicate digitally across and with wider supply chain participants (e.g. on traceability data point through blockchain).
- No longer focusing solely on on-the-ground operations, farmers increasingly need to be competent in negotiating relationships and contracts, an area crucial in the adoption of any farm technology. This role would require aptitude in the STEM skills and more importantly, the digital capabilities identified in this report.
- Increasing interest to develop apps allowing industry stakeholders to operate and communicate more easily within their ecosystem.
- Enhanced ability to communicate with regulators to ensure compliance with domestic and export protocols in a safe and cost-effective way.

Incident management



Implements actions to minimise the impact of incidents that cannot be prevented. Manage the incidents that have occurred despite preventative actions.

- Problem-solving in product lifecycles often requires specialised expertise in both hardware and software.
- Increasingly sophisticated technology is making farm operations more risk-averse, farmers must be equipped with the capabilities necessary to take advantage of digital safety measures.

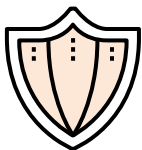
- If technology integration competencies are not complemented by problem-solving competencies, the value of technology significantly decreases as the margin for mishaps such as breakdowns increases.
- Augmented problem-solving skills compensate for the debilitating distance separating farmers from service providers, farmers’ solving of problems autonomously leads to financial and operational benefits. While farmers have always been highly flexible and adaptive to agricultural issue management, enhanced digital capabilities in this space hold the potential for more stable and consistent production and improve safety conditions across the workforce.

76 Australian Department of Agriculture and Water Resources, 2018, *Accelerating Precision to Decision Agriculture: A big data reference architecture for digital agriculture in Australia*
 77 ABARES, 2018, *Information and communication technology use in Australian agriculture*

Key facts

Takeaways for the Australian agricultural workforce

Data management



Understands the importance of data governance by ensuring it is collected, managed, recorded, stored and disposed of safely and securely, and in accordance with the principles driving use of personal and non-personal data.

- There is lack of understanding of technical contract terms in digital technology transactions. In a survey conducted by the P2D project, 47 percent of respondents reported 'don't know at all' in regards to the terms and conditions relating to data collection in agreements with service providers. Only three percent responded 'know very well'.⁷⁸
 - Yield mapping (51 percent) and soil mapping (41 percent) reported as most collected agricultural data by cropping industries.
 - The P2D survey found that the most popular forms of data storage was on-farm electronically (averaging 54 percent), with in-cloud storage at 14 percent.⁷⁹
 - Different types of data sharing have different levels of trust with providers: 34 percent farmers are comfortable sharing soil test data, 54 percent weather station data, 17 percent with production data.⁸⁰
 - Privacy concerns and perceptions that their data will be used for profit or market influence purposes resulted in 56 percent of farmers displaying no trust in service and technology providers who have direct access to their data; common barriers are fears of data use for market influence and profit.⁸¹
- Agricultural storing systems that are backed by cloud-based data enable greater accessibility of resources and efficiency of retrieval and transport, enabling faster time-to-market and cost efficiency.⁸²
 - Over time, farmers' use of data management capabilities to store larger amounts of data will lead to more precise resource use, less waste, quicker speed to market, improved traceability and biosecurity, and safer food.⁸³ Data management capabilities need to be supported to unlock the above benefits.

78 Australian Department of Agriculture and Water Resources, 2018, *Accelerating Precision to Decision Agriculture: A big data reference architecture for digital agriculture in Australia*

79 Precision Agriculture, 2018, *Producer Survey and Report*, p. 24.

80 Farm Policy Journal, 2018, *Surveying the Needs and Drivers for Digital Agriculture in Australia*,

81 Farm Policy Journal, 2018, *Surveying the Needs and Drivers for Digital Agriculture in Australia*,

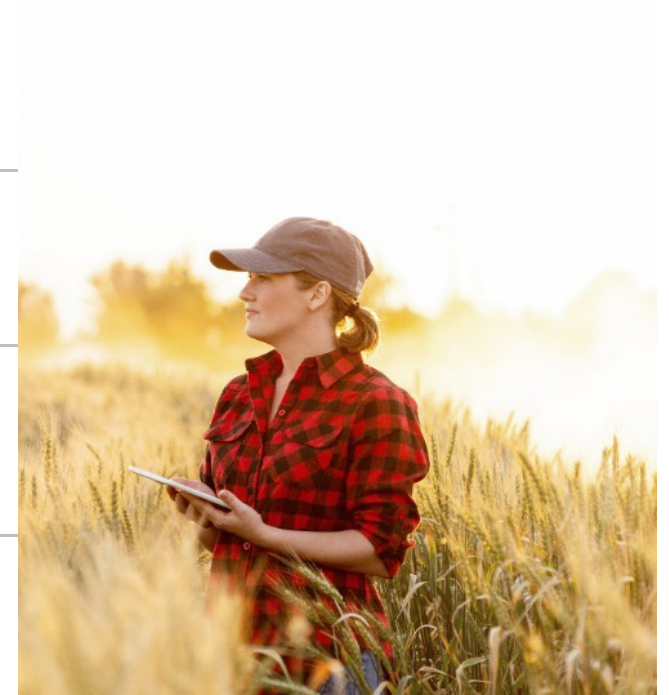
82 PWC, 2017, *Technology and Supply Chains for Critical Industries*.

83 AFI, 2016, *The implications of digital agriculture and big data for Australian agriculture*

3. Insights of current existing training providers and learning pathways

Key insights

- 1 There is currently no systematic approach to defining digital capabilities across the formal and informal training sectors. While universities and informal training providers, such as industry associations and agribusinesses, deliver privately-designed educational courses, only the VET sector publicly specifies national skills standards for job roles that utilise digital technologies.
- 2 Most digital capabilities training in the VET sector focus on lower-level, applied technology operation, while universities' emphasis is on agricultural science and data analysis. There are also a variety of informal, online and industry-driven options for bespoke training solutions.
- 3 There is potential for increasingly embedding digital capabilities development within agricultural education; however, training availability is limited due to providers' difficulties in attracting staff with suitable knowledge and experience, expensive equipment requirements and low demand from an industry that is lacking in digital technologies leadership and adoption.
- 4 Generally, industry possesses low levels of knowledge about existing training opportunities. To drive a national development agenda, there is the need for increased industry involvement and a coordinated national plan to utilise and publicise digital capabilities standards across educational activities.



Introduction

The training of digital capabilities in Australia takes place through formal and informal pathways, and is not limited to formal education or training. Most skills and digital capabilities training takes place in the workplace, through on-the-job learning and informal training, as well as through the Vocational Education and Training (VET) sector, which accounts for more than 80 percent of measurable formal training across the agriculture-related industries. This review covers formal training, through VET and universities, and informal training provided by such organisations as RDCs, agribusinesses and industry associations.

The *Review of the Australian Qualifications Framework: Discussion Paper*⁸⁴ notes that there has been a change in how training is being undertaken, and that “people want faster, cheaper, self-directed and on-demand learning. Employers prefer shorter, sharper education and training, but to supplement, not replace, a full qualification like a Certificate III or a Bachelor degree.” The increasing use of self-directed learning, identified in broader educational research, diffuses the range of learning pathways as learners turn to digital sources such as social media, apps and knowledge sites (gaming, wiki, video and how-to guide sites). It is, however, beyond the scope of this review to establish the level of informal and self-directed learning taking place.

In 2017, there were just over 94,000 enrolments in the tertiary education sector (including higher education and VET) relating to the agricultural occupations identified as part of the scope of this project. Over the past five years, enrolments across the whole VET sector have been declining, and the agricultural workforce qualifications mirror that decline. In 2017, there were:

- A total of 75,651 enrolments in VET qualifications across the training packages, Agriculture, Horticulture and Conservation & Land Management (AHC), Australian Meat Processing (AMP), Forest and Wood Products (FWP) and Seafood Industry (SFI), with more than 800 RTOs having agricultural workforce training on scope.
- 18,386 enrolments in Agriculture, Environmental and Related Studies university

degrees across 33 Universities and two non-university higher education providers.

Agricultural workforce skills in VET training packages have high enrolments in qualifications that are generally taught for specific job roles and tasks, mostly aimed at entry level learners. However specific digital capability units of competency are more likely to be undertaken by existing members of the workforce at early career stages (ages 20-29), rather than experienced workers reskilling or up skilling. Most of the specific digital capability units of competency are included in higher level (post-trade) qualifications with low enrolments compared to entry and trade level qualifications.

Many VET units delivering digital capabilities are written generically so that they may be contextualised according to different workplace contexts and resources. Accordingly, given the focus on broad concepts such as mobile communications, the true extent of training for digital and precision agriculture cannot be established without further research.

Universities take a different approach to digital capabilities, with a strong focus on research and development, analysis and statistics. Generally, digital capabilities curricula in the university sector fall across three categories:

- precision agriculture;
- scientific approaches (especially analysis); and
- extension work (communications).

⁸⁴ Australian Government Department of Education 2018, p.13, “Review of the Australian Qualifications Framework Discussion Paper”

Vocational Education and Training (VET)

The VET landscape

Formal agricultural training and assessment is mostly carried out through registered training organisations (RTOs), including TAFEs and private training providers, who must seek registration from the VET regulator, the Australian Skills Quality Authority (ASQA), before delivering specific training package components (inclusive of qualifications and units of competency). RTOs are responsible for designing and establishing the learning materials, conditions and contextualisation using the framework provided by training packages (this point is explored in detail below). Due to the diversity of provider structures and locations, training is conducted through a range of modes, including classroom-based delivery, online distance learning, skills workshops and farm/work-based learning.

VET training packages are substantial national intellectual property, created through a partnering of the Commonwealth and State Governments and industry to capture, describe and benchmark national skills standards to Australian job activities and roles. Skill descriptors (units of competency, hereafter 'units') are grouped into broader intended job outcomes through qualifications⁸⁵ (each qualification has an intended ANZSCO-based occupational outcome). The system is designed for accountability and continuous improvement, whereby industry experts play a key role, and are actively involved and consulted, in regularly reviewing and developing qualifications and units so that they reflect current, and anticipate future, occupational skills and knowledge requirements. Industry representation is facilitated by the Australian Industry Skills Council (AISC), Industry Reference Committees (IRCs) and Skills Service Organisations (SSOs).

Contextualisation

Prior to analysing digital skills training across the VET sector, an important caveat must be established: the extent to which digital capabilities are truly delivered by RTOs is somewhat elusive given units' rich potential for contextualisation. SSOs consult with industry representatives and technical experts to ensure that training package components, such as qualifications and units, reflect real work activities and current skills standards. While a training package does specify workplace skills and knowledge requirements, it does not suggest how a learner should be trained: components must be contextualised by the RTO to be sector- and resource-appropriate. As such, the language of training packages is generally non-prescriptive regarding machinery, locations and sectors.

RTOs develop training and assessment strategies that support the needs of their learners within the contexts that they are placed. For this reason, units such as *SFIAQU206 - Feed stock*⁸⁶ (which allows for hand and mechanical feeding as appropriate) are included in this analysis because of their malleability to digital and automated process contextualisation; however, while all its enrolments are included in the digital capabilities training figures below, it is not possible to quantify how many RTOs are actually facilitating digital capabilities through this unit.

The advantage of designing training package components to be contextualisable is that units would be relevant for operations of all sizes, from the small, family-run farm, to large AgTech-intensive agribusinesses. Furthermore, the emergence of new technologies will not necessarily render units obsolete. The technology may be different, but the workplace objective is not; hence new technologies can be integrated into existing training and assessment through contextualisation, which is especially beneficial for an industry subject to rapid technological change.

⁸⁵ Skill sets, sometimes referred to as micro-credentials, are also offered as part of the VET system. These are single or combinations of units of competency from a training package which link to a licensing or regulatory requirement, or a defined industry requirement.

⁸⁶ training.gov.au 2019, "Unit of competency details: SFIAQU206C - Feed stock"
<https://training.gov.au/Training/Details/SFIAQU206C>

Case study: the co-evolution of technologies, work practices and units

Consultation with aquaculture and fisheries stakeholders has helped prepare the Seafood Industry Training Package for increasing automation and mechanisation in the industry.

Units designed for manual processes are now being updated to allow technological contextualisation where appropriate. The aquaculture unit, SFIAQUA507C - Plan and design water supply and disposal systems⁸⁷ was designed to apply to “manually operated systems and monitoring, or fully automated systems with computer control and monitoring” in aquaculture. While the unit title does not overtly reference digital capabilities, they are embedded within the content of the unit to allow contextualisation.

This unit will soon be superseded by an updated version (code *SFIAQU507*), which “describes the skills and knowledge required to plan and determine the design and hydraulic requirements for water supply and disposal systems. It includes the ability to allocate pumps and infrastructure, design distribution, storage and treatment systems, and manage budgets and operational procedures.” This update illustrates that it is no longer necessary for the unit to differentiate between manual and automated systems because of the extent to which technology is now embedded within modern work practices.

Such training package development allows for the integration of new and emerging technologies in an inclusive manner, aimed at meeting the desired ends rather than treating technologies as beginnings in themselves.

However, this flexibility arguably comes at the expense of training packages’ potential for acting as vehicles for driving technological advancement and innovation. There is little guidance within units about how technology can or might be used, applied and implemented; rather, their adaptability is exemplified by performance evidence statements such as ‘apply technology to ensure most efficient performance of operations’ (here, in the unit *AHCBAC307 - Maintain agricultural crops*). Relevant technological training may be minimal where this is stipulated, which could reflect an RTO’s limited capacity for change (both in terms of training material development and

access to technologies) and a lack of industry or product knowledge. Over recent years, the regulation of RTOs has tightened; however, the remit of the auditing body, the Australian Skills Quality Authority (ASQA), is to ensure compliance with training package rules rather than evaluate the extent to which training and assessment utilises cutting-edge technologies for the advancement of industry.

The true extent of RTOs’ contextualising materials for digital skills training, therefore, remains unclear. To date, there is no research on the degree to which digital capabilities are embedded by RTOs within ‘contextualisable’ units, what technologies and skills are utilised, and how training is designed.

Digital capabilities training







The Agriculture, Horticulture and Conservation and Land Management (AHC), Seafood Industry (SFI), Australian Meat Processing (AMP), and Forest and Wood Products (FWP) training packages comprise 1,880 units of competency, of which around 85 (five percent) are designed to facilitate digital capabilities, whether as a focus or embedded as part of a broader educational objective (see [Appendix A](#) for a description of the methodology for identifying units). Included in this figure are units from other training packages that are imported for their transferability.

The 85 digital capabilities units broadly align with the capabilities defined in this report, with a strong emphasis on technology operation, digital literacy and data monitoring, analysis and interpretation (this is unpacked in greater detail below).

⁸⁷ training.gov.au 2019, “Unit of competency details: SFIAQUA507C - Plan and design water supply and disposal systems”

<https://training.gov.au/Training/Details/SFIAQUA507C>

Table 1: VET - Examples of units across the digital capabilities

Digital capability	No. of units	Key words in units on training.gov.au	Example units
Digital literacy 	23	research, plan, develop, manage (change), awareness	<i>AHCBUS405 - Participate in an e-business supply chain</i> <i>AMPMT501 - Design and manage the food safety system</i>
Technology operation 	33	implement, use, operate	<i>AHCAGB507 - Select and use agricultural technology</i> <i>AHCMOM311 - Operate precision control technology</i>
Data management 	5	manage (data), storage, sharing, integrity	<i>AHCWRK502 - Collect and manage data</i>
Data monitoring, analysis & interpretation 	19	analyse, interpret, monitor	<i>AMPX405 - Conduct statistical analysis of process</i> <i>AHCAGB402 - Analyse and interpret production data</i>
Digital communication 	4	present, promote, network, connect	<i>SFILEAD501C - Develop and promote industry knowledge</i>
Incident management 	1	faults, resolve	<i>MSMSUP303 - Identify equipment faults</i>

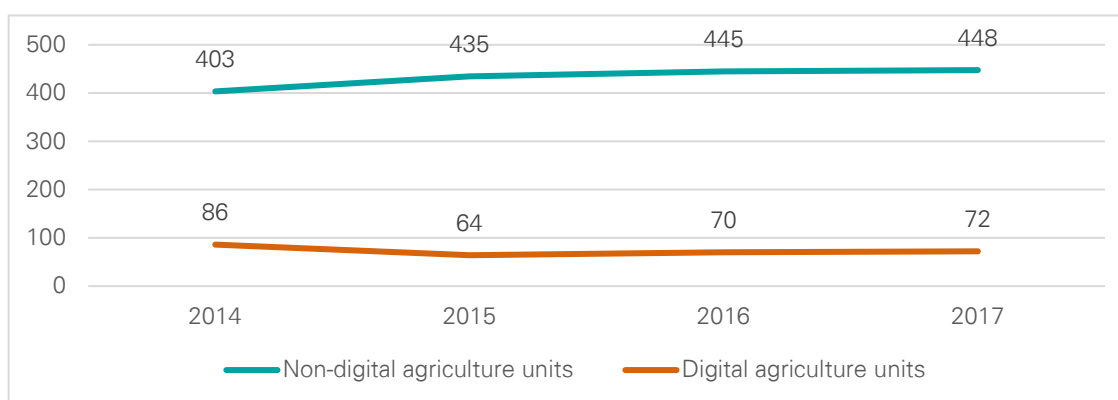
The 85 digital capabilities units appear across 67 qualifications⁸⁸ in the Agriculture, Horticulture and Conservation and Land Management (AHC), Seafood Industry (SFI), Australian Meat Processing (AMP), and Forest and Wood Products (FWP) training packages. These qualifications are delivered across Australia, largely in cities, inner regional and outer regional areas (the challenges of delivery by RTOs are discussed below). The map in [Appendix F](#) shows where the 67 qualifications, which include the 85 digital capabilities units (largely on a non-compulsory basis, a point unpacked below), are delivered.

Across the AHC, SFI, AMP and FWP Training Packages (excluding imported units), the average enrolments in a digital capabilities unit in 2017 were only around 16 percent of the average for a non-digital capabilities unit.⁸⁹

Despite the numerous locations displayed in the map in [Appendix F](#) where digital capabilities units might be offered as part of qualifications, there is a generally low uptake of these units. National Centre for Vocational Education Research (NCVER) statistics reveal that there were a total of 5,633 enrolments in the 85 identified units in 2017. Of these 85 units, 71 showed fewer than 100 enrolments each, including 34 that had zero enrolments. Refer to [Appendix F VET training delivery locations of the 67 qualifications with digital capabilities units as core/electives](#) for a visual representation of the delivery locations.

⁸⁸ A unit can appear as core or elective in as many different qualifications as have been deemed relevant by the qualification designers (following extensive industry consultation).

⁸⁹ These figures include only units in the AHC, SFI, AMP and FWP Training Packages for which NCVER displays data. It excludes relevant units 'imported' from other training packages as it is beyond the scope of this analysis to assess the average enrolments of *all* units imported across these training packages. The data is derived from raw counts and does not take account of which units are 'core' (mandatory) or 'elective' (optional) across the qualifications in which they appear (in different qualifications, individual units may be 'core' or 'elective').

Figure 1: Average enrolments in digital and non-digital agriculture units

Source: *NCVER VOCSTATS, TVA subject enrolments 2014-2017*

This is, in part, due to the Australian Qualifications Framework (AQF) level for which digital capabilities units are designed.⁹⁰ The first graph below shows that the majority of digital capabilities units are designed for Certificate IV and Diploma-levels. The second graph shows that the large majority of relevant qualification enrolments are at Certificate II and Certificate III level (the average number of RTOs that offers qualifications at these levels mirrors this pattern); thus, the qualification levels at which most learners enrol are below the AQF level of the majority of available digital capabilities units.

On the other hand, the proportion of enrolments in digital capabilities units, compared with relevant qualification enrolments, increases relative to the AQF level, demonstrating that, while there are fewer enrolments at higher AQF levels, digital capabilities are far more pronounced within that learning.

The nature of the digital capabilities training also changes according to the AQF level. Broadly, technology operation is a greater focus of the lower AQF levels, while digital literacy (including for leadership positions) and data monitoring, analysis and interpretation are prevalent at Certificate IV level and above.

Nevertheless, the largest proportion of the learner cohort (35 percent) who undertook digital capabilities units in 2017 were between the ages of 20 and 29 years, indicating that most individuals are accessing training at the entry level to prepare to be early career agriculturalists rather than digital specialists, or existing workers who are re-training or up skilling.

Beyond this analysis of AQF levels, it must be distinguished that low enrolments are a result of a multitude of context-dependent reasons why learners are not pursuing digital capabilities or, more pertinently, are not being offered pathways to them. The following sections discuss some of these issues.

Refer to [Appendix G](#) for further details on VET – Digital capabilities training.

Core/elective units

Lower uptake of digital capabilities units is also partly due to many being non-compulsory elective units and are thus not central to students' learning. Based on training packaging rules, qualifications comprise mandatory core units and an often extensive list of elective units from which the student may select a set number. In other words, core units facilitate the knowledge and skills that are essential backbones of the learning, and electives may be chosen to provide greater contextual learning for vocational outcomes.

Digital capabilities units are almost exclusively included in qualifications as electives. Indeed, these 85 units appear across 67 relevant qualifications a total of 176 times (for example, 'AHCSOL501- Monitor and manage soils for production projects' appears in five of those qualifications); within that distribution, there are only 11 instances of digital capabilities units being defined as core.

Refer to [Appendix G](#) for further details on VET – Digital capabilities training.

⁹⁰ Qualifications and units are designed to correspond with an AQF level; for example, qualifications and units designed for Certificate I-level are AQF level 1; those at Certificate IV-level are AQF level 4. For more information, see: Australian Qualifications Framework Council 2013, "Australian Qualifications Framework" <https://www.aqf.edu.au/sites/aqf/files/aqf-2nd-edition-january-2013.pdf>

RTO approval to deliver elective units

As digital capabilities elective units are non-compulsory within qualifications, their lower uptake may also be a reflection of RTOs excluding them from their education packages due to the challenges (financial and technical) of delivering them.

An RTO is required to submit a formal application before being granted registration to have a unit on its scope and offer it as an elective as part of a qualification. There is no requirement for any individual elective to be offered by an RTO or, when available, that it be chosen by the learner (albeit, RTOs frequently offer pre-packaged qualifications with set electives that reflect their own training capabilities and access to technologies).

An average of 19 RTOs are approved to deliver each of the identified digital capabilities units (excluding imported units), thus demonstrating the limited availability of relevant training. There may be numerous reasons for low rates of RTOs applying for approval to deliver units, including a lack of demand, low operational capacity, trainer skills deficits or lack of access to the appropriate, perhaps expensive, technology. To be sure, RTOs focus on obtaining maximum enrolment numbers, business viability and lowering regulatory risk. The business model is therefore aimed at allocating training resources accordingly: to deliver cost-effective training with historical and anticipated demand.

Supply/Demand

As has been discussed, training packages are designed to reflect current and emerging industry practices and standards. An implication, then, is that the lack of emphasis on digital capabilities in VET is reflective of the wider industry, and that RTOs are offering training for current practices. If the agricultural industry itself is not adopting new technologies, then RTOs are arguably less likely to deliver training to students on digital capabilities that will go unused.

This is reflected by Leonard et al.⁹¹, who state that “Digital agriculture in Australia is in an immature state in many parts including strategy, culture, governance, technology, data, analytics, and training. This is to the detriment of innovation and producer adoption of digital agriculture in Australia.”

Meanwhile, as Jones⁹² argues, the challenges of a strict regulatory environment and frequent training reforms limits RTOs’ potential for innovation:

“Significant public institutions that ought to be trusted to manage their own quality must instead devote resources to the satisfaction of overly burdensome external compliance requirements and continual requests for information. These resources could otherwise be invested in the innovation increasingly needed to adapt to changing learner and industry needs. Meanwhile, Australia’s vocational education sector remains in the past, painstakingly preparing people to perform known, narrowly defined tasks for yesterday’s industries.”

If RTOs are unable to access the technologies, knowledge or markets to enable digital capabilities unit training, if learners’ options for choosing digital capabilities units are therefore limited, if farmers are then not accessing an appropriately trained workforce who can assist in implementing digital technologies (and do not necessarily have the capacity themselves to re-train), this points to a lack of leadership in driving digital capabilities development in agriculture.

91 Leonard, E. (Ed), Rainbow, R. (Ed), Trindall, J. (Ed), Baker, I., Barry, S., Darragh, L., Darnell, R., George, A., Heath, R., Jakku, E., Laurie, A., Lamb, D., Llewellyn, R., Perrett, E., Sanderson, J., Skinner, A., Stollery, T., Wiseman, L., Wood, G. and Zhang, A. 2017, p.3, “*Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia*” Cotton Research and Development Corporation, Australia.

92 Jones, A. 2018, p.3, “*Vocational education for the twenty-first century*” https://melbourne-cshe.unimelb.edu.au/_data/assets/pdf_file/0011/2845775/Final-Anne-Jones-paper1.pdf

Regional delivery and diversity issues

Digital skills gaps are further widened because of the challenges of delivering training in regional and remote areas, and catering to different learning preferences, demographics and needs. As Agriculture Victoria⁹³ discusses:

“Some groups may have difficulties undertaking the skills development they require because of where they live or their specific needs. This can include farmers working in remote areas, women, those new to farming, young farmers, culturally and linguistically diverse populations, Aboriginal and Torres Strait Islanders, and those considering transitioning out of agriculture.”

Returning to the issue of supply and demand, RTOs experience great budgeting difficulties in providing training in regional and remote areas due to the often-limited student cohort. These issues are exacerbated by language, literacy and numeracy challenges, low retention rates and issues with internet connectivity.

Graduates and outcomes

Regardless of the true extent to which digital skills are being enabled through VET, there is a critical concern over attracting the next generation of workers to industry training and demonstrating potential occupation pathways to them. As shown in the table below, there are variable success rates across the relevant training packages and thus there is an on-going challenge for the VET system and the agricultural industries to nurture and retain the digital skills needed today and in the future.

Importantly, funding is often only available to RTOs when learners enrol in full qualifications, even when the intent of the learner is to achieve one or a few units of competency for specific work purposes. Learners will cancel the qualification after finishing these units, having achieved their objective, but will be recorded as a non-completion against a full qualification; they will be recognised as a problem when in fact they are a satisfied customer. Certainly, more than 85 percent of graduates in the VET sector were satisfied with the overall quality of the training⁹⁴, suggesting that non-completions are a far more complex issue that is implied by the statistics alone.

Table 2: Completion rates and employment outcomes

Training package	Completion rates ^a	Employed in the same occupation as training ^b
Agriculture, horticulture and conservation and land management	37.8%	25.6%
Seafood industry	54.3%	12.6%
Australian meat processing	52.3%	40.0%
Forest and wood product	12.9%	20.9%

Source: NCVET, a) private data request; b) Visual Analytics: Graduate outcomes information

93 Agriculture Victoria 2018, p.10, “Victoria’s Agriculture Skills Statement: Smarter, safer farms” http://agriculture.vic.gov.au/__data/assets/pdf_file/0009/438039/DEDJTR-AG-Vic-Smarter-Safer-Farms-Final-2018-Web.pdf
 94 NCVET 2018, “Australian vocational education and training statistics: VET student outcomes 2018” https://www.ncver.edu.au/__data/assets/pdf_file/0037/4284649/VET-student-outcomes-2018.pdf

University sector

The university landscape in Australia

There are two Australian non-university higher education institutions, and 33 universities (out of 43) providing formal education to the agriculture workforce, excluding the use of more general degree qualifications within the sector (such as accountancy, economics or science). There were more than 18,000 enrolments across these institutions in 2017 (of approximately 1.5 million total enrolments across all degrees), representing slightly less than 20 percent of the formal training being undertaken in the sector in Australia. Only 1.2 percent of university students in Australia were enrolled in studies related to the agricultural workforce, compared to 3.5 percent of total enrolments in the VET sector.

In addition, there are seven Cooperative Research Centres (CRC) operating in the agricultural sector or in closely-related areas that are undertaking agricultural projects:

- High Integrity Australian Pork CRC;
- Data to Decisions CRC;
- Sheep Industry Innovation CRC (proposed end date 30 June 2019);
- Food Agility CRC;
- CRC for Developing Northern Australia;
- Food Waste CRC; and
- Future Food Solutions CRC.

CRCs must also be supported and endorsed by Industry Growth Centres, including, for example, Food Innovation Australia Limited, which is the industry growth centre for food and agribusiness. Many universities have also established their own centres of learning, research or innovation to service the sector, including partnerships with industry or other universities. Examples include the newly-established centre for Digital Agriculture (Partnership between Curtin and Murdoch Universities), the Centre for Precision Agriculture (partnership between CeRDI [Federation University] and a private business called Precision Agriculture Limited), the Precision Agriculture Laboratory (University of Sydney) and the James Cook University's Centre for Tropical Environmental and Sustainability Science, and Marine and Aquaculture Research Facility.

Identifying digital capabilities delivery

Unlike the VET sector, the university sector does not have national skills standards. As a result, the digital capabilities being delivered are unique to each institution.

Each university is required to publish standard information about the courses (subjects) within each qualification, however, the information provided is typically general. Rather than identifying specific skills, the focus is on broad learning outcomes and assessment requirements.

Digital capability themes

An analysis of the programs offered by universities identified three key digital capabilities themes:

- Theme 1: Precision agriculture;
- Theme 2: Scientific and analytical capability; and
- Theme 3: Extension work.

These themes are outlined in greater detail below. Comparing these themes to the digital capability framework of this document, and based on the available information within the scope of this review, it would appear that universities are delivering or requiring digital capabilities in at least five of the identified digital capabilities, namely:

- **Digital literacy:** All programs either require or deliver education for capabilities related to digital literacy.

- **Technology operation:** These capabilities are mainly delivered in programs related to the precision agriculture theme, and usually in specialised circumstances focused on the specific technology required to complete an identified precision agriculture function, rather than broad education in technology operation.
- **Data management:** The scientific and analytical capability theme programs deliver data management digital capabilities, while other programs implicitly require some data management capabilities.
- **Digital communication:** The extension work theme programs deliver digital communication capabilities, however, all programs have some degree of digital communication embedded in their delivery, usually relating to working collaboratively, delivering findings or identifying solutions while exercising other digital capabilities.
- **Data monitoring, analysis and interpretation:** All programs require and deliver education for these capabilities, and usually in some depth.
- **Incident management:** It is unclear from the available information that degree programs are delivering incident management digital capabilities, though some of these capabilities will be embedded in some programs. We are unable to identify any systematic focus or delivery of these skills within the university sector.

However, it is not possible to provide sufficient statistical or qualitative analysis to allow for detailed descriptions of digital capabilities at individual degree, program or university level.

Theme 1: Precision agriculture

Precision agriculture combines the increasing abilities to analyse and use big data, and to collect and utilise data in real-time from a variety of sources, with improving robotics and technology. While initially focused on fields and crops, the application of precision agriculture continues to expand, and is now used in agriculture, horticulture, livestock and aquaculture, and forestry.

The University of New England notes that precision agriculture “has traditionally focused on the development of sensing systems such as yield monitoring and satellites, and management strategies such as variable rate fertiliser application, but it is now much more than this. New advanced ground-based sensing systems (Lidar and active optical), remote piloted aircraft, ground robotics, autonomous livestock monitoring systems and virtual fencing are now revolutionising the way we farm”⁹⁵

Theme 2: Scientific and analytical capability

More generic scientific digital capabilities are being contextualised in agriculture, especially relating to research, sampling and data analysis. There is an expectation that students enrolling in some electives will have foundational maths knowledge, and there are also elective programs covering physics and chemistry within an agricultural context.

Examples of these skills found in Charles Sturt University programs include but are not limited to:

- Principles of qualitative data analysis and survey design;
- The interpretation and presentation of experimental and model-based data in agricultural contexts;
- Carry out benchmarking and best practice analysis of individual agribusiness and understand industry expectations, including the consideration of environmental assets and agribusiness sustainability;
- Agribusiness decision making and risk management;
- Capital investment appraisal; and
- Measures of yield and productivity in agricultural production systems and their use in analysing farm and industry sector performance.

95 University of New England 2019, “Precision Agriculture” <https://www.une.edu.au/study/study-options/study-areas/agriculture-and-agronomy/precision-agriculture>

Theme 3: Extension work

Extension work relates to the need to be able to create pathways of knowledge and to communicate the benefits of research and development in ways that allow for that utilisation of innovation in agricultural practice. Digital capabilities in extension generally relates to communication of results, the utilisation of digital media and digital engagement methodologies.

Informal, online and industry-driven technical skills development

In addition to formal training provider pathways, other programs and courses are available to help primary producers develop digital literacy. These include Rural Development Corporations (RDCs), cooperatives and industry associations offering various programs, both online and face-to-face, and agribusinesses facilitating technological service provision and capacity building.

Rural Development Corporations

In general, RDCs say while their research investments cover digital technologies, they are not currently delivering programs to help producers develop their own technology skills. On the other hand, they can all identify technology development activities conducted by others such as consultancy groups, agribusiness and industry associations.

Examples of some of the current projects being conducted by RDCs are:

- Meat & Livestock Corporation (MLA) with support from a range of RDCs are hosting the inaugural Australian Agriculture Immersive Technology Conference in Melbourne on 10-11 July 2019, following on from the inaugural EvokeAG Conference held in Melbourne in February 2019 funded by the RDCs and hosted by AgriFutures (the second iteration is scheduled for February 2020), indicating an increasing market for networking and educational events around digital technologies and associated capabilities;
- The Cotton RDC is working with private provider PCT-Ag for extension and training in digital agriculture;
- Hort Innovation is developing case-study vegetable farms in each state for research and extension – including training events and field days – and will develop video and fact-sheet resources to showcase potential applications of relevant precision technologies;
- Farmers2Founders (F2F) is a program run in partnership with five RDCs: AgriFutures, MLA, Australian Wool Innovation, GRDC and Wine Australia. It equips producers to help them act as frontline innovators and supports them to develop entrepreneurship and technology capabilities.⁹⁶ The program starts with a free one-day innovation and ideation workshop where participants learn how technologies are shaping the future of agriculture and how these technologies might be used to benefit their business;
- Sugar Research Australia has been working with the Primary Industry Education Foundation, the leading body for agriculture, forestry and fisheries education for the primary and secondary school sectors, therefore providing foundation agricultural skills for the next generation of producers;
- Australian Eggs engaged AgThentic to research egg industry issues that may be able to be resolved by AgTech solutions; and
- MLA has engaged KPMG to audit how data is captured, stored and exchanged throughout the Australian red meat supply chain and identify barriers and enablers to data sharing.

⁹⁶ Farmers2Founders 2019, "Supporting producers to transform agrifood and fibre" <https://www.farmers2founders.com/>

Agribusiness

The agribusiness service industry works directly with farmers to improve production profitability. Agribusinesses and consultancy services offer producers a wide range of advice on product marketing, insurance, finance, farm supplies and products, and, notably, agronomy, especially in the use and application of precision technology.

Various agribusinesses have established digital capability teams to enhance their own, and so facilitate others' professional development. The services they offer require that their employees regularly update their skills and market awareness. This is enabled through in-depth training with product developers and manufacturers. Agribusinesses also trial and test new technologies under paddock conditions. These mutually-beneficial relationships assist with the dissemination and implementation of new digital technologies and skills in the wider agriculture community.

Agronomy services are generally tailored to client requirements due to variations across each farming operation. All farms are unique businesses, with their own operational constraints. For example, according to the capabilities and knowledge of the farmer, availability of capital, land and soil types (and quality), and production methods. The extent of on-farm mechanisation and automation is a key variable. Agribusinesses' agronomists work directly with farmers to assess, plan and implement long-term objectives for digital and precision agriculture. Consultations begin with operational audits, followed by broader, on-farm field days and evenings to discuss how operations can be developed.

Agronomists working closely with farmers report on their challenges with maintaining and effectively utilising any installed digital technologies. Many farmers are under-skilled at trouble-shooting products and researching how best to use them. Whereas in the past technicians could generally be called out as part of the service, manufacturers are increasingly seeing this as a business opportunity, whereby an experienced technician comes at a cost.

Agronomists also seek to facilitate evidence-based decision-making by establishing local farmer networks to collect, interpret and analyse production data. This provides information upon which farmers can be advised on the potential efficiencies of implementing digital and precision agricultural techniques and machinery.

Case Study

Burdekin Productivity Services currently conducts digital training for sugarcane growers based around IrrigWeb, an online irrigation scheduling and recording tool. They run regular training sessions to assist growers in understanding the program, as well as helping to set up their farm with the software so that all their irrigation events can be recorded. This is combined with daily weather data downloaded from local weather stations to provide site-specific irrigation scheduling advice.

Industry associations

Industry associations are formed to look after the welfare of their designated sector and members by providing information and advocacy.

Engagement with key industry and farmer associations indicates that most do not offer digital capability-building activities to their members (although some exceptions are referenced below) or are limited to commissioning investigative reports on the types of digital capabilities opportunities that exist.

Numerous industry associations acknowledge that they would like to offer workshops directly, or in collaborative partnerships with appropriate organisations, with the aim of developing members' understandings of, and abilities to implement, new technologies.

One state farmers' association, the Queensland Farmers' Federation (QFF), is currently organising educational activities for primary producers. In 2018, the QFF conducted one-day data-driven-decisions workshops and this winter are offering a series of two-day workshops titled *Embracing Digital Innovation in the Agricultural Sector*⁹⁷ to provide Queensland farmers/workers in the agriculture sector with the knowledge and confidence to implement AgTech solutions to increase efficiency and productivity. Topics include connectivity, remote sensing, GIS, process automation, drones, precision control technology,

97 Queensland Farmers' Federation 2019, "Emerald embracing digital innovation in the agriculture sector workshop" <https://www.qff.org.au/events/emerald-emerging-digital-innovation-agriculture-sector-workshop/>

property mapping, soil mapping, e-business supply chains, internet of things, artificial intelligence and big data, virtual reality and 3D printing.

The Society of Precision Agriculture Australia (SPAA) is a member-based association supporting precision agriculture initiatives to explore and adopt new technologies. SPAA advocates for, and facilitates, increased precision technology research, extension and adoption in the primary production industries. SPAA conduct regular workshops and an annual symposium, in which they invite farmers to present and share their own digital capabilities journeys first-hand. SPAA, along with many of the industry-based associations, use monthly members' publications (e.g. newsletters) to highlight the variety of new technologies that are being used by individuals or businesses and so promote their adoption and knowledge of them.

Online learning

There are numerous online agriculture skills courses and tutorials, either for free or fee-for-service, including:

- Be Connected⁹⁸, a free Australia-wide initiative on how to thrive in a digital world. It provides online learning resources and a network of community partners who offer in-person support. Online resources cover absolute basics, equipment use, online safety and security, connectivity and media, data, wi-fi and mobile networks, apps and games, phones and tablets.
- Business Foundations⁹⁹, a private online provider of a \$25 digital skills course for businesses. Topics include digital literacy, websites, online booking systems and cyber meetings, business in the cloud, bookkeeping, marketing and promotion, and using G-suite.
- Grow Your Digital Skills¹⁰⁰, aimed at business owners, offers seven courses: Grow your career, Social media, Web analytics, Digital marketing, User experience, Retail, and Mobile. This program is offered through FutureLearn, a social learning platform. The courses are easily accessible and optimised for mobile phones to enable learning anytime, anywhere.

There are also digital literacy training websites that are used by the agricultural workforce to enhance the foundational skills of their workforce:

1. USA-based Internet Society¹⁰¹ offer free online tutorials on managing one's own security such as privacy and identify, digital footprint, combatting spam;
2. Digital Literacy and Citizenship¹⁰² is a UK-based site providing free materials to help primary and secondary students to think critically, behave safely and participate responsibly in the digital world;
3. Coursera¹⁰³ partners with universities and organisations to provide online access to large number of courses. Courses are ranked beginner, intermediate etc. Learners must sign up for courses and follow the delivery timetable;
4. A study by Swinburne University found that the number one leading choice in learning resources for Australian workers were online tutorial platforms such as Lynda or Kahn (46 percent of workers);¹⁰⁴ and
5. There are also a number of digital ability initiatives taking place in Australia right now, funded by various governments, and government and business partnerships. Those that relate to the digital capabilities in this report include:
 - Australia's Tech Future: Under its strategy for a strong, safe and inclusive digital economy, the Government has committed to exploring initiatives to reduce the digital inclusion divide and support greater lifelong engagement in evolving technological resources;

98 Australian Government 2019, "Be Connected: Every Australian Online" <https://beconnected.esafety.gov.au/topic-library>

99 Business Foundations 2019, "Digital Skills for Small Business - Online Training" <https://www.businessfoundations.com.au/upcoming-events/digital-skills-online-training>

100 FutureLearn 2019, "Grow Your Digital Skills with Accenture" <https://www.futurelearn.com/career-advice/grow-your-digital-skills>

101 Internet Society 2019, "Tutorials" <https://www.internetsociety.org/tutorials>

102 The South West Grid for Learning 2019, "Digital Literacy & Citizenship" <https://digital-literacy.org.uk/>

103 Coursera 2019, "AI For Everyone" <https://www.coursera.org/learn/ai-for-everyone>

104 Swinburne University of Technology, 2019, *Peak Human Potential: Preparing Australia's workforce for the digital future*, p. 4.

- Digital Agriculture Strategy: Ensures that Victoria’s farmers are at the forefront of agriculture’s digital revolution;
- Digital business workshops: Designed for small-to-medium enterprises (SMEs) and not-for-profits (NFPs) to identify ways of improving their digital capability and become more competitive in today’s digital marketplace;
- Digital Ready for Daily Life: Aims to increase digital literacy in specific groups via seminars, workshops and research;
- Inspiring all Australians in Digital Literacy and STEM: helps students embrace the digital age and prepare for the jobs of the future; and
- Small Business Digital Grants Program: Provides matched funding of up to \$10,000 to assist small businesses to access digital technologies and services to help them work smarter, engage with the global economy and make the most of online business opportunities.

International benchmarks

There are numerous international examples of digital capabilities training innovations and management that may influence the direction of Australian agricultural education through its best practice benchmarking.

Training organisations in Singapore, for example, are utilising virtual and augmented reality devices to offer students experiences of using digital technologies in a controlled environment. Australian agribusinesses are just starting to realise the potential of these technologies; for example, Case IH Australia is working with Tim Gentle of Farm VR to produce 3D videos for the agriculture industry.¹⁰⁵ While these Australian developments are not facilitating agricultural digital skills per se, they point to numerous opportunities for developing the scope of such programs and for attracting a new generation of tech-savvy agriculturalists.

The USA's framework for agricultural education is inspiring Australian educators to promote a transformation in schools.¹⁰⁶ The 2015-16 winners of the Hardie Fellowship, Andrew Harris and Mick Davy, completed nine weeks of agricultural education studies in eight American states, including at Cornell University. Feedback from this experience included that there is a strong commitment across schools to offer agricultural education based on a national model. Classroom laboratories are driven by a collaboratively-constructed curriculum that enables agricultural science to be practised consistently, including both applied and technical training. Students are encouraged to run community projects, supervised and assessed by agriculture teachers and supported by the universities, which serve to bridge the gap between agricultural theory and practice.

The European Union (EU) consistently reviews its strategies for developing the agricultural sector, especially for enhancing the quality of vocational training for agricultural specialists.¹⁰⁷ Countries such as France and Germany frequently update the content of agricultural training packages so that they reflect trends in the application of advanced technologies, including through individualised education. The prominence of vocational training in the EU, including 1,136,356 enrolments in Germany and 1,566,407 enrolments in Italy in 2017¹⁰⁸, is reflective of the successful promotion of training pathways to establishing a career as a highly-qualified and digitally-literate agricultural specialist. Such training is supported by initiatives including Rural Agree¹⁰⁹ (which is funded by the EU, and partners with numerous organisations, including Erasmus), which facilitates digital training for agricultural sector entrepreneurship in rural areas.

These EU endeavours are founded upon the Strategic Research and Innovation Agenda developed by ERA-NET ICT-AGRI¹¹⁰, a research area network that aims to coordinate European research and training in ICT and robotics. Based on shared priorities, ICT-AGRI is supporting the development and implementation of these new technologies for competitive and environmentally-sustainable agriculture across Europe.

Opportunities

Ongoing skills development and addressing skills gaps

Feedback from industry participants and learners has identified a gap between the knowledge base provided by university education and the competency base provided by VET. A specific example illustrates this growing concern across the sector.

The Australian Industry and Skills Committee (AISC) has recently approved the development of national standards to support a Diploma of Agronomy.¹¹¹ This will be available as an alternative or as a supplement to four-year agricultural science degrees. The current Victorian program is also utilised by those who have completed the university degree and have identified the need to undertake more practical and on-farm training. While agronomy degrees are producing scientists capable of guiding soil management and field crop production, industry participants have identified a skills shortage in practice-based, applied agronomy.

105 ABC News 2018, "Agricultural industry turns to virtual reality to boost big business and attract new blood"

<https://www.abc.net.au/news/2018-03-02/vr-farming-takes-off-in-agribusiness/10851278>

106 ABC News 2016, "Triple target to transform agricultural education in Australia" <https://www.abc.net.au/news/rural/2016-07-28/us-ag-education-study-shows-way-for-australia/7667324>

107 Barbinov, V. 2018, "Vocational Training Of Future Agricultural Specialists: European Experience", *Comparative Professional Pedagogy* 8(2)/2018

108 Eurostat 2019, "Pupils enrolled in vocational upper secondary and post-secondary non-tertiary education by education level, sex and field of education" <https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do>

109 Rural Agree 2019, "Digital Training For Agricultural Sector Entrepreneurship In Rural Areas"

<http://www.ruralagree.eu/index.php/about-us>

110 ERA-NET ICT-AGRI 2018, "Strategic Research and Innovation Agenda: ICT and robotics for sustainable agriculture"

111 Skills Impact 2019a, p.21, "IRC Skills Forecast and Proposed Schedule of Work 2019-2022: Agriculture, Horticulture and Conservation and Land Management Industry Sector" https://www.skillsimpact.com.au/site/skillimpactmedia/uploads/2019/05/ISF.AHC_IRCskillsForecast.2019-2022.Final_.pdf

Currently, there are no nationally-accredited VET agronomy qualifications. The project was approved in recognition of the potential to facilitate the digital capabilities required for evidence-based decision-making in all aspects of production and business.

In addition to industry and learner feedback, the project was developed as a response to the Australian Government Department of Jobs and Small Business placing Agricultural Consultant/Scientist (ANZSCO 234111, 234112) on the national skills shortage list, noting that the supply of job candidates has “increased through rising agricultural science graduate numbers, but candidates are often regarded as unsuitable because they lack the required experience.”¹¹²

This development is consistent with a view expressed in Trindall *et al.*'s¹¹³ report that regional stakeholders believe that Australian universities are not producing enough agronomists with the necessary skills. They find that “education and training are required at all levels within the industry to increase knowledge and understanding of connectivity options, best practice in data management and use and data licensing. New programs should also be developed to provide the relevant skills to the emerging agricultural workforce that will be required to progress decision agriculture.”

This example highlights the need for a multi-level approach to the development of digital capabilities. Ongoing digital capability development will require recognition of the changing nature of learning and industries' responses to this through a range of workplace-based, informal and supplier-delivered learning activities. Many skills are best learnt on the job due to the nature of the specific skills formation and the needs of learners in employment. On-the job learning is especially relevant to the development of digital capabilities.

A recent study by Swinburne University noted that 38 percent of Australian workers prefer learning on the job and that the more digitally disrupted an industry is, the more workers prefer this form of education.¹¹⁴ There is currently an educational gap in this type of practical on-farm training to produce industry-ready skills and job candidates. One of the inhibiting factors is appropriately recognising shorter form credentials achieved through combined and multi-modal learning, whether formal or informal. There is a greater emphasis on formal education and training at the expense of formal competency assessment and certification, including industry, informal and non-formal training and learning.

Funding and opportunities

As has been widely documented, training delivery rates are largely impacted by the availability of government or state funding for training providers, with associated opportunities in apprenticeships, traineeships and the VET in Schools program, which seeks to promote industry and its future employment prospects to young adults. There is ample opportunity here both to incentivise providers in offering digital skills units as part of their training and to shape the future digital skills agenda.

There are also emerging industry-led and government-funded opportunities for digital agriculture skills. For example, AgSkilled¹¹⁵ is a flexible training strategy, administered under the NSW Government's Smart and Skilled program, for the cotton and grains industries. It offers opportunities for participating in qualifications, from Certificate I to Advanced Diploma that are tailored to suit the needs of businesses, including for precision agriculture.

Other competencies

Extending the arguments already addressed in this report concerning supply and demand, another consequence of the thin training market is that many businesses are choosing to train staff on-the-job to develop digital capabilities, which further reduces viability for RTOs in applying for and promoting their own digital training.¹¹⁶

112 Australian Government, Department of Jobs and Small Business 2018, p.1, “Agricultural Consultant/Scientist”

https://docs.employment.gov.au/system/files/doc/other/23411112ausagriconssciant_1.pdf

113 Trindall, J., Rainbow, R. and Leonard, E. 2018, p.5, “Enabling Digital Agriculture in Australia” Farm Policy Journal, Vol.15: No.1, Autumn Quarter 2018

114 Swinburne University of Technology, 2019, *Peak Human Potential: Preparing Australia's workforce for the digital future*, p. 4

115 NSW Government 2018, “AgSkilled: Industry-led training for the cotton and grains industries”

https://www.training.nsw.gov.au/forms_documents/programs_services/agskilled/AgSkilled-brochure-pub18-218.pdf

116 Skills Impact 2019b, p.18, “IRC Skills Forecast and Proposed Schedule of Work 2019-2022: Forest and Wood Products Industry Sector”

https://www.skillsimpact.com.au/site/skilliampactmedia/uploads/2019/05/ISF.FWP_IRCSkillsForecast.2019-2022.Final_.pdf

For example, the forest and wood products industry invests internally in skills development on an ad hoc basis according to specific local contexts and requirements. Most employers provide training at the outset or during the course of employment, and to upskill the workforce as required (for example, when new digital technologies are implemented). These businesses will often utilise the national standards, as defined in training packages, to design their informal, non-accredited training. While helpful in equipping employees with essential digital skills, these training activities are not captured in national vocational education and training data collection.

Following The Honourable Steven Joyce's *Strengthening Skills: Expert Review of Australia's Vocational Education and Training System*¹¹⁷ in 2019, potential VET reforms have been discussed, including for industry to be formally involved in learner credentialing, which is seen by many as a potential method for uncovering the true scope of informal training that is occurring in industry.

Encouraging engagement with digital capabilities training

Informal, online and industry-driven technical skills development offers multiple opportunities in its potential for being tailored to the specific needs of agriculture businesses. However, there are generally low engagement levels with these training platforms due in part to:

- The agricultural workforce lacking knowledge of how to monitor notifications about suitable events, workshops or businesses offering bespoke training;
- Most training opportunities being advertised through subscription-based platforms, such as newsletters, and industry websites and newspapers. This requires that these sources be actively sought out and monitored for opportunities that arise;
- Events and workshops being run on an ad hoc basis and are often in locations that are relatively inaccessible to farmers in regional and remote areas; and
- Lack of formal training experience amongst agriculture business owners which cultivates an antipathy towards educational arrangements, with a general predilection for engaging in experiential and applied learning on-the-job.¹¹⁸

In some local farming districts around Australia, farmer-led research groups have been established to provide responses to localised production issues. A number of these groups apply for project funding from RDCs to contribute to demonstrations in the use of new technologies. These projects illustrate that cooperative endeavours provide opportunities for offering exposure to new digital technologies and the uses to which they can be put.

It appears that the industry could benefit from the establishment of a centralised information hub, where all state and national educational opportunities and events, including those associated with RDCs, government agriculture departments and primary producer organisations, can be advertised. This could further act as a networking space for disseminating digital capabilities education and advice.

117 Commonwealth of Australia, Department of the Prime Minister and Cabinet 2019, "*Strengthening Skills: Expert Review of Australia's Vocational Education and Training System*" https://www.pmc.gov.au/sites/default/files/publications/strengthening-skills-independent-review-australia-vets_1.pdf
118 Grains Research and Development Corporation 2013, "Understanding Farmer Decision Making And Adoption Behaviour" <https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2013/02/grdc-updatepaper-long2013-decisionmakingandadoption>

Future state assessment

1. Digital capability framework to define future-required skills

In conducting a comprehensive current state and future state assessment of the agricultural workforce, two different types of capabilities were considered. Digital capabilities as defined below, outline an individual’s competency in technological domains. Enabling capabilities, also defined below, are soft skills in which individuals need to be capable in order to achieve stronger digital capabilities. These two domains are vital to consider and uplift the digital capabilities of the agricultural workforce in the future.

Digital capabilities

Digital capabilities are defined as the wide-ranging skills an individual, organisation or industry require to ensure they have the capacity to actively participate in a current and future environment that is heavily reliant on digital resources and technologies. In Australia’s agriculture industry, this means that stakeholders possess the digital capacity or capability to live, learn and work in a digital environment.

Extensive explanations of the key components for each maturity level associated with digital capabilities can be found in the report **Agricultural workforce digital capability framework - Digital Training and curricula handbook for education and training providers.**



Digital literacy

The ability to acquire and maintain a basic awareness and knowledge of current and emerging technologies impacting on the agricultural industry.



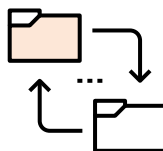
Technology operation

Proficiency in operating all relevant technologies and other digital devices applicable to business activities and processes. Anticipates the occurrence of digital problems including errors, issues and road blocks and proactively implements preventative actions.



Data management

Understands the importance of data governance by ensuring it is collected, managed, recorded, stored and disposed of safely and securely, and in accordance with the principles driving use of personal and non-personal data.



Data monitoring, analysis & interpretation

Critically monitors and analyses collected data and data sources along with other digital outputs from leveraged technologies. Selects and interprets data to identify trends, problems and other points of interest quickly and accurately to make informed decisions to improve the business, make the required adjustments, drive opportunities and mitigate risks.



Digital communication

Effectively communicates and reports in digital spaces including within the organisation, with digital service providers, regulatory entities, digital communities and other identified stakeholders.



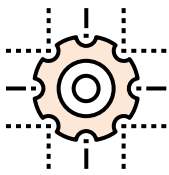
Incident management

Implements actions to minimise the impact of incidents that cannot be prevented. Manage the incidents that have occurred despite of the preventative actions.

Enabling capabilities

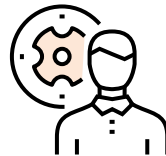
Enabling capabilities are also known as soft skills and are those capabilities that individuals possess including personal attributes and traits, communication skills and behaviours. They enable individuals to grasp basic digital skills and knowledge and promote innovative behaviour in using new and advanced technologies now and in the future.

Extensive explanations of the key components for each maturity level associated with enabling capabilities can be found in the report **Agricultural workforce digital capability framework - Digital Training and curricula handbook for education and training providers**.



Process improvement

Continuously identifies and implements improvements and innovation to enable increased business performance, and process efficiency.



Personal learning & mastery

Takes accountability for the acquisition of knowledge or skills through study, experience, or being taught while displaying a concentrated effort to gain comprehensive knowledge or skill in that particular subject or activity.



Collaboration

Ability to work effectively in a team or with a group of stakeholders to build and maintain strategic and professional relationships while driving business outcomes, achieving a common purpose and managing conflict.



Business transformation

Senses new opportunities and responds to shifts in the environment by making fundamental changes to how a process, business or industry operates. Responds flexibly to changing circumstances in order to minimise impact to activities, program or schedule of work.



Critical thinking

Creating new knowledge and/or using existing knowledge in new and creative ways in order to generate new concepts, methodologies and understandings.

Example of specific applications of digital capabilities to the agriculture sector across the supply chain

		Value chain			
		Inputs	Production	Storage & handling	Processing & manufacturing
Digital capabilities	Digital literacy	The ability to recognise new technology advancements in fish gene editing	Attending precision agriculture conference to gain insight into new technologies and applications	Ability to identify solutions able to remotely monitor and adjust the temperature sensor in a cold storage truck	Ability to communicate with stakeholders involved a processing ecosystem (e.g. milk processing) about the new technologies available on the market
	Technology operation	The ability to operate a handheld device to determine soil composition	Programming and operating GPS technology via tractor integrated system for crop row spacing	Ability to identify the latest moisture sensor to monitor grain storage facilities	Communicate with regulatory bodies to determine legal and compliance changes relevant to the processing of livestock
	Data management	Reading and interpreting data received from water quality readers positioned in a fish farm to determine timing of hatchery initiation	Collecting soil moisture and irrigation data to determine which paddock requires more water supply	Accurately maintains delivery docket system in grain storage facility made digitally available to grower	Sharing carcass quality information with the correct producer for the right carcass delivery
	Data monitoring, analysis & interpretation	Ability to review weather forecasts and determine impact on production plan i.e. planting or harvesting windows	Ability to monitor weather forecasts, predicted planted area and current chemical inventory to ensure adequate product available for clients	Securely storing compliance inspection reports received by government agencies on animal health	Ability to assess carcass quality scores across multiple suppliers to identify key trends
	Digital communication	Attending a conference on latest versions of weed management technology to assess feasibility of on-farm implementation	Sharing and accessing AgTech insights and success and failure stories between growers at on-farm demonstrations and via social media	Organising annual meeting with service provider to determine whether current use of storage technology is optimal and any necessary improvements to action	Attending annual supplier reviewer meetings to compare trends in processing and manufacturing in AgTech
	Incident management	The ability to communicate with a dealer and repair a breakdown remotely	Utilise a weather app to foresee high winds and stop programmed spraying accordingly	Using sensors to screen uploading of grain to identify foreign material matter or minimum residue level breach before co-mingling in storage occurs	Ability to monitor temperature control parameters and identify temperature breach of dairy vat before packaged for customer

2. How will technologies impact the agricultural workforce?

Approach

The analysis below was conducted on augmenting and automating technologies. The results provide a view of the overall industry and the various job roles impacted, these are divided into categories and sub-categories. It is worth noting that insights could vary between specific agricultural sectors and businesses.

The subcategories of roles analysed can be found in [Appendix C](#).

Specific category:	Fisheries and aquaculture farming	Livestock farming	Cropping and horticulture	Mixed crop farming	Product processing
Generic category:	Science and engineering	Governance	Business management	Vehicle operation and maintenance	Building and Property maintenance

Introduction

The current Agriculture Industry has an older workforce: on average, a farmer is 17 years older than the typical worker¹¹⁹ and about 23% of the sector’s workforce is likely to retire in the next five years.

Furthermore, only 800 agricultural graduates are leaving tertiary institutions, which only covers 40% of the estimated people demanded. This provides a strong case for accelerating the adoption of automating and augmenting technologies, as they could help close the gap between the food supply needed by a growing population, and the limited supply of agricultural workers.

Based on the definitions available in the [Abbreviations and Glossary of Terms](#), automating technologies prompt the need to redefine role description and ensure capability evolution for relevant workforce to fully capture the opportunities of automating technologies. Augmenting technologies, on the other hand, will require the workforce to up-skill or build new digital and enabling capabilities to seize the opportunities offered by technologies in the future.

Careful consideration will be required in working out which resources need to be trained in those technologies that foresee their roles augmented. Every role will require a specific skills development to prepare for the future and to enable individuals to harness the opportunities offered by augmenting technologies. It may be helpful to look into the specifics of which sectors within agriculture and which particular technologies present the greatest automation opportunities, in order to prioritise capability development focus.

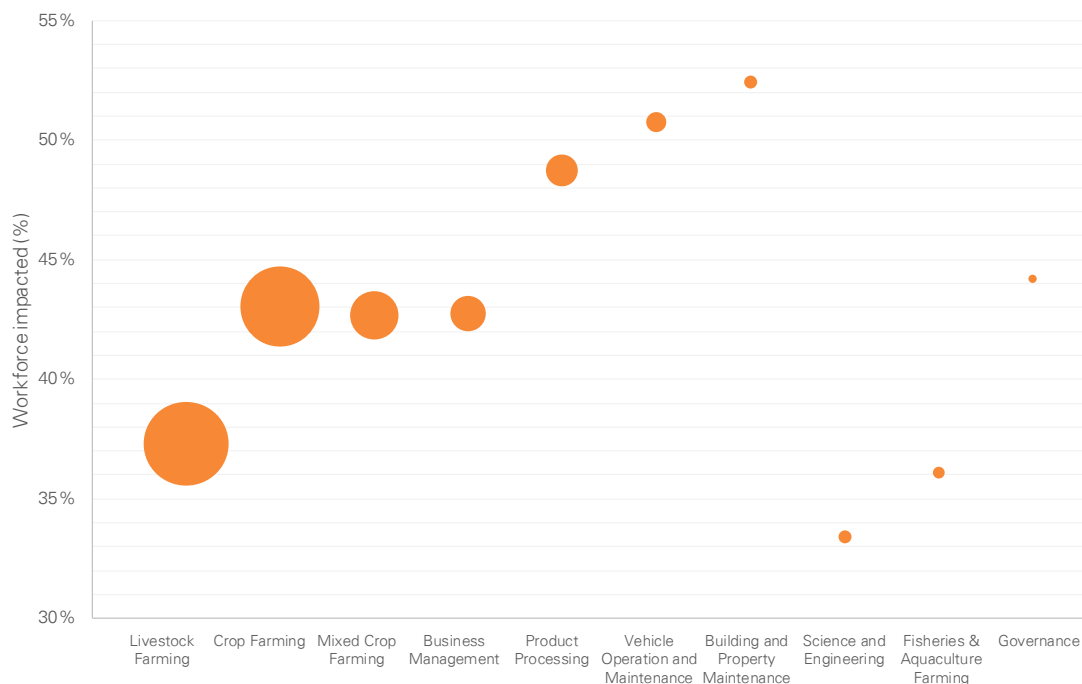
119 ABARES Insights, 2018, Snapshot of Australia’s Agricultural Workforce, p.2.

Overall automation and augmentation in the agricultural roles categories

The Fourth Industrial Revolution will bring significant changes to the job composition of all industries as some jobs are automated, augmented or created due to the implementation of AI and robotics technologies. Over the next 10 years, Faethm modelling indicates 41% (93,617) of jobs in the Agricultural Industry will be transformed through the impact of both automating and augmenting technology.¹²⁰

Through the adoption of new AI and robotics technologies, the industry will be able to automate manual tasks and augment others, achieving a higher productivity rate. This imperative to leverage these technologies will also drive the need to hire for and create jobs that can own their implementation and operation.

Figure 2: Overall Automation and Augmentation in agriculture categories (measured in FTE)



Source: Faethm analysis

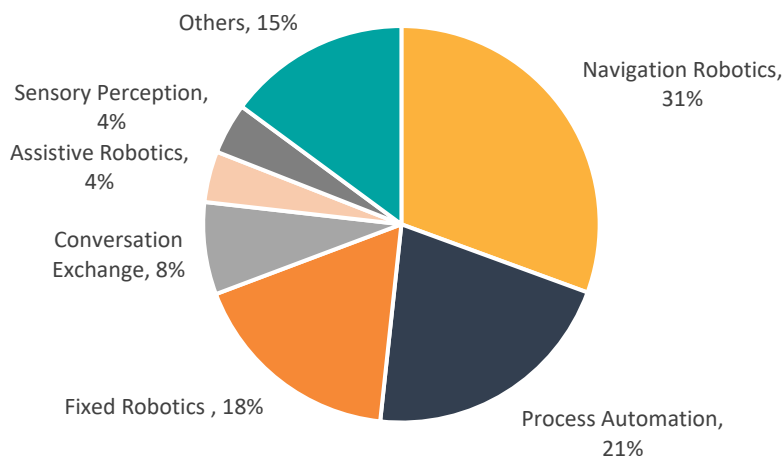
The chart shows the anticipated automation and augmentation impact on the agricultural workforce by industry category. Impact on total workforce per category is measured as a percentage of FTE, while the size of the workforce impacted is measured as FTE (blob size).

Key Insights

- The analysis shows that the highest impact to jobs and people is modelled to be concentrated within the Livestock and Crop Farming categories. Although these are not the most impacted categories as a percentage of FTE, their workforce should be prioritised to reskill (and potentially transition into high demand jobs) or upskill to be able to capture the productivity advantages created by the adoption of new technologies. This is due to the volume of FTEs in this category being the highest.
- Building and Property Maintenance, Vehicle Operation and Maintenance and Product Processing categories are also modelled to have the highest percentage of augmentation and automation in their workforces. Despite their lower amount of total FTE impacted, the workforce in these categories should focus on continuing education to be able to navigate through the technological advancements.

¹²⁰ Based on the agricultural workforce estimated to 228,692 in the 2016 Australian Census

Figure 3: Overall estimated impact on the agricultural workforce by augmenting and automating technology over the next 10 years



Source: Faethm analysis

Figure 3 shows the impact in FTE by technology as a percentage of total technological impact. Navigation Robotics, Process Automation and Fixed Robotics will account for almost 70% of the total automation and augmentation in the Agricultural Industry workforce. These categories of AI and robotics can be identified across many key AgriTech applications such as Variable Rate Technology leveraged in precision agriculture.

Key Insights

- Navigation Robotics technologies are robots that can navigate autonomously in unstructured environments with specific functions. Examples of Navigation Robotics include self-driving vehicles, autonomous drones and planning and exploring agents. All of these technologies have been identified as likely to play a major role in the digitisation of the agriculture workforce in Australia. An example of this is the uptake and use of driverless tractors which rely on satellite GPS signals built into a software program and allows farmers to instruct a tractor to perform activities such as ploughing sowing or spraying crops automatically.
- Each emerging technology will have a different impact on each of the agricultural industry categories. For example, as highlighted in [Appendix H](#) for Livestock and Crop farming, Navigation Robotics will have the highest impact on the workforce, while for Business Management, Other technologies will affect jobs more.
- As the digital maturity of the agriculture industry increases the role descriptions in use will likely evolve to include new, distinguishing language. This is the language that the Faethm technology will identify as being more aligned to the attributes of the digital technologies that could augment or automate roles. As the language we use for describing roles in agriculture begins to incorporate more references such as analyse, assess, predictive, contrast, recommend, interpret, data, it is possible that the assessed impact of technologies such as suggestion provision, dexterous robotics, predictive analysis and recognition vision could have an even greater estimated impact on augmented and automated roles.
- Suggestion provision for instance is a technology that reactively uses Machine Learning to prioritise and rank data to identify relevant recommendations for specific parameters or goals. An example of suggestion provision augmenting technologies is the use of applications and softwares as a decision support tool that provides crop farmers with paddock-specific yield forecasts that have the potential to optimise investments. Such applications could be to use a crop farmer's own data (e.g. soil test, rainfall, irrigation, fertiliser and cultivations data), to estimate the probabilities of a specific paddock obtaining a

range of yields and consequently recommendations as to what course of action the farmer should take. These technologies are providing the industry with more efficiencies and greater accuracy.

- Most technology advances in market (e.g. predictive analytics for crop quality and yield) will leverage multiple technology types of AI and/or robotics (recognition vision, predictive analysis and more).
- For instance, AgTech predictive analytics can enable the agriculture workforce to more efficiently assess ecological systems and predictive impact on crop condition. Leveraging this augmenting technology type presents an up-skilling need.
- Refer to the section [Technology development and anticipated future technology](#) for more details.

New jobs opportunities created in the Agricultural industry

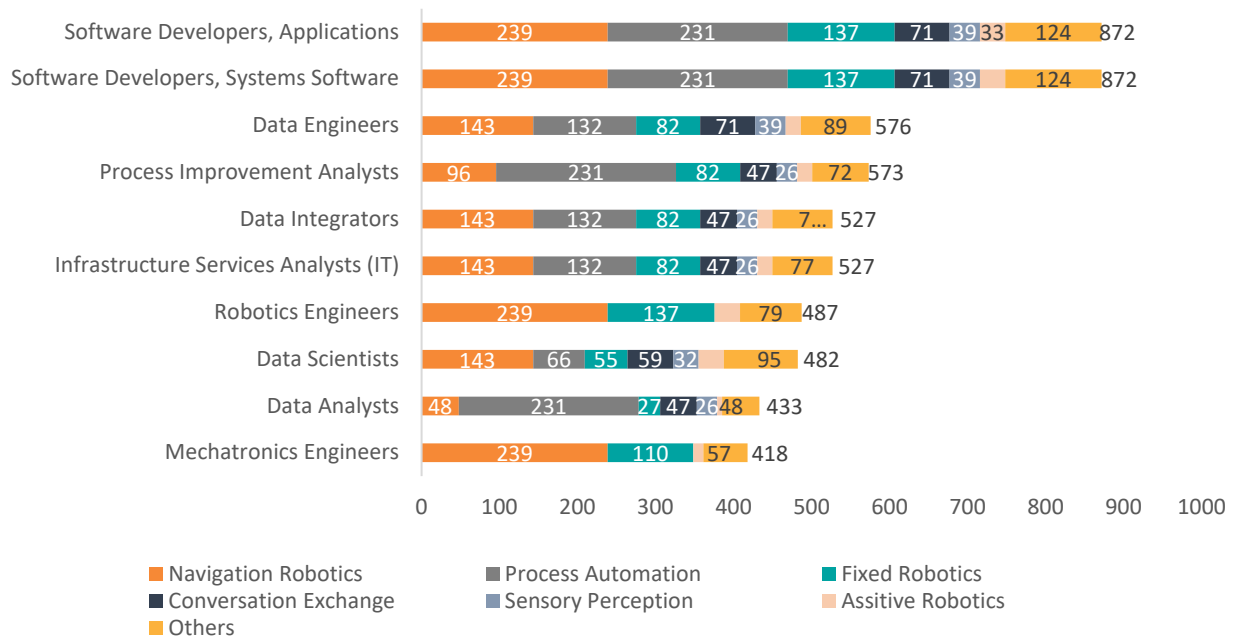
Additionally, although historically the Agriculture industry has required less technical jobs than others, this is changing rapidly. Faethm has predicted that in the next 10 years one in three new jobs created in Agriculture, Forestry and Fishing will be tech related. Software Developers, Data Engineers and Data Scientists are some of the new roles that will be needed to make the most of technologies such as Navigation Technology, Process Automation and Fixed Robotics amongst others. Additionally, jobs within the industry will also need to adapt and include future-of-work capabilities to reach the full potential of the productivity increase.

For example, Navigation Technology, such as Global Navigation Satellite Systems or GNSS, will demand new jobs for Software Developers, Data Engineers, Data Scientists and Infrastructure Services Analysts. This technology can be used for altitude mapping¹²¹, which can be used by farmers in draining and cropping plans. However, for this to happen, farmers need to be able to understand high and low yield areas of the fields through the technology, along with how different chemicals can be used to improve yield and diminish environmental impact¹²².

¹²¹ Source: Precision Agriculture - European Space Agency.

¹²² Drones are already being used to collect, manage and interpret agricultural data. Drone Deploy is a company that uses this technology to inform clients on which seeds or nutrients to buy, additionally to allowing for a fast monitoring of the crop fields.

Figure 4: Top 10 tech jobs in the Agriculture Industry in 10 years, by total number of new workers added



Source: Faethm analysis

Key Insights:

- New technological jobs added to the Agriculture Industry will be driven mostly by Navigation and Process Automation technologies.
- Software Developers, both of Applications and System Software, will be the top technological jobs demanded by the Agricultural Industry. Data-intensive jobs will also support in reshaping the future of the industry.

In conclusion, technology will evolve all jobs and industries as we know them. Workers whose roles can be augmented by technology will need to be adept in digital and data skills and have future-of-work capabilities in order to achieve their full productivity potential. Workers whose tasks can be automated will have the need of reskilling and upskilling, especially in digital skills, in order to successfully transition into new roles. And finally, there will be new roles added, some, to foster technological development, and some which have not even been imagined. What is certain is that digital and data literacy will be an essential part of the future-of-work capabilities.

3. Technology developments and anticipated future technology

The follow categorisation was developed using Faethm Technology Taxonomy, which includes 17 AI and robotics technology classes (definitions are in Appendix E.)

Key:

Digital literacy
 Technology operation
 Data management
 Data monitoring, analysis & interpretation
 Digital communication
 Incident management

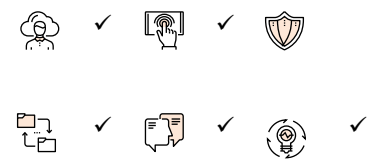

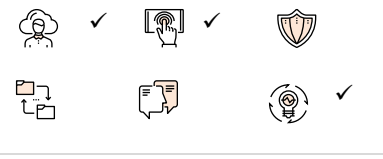
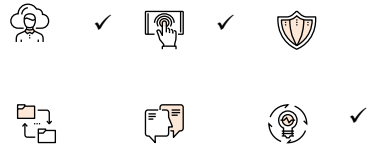
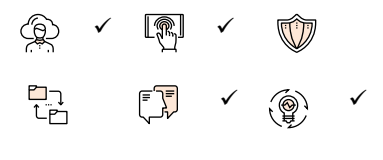
Navigation robotics



Definition	Benefits	Agriculture examples	Case examples: agriculture use	Relevant digital capabilities
Navigation robotics technologies are robots that can navigate autonomously in unstructured environments with specific functions. This works by applying reinforced learning, advanced sensors and mechanics to plan and conduct live movement between environments. E.g. drones, driverless cars, planning and exploring agents.	Save large amounts of time, human labour, and financial expenditure on human resources. Increase production yields, high return on investment.	Self-driving tractors: – John Deere – CNH – AGCO	– Paddock harvest with limited labour and time resources – Collect information on soil conditions whilst planting or harvesting	✓ ✓ ✓ ✓ ✓
	Allow large spaces to be tended to and monitored. Enable consistent performance.	Autonomous drones: – HerdInflight (Ireland) – Cattle Watch	– Crop monitoring for field and soil analysis – Crop health assessment	✓ ✓ ✓ ✓ ✓ ✓
		Smart collars/smart ear tags: – Cowlar – HerdInsights (Ireland)	– Rumination tracking – Livestock mustering – Livestock pregnancy monitoring	✓ ✓ ✓ ✓ ✓ ✓
		Virtual fencing/ herding technology: – Agersens	– Livestock maintenance – Cattle monitoring	✓ ✓ ✓ ✓ ✓ ✓

Process automation


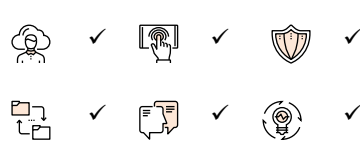


Definition	Benefits	Agriculture examples	Case examples: agriculture use	Relevant digital capabilities	
<p>Process automation technologies use code programmed to complete pre-defined, logical and rule-based processing tasks, such as quantitative calculations, process onboarding, monitoring and simple robotic jobs and movements. This works by applying rules-based logic to take structured inputs and using predefined executable steps, deliver structured outputs.</p> <p>E.g. Robotic Process Automation (RPA)</p>	Save large amounts of time, human labour and financial expenditure on human resources.	Automated smart sprayers: <ul style="list-style-type: none"> - AccuSpray - Smart furrow 	<ul style="list-style-type: none"> - Avoidance of spray drift while irrigating <p><i>Reports show an average saving of 10 percent in pesticide spray applications in grain farming systems attributed to accurate machine guidance¹²³</i></p>		
	Increase process speed.	<ul style="list-style-type: none"> - Walk-in weighing systems/remote livestock management systems - Tru-test 	<ul style="list-style-type: none"> - Rumination tracking - Livestock monitoring and data collection 		
	Decreased margin for error.	<ul style="list-style-type: none"> - Gate sensors - IoT Australasia 	<ul style="list-style-type: none"> - Remote gate status monitoring 		
	Labour productivity increase.	<ul style="list-style-type: none"> - Auto-drafting - Shearwell Australia 	<ul style="list-style-type: none"> - Drafting based on flock list imported into app and on weight - Mob management 		
	Product quality improvement.	<ul style="list-style-type: none"> - Automated milking system - DeLaval Inc (USA) - Lely - Robotic Rotary Dairy (FutureDairy) 	<ul style="list-style-type: none"> - Milking livestock in less time with less human labour 		
	Enable consistent performance.				
	Employee safety improvement.				
	Handle processes unable to be completed manually.				

123 Precision Agriculture, 2018, *The profitability of precision spraying on specialty crops; a technical-economic analysis of protection equipment at increasing technological levels*, p. 1.


Process automation (cont.)



Definition	Benefits	Agriculture examples	Case examples: agriculture use	Relevant digital capabilities
		<ul style="list-style-type: none"> Soil moisture probes AquaTerra 	<ul style="list-style-type: none"> Efficient soil moisture monitoring 	
		<p>Supply chain automation</p> <ul style="list-style-type: none"> Matthews BlockGrain 	<ul style="list-style-type: none"> Product ID and inspection solutions RFID tagging and tracking Coding <p><i>An increasingly popular trend for data driven software and devices designed to optimise the movement of agricultural cargo, as well as automated material handling, storage and retrieval systems to move materials with speed necessary to meet production and shipping requirements.</i> ¹²⁴</p>	

Conversation exchange



Definition	Benefits	Agriculture examples	Case examples: agriculture use	Relevant digital capabilities
<p>Conversation exchange technologies are systems that use machine learning and sensors to interpret and engage in conversation, exchanging ideas and information with humans. This works by applying auditory and speech sensors in combination with natural language processing and speech generation technologies to detect communication and to respond in social dialogue.</p> <p>E.g. smart assistants, advanced chatbot, social robotics.</p>	<p>Save large amounts of time, human labour and financial expenditure on human resources. Large amounts of data can be processed at speeds significantly higher than human capabilities.</p> <p>Improved customer service.</p> <p>Faster and augmented customer engagement.</p> <p>Better lead generation.</p>	<ul style="list-style-type: none"> Smart exchange technologies have not yet been developed in Australian agriculture in the production space. 	n/a	



Definition	Benefits	Agriculture examples	Case examples: agriculture use	Relevant digital capabilities
<p>Dexterous robotics technologies are robots with flexible functions capable of adapting dynamically to complex tasks and scenarios.</p> <p>This works by using applying advanced robotics technologies and mechanics capable of manipulating objects and adjusting dynamically using sensors and machine learning.</p> <p>E.g. 3D house and materials printing, nano-robots, advanced manufacturing robotics</p>	<p>Save large amounts of time, human labour and financial expenditure on human resources.</p> <p>Helps understand systems and prototype new machinery and equipment.</p> <p>Print spare parts on-demand.</p> <p>Risk mitigation.</p> <p>Complexity and design freedom, customisation.</p> <p>Sustainability.</p>	<p>Planting and harvesting robots:</p> <ul style="list-style-type: none"> - The Small Robot Company (UK) - Fendt Xaver (robotic planter) 	<ul style="list-style-type: none"> - Crop planting with minimised soil compaction 	
		<p>Weeding robot:</p> <ul style="list-style-type: none"> - Farmwise (US) - SwarmFarm 	<ul style="list-style-type: none"> - Weed identification and removal without herbicide use 	
		<p>3D printing:</p> <ul style="list-style-type: none"> - Foodini (Spain) - Lab 22 (CSIRO innovation Centre) - Deakin University & University SA 	<ul style="list-style-type: none"> - Farm machinery spare part production 	

Suggestion provision









Definition	Benefits	Agriculture examples	Case examples: agriculture use	Relevant digital capabilities
<p>Suggestion provision technologies are tools that reactively prioritise and rank data to identify relevant recommendations for specific parameters and goals.</p> <p>This works by filtering data, using machine learning and specific parameters of a problem, distinguishing and ranking outcomes to provide estimated solutions.</p> <p>E.g. social media site recommendations, online targeted advertising, search engines.</p>	<p>Save large amounts of time, human labour and financial expenditure on human resources.</p> <p>Enables greater innovation by facilitating group thinking.</p>	<p>Farm management software</p> <ul style="list-style-type: none"> – Agri360 – Mistro – YieldProphet – AgriDigital – AgriWebb 	<ul style="list-style-type: none"> – Maintain current and historic farm records in one place for easy reference – Upload yield data to make informed decisions regarding fertilisation and irrigation 	<p>Icon 1: ✓</p> <p>Icon 2: ✓</p> <p>Icon 3: ✓</p> <p>Icon 4: ✓</p> <p>Icon 5: ✓</p>
		<p>Agriculture social networks:</p> <ul style="list-style-type: none"> – Australian Farmers Online – Platform – Farmers Business Network 	<ul style="list-style-type: none"> – Discuss with other farmers to share/receive advice and tips on fertilisers 	<p>Icon 1: ✓</p> <p>Icon 2: ✓</p> <p>Icon 3: ✓</p> <p>Icon 4: ✓</p> <p>Icon 5: ✓</p>
	<p>Greater customisation of customer needs – strengthened user experience and relationships.</p> <p>Enhanced data exploration and problem solving.</p>	<p>Agriculture search engines/information portals:</p> <ul style="list-style-type: none"> – AgWorld – Fert\$mart plan – SoilMapp – CottonMap 	<ul style="list-style-type: none"> – Search for information on new cotton irrigation methods before investing in new machinery 	<p>Icon 1: ✓</p> <p>Icon 2: ✓</p> <p>Icon 3: ✓</p> <p>Icon 4: ✓</p> <p>Icon 5: ✓</p>
		<p>Online commodity maintenance/ assessment tools:</p> <ul style="list-style-type: none"> – EnergyCalc – WeedSmart/WeedSeeker – Day degree calculator 	<ul style="list-style-type: none"> – Answer questions about one’s farm for a tool to assess herbicide resistance and rate weed seed bank risk 	<p>Icon 1: ✓</p> <p>Icon 2: ✓</p> <p>Icon 3: ✓</p> <p>Icon 4: ✓</p> <p>Icon 5: ✓</p>
	<p>Variable rate/centre-pivot irrigators</p> <ul style="list-style-type: none"> – Agnflow – Water Dynamics – Valley Control technology – Swan Systems 	<ul style="list-style-type: none"> – Weather-based semi-regular irrigation – Advanced precision irrigation using detailed field data 	<p>Icon 1: ✓</p> <p>Icon 2: ✓</p> <p>Icon 3: ✓</p> <p>Icon 4: ✓</p> <p>Icon 5: ✓</p>	

Gap analysis of digital and enabling capabilities






Approach

A gap analysis was undertaken between the estimated current state and future state of the agricultural workforce's digital and enabling capabilities as defined in the digital capability framework in the [Future state assessment section](#). The digital capability framework includes:

Digital capabilities

	Digital literacy
	Technology operation
	Data management
	Data monitoring, analysis & interpretation
	Digital communication
	Incident management

Enabling capabilities

	Process improvement
	Personal learning & mastery
	Collaboration
	Business transformation
	Critical thinking

The current state capabilities for the digital and enabling capabilities were estimated based on Faethm's algorithm relying on the set of assumptions below. A detailed explanation of Faethm's approach to capability modelling can be found in [Appendix A](#).

- The agricultural in-scope roles are described with 244 job attributes of different ability level;
- Each of the six digital capabilities and five enabling capabilities were assigned a set of attributes describing the associated skill set of that capability, based on the digital capability framework identified in the future state assessment and Faethm's list of 244 job attributes of different ability levels; and
- Extent of technology use in each role applied across the digital capabilities.

Future state capabilities were estimated based on the impact that augmentation and automating technologies have on each job over 10 years. Demonstrating the need for individuals to up-skill to perform their roles in a more digitised environment.

The maturity of each digital and enabling capability, for current and the future states, were determined according to the following capability levelling:

- Expert: 81-100
- Proficient: 61-80
- Competent: 41-60
- Novice: 1-40

The gap analysis was undertaken by role category. The list of roles in scope of this report were grouped under meaningful, specific, and generic role categories used to analyse the maturity of digital and enabling capabilities in the current and future states as well as identify a gap analysis. Data on these role categories and their corresponding industries was leveraged from the Faethm analysis.

The role categories used were as follows:

Specific:	Fisheries & aquaculture farming	Livestock farming	Cropping and horticulture	Mixed crop farming	Product processing
Generic:	Science and engineering	Governance	Business management	Vehicle operation and maintenance	Building and property maintenance

The sub-categories analysed within these categories can be found in [Appendix C](#).

Additionally, the roles mapped against the agricultural value chain can be seen in [Appendix B](#). Refer to in the [introduction](#) section for further details on the scope of agricultural role classification.

Key insights

- 1 Technology operation is currently and consistently the least mature digital capability among the categories, also highlighting the most important gap with the estimated future state. Remaining digital capabilities show significant variances between the categories and even across the roles within the same category.

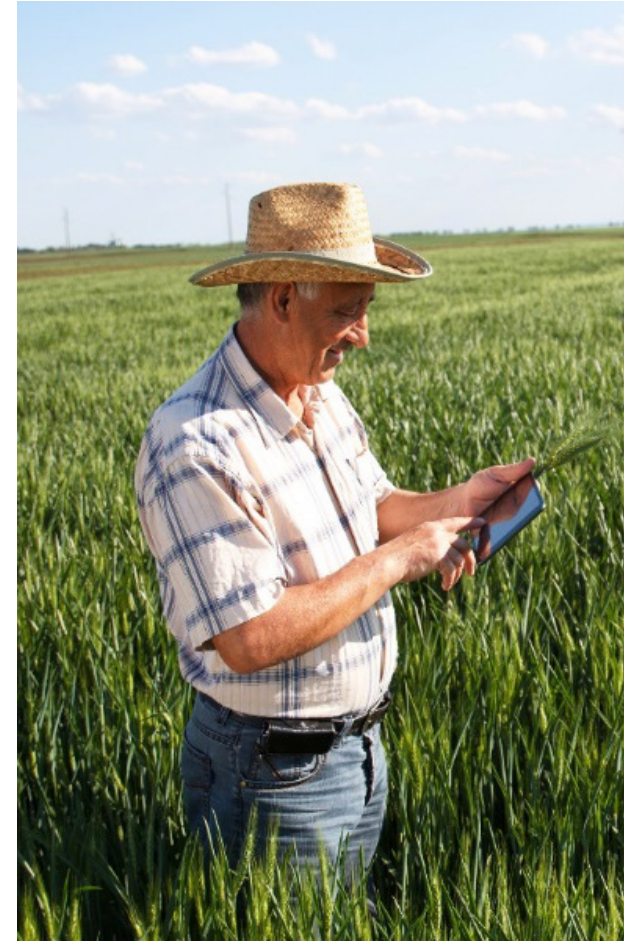
- 2 It is acknowledged that not every role category requires the same level of maturity in the future. In addition, it is worth considering that the level of maturity expected for each role within one category would vary.

- 3 In terms of future state, the full range of digital capabilities will be required to evolve in a highly digital environment, with greatest expectations around data management.

- 4 Enabling capabilities are anticipated to be consistently required in the future. The ability to manage business transformation is seen to be the weakest capability, requiring significant up-skilling efforts to close the gap with future state. However, communication and critical thinking are expected to be the most important enabling capabilities to own and develop within a digital environment.

- 5 Overall and on average, the role categories identified as generic show an estimated higher level of maturity in both digital and enabling capabilities than the agriculture specific role categories, and in particular science and engineering, governance and business management categories with a specific expertise on ICT sub-category.

- 6 Agriculture-specific role categories have scored estimated lower levels of maturity (novice) in current state, with the exception of fisheries and aquaculture farming which is assessed to possess competent digital and enabling capabilities on average.



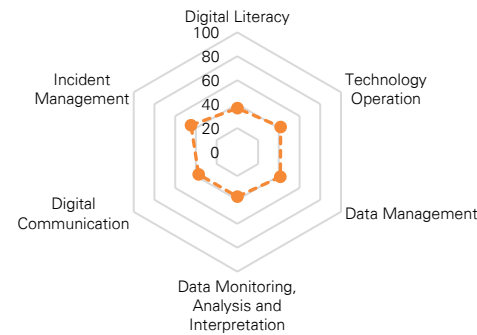
Gap analysis by category

Fisheries and aquaculture farming

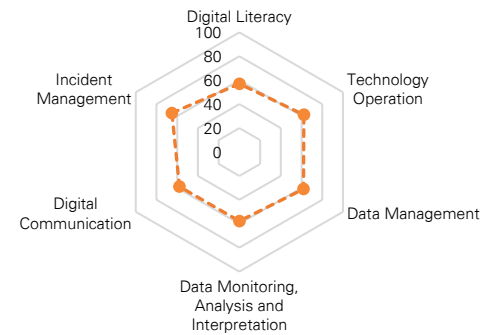
Insights

- The estimated range of maturity across the digital capabilities within the fisheries and aquaculture farming category varies significantly. Fishing hands and aquaculture farmers are currently identified as novice (score 1-40) and fishers and related fishing workers and marine transport professionals as competent across the digital capabilities.
- Collaboration is consistently estimated to be the greatest enabling capability and business transformation as the weakest for this category.
- In future state, there is a clear need to possess and up-skill the full range of digital and enabling capabilities to perform fisheries and aquaculture farming. On average, a proficient level is expected to be required for all the capabilities, however a more detailed analysis highlights that the level of maturity expected is higher for fishers and related fishing workers and marine transport professionals. However, in terms of skill gaps, aquaculture farmers will need to achieve largest improvement from current to future state digital capabilities, particularly in digital communication, data management and digital literacy.

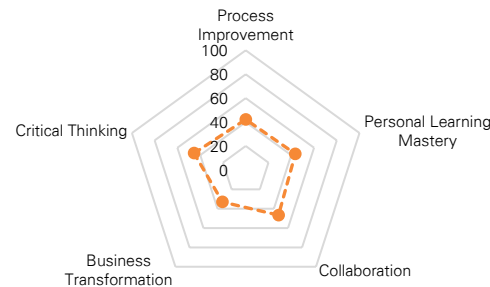
Digital capabilities – Current state



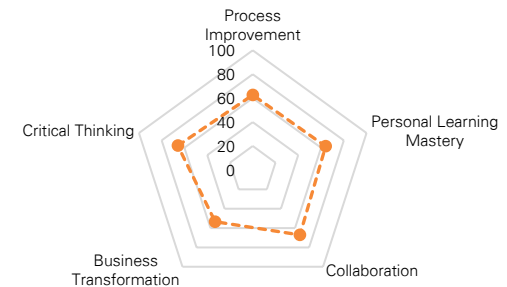
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



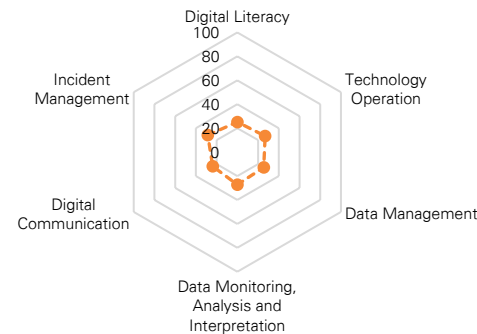
Source: Faethm, using Faethm's algorithm and the national digital capability framework

Livestock Farming

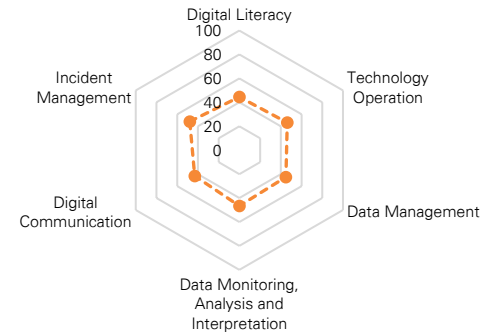
Insights

- Most roles within this category have similar scores in digital capabilities, apart from outliers farm managers and product graders (eggs) whose capabilities are significantly higher and as competent (score 41-60) in the current state.
- In the future state, digital and enabling capabilities would be required to be at a proficient level across livestock farming, with slightly higher capability demand for farm managers and product graders (eggs), yet the skills gap is the less challenging for those roles.
- However, current digital capabilities and enabling capabilities of wool classer and fencers are ranked below the livestock farming category average, involving the requirement of a very significant up-skill of their capabilities to work in a digital environment in the future state.
- An example of a context in which digital capabilities will be crucial for fencers is the emergence of virtual fencing. GPS technology is being used to draw virtual fences in properties, in which livestock will be maintained using electric fence collars.
- Business transformation will require the most important effort to up skills the enabling capabilities among livestock farming in the next 10 years.

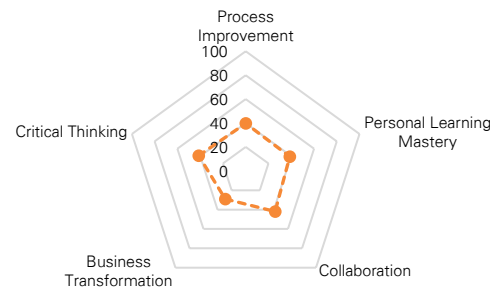
Digital capabilities – Current state



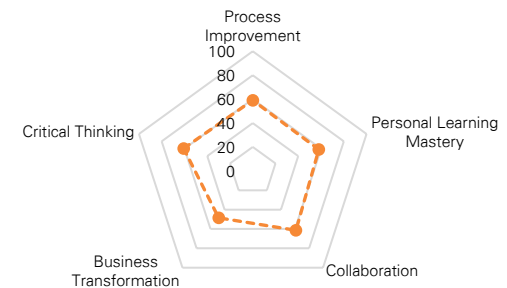
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



Source: Faethm modelling and the national digital capability framework

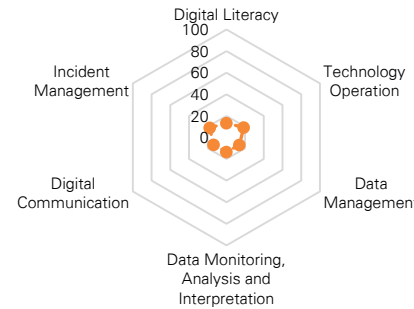
Cropping and horticulture



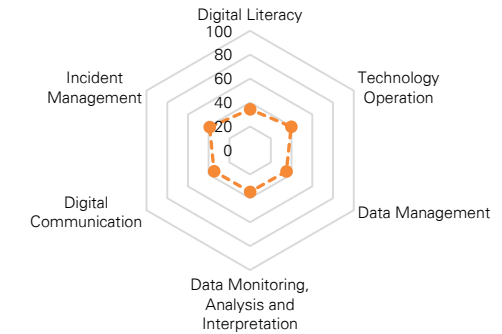
Insights

- Within the crop farming and horticulture category, there are significant variances between roles in terms of current maturity of digital capabilities. For instance, farm managers' digital capabilities are currently determined as competent, whereas handypersons and pest controllers as novice. A wide range of growers (sugar cane, vegetable growers, cotton, flower, fruit and nuts, grain, grape) score a low maturity level and are considered novice. Even if the future state of digital capabilities for those roles is required to be competent to perform in a digital environment, still the need for up-skilling will be quite significant, whether it is relevant to farm management or crop farming.
- Geopolitical drivers relating to access to labour are accelerating the investment focus on robotics in the horticulture sector, especially in leading agtech markets such as the US. The effects of this focus are anticipated to be felt in the next three years, and could lead to higher automation impact in the Australian horticulture sector which should be considered when prioritising digital capability development for this sector.
- Although there is a perception that the cotton and grain sectors have had significant technology deployment in the past few years, the indicative analysis found that there is still opportunity for improvement to develop digital capabilities.
- Current state of enabling capabilities are ranked between novice and competent across crop farming, with the highest score among farm managers, handyperson, pest controller, forestry worker and logging assistant.
- Skills gap for enabling capabilities is consistently more significant in business transformation, process improvement and personal learning mastery.

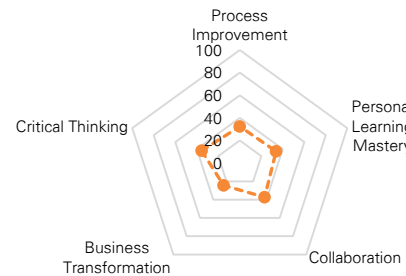
Digital capabilities – Current state



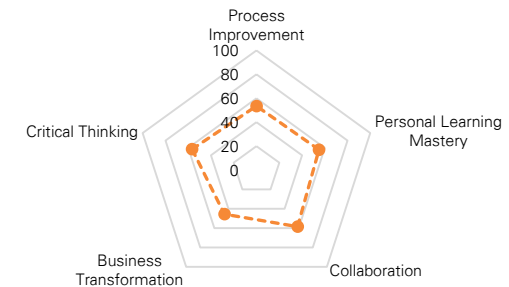
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



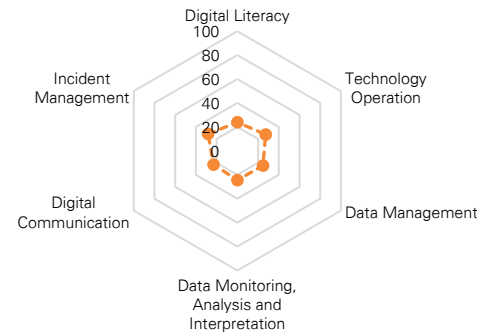
Source: Faethm modelling and the national digital capability framework

Mixed crop farming 

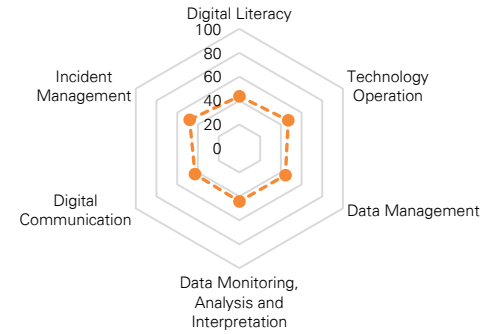
Insights

- In current state, capabilities within mixed crop farming range from highest scores by farm managers to lowest scores of mixed crop farmers. There is little range within the digital capabilities, with incident management and technology operation scoring the highest on average.
- Within the enabling capabilities, critical thinking has significantly higher scores across the mixed crop farming category.
- The gap analysis between current and future state indicates a strong need for improvement in all digital capabilities for fencers and mixed crop farmers to achieve a competent level of maturity required in the future state.

Digital capabilities – Current state



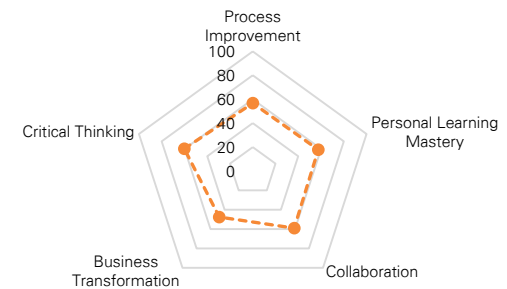
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



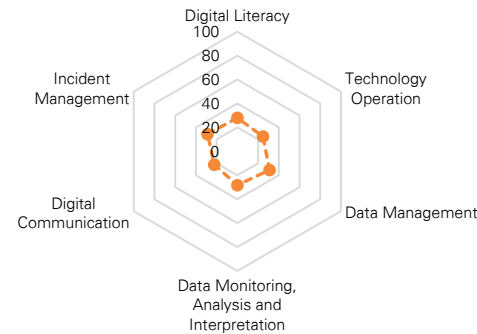
Source: Faethm modelling and the national digital capability framework

Product processing 

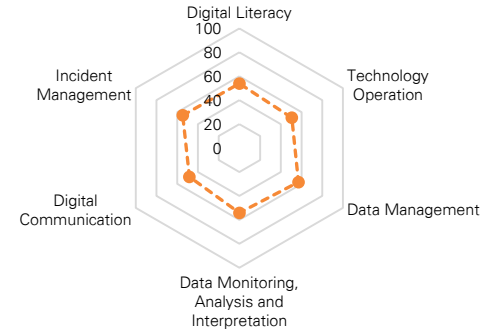
Summary:

- The category product processing includes three sub-categories: food processing, packing and processing equipment operation.
- The estimation of the current state of digital capabilities within product processing varies greatly, between a level of maturity from novice to proficient regardless the sub-categories.
- However, setting aside managers and administrators’ roles, the maturity of digital capabilities is on average novice. There is a significant skills gap across all digital capabilities and in particular for technology operation, digital communication and incident management when assessing the needs of future capabilities.
- Low capability scores in the current state may be partly explained by the wide range of roles in this category, for example less digitally literate roles such as yarn carding, slaughterer or seafood process worker lower average scores.
- Collaboration, critical thinking and personal learning mastery are expected to be the most required enabling capabilities in the future for product processing, and while the skills gap is high for those capabilities, it is even more important for process improvement and business transformation.

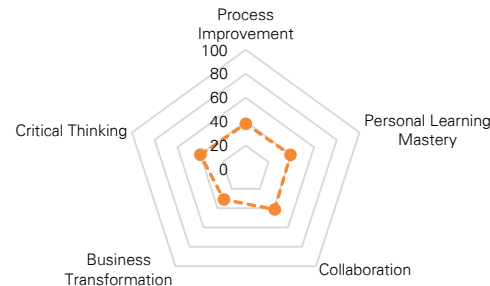
Digital capabilities – Current state



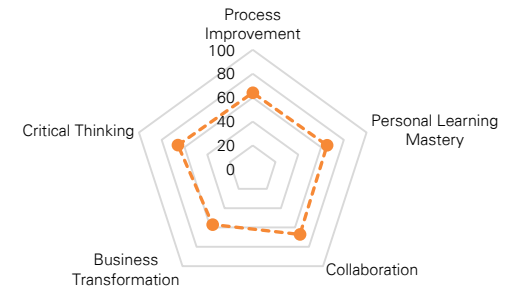
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



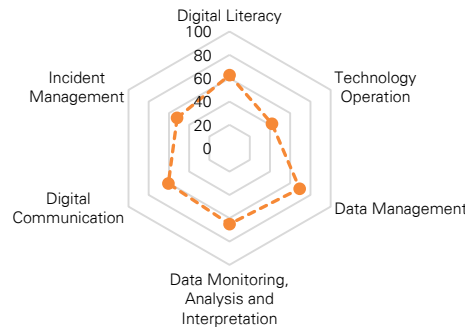
Source: Faethm modelling and the national digital capability framework

Science and engineering 

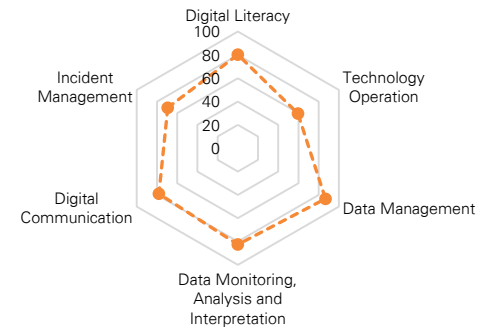
Insights

- The science and engineering category consists of research, development and innovation, environmental assessment and management, and extension and adoption.
- Overall, the current state is estimated to be mature in digital capabilities and enabling capabilities, mostly identified as competent to expert. Digital literacy, data management, and data monitoring and analysis score above average of the category. However, technology operation, incident management, and business transformation for specific roles are estimated as novice, this might indicate a less intensive digital environment to operate.
- The majority of roles within science and engineering are expected to demonstrate a high level of maturity for both digital and enabling capabilities from proficient to expert. An expert level, on average, would be expected in the future in digital literacy, data management, and data monitoring and analysis. This can be explained by the numerous science and engineering agricultural technologies emerging, for example advanced gene editing, use of enzyme biosensors, DNA testing, and RNAi technology.

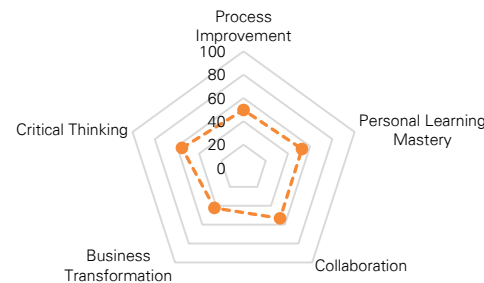
Digital capabilities – Current state



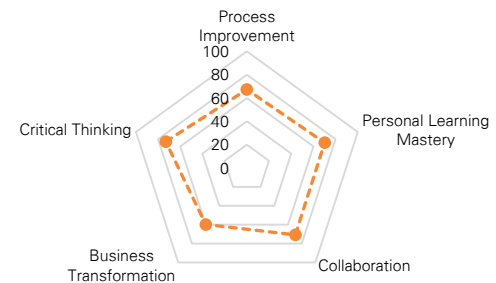
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



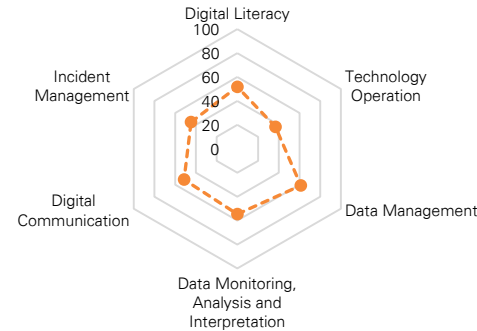
Source: Faethm modelling and the national digital capability framework

Governance 

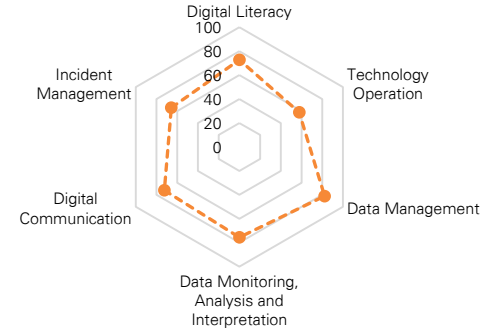
Insights

- Governance, which includes roles related to policy, regulation and compliance are estimated to possess a competent to proficient level of digital and enabling capabilities in its current state.
- In the future, it is expected that data management will be required at an expert level across the category, supported by proficient to expert data monitoring and analysis and data communication skills.
- It is anticipated that a workforce operating in governance roles would progress in a highly digital environment with trends such as RegTech impacting the way people collect and analyse data to make informed decisions but to also drive change in policy.
- Strong collaboration is expected to be a future requirement, represented as one of the highest scores across the supply chain.

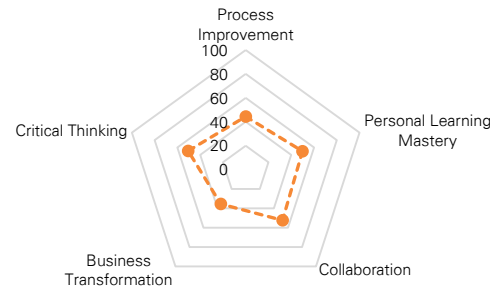
Digital capabilities – Current state



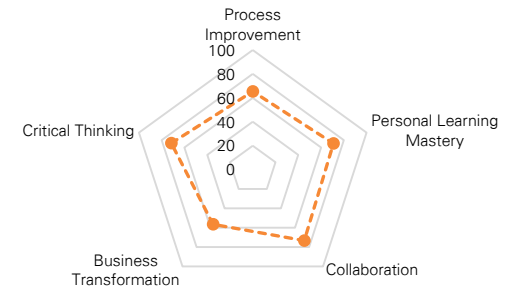
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



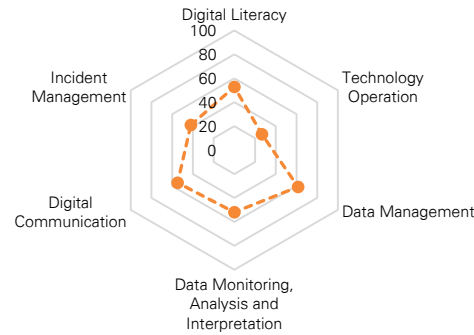
Source: Faethm modelling and the national digital capability framework

Business management 

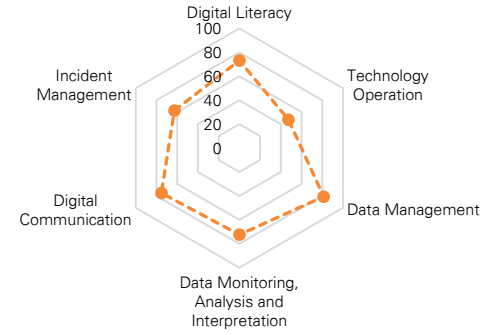
Insights

- High levels of variance within this category exist, for example, systems and database administrators are estimated to achieving near perfect scores, while other roles in general administration are estimated to have low level of maturity across all digital and enabling capabilities.
- With science and engineering, and governance, it is expected that business management will require the highest level of maturity in digital capabilities, especially in digital literacy, data management, and data monitoring and analysis.
- Roles in ICT and commodity trading are expected to require the most mature level of digital skills, with four out of 6 digital capabilities to be delivered at an Expert level.
- Closing the gap between current and future state would need to focus on technology operation, incident management and business transformation.

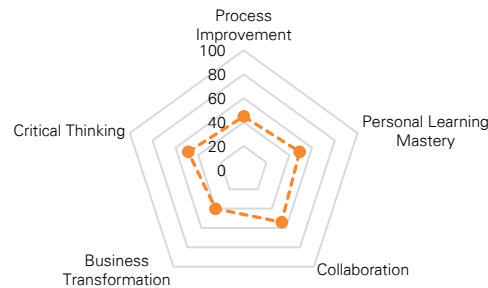
Digital capabilities – Current state



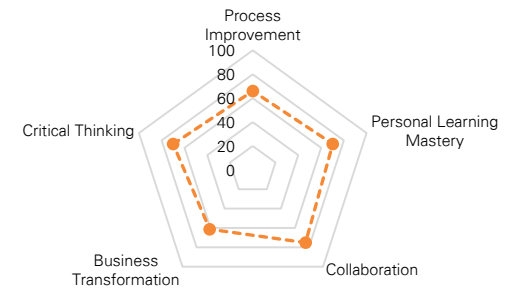
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



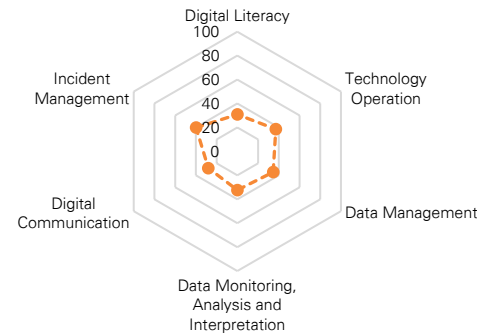
Source: Faethm modelling and the national digital capability framework

Vehicle operation and maintenance

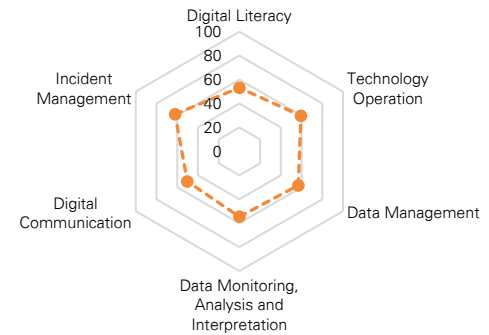
Insights

- A large gap is estimated between those in this workforce who require extensive qualifications in driving/piloting with comparison to those who perform maintenance. For example, aeroplane pilots are estimated to have/require digital capabilities much higher than bulldozer and excavator operators, both in current and future states.
- There is an overall need for consistent up skilling in enabling capabilities across all job roles in this role category.
- It is estimated that a growing emergence of digital supply chain, improved technology operation and incident management will occur in the future. Additionally, the emerging trend of data-driven software in optimising the movement of agricultural cargo might explain a similar growth in the level of maturity estimated in the future for data management, and data monitoring and analysis capabilities.
- The category will also see the emergence of new roles to manage new technologies such as driverless tractors designed to improve business operations.

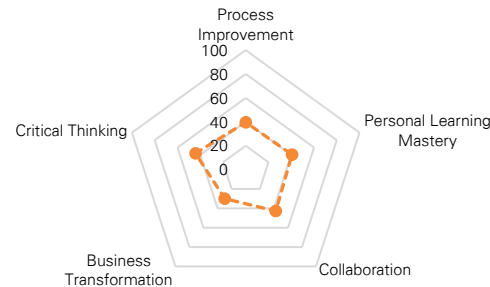
Digital capabilities – Current state



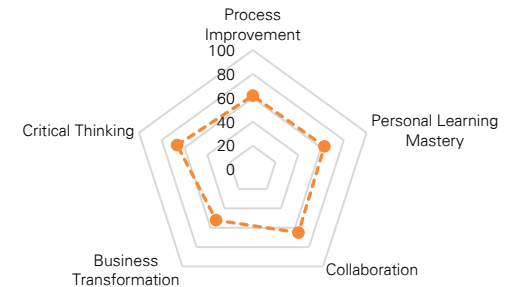
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



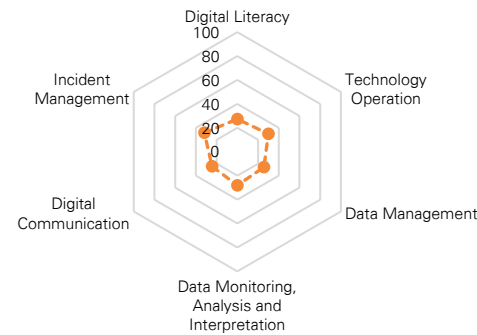
Source: Faethm modelling and the national digital capability framework

Building and property maintenance

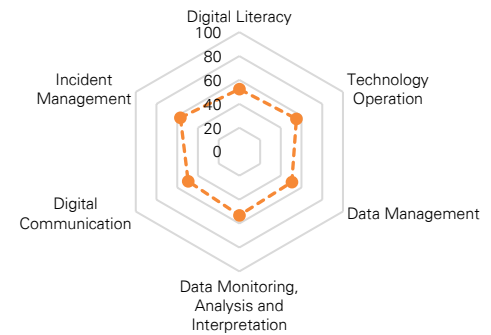
Insights

- Among the generic categories described in the approach, the building and property maintenance category is estimated to be the least mature in terms of both digital and enabling capabilities, indicating a skills gap that is most important for up skilling of current capabilities.
- The range of capability scores is consistent across the category but also across the digital and enabling capabilities.
- The gap analysis demonstrates a consistent need to up skill workforce capabilities.

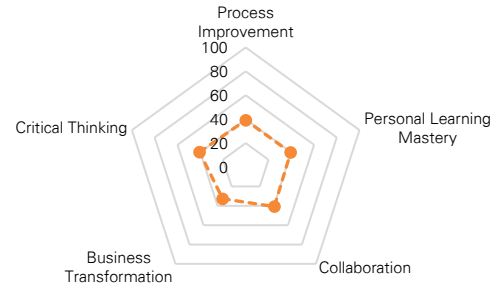
Digital capabilities – Current state



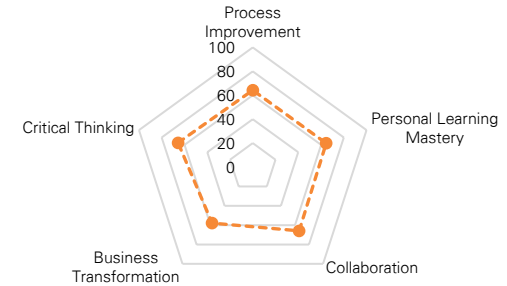
Digital capabilities – Future state



Enabling capabilities – Current state



Enabling capabilities – Future state



Source: Faethm modelling and the national digital capability framework

Appendices

- Appendix A** Approach
- Appendix B** List of roles included in the scope of agriculture industry
- Appendix C** Role categories and sub-categories
- Appendix D** Snapshot of the Australian agricultural industry
- Appendix E** Faethm technology taxonomy
- Appendix F** VET: detailed insights of digital capabilities training
- Appendix G** Map of locations for digital units training
- Appendix H** Technology impact on the agricultural workforce

Appendix A: Approach

Definition of the scope

In identifying the scope for the agriculture workforce, the following steps were taken:

1. Consultation of the Australian and New Zealand Standard Classification of Occupations (ANZSCO) website which provides a basis for the standardised collection, analysis and dissemination of occupation data for Australia and New Zealand. All occupation data including roles were examined and any relating to the agricultural industry were identified and selected.
2. Roles that were identified to be agricultural in nature were then vetted by KPMG's agribusiness team. The end list of job roles were presented to the Cotton RDC Steering Committee for confirmation.
3. Job roles pertaining to the same agricultural sector were then grouped into sub-categories to further decrease the complexity of the data that was to be analysed.
4. These newly formed sub-categories were further grouped into categories which can be defined as the parent group (for sub-categories and their corresponding job roles).

Overall, approximately 250 roles are included the scope of this analysis, grouped into categories and sub-categories. Further details are available in [Appendix C: Approach to determining sub-capabilities](#).

Desktop research

Comprehensive desktop research was conducted in order to gain an in-depth understanding of the Australian agricultural workforce, the digital capabilities central to agriculture and identification of case studies. Additionally, developing insights on emerging technologies and trends was essential in the desktop research stage to enable an informed approach in scoping relevant technologies to this report. Reports, thought leadership papers, existing surveys and articles were considered and were sourced from a wide range of industry bodies, government agencies, and internationally renowned agricultural academic centres.

Collaboration with an industry cohort

The project relied on a collaborative approach, ensuring that we consider the initial objectives at each stage of the project and utilise the industry knowledge fully. In particular, a workshop involving 30 participants across 21 industries, research and university organisations took place to involve core stakeholders, refine the national digital capability framework to ensure it resonated with the sectors and aligned with the current state sector-specific priorities on digital technologies.

Faethm approach to capability modelling

Faethm modelled the current- and future-state digital, and enabling capabilities for each role in the agricultural workforce to determine the gap in future capability needs. The approach is as follows:

- All agriculture jobs were downloaded from the Australian census and mapped to standard Faethm jobs families. Each Faethm-job is described by 244 job attributes of different levels of ability.

- Each of the 11 digital and enabling capabilities were assigned a set of skills (from the set of 244) describing the associated skill set of that capability. A further general IT capability was used to determine the current use of technology in each role and applied across the digital capabilities.
- Current state capability measures were calculated based on the current skills mix of each job, and for digital capabilities, the extent of current technology use.
- Future state capabilities were measured from the impact of augmentation and automating technologies to each job over 10 years: the percentage rates of augmentation and automation are used to determine the extent of increased digital and enabling capabilities. The assumption being, if a job faces augmenting or automating technology the individual will need to up-skill to either perform adequately in their current job, or to find a new job.
- Un-weighted averages were used to present the impact across 242 unique job types across each industry. A weighted approach, that considers the workforce size for each role is not presented, this is because the large un-skilled seasonal labour force hides significant trends in current capabilities.

In-depth review of current training providers and curricula

Existing training programs including VET units and University sector were reviewed as part of this project.

Relevant units of competency were identified for their overt or contextualisable content using the Department of Education prototype 'training.gov.au Text Analytic Search and Cluster Tool'. This tool searches the content of around 17,000 units on the website training.gov.au.

Unlike the VET sector, the university sector does not have National Skills Standards. As a result, the digital capabilities being delivered are unique to each institution. Each university is required to publish standard information about the courses (subjects) within each qualification. An analysis of the programs offered by 33 universities and two non-university higher education institutions providing formal education to the agriculture workforce. A review of general degree qualifications (such as accountancy, economics or science) within the sector was excluded as it is not relevant for the scope of this report.

At last, a review of informal, online and industry training was undertaken, identifying current projects being conducted by RDCs.

Unit identification methodology (VET) and data analysis and limitation

Methodology

Relevant units of competency were identified for their overt or contextualisable content using the Department of Education prototype 'training.gov.au Text Analytic Search and Cluster Tool', which is not yet publicly available. This tool searches the content of around 17,000 units on the website training.gov.au to identify those which include the words defined by the user. The interface is modelled on Google Advanced Search, with three fields wherein the user can define if 'any', 'all' or 'none' of the terms should be returned.

The tool searches training.gov.au unit pages for text in the following sections:

- Title
- Description (application, unit descriptor and application of the unit)
- Elements and performance criteria
- Performance and knowledge evidence
- Required skills and knowledge

For this analysis, key terms relevant to digital skills in the agriculture-related training packages were established through an iterative process, including:

- Content analysis of six key units that were identified prior to this broader search, including in the ‘Agriculture, Horticulture and Conservation and Land Management’ (AHC), ‘Seafood Industry’ (SFI), ‘Australian Meat Processing’ (AMP), and ‘Forest and Wood Products’ (FWP) Training Packages;
- Content analysis of several units that are not digitally-focussed, but which have the potential to be contextualised for digital agriculture by RTOs (including units from the above training packages and units that have been ‘imported’ from other training packages for their transferability to AHC, SFI, AMP or FWP qualifications)
- Adding new terminologies to the key search terms as they became apparent when analysing units that the search tool uncovered.

Key words were designated as ‘technical’, ‘contextual’ or ‘industry’ as part of a hierarchy of search terms. These were:

Designation	Words
Technical	digital, biotechnology, software, satellite, big data, geospatial, electronic, GIS, technology, ICT, GPS, wireless, automate, robot, drone, download, spatial, data, science, forecast, computer, internet, mechanisation, online, precision, sensor, surveillance, traceability
Contextual	analysis, application, assess, chain, collection, communications, distribution, e-business, hardware, information, markets, model, monitor, packing, process, production, research, supply, system
Industry	irrigation, nutrition, breed, farm, livestock, horticulture, cotton, crop, chemicals, forest, dairy, grape, egg, aquaculture, fish, behaviour, flower, agriculture, animals, environment, soils, plant, seafood, poultry, logging, pest, meat, nursery, sugar, timber, vegetable, veterinary, viticulture, water, wine, wood, wool, yields

Searches were conducted by entering select combinations of these words in the ‘any’ and ‘all’ fields. The option to ‘add’ units to a master list or ‘discard’ them from further searches entailed that the process was exhaustive; that is, it continued until there were no units left to analyse and so ‘add’ or ‘discard’.

Establishing the final list of 85 units required subjective decision-making as to what was relevant, or potentially so. For example, the unit ‘*BSBITS411- Maintain and implement digital technology*’ (imported from the ‘Business Services’ Training Package into the qualification ‘*FWP40216 - Certificate IV in Timber Processing*’), is not defined according to agricultural skills but is contextualisable to the industry by the training provider, hence was included.

Data analysis and limitations

All VET data should be read in light of the contextual caveats discussed in the sections on:

- Contextualisation;
- Core/elective units;
- RTO approval to deliver elective units;
- Supply/Demand; and
- Regional delivery and diversity issues.

To be sure, low enrolments in particular units do not necessarily entail that learners are avoiding enrolling in them, but that RTOs may to a large extent determine the electives a learner undertakes (due to issues such as lack of access to appropriate technologies).

All VET qualification and unit enrolment data is sourced from NCVER's online VOCSTATS platform. At the time of writing, the latest data is for 2017. This delay entails that the data does not necessarily display the current versions of units. Where it displays current and superseded versions of a unit their statistics have been merged to offer better insights into subject enrolments.

One of the limitations of this method is that merging data culminates in an imperfect data set: merging occurred with the use of Excel formulas where the title of subsequent unit releases within a training package were identical; however, where there were minor title changes the formulas did not recognise unit lineage. Manual data cleansing was undertaken to correct this, but it is likely that errors remain.

Also, due to the delay in NCVER collecting and publishing unit enrolment data, there are some inconsistencies between the number of units identified as relevant to this project and the number of units for which there is data available. For example, if a new unit was released after the NCVER data collection deadline, it does not feature in the quoted statistics.

There may also be minor inconsistencies in the data because of NCVER VOCSTATS utilising a proprietary algorithm called perturbation to protect students' confidentiality. The perturbation module automatically adjusts enrolment values each time a query is entered so that individuals cannot be accurately identified where there are low enrolments values. However, this complex calculation is specifically designed not to reduce the usefulness of the data by disrupting overall trends or introducing bias.

Appendix B: List of roles included in the scope of agriculture industry

Value Chain Segment	Inputs														
Category <small>(ANZSCO Major/Minor Group)</small>	Life science (2345)	Agriculture science support (3111)	Science support (3114)	Environmental science (2343)	Engineering (2339)	Land economy and valuing (2245)	Structural steel and welding work (3223)	Motor mechanical work (3212)	Earth moving work (7212)	Metal fitting and machinery operating (3222)	Inspection and regulation (5996)	Vehicle driving (7331)	Driving forklifts (7213)	Nursing animals	Animal medicine (2346)
Roles	234511 Life Scientist (General)	311111 Agricultural Technician	311413 Life Science Technician	234311 Conservation Officer	233912 Agricultural Engineer	224511 Land Economist	322312 Pressure Welder	321211 Motor Mechanic (General)	721211 Earthmoving Plant Operator (General)	323211 Fitter (General)	599514 Noxious Weeds and Pest Inspector	733111 Truck Driver (General)	721311 Forklift Driver	361311 Veterinary Nurse	234711 Veterinarian
	234516 Botanist		311499 Science Technicians nec	234312 Environmental Consultant	233915 Environmental Engineer	224512 Valuer	322313 Welder (First Class)	321212 Diesel Motor Mechanic	721212 Backhoe Operator	323212 Fitter and Turner	599521 Water Inspector				
	234517 Microbiologist			234313 Environmental Research Scientist					721213 Bulldozer Operator	323213 Fitter-Welder	599599 Inspectors and Regulatory Officers nec				
	234599 Life Scientists nec			234399 Environmental Scientists nec					721214 Excavator Operator	323299 Metal Fitters and Machinists nec					
									721215 Grader Operator						
									721216 Loader Operator						
									821113 Earthmoving Labourer						

Value Chain Segment	Inputs										Production					
Category <small>(ANZSCO Major/Minor Group)</small>	Research and development (1325)	Training and development professionals (2233)	Air transport (2311)	Other specialist management (1399)	Agriculture and forestry science (2341)	Marine maintenance and fishing (8992)	Nursery management (3624)	Marine transport management (2312)	Metal casting, forging and finishing (3221)	Aquaculture Farming (1211)	Crop Farming (1212)	Livestock farming (1213)		Product Quality Controllers (8393)	Mixed crop and livestock farming (1214)	Forestry and logging (8413)
Roles	132511 Research and development manager	223311 Training and Development Professional	231111 Aeroplane Pilot	139912 Environmental Manager	234111 Agricultural Consultant	899211 Deck Hand	362411 Nursery person	231211 Master Fisher	322111 Blacksmith	121111 Aquaculture Farmer	121211 Cotton Grower	121311 Aperist	121318 Pig Farmer	839312 Product Grader (Eggs)	121411 Mixed Crop and Livestock Farmer	841311 Forestry Worker
			231114 Helicopter Pilot		234112 Agricultural Scientist	899212 Fishing Hand		231299 Marine Transport Professionals nec	322112 Electroplater		121212 Flower Grower	121312 Beef Cattle Farmer	121399 Livestock Farmers nec			841312 Logging Assistant
					234113 Forester (Aus)/ Forester Scientist (NZ)				322113 Farrier		121213 Fruit or Nut Grower	121313 Dairy Cattle Farmer	121321 Poultry Farmer			841313 Tree Faller
											121214 Grain, Oilseed or Pasture Grower	121314 Deer Farmer	121322 Sheep Farmer			
											121215 Grape Grower	121315 Goat Farmer				
											121216 Mixed Crop Farmer	121316 Horse Breeder				
											121217 Sugar Cane Grower	121317 Mixed Livestock Farmer				
											121221 Vegetable Grower					

Value Chain Segment	Production			Storage and Handling			Processing and Manufacturing								
Category (ANZSCO Major/Minor Group)	Other Farming, Forestry and Gardening Work (8419)	Fencing (8213)	Shearing	Purchasing and supply logistics (5911)	Financial brokerage (2221)	Miscellaneous technical operations (3999)	Butcher work (3512)	Food factory work (8311)	Meat work (8312)	Meat process work (8313)	Chemical science (2342)	Packing (8321)	Production management (1335)	Retail and wool buying	Primary product inspection (3113)
Roles	841911 Hunter-Trapper	821311 Fencer	361211 Shearer	591112 Production Clerk	222111 Commodities Trader	399917 Wool Classifier	351211 Butcher or Smallgoods Maker	831114 Dairy Products Maker	831211 Meat Boner and Slicer	831311 Meat Process Worker	234211 Chemist	832112 Container Filler	133511 Production Manager (Forestry)	639212 Wool Buyer	311311 Fisheries Officer
	841913 Pest Controller			591113 Purchasing Officer				831115 Fruit and Vegetable Factory Worker	831212 Slaughterer	831312 Poultry Process Worker	234212 Food Technologist	832113 Fruit and Vegetable Packer	133512 Production Manager (Manufacturing)		311312 Meat Inspector
	841999 Farm, Forestry and Garden Workers nec			591115 Stock Clerk				831116 Grain Mill Worker		831313 Seafood Process Worker	234213 Wine Maker	832114 Meat Packer			311313 Quarantine Officer
				591116 Warehouse Administrator				831117 Sugar Mill Worker					832115 Seafood Packer		
			591117 Order Clerk				831118 Winery Cellar Hand					832199 Packers nec			

Value Chain Segment	Processing and Manufacturing					Packaging & Distribution	Transport & Logistics	Corporate services							
Category <small>(ANZSCO Major/Minor Group)</small>	Plant operation (7211)	Occupational and environmental health management (2513)	Textile and footwear production machine operation (717)	Paper and wood processing (7113)	Auctioning and agricultural advising (6111)	Timber and wood processing (8394)	Importing, exporting and wholesaling	Retail management (1421)	Transport and despatch management	Supply, distribution and procurement management	Data entry (5321)	Payroll management (5513)	Personal assistance (5211)	Human resource management (1323)	Human resource professional management (2231)
Roles	721111 Agricultural and Horticultural Mobile Plant Operator	251311 Environmental Health Officer	711711 Footwear Production Machine Operator	711313 Sawmilling Operator	611111 Auctioneer	839411 Paper and Pulp Mill Worker	133311 Importer or Exporter	142111 Retail Manager (General)	591211 Despatching and Receiving Clerk	133611 Supply and Distribution Manager	532111 Data Entry Operator	551311 Payroll Clerk	521111 Personal Assistant	132311 Human Resource Manager	223111 Human Resource Adviser
	721112 Logging Plant Operator	251312 Occupational Health and Safety Adviser	711712 Hide and Skin Processing Machine Operator	711314 Other Wood Processing Machine Operator	611112 Stock and Station Agent	839412 Sawmill or Timber Yard Worker	133312 Wholesaler	611312 Sales Representative (Business Services)	591212 Import-Export Clerk	133612 Procurement Manager	532112 Machine Shorthand Reporter				223112 Recruitment Consultant
			711713 Knitting Machine Operator			839413 Wood and Wood Products Factory Worker					532113 Word Processing Operator				223113 Workplace Relations Adviser
			711714 Textile Dyeing and Finishing Machine Operator			712916 Paper and Pulp Mill Operator									
			711715 Weaving Machine Operator												
			711716 Yarn Carding and Spinning Machine Operator												
			711799 Textile and Footwear Production Machine Operators nec												

Value Chain Segment	Corporate services															
Category <small>(ANZSCO Major/Minor Group)</small>	Corporate services management (1321)	Storage management (7411)	Organisation leadership (1111)	Sales representation (6113)	ICT management (1351)	ICT support (3131)	Business and systems analytics (2611)	ICT systems and security management (2621)	General management duties (1112)	Office management (5121)	Bookkeeping (5512)	Making sales (6211)	Contract, program and project administration (5111)	Account management (5511)	Accounting (2211)	
Roles	132111 Corporate Services Manager	741111 Storeperson	111111 Chief Executive or Managing Director	611311 Sales Representative (Building and Plumbing Supplies)	135111 Chief Information Officer	313111 Hardware Technician	261111 ICT Business Analyst	262111 Database Administrator	111211 Corporate General Manager	512111 Office Manager	551211 Bookkeeper	621111 Sales Assistant (General)	511111 Contract Administrator	551111 Accounts Clerk	221111 Accountant (General)	
				611399 Sales Representatives nec	135112 ICT Project Manager	313112 ICT Customer Support Officer	261112 Systems Analyst	262112 ICT Security Specialist	139999 Specialist Managers nec				511112 Program or Project Administrator	551112 Cost Clerk	221112 Management Accountant	
					135199 ICT Managers nec	313113 Web Administrator		262113 Systems Administrator								221113 Taxation Accountant
						313199 ICT Support Technicians nec										

Value Chain Segment	Corporate services						General
Category <small>(ANZSIC Major Group)</small>	Public relations management (253)	Advertising, sales and marketing (1311)	Advertising and marketing professionals (251)	Secretarial duties (5212)	General administration (5311)	Financial management (1322)	Facility maintenance (8893)
Roles	225311 Public Relations Professional	131111 Advertising and Public Relations Manager	225111 Advertising Specialist	521211 Secretary (General)	531111 General Clerk	132211 Finance Manager	889311 Handyperson
		131111 Advertising and Public Relations Manager	225112 Market Research Analyst	521212 Legal Secretary			
		131112 Sales and Marketing Manager	225113 Marketing Specialist				

Appendix C: Role categories and sub-categories

Specific roles: categories and sub-categories

Extensive analysis of ANZSCO roles combined with industry consultations enabled the development of a taxonomy of roles in the agriculture sector divided into categories and sub-categories. While some categories, for example livestock farming, apply purely to the agriculture industry, others are generic roles such as engineers that exist in a range of industries additional to agriculture.

Role category	Role sub-category
Fisheries and aquaculture farming	– Fisheries management
	– Aquaculture farm management
Livestock farming	– Livestock management
	– General farm management
	– Business management
Crop farming and horticulture	– Perennial crops
	– Annual crops
	– General farm management
	– Business management
Mixed crop farming	– Mixed crop management
	– General farm management
	– Business management
Product processing	– Packing
	– Food processing
	– Processing equipment operation

General role categories and sub-categories

Role category	Role sub-category
Science and engineering	– Environmental assessment and management
	– Research, development and innovation
	– Extension and adoption
Governance	– Policy
	– Regulation
	– Compliance
Vehicle operation and maintenance	– Marine vehicles
	– Air vehicles
	– Ground vehicles
	– Other vehicle operation
	– Servicing
Building and property maintenance	– Building and trade
	– Maintenance
Business management	– Business leadership
	– Procurement and finance
	– Human resources
	– ICT
	– Marketing and advertising
	– Supply chain and sales
	– General administration
	– Commodity trading

Appendix D: Snapshot of the Australian agricultural industry

Snapshot of the Australian agricultural industry



In 2017-18 the gross value of agricultural production was \$59 billion¹²⁵
To deliver this revenue, 228,372 Australians are employed by the agricultural sector¹²⁶



According to the ABARES June quarter 2019 report, national farm production value for 2019-20 is forecast to remain at \$59 billion¹²⁷, reflecting slowed growth due to drought. Production is expected to reach \$64 billion in 2023-24.¹²⁸



There were 85,000 farm businesses in Australia in 2018¹²⁹, each earning an estimated average of \$201,300 per year 2017-18.¹³⁰ Each Australian farmer produces enough food to feed 600 people: 150 at home and 450 overseas. Australian farmers produce almost 93 percent of Australia's daily domestic food supply.¹³¹



2018-19 cash incomes for around 50 percent of Australian broadacre farms are expected fall by 18 percent from \$201,300 per farm in 2017-18 to \$173,000 per farm in 2018-19, while incomes on sheep industry farms are projected to increase from \$131,600 per farm in 2017-18 to \$142,000 per farm in 2018-19.¹³²

Top revenue commodities

Livestock: Cattle and calves \$13 billion – milk \$4 billion

Crops: Wheat \$6.2 billion – barley \$2.2 billion

Horticulture: Grapes \$1.3 billion – almonds \$700 million¹³³

- 4,331 ha** Average Australian farm size, an increase of 0.3 percent since 2014-15¹³⁴
- 47,021** Number of beef-producing farms
- 530** Number of chicken-meat producing farms
- 1,200** Number of cotton farms
- 6,102** Number of dairy farms
- 2,800** Number of piggeries

Distribution of farms in Australia¹³⁵:

125 ABARES, 2018, *About my region: regional profiles, Agriculture sector*: <http://agriculture.gov.au/abares/research-topics/aboutmyregion/vic#agricultural-sector>

126 ABARES Insights, 2018, *Snapshot of Australia's Agricultural Workforce*, p.2.

127 ABARES, 2019, *Agriculture overview June quarter 2019*, <http://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/jun-2019/agriculture-overview>

128 ABARES, 2019, *Agriculture overview March quarter 2019* <http://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/mar-2019/agriculture-overview>

129 National Farmers Federation, 2017, *Food, Fibre & Forestry facts*

130 ABARES, 2019, *Agriculture overview June quarter 2019*, <http://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/jun-2019/agriculture-overview>

131 Rural Skills Australia, 2019, *Agriculture & farming: Case studies, qualifications and job choices*, <http://www.ruralcareers.net.au/agriculture/>

132 ABARES, 2019, *Agriculture overview March quarter 2019*. <http://www.agriculture.gov.au/abares/research-topics/agricultural-commodities/mar-2019/agriculture-overview>

133 ABARES, 2017, *Australia's Agricultural Industries 2017*,

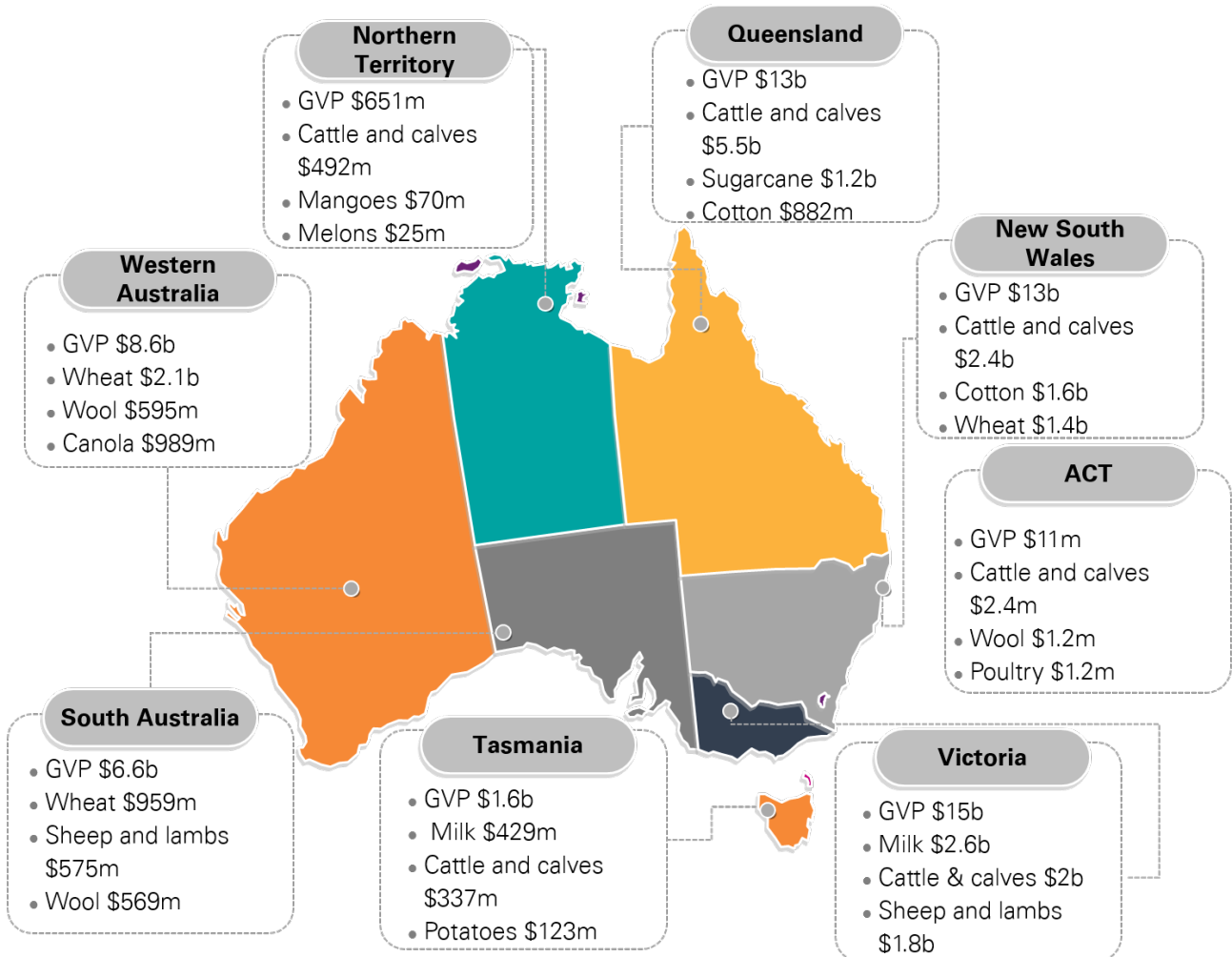
http://data.daff.gov.au/data/warehouse/9aal/2017/aim17_20171121/AusAgIndMap2017_v.1.1.0.pdf

134 KPMG, *Talking 2030: Growing agriculture into a \$100 billion industry*, p. 74.

135 National Farmers Federation, 2017, *Food, Fibre & Forestry facts*, p.24

Agricultural GVP regional distribution

The map below shows Agricultural GVP according to region. Victoria was the biggest contributor to the Australian agricultural industry in 2018, producing 25 percent of farm gate output by value, followed closely by NSW and Queensland which produce 23 percent. According to ABARES statistics¹³⁶, the top commodities were cattle and calves, milk and cotton. ACT and NT had the lowest output.



The Food and Agriculture Organisation (FAO) of the United Nations estimates that global food production will increase by 60 percent between 2005-07 and 2050, an increase in which agriculture will play a key role.¹³⁷ Global factors that can be attributed to agricultural growth include development of middle classes, increasingly open trade and market access, and heavy investment in research and development.¹³⁸

With an ageing and shrinking workforce not experiencing the same level of progressive development, the Australian agricultural industry will need to streamline the processes and attract skilled workforce to cater to such high levels of forecasted production increase.

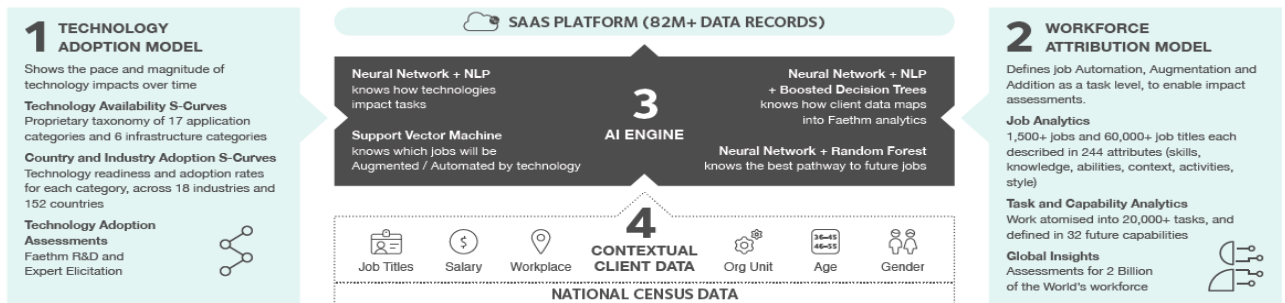
136 ABARES, 2018, *About my region: regional profiles, Agriculture sector*: <http://agriculture.gov.au/abares/research-topics/aboutmyregion/vic#agricultural-sector>

137 KPMG and National Farmers Federation, 2018, *Talking 2030: Growing agriculture into a \$100 billion industry*, p. 60.

138 The United States Studies Centre at the University of Sydney, 2018, *Seeds of Success: Advancing Digital Agriculture from point solutions to platforms*, p. 3.

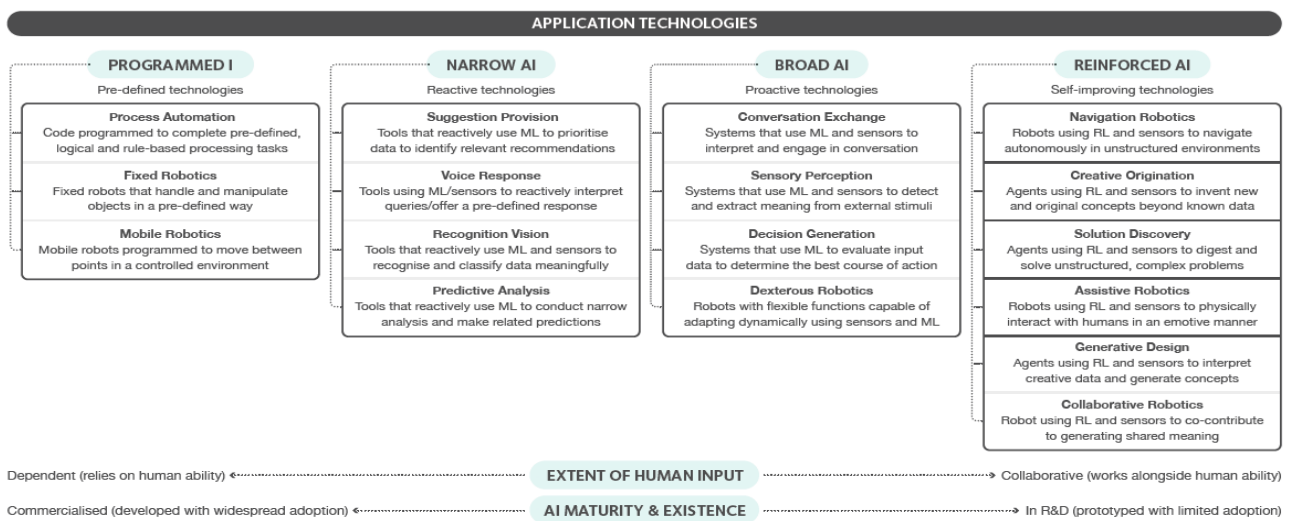
Appendix E: Faethm technology taxonomy

The Faethm Technology Taxonomy is a human-centred classification of technology. Using this classification system, we first identified human abilities required for work and then used those to construct a mutually exclusive collectively exhaustive (MECE) grouping of technologies that could either disrupt or enhance one or more of these abilities. Each of the 17 AI and robotics technology classes represent a group of many technologies that directly impact work that are either currently available or will be within the next 10 years.



Faethm Technology Taxonomy

AI/Robotics layer - Categorises types of AI/Robotics that have a direct impact on human tasks and work.

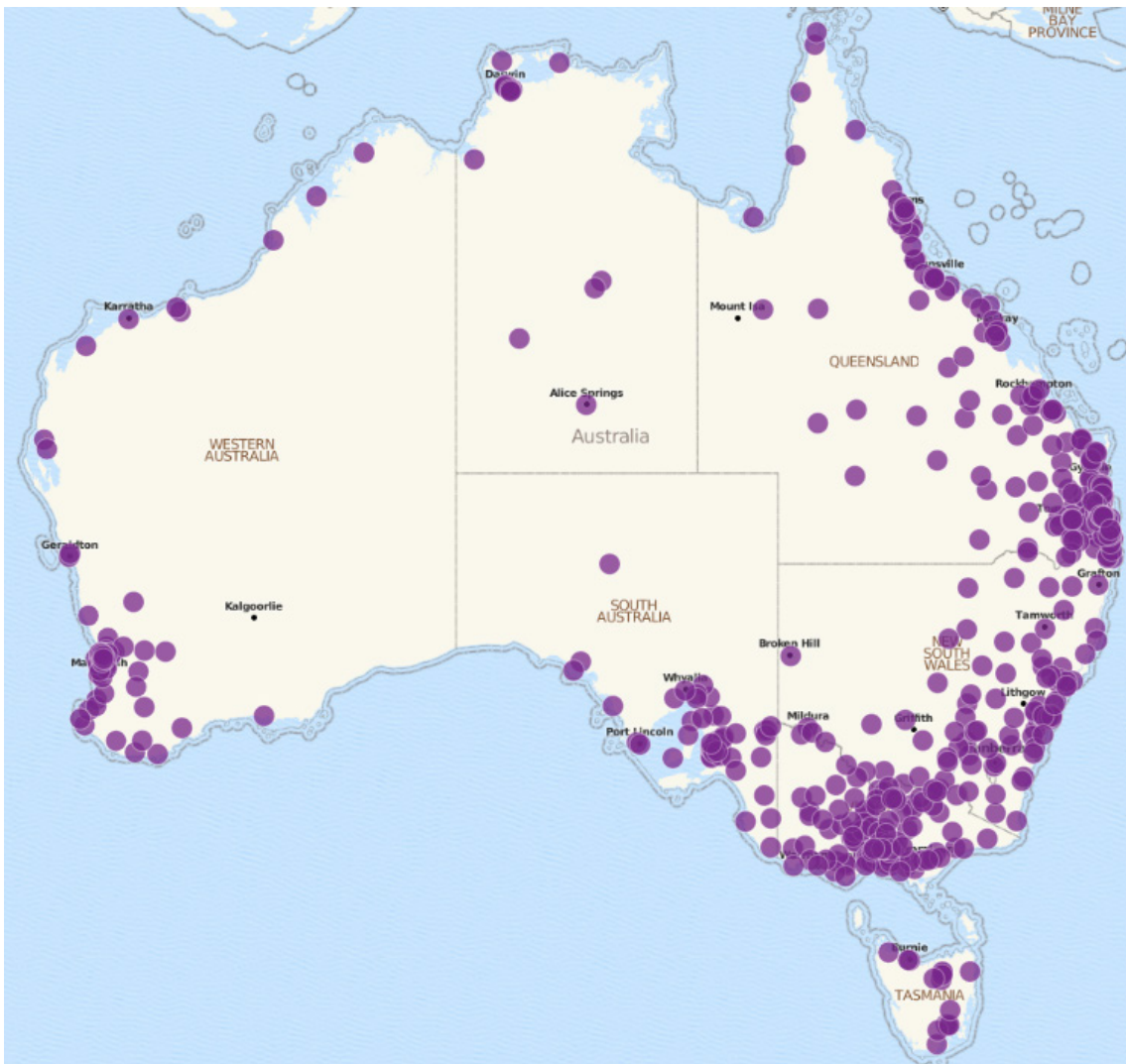


Infrastructure Technology layer - Categorises technology types that enable the application of AI/Robotics.

INFRASTRUCTURE TECHNOLOGIES					
Interface technologies Enables AI/robotics to interact and be used	Immersive technologies Enables AI/robotics to be telepresent in spaces	Energy technologies Enables AI/robotics to be powered and run	Fabrication technologies Enables AI/robotics to be physically created	Network technologies Enables AI/robotics to connect and network	Computing technologies Enables AI/robotics to accelerate calculation and function
EXAMPLES					
Voice Wearables Vehicles Brain-Computer	Digital Twins Mixed Reality Augmented Reality Virtual Reality	Microgrids Hot Solar Cells Advanced Fusion/Fission Reactors Lithium/Sodium-Ion Batteries	Advanced Materials Additive/3D Printing Microfabrication Nanomaterials	Internet of Things (IoT) 5G Li-Fi SmallSat	High Performance Quantum Neuromorphic Optical/Photonic

Appendix F: Map of locations for digital unit training

Figure 5: VET training delivery locations of the 67 qualifications with digital capabilities units as core/electives



Source: NCVER, *Atlas of Total VET*, <https://www.ncver.edu.au/research-and-statistics/visualisation-gallery>

Note: A detailed map of unit training delivery locations is not available through NCVER; because many of the units are not compulsory components of the qualifications, this map should not be read as a definitive guide as to where digital skills training is occurring, but where it might be offered.

Appendix G: VET: detailed insights of digital capabilities training

Figure 6: Qualification levels of digital capabilities units¹³⁹

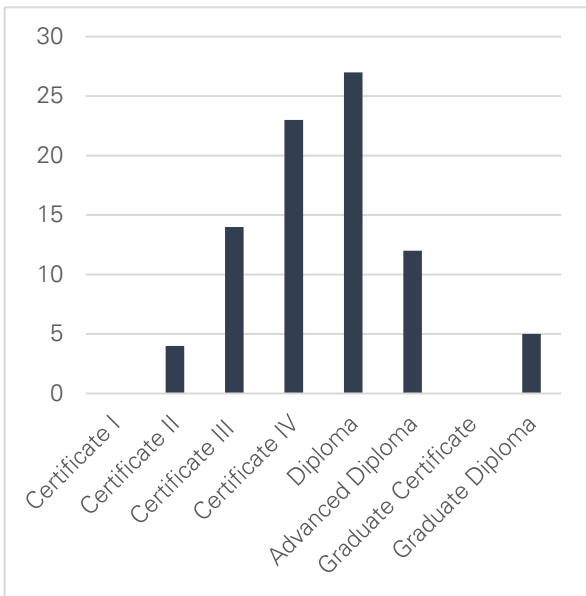


Figure 7: Relevant qualification enrolments¹⁴⁰

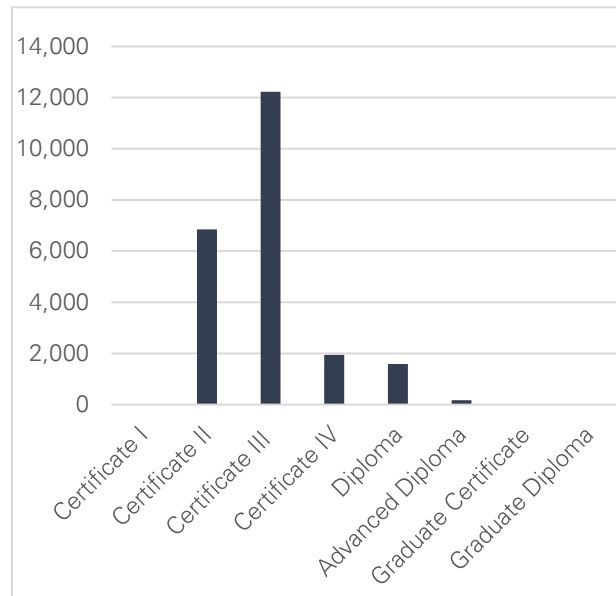
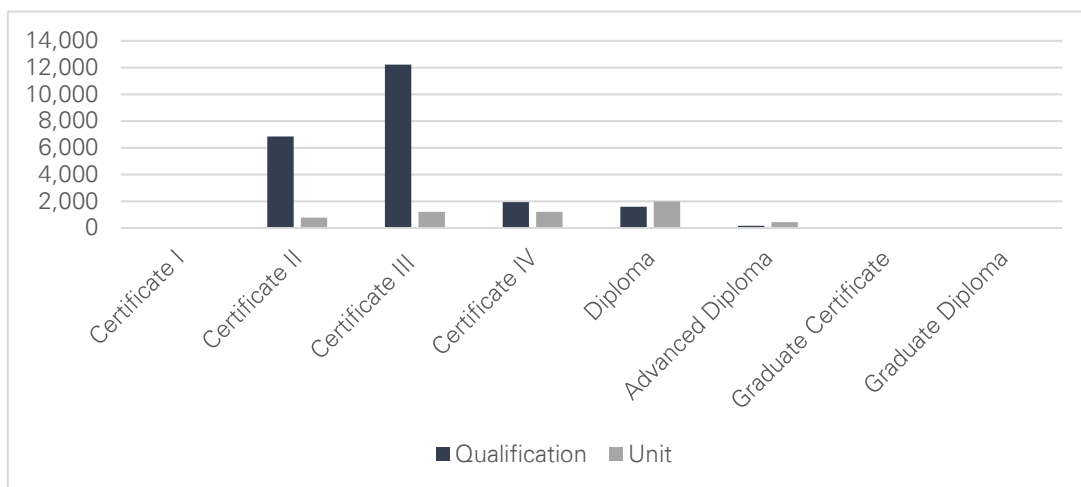


Figure 8: Relevant qualification and digital capabilities unit enrolments¹⁴¹



¹³⁹ Training.gov.au

¹⁴⁰ NCVET VOCSTATS, TVA program enrolments

¹⁴¹ NCVET VOCSTATS, a) TVA program enrolments; b) TVA subject enrolments

Figure 9: Digital capabilities mapped across unit AQF level¹⁴²

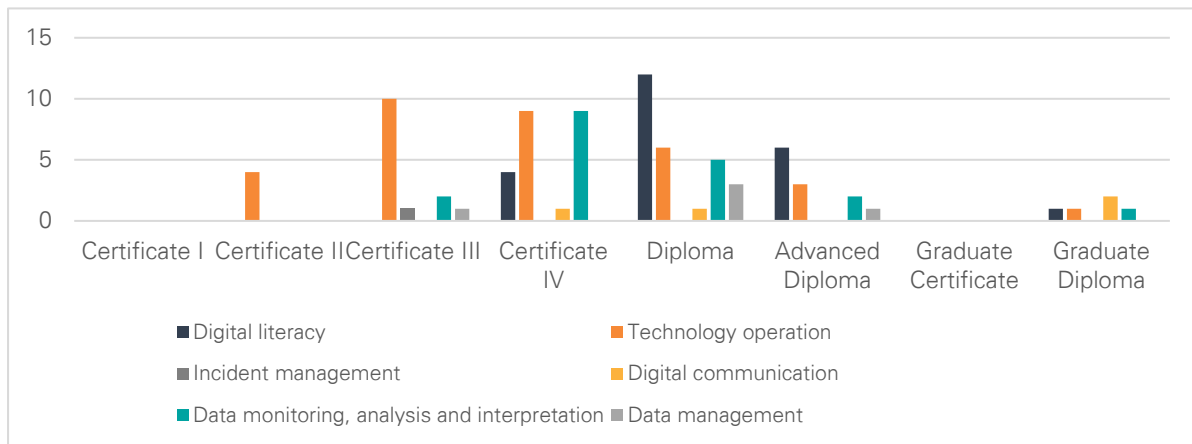
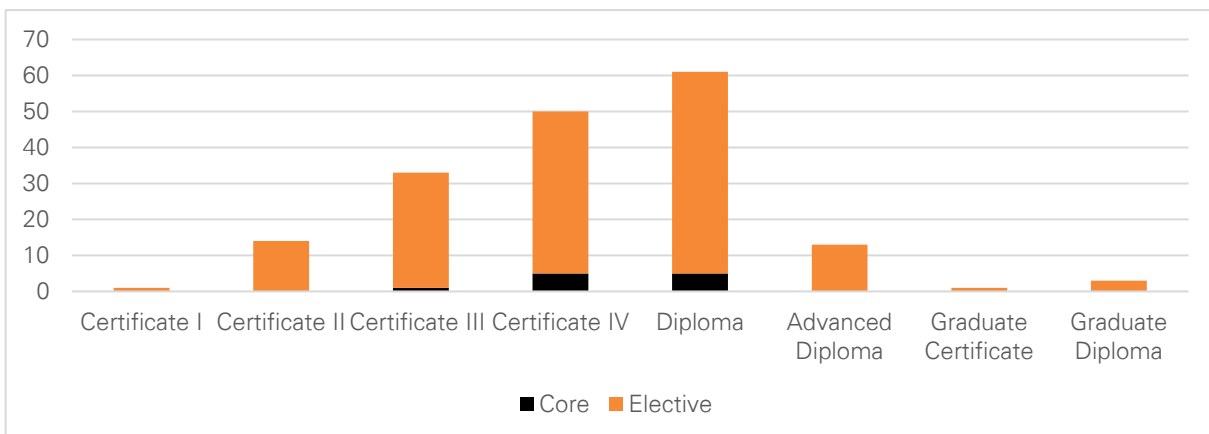


Figure 10: Distribution of digital capabilities units as core/elective across qualification levels¹⁴³

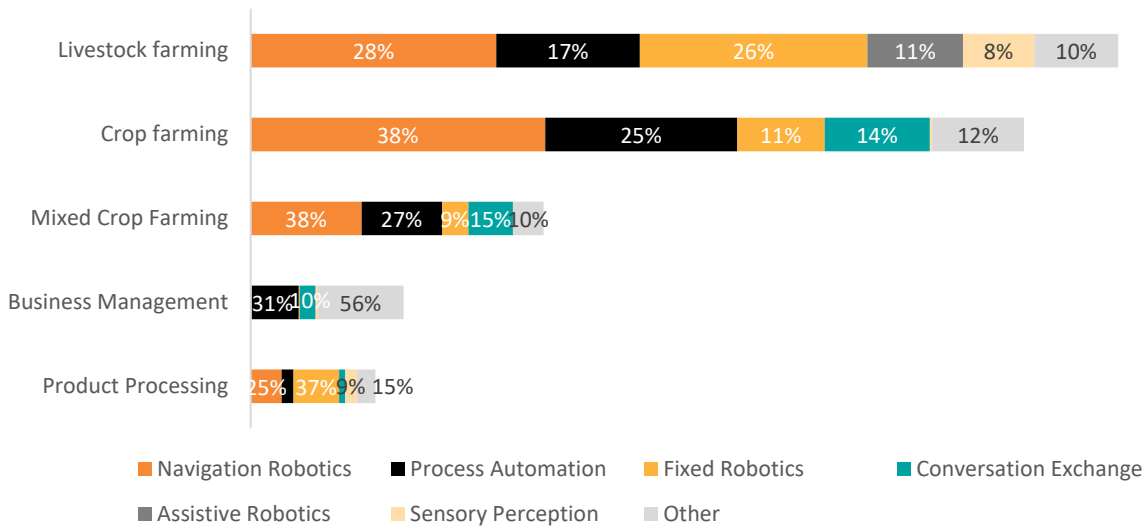


This demonstrates that specific agriculture digital capabilities are not embedded within qualifications, and that many learners can be deemed competent for a job outcome having developed only generic digital capabilities. It also shows that an already-stretched industry, which plays a key role in reviewing and developing skills standards for training packages, is unable to instil digital capabilities as a top priority for the national vocational training agenda, conceivably due to on-going struggles to attract new workers with basic work skills, let alone workers with mid-level or advanced digital skills.

142 NCVER VOCSTATS and Skills Impact analysis
 143 Training.gov.au

Appendix H: Technology impact on the agricultural workforce

Figure 11: Technology impact over the next 10 years as a percentage of total impact by top five Agricultural Categories according to amount of impacted FTE



Source: Faethm analysis

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 Training.gov.au
 United Nations
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 University of New England

Notes

KPMG

KPMG are leaders in the Australian IoT and AgriFood Tech markets, with specialists who understand the latest technologies and have the capability to determine how these can be used to create competitive advantage in the agri-food sector. KPMG is actively involved in AgriFood Tech and IoT through formal partnering, investing and advising organisations from start-ups through to multi-national agri-corporate and research institutions. Its dedicated IoT, AgriFood Tech and Agribusiness teams have a deep and practical understanding of the local and global marketplace and the key trends which are driving the industry.

Skills Impact

Skills Impact is a not-for-profit organisation that works across Australia to benchmark learning and skills standards for industry.

As part of their Skills Service Organisation role, they work with 12 Industry Reference Committees (IRCs) to review and update their respective national training packages. IRCs are comprised of industry leaders from across big business, small business, peak bodies and unions, who understand the skills needs of their sector, industry or occupation. The committees they support are in:

- Animal Care and Management
- Agriculture, Horticulture and Conservation and Land Management
- Australian Meat Processing
- Food, Beverage and Pharmaceutical
- Forest and Wood Products
- Pulp and Paper Manufacturing
- Racing and Breeding
- Seafood.

The majority of the work carried out for this project has been done by members of Skills Impact's industry engagement team whose role is to consult and collaborate with industry, government and training providers to gather intelligence and identify and investigate current trends relating to skills gaps, emerging markets and changing work methods. These findings are documented annually in IRC endorsed Skills Forecast documents, with intelligence backed by extensive research and data. Skills Impact is also leading a cross-sectoral project on environmental sustainability as it relates to all training packages and industries.

Faethm

Faethm is a globally unique SaaS Analytics Platform that enables companies and governments to understand the impact of emerging technologies (AI and Robotics) on the future of work. Faethm distributes both directly to Government, Education, Investor and Enterprise clients globally as well as via its partner ecosystem consisting of some of the world's largest consulting, HR benefits, recruitment and technology firms. Faethm currently has 64 customers in 14 countries across 18 industries.

Faethm's AI SaaS platform shows the future impact of emerging technology on any economy, industry, company or job. Enterprise, government and investment leaders use Faethm daily to plan and deliver technology and workforce transformation. Faethm's unique Job Corridor capability enables our clients to identify:

- most impacted workers by automating technology;
- employees best positioned to take advantage of augmentation capabilities to increase;
- capacity and allow them to work on more value-added tasks;
- new jobs and skills required in the future; and
- roles both inside and outside the organisation to transition at-risk through re-skilling pathways. Enabling companies to move from a 'fire and hire' strategy to a 'retrain and redeploy' strategy with significant benefits for individuals, organisations and society.

The University of Queensland

The University of Queensland (UQ) is one of Australia's leading research and teaching institutions, striving for excellence through the creation, preservation, transfer and application of knowledge. UQ has a strong focus on teaching excellence, having won more Australian Awards for University Teaching (AAUT) than any other in the country and attracting the majority of Queensland's highest academic achievers, as well as top interstate and overseas students. UQ is one of only three Australian members of the global Universitas 21, a founding member of the Group of Eight (Go8) universities, and a member of Universities Australia. The university executes a strong focus on research through its eight esteemed research institutes, including Queensland Alliance for Agriculture and Food Innovation and the Global Change Institute. For more than a century the University has educated and worked with outstanding people to deliver knowledge leadership for a better world.

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