THE FUTURE OF AUSTRALIA'S

AGRICULTURAL WORKFORCE

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Australia's Innovation Catalyst

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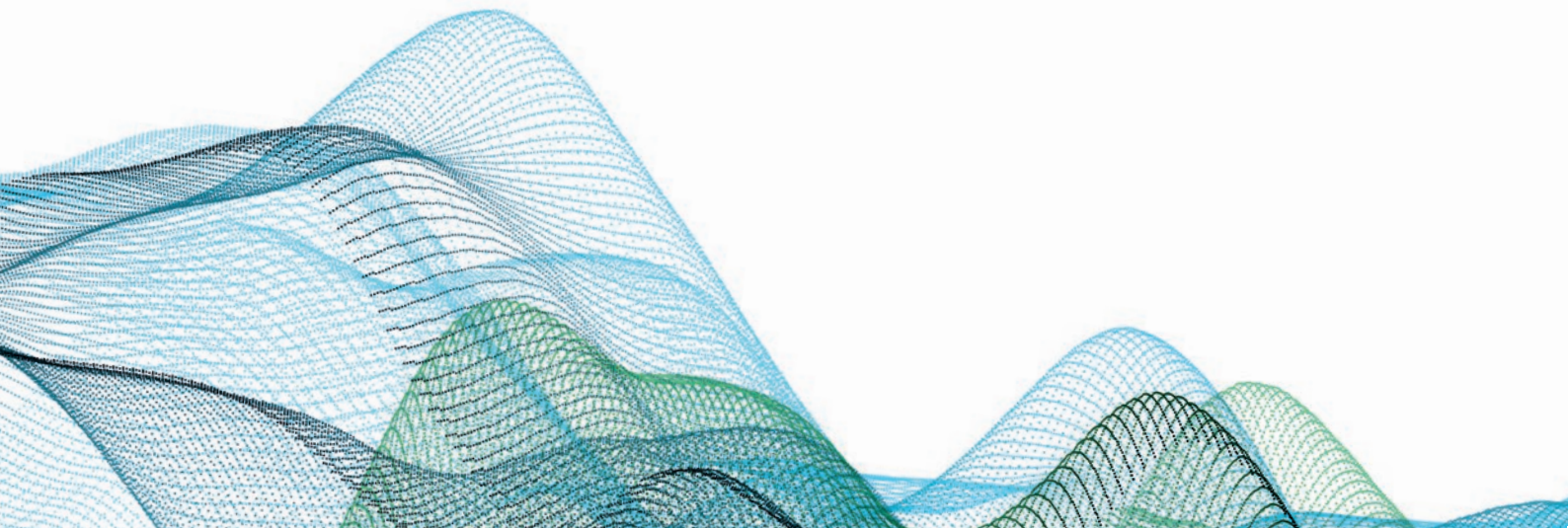

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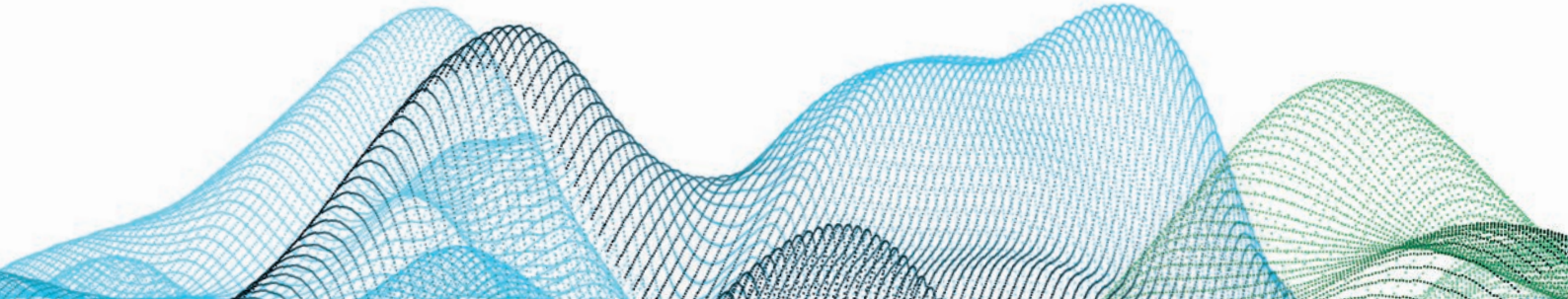


EXECUTIVE **SUMMARY**

The Australian agricultural sector plays a crucial role in the national economy. The sector directly employs around 228,000 on-farm domestic workers and contributes nearly $60 billion to the nation's economy.[1–3] In addition, over 1.5 million Australians are employed in diverse industries servicing and providing support to the agricultural sector across the country, including manufacturers, drivers, retailers, teachers, research scientists, veterinarians, technology developers, biosecurity officers and engineers.[2,4–6] The potential for the sector to grow into a $100 billion industry over the next decade will depend on its ability to work collaboratively, grow sustainably, understand the needs of future customers, unlock the value of new technologies across the entire supply chain, and attract people and capital.[7,8]

Accelerating global population growth is presenting new opportunities for Australian agriculture to expand and feed an increasingly hungry world.[9] However, the rising cost of human labour, urbanisation, changes to consumer preferences and behaviours and growing environmental impacts on agricultural land across Australia are putting more pressure on the sector to meet the growing global demand for food. According to the United Nations Food and Agriculture Organization, the world must increase agricultural output by 70% by the year 2050 to sufficiently feed the growing and more urbanised global population.[10] Although new agricultural technologies are changing the face of modern Australian agriculture and could potentially help address challenges relating to productivity increases over the next decade, uncertainties remain around the future skills needed to efficiently integrate these technologies to on-farm operations and workforce demands.

This report opens with the outcomes of a horizon scan of interconnected social, economic, geopolitical, technological and environmental trends driving workforce change and labour use across the agricultural sector and related services, and further summarises specific trends unique to the horticulture, livestock, grain and dairy industries. For example, the horticulture industry heavily relies on seasonal low-skilled labour, while the grain industry has seen high uptake of automated precision agriculture technologies that are likely to demand a highly tech-skilled workforce in the near future. The dairy industry has seen an increase in domestic demand for milk products, which is likely to change staffing needs in the future.[206] In contrast, the livestock industry is experiencing rising export demand. Growth in the international markets over the next decade is likely to demand skill sets that can efficiently manage an increasing size of herds across the Australian landscape. These unique industry-specific conditions and patterns of change are likely to impact the workforce requirements of each industry differently.

Building on the analysed trends, the second part of the report presents plausible future scenarios in 2030 that describe the supply and demand of the future agricultural workforce and labour use. In this report, we define agricultural workforce as people working directly in the agricultural sector, as well as those working across other sectors providing services to agriculture, including manufactures, drivers, retailers, teachers, researchers, technology developers, biosecurity officers and engineers. The scenario planning process involves developing axes that represent separate continuums of broad uncertainties derived from the current and emerging workforce-related trends and have the highest impact on workforce and labour change across the agricultural sector and related services over the next decade. Our analysis of the trends highlighted several areas of uncertainty. In particular, we found the following two areas as critical:

1. The level of regional development
2. The extent of technology advancement and uptake across the agricultural sector

Representing the two critical areas of uncertainty as separate axes, and crossing them, creates a four-quadrant conceptual scenario model (Figure 1). The conceptual scenario model represents a simplified characterisation of a much more complex reality. Scenarios are derived from the extreme endpoints of each axis. Each scenario tells a story of how these uncertainties might interact and shape the agricultural workforce in 2030.

For the regional development axis, urbanisation could continue and lack of population growth in regional Australia may restrict the developments to infrastructure that are needed to grow the agricultural workforce in regional areas. However, the increasing cost of housing and growing congestion in the large cities of Australia, along with changing business and employment models that are supporting an increasingly mobile workforce, could see regional towns and centres transformed over the next decade. For the technology advancement and uptake axis, integrating new technologies across the sector could potentially present many benefits in the future, uncertainty remains around the extent of technology advancement and adoption across the different agricultural industries and the sector. The development in remote sensors, robotics and automation has the potential to replace low-skilled human labour and increase demand for a workforce with a range of technology-related skills. However, many farms across Australia still do not have access to reliable internet.[13,99] In addition, high upfront costs of new technologies and difficulties around integrating new technologies into on-farm practices impose challenges for large-scale adoption of technologies across the sector over the next decade.

Using the key uncertainties identified from the trends analysis, this report describes four plausible futures for the Australian agricultural workforce and highlights the key factors driving changes in the demand and supply of agricultural labour over the next decade. With these insights, Australian agricultural stakeholders and communities will be able to better understand, anticipate and respond to future changes impacting the agricultural workforce.

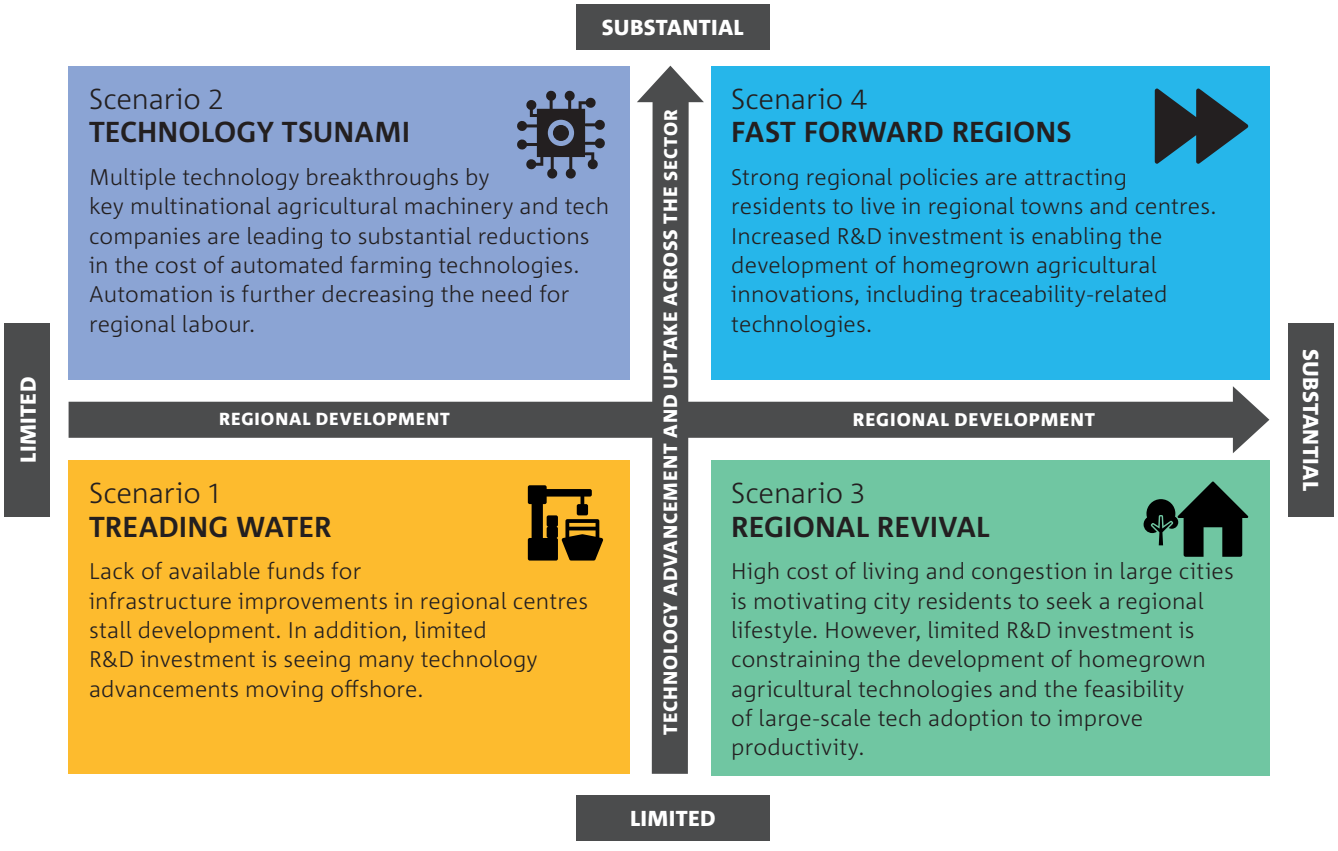
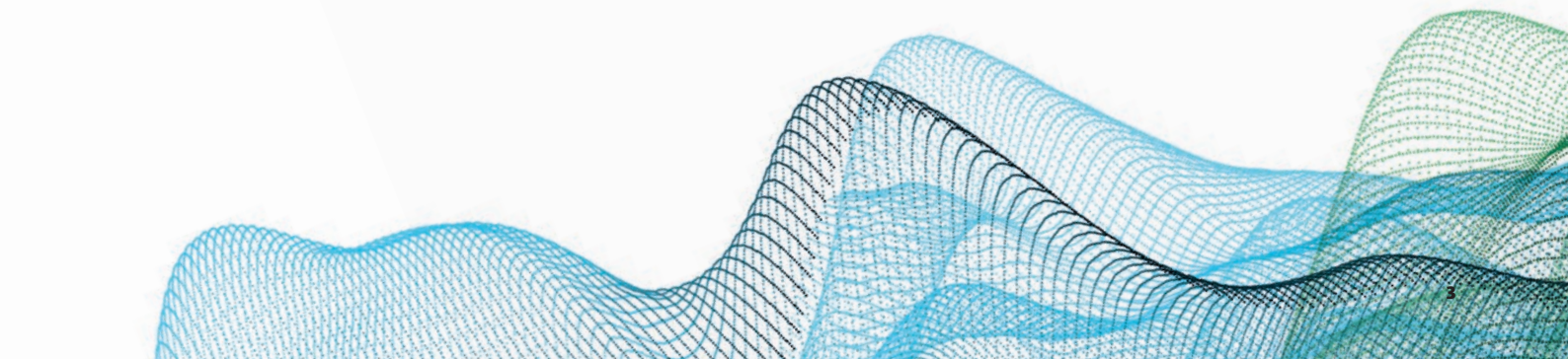


Figure 1. Four plausible future scenarios describing the Australian agricultural workforce in 2030.

Future opportunities

Developing scenarios that discuss the supply and demand of the future agricultural workforce in 2030 highlights the possibility of several challenges and opportunities over the next decade for the Australian and state governments, agricultural stakeholders and communities.

- Placing a greater emphasis on equipping students with relevant skills, as well as promoting agricultural knowledge and career opportunities at every stage of education within both regional and urban schools, could help increase awareness among young people of the career opportunities in agriculture.
- Adapting education curricula and catering to the emerging skills requirements driven by technologies could further unlock the true value of precision agriculture, robotic technologies and innovative farming techniques that are changing the way food and fibre is grown and produced in Australia.
- Agricultural jobs and occupations have changed, but the standard industry and occupation classifications do not reflect these changes. Updating the methods and classifications used to collect data on the agricultural workforce, and collecting these data consistently and frequently would help provide a more accurate picture of its current status, trends, challenges and opportunities.
- Establishing open data initiatives that enable well-coordinated big data on all agricultural inputs to be freely shared between farm operators and stakeholders has the potential to improve overall agricultural productivity over the next decade. However, there is a need to develop an agricultural research workforce with sufficient technological knowledge and skills to understand, adapt and efficiently apply big data approaches in agriculture.
- Introducing the need for labour providers to be accredited and consistent monitoring of third-parties that help secure seasonal labour for farms would help reduce the likelihood of worker exploitation.
- Funding trials to test new technologies and address issues that arise with early adoption could accelerate uptake of technology across Australian farms.
- Creating opportunities for Australia's private sector to invest in new and emerging agricultural innovations could improve the responsiveness and usefulness of agricultural technologies on Australian farms.
- Continued public and private investments on agricultural mitigation options addressing societal concerns over climate change could offer Australian agriculture an avenue for competitive advantage.
- Making regional cities and towns more attractive places to live and locate businesses via investment in key infrastructure (including digital infrastructure to address connectivity issues), as well as improving access to education and health services within regional areas, would help agricultural firms attract and retain more skilled labour.



INTRODUCTION

Agriculture is the backbone of Australia's economy. The direct labour employed across the Australian agricultural sector represents around 3% of the Australian workforce and its activities contributed $59 billion to the nation's economy in 2018.[1-3] In addition, over 1.5 million Australians are employed in diverse industries servicing the sector across the country, including manufacturers, drivers, retailers, teachers, research scientists, veterinarians, technology developers, agronomists, biosecurity officers and engineers.[2,4-6] Over the next decade, the potential for the sector to grow into a $100 billion industry will depend on its ability to work collaboratively, grow sustainably, understand the needs of future customers, unlock the value of new technologies across the entire supply chain, and attract people and capital.[7,8]

A growing world population is rapidly increasing the global demand for food. According to the United Nations Food and Agriculture Organization (FAO), the world must increase agricultural output by 70% by the year 2050 to meet this demand.[10] In particular, accelerating population growth and urbanisation across Asia are presenting new opportunities for Australia to establish new export markets for its diverse range of agricultural produce.[9,11] However, the increasing cost of human labour, urbanisation, changing consumer preferences and behaviours and growing environmental impacts on agricultural land across Australia are putting more pressure on the sector to address these challenges while meeting the growing global demand for food. Addressing these challenges will likely demand an agricultural workforce with diverse and changing skill sets over the next decade.

New agricultural technologies have the potential to help address the challenges of increasing production over the next decade and are already changing the face of modern Australian agriculture. Integrating agricultural technologies into on-farm operations could replace much of the repetitive manual labour that farm operators rely on today and demand a workforce with a range of technology-related skills in developing, optimising, monitoring, maintaining and repairing these technologies. The sector's ability to harness new technologies and improve productivity over the next decade will therefore highly depend on its ability to efficiently develop, transition and expand its workforce to meet the changing skills demands. However, there are still uncertainties around cost, the ease of integration and return on investment from these technologies. Thus, there is a need for further research to gain a better understanding on these issues.

To better understand future changes and the risks and opportunities that these changes will entail, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) conducted a strategic foresight study and prepared a report for the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) describing the influencing factors driving change in the agricultural workforce and labour use over the next decade. The first part of this report outlines the current and emerging workforce-related trends across the agricultural sector and summarises specific trends relating to the horticulture, livestock, grain and dairy industries. A 'trend' refers to a pattern of change in the Australian agricultural workforce that may influence future labour use and skill demands. Trends can be social, economic, geographical, technological, environmental or political. The industry-specific trends highlight the unique conditions and factors that are impacting the four industries and their future workforces. For example, the horticulture industry heavily relies on imported low-skilled labour, while the grain industry has seen high uptake of automated precision agriculture technologies that are likely to demand a highly skilled workforce in the near future. The dairy industry has seen an increase in domestic demand for milk products, which is likely to change staffing needs over the next decade. In contrast, the livestock industry is seeing rising export demand and increasing exposure to international markets. This will likely increase the demand for skill sets that can efficiently manage increasing herd sizes across Australian farms over the next decade. In addition, the varied application of agricultural technologies between industries is likely to demand different skill sets. For example, GPS-enabled technologies are widely used on horticulture and grain farms, while electronic identification and herd management tools are commonly used on dairy and livestock farms.[12,13] In the future, these unique industry-specific conditions and patterns of change are likely to have different impacts on the workforce requirements of each industry.

Building on the current and emerging trends outlined in the first part of the report, the second part describes the future of Australian agricultural workforce across the whole sector. Using the key uncertainties identified from the clusters of interconnected trends driving workforce change, the report outlines four plausible scenario narratives describing the Australian agricultural workforce in 2030. The scenarios outlined in this report are not intended to predict the future, but rather to identify and describe a range of plausible future workforce conditions across the whole sector. With these insights, Australian agricultural stakeholders and communities will be able to better understand, anticipate and respond to future changes impacting the agricultural workforce.

CURRENT PROFILE OF **AUSTRALIA'S AGRICULTURAL WORKFORCE**

GENERAL

According to the 2016 census, the Australian domestic agricultural workforce represents around 3% of the overall Australian workforce, and consists of around

228,000
ON-FARM DOMESTIC WORKERS

including owner-managers, unpaid family members, high- and low-skilled employees.[1] Around 40% of the agriculture workforce is employed part-time.[2]

Although the unemployment rate in both regional and capital cities was around 7% in 2016, the economic dynamics across regions can be very different.[16] In 2018, six regions with

THE HIGHEST UNEMPLOYMENT RATES WERE IN REGIONAL AREAS.[16,17]

There is a

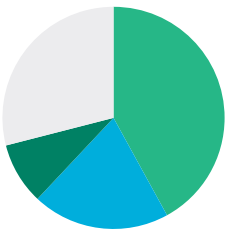
SKILLS GAP

between regional and urban job markets. Growth in demand for high-skilled workers has largely occurred in capital cities, while regional areas are generally experiencing growing demand for low-skilled workers.[18]

Between 2006 and 2016, the number of self-reported

AGRICULTURAL WORKERS FELL BY OVER 7%.[1,14]

GRAIN AND LIVESTOCK INDUSTRIES ARE THE BIGGEST AGRICULTURAL EMPLOYERS OF DOMESTIC LABOUR[15]



In 2018, nine out of the top ten districts showing the greatest growth in job advertisements were in regional locations.[20] As of March 2019, over

46,000
JOBS

were advertised outside of mainland capital cities.[19]

Job vacancies in regional areas grew by

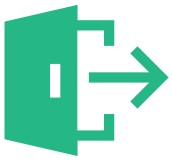
14%

between 2018 and 2019, compared to around 8% in capital cities.[19]

FARMER AND FARM WORKERS ARE BY FAR THE MOST COMMON OCCUPATIONAL CATEGORY IN AGRICULTURE

with livestock farmers accounting for 25% of agricultural occupations, followed by crop farmers (16%) and mixed-crop and livestock farmers (10%).[1]

Plant operators, packers and truck drivers are some of the most common off-farm agricultural occupations across the sector.[1]



Between 2011 and 2016, approximately 59% of low-skilled and

45% HIGH-SKILLED AGRICULTURAL EMPLOYEES LEFT THE SECTOR.[1]

EDUCATION

TASMANIA AND NEW SOUTH WALES HAVE INTRODUCED COMPULSORY AGRICULTURAL EDUCATION TO PARTS OF THEIR SCHOOL CURRICULUM.[24,25]

Schools in other states and territories have access to agricultural science units through the Australian curriculum. However, the implementation of agricultural science units to the school curriculum is not mandatory.[26]

Agricultural science graduates were offered

A MEDIAN SALARY OF AROUND $58,300 IN 2018

—similar to those graduating from business management, and architecture and building.[27]

ONLY 15

out of 43 Australian universities offer degrees in agriculture.[6] However, there are over 150 organisations across Australia that provide vocational training in agriculture.[28]

PERCENTAGE OF WORKFORCE **BY EDUCATIONAL ATTAINMENT**

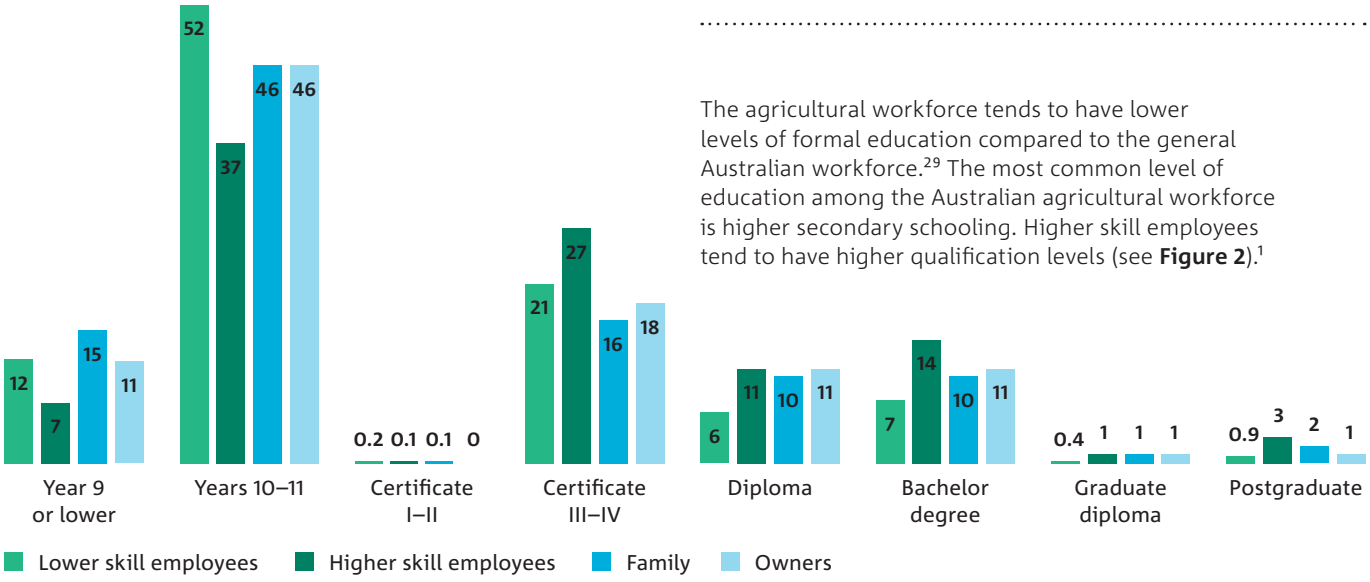


Figure 2. Percentage of the Australian agricultural workforce by different levels of educational attainment in 2016.[1]

The agricultural workforce tends to have lower levels of formal education compared to the general Australian workforce.[29] The most common level of education among the Australian agricultural workforce is higher secondary schooling. Higher skill employees tend to have higher qualification levels (see **Figure 2**).[1]

THE AGRICULTURAL WORKFORCE IS BECOMING INCREASINGLY EDUCATED.

Between 2001 and 2016, there was a 9% increase in the share of the agricultural workers with post-secondary educational qualifications.[1] This was the sixth-highest increase across all industries in Australia.[1]

Among agricultural workers who hold a post-secondary qualification, the most popular fields include

AGRICULTURAL AND ENVIRONMENTAL SCIENCE, ENGINEERING AND COMMERCE.[1]

DEMOGRAPHICS

GENDER

GENDER BALANCE ACROSS THE AGRICULTURAL SECTOR IS SKEWED TOWARDS MALES

(see **Figure 3**).[1] Between 2009 and 2019, the male full-time agricultural workforce saw an approximate 5% decline, while the male part-time workforce increased by around 36%.[21]

Women represent around

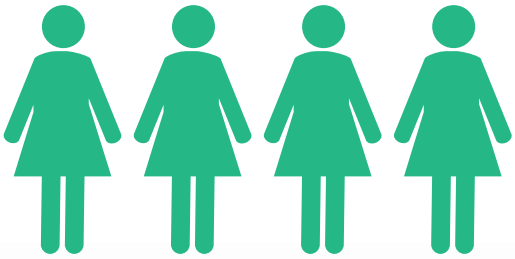
31%

of the agricultural workforce and have the lowest rate of employment in higher skill positions (see **Figure 3**).[1]

Employment in agriculture is slowly shifting to include a greater share of women. Between 2011 and 2016, the share of female lower skill employees increased from 32% to 35%, while

THE SHARE OF FEMALE HIGHER SKILL EMPLOYEES INCREASED FROM 19% TO ALMOST 21%.

The share of female owner-managers and unpaid family labourers declined over the same period.[1]



MALE AND FEMALE
WORKERS IN THE INDUSTRY

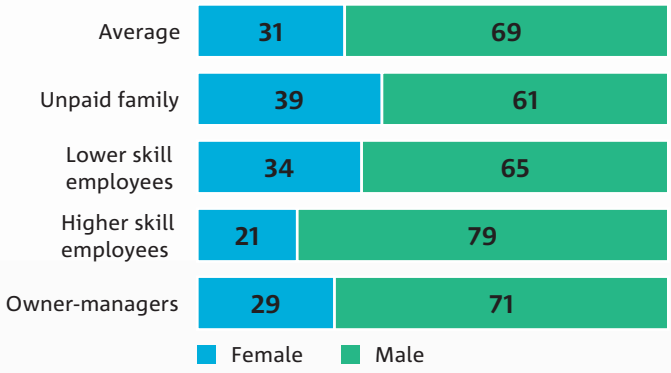


Figure 3. Percentage of male and female workers in the agricultural workforce in 2016.[1]

Note: Higher skill employees include managers, professionals and trades. Lower skill employees include labourers and drivers.

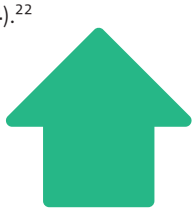
AGE

THE DAIRY AND SUPPORT SERVICES INDUSTRIES HAVE THE YOUNGEST WORKFORCES

across the sector (see **Figure 4**).[22] In 2016, the average age of the support services workforce was 43 years and the average age of the dairy workforce was 45 years.[1]
The livestock industry workforce was among the oldest, with an average age of 49 years.[1]

THE AVERAGE AGE OF THOSE WORKING IN THE LIVESTOCK, HORTICULTURE, DAIRY, GRAIN AND AGRICULTURE SERVICES INDUSTRIES HAS INCREASED

over the past 15 years (see **Figure 4**).[22] Factors such as lengthening education spans, later retirement, increased capital requirements, later partnering and household formation could have driven the increase in age over this period.[23]



MEDIAN AGE
BY SECTOR

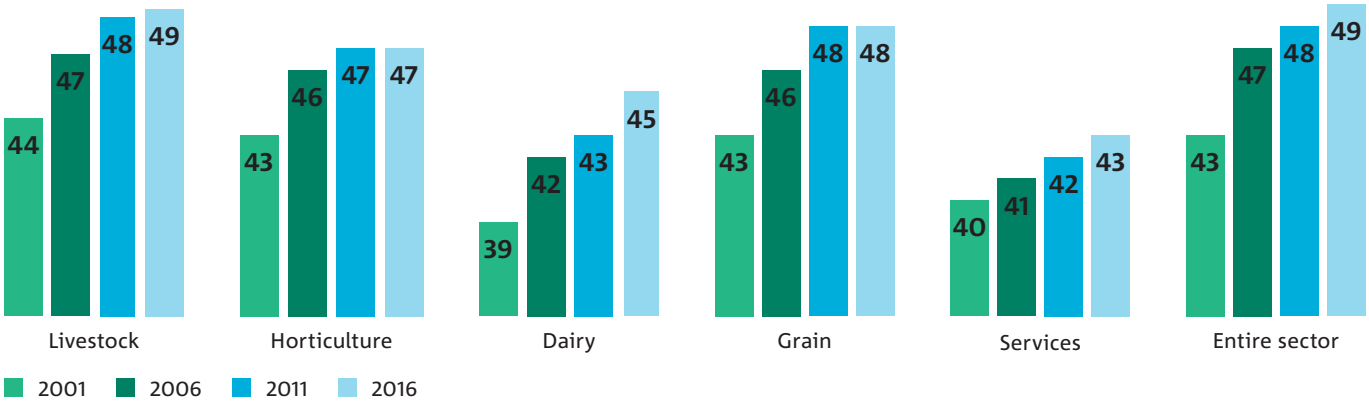


Figure 4. Median age of the agricultural workforce in Australia.[22]

Note: Services in this table includes cotton ginning, shearing, other agriculture and fishing industry support services, as per ABS data.

Regardless of skill level, on average across all agricultural industries,

FAMILY MEMBERS AND OWNERS OF FARMS ARE OLDER THAN EMPLOYEES

(see **Figure 4**).[22]

Over the past 15 years, the average age of unpaid family members working on farms across the dairy, horticultural, grain and livestock industries increased from

47 TO 61 YEARS

(see **Figure 5**).[22]

MEDIAN AGE
BY POSITION

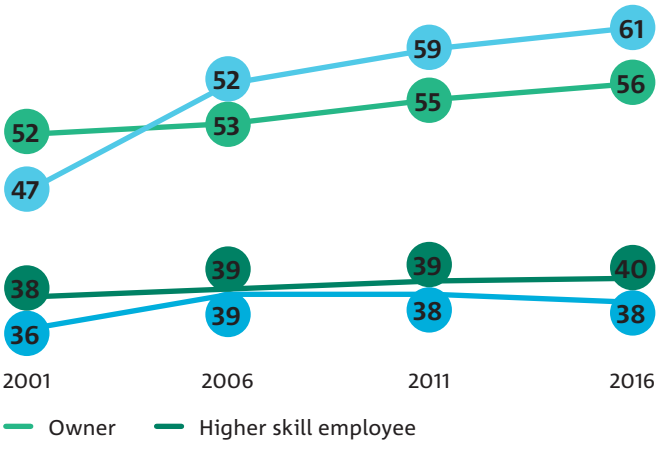


Figure 5. Median age (years) of the Australian agricultural workforce across the livestock, horticulture, dairy, grain and services industries by type of position between 2001 and 2016.[22]

SEASONAL AND BACKPACKER VISAS

SEASONAL AND BACKPACKER LABOUR HAS BEEN A PRIMARY SOURCE OF LABOUR FOR MANY AGRICULTURAL INDUSTRIES

due to highly intense seasonal labour requirements and difficulties in finding available domestic labour.[30]

THERE IS A SHIFT TOWARDS EMPLOYING NON-AUSTRALIAN CITIZENS IN AGRICULTURE

for low-skilled work.[1]

There are other skilled and regional work visas that support the agricultural workforce in a much smaller capacity than the

SEASONAL AND WORKING HOLIDAY VISA PROGRAMS.[31]

THE THREE KEY VISAS SUPPLYING SEASONAL AGRICULTURE WORKERS IN AUSTRALIA[32–38]

	WORKING HOLIDAY VISA 417	WORK AND HOLIDAY VISA 462	SEASONAL WORKER VISA 403
Number of visa holders in Australia (2018)	**118,524**	**16,385**	**8,457**
Eligible countries	Belgium, Canada, Republic of Cyprus, Denmark, Estonia, Finland, France, Germany, Hong Kong, Republic of Ireland, Italy, Japan, Republic of Korea, Malta, the Netherlands, Norway, Sweden, Taiwan, The United Kingdom of Great Britain and Northern Ireland	Argentina, Austria, Chile, the People's Republic of China, Czech Republic, Hungary, Indonesia, Israel, Luxembourg, Malaysia, Peru, Poland, Portugal, San Marino, Singapore, Slovak Republic, Slovenia, Spain, Thailand, Turkey, Uruguay, United States, Vietnam	Fiji, Kiribati, Nauru, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, Vanuatu

METHODOLOGY

The strategic foresight process

The strategic foresight process is a structured analysis of future trends, scenarios, opportunities and risks designed to inform present-day strategic decision-making. In broad terms, 'foresight' involves identifying and describing plausible futures, and 'strategy' involves identifying, choosing and implementing actions for achieving desired outcomes. CSIRO has developed a generic strategic foresight process for identifying evidence-based and relevant trends impacting an industry, region, organisation or society over time (see **Figure 6**). The strategic foresight process has been applied in this report to first identify the current and emerging trends impacting the Australian workforce across the horticulture, livestock, grain, dairy and support services industries, and then develop potential plausible future scenarios reflecting the future supply and demand of agricultural labour out to 2030.

Interview and workshop outcomes

As part of the broad horizon scan, 30 stakeholder interviews were conducted to gather and validate the trends outlined in this report. The 30-minute interviews used the convergent interviewing technique.[39,40] To validate the plausibility of each of the four scenarios outlined in this report, a three-hour stakeholder workshop was conducted with 25 participants. The stakeholders who participated in the interviews and workshops were representatives from government and agricultural industries. The CSIRO Social Science Human Research Ethics Committee approved these research protocols.

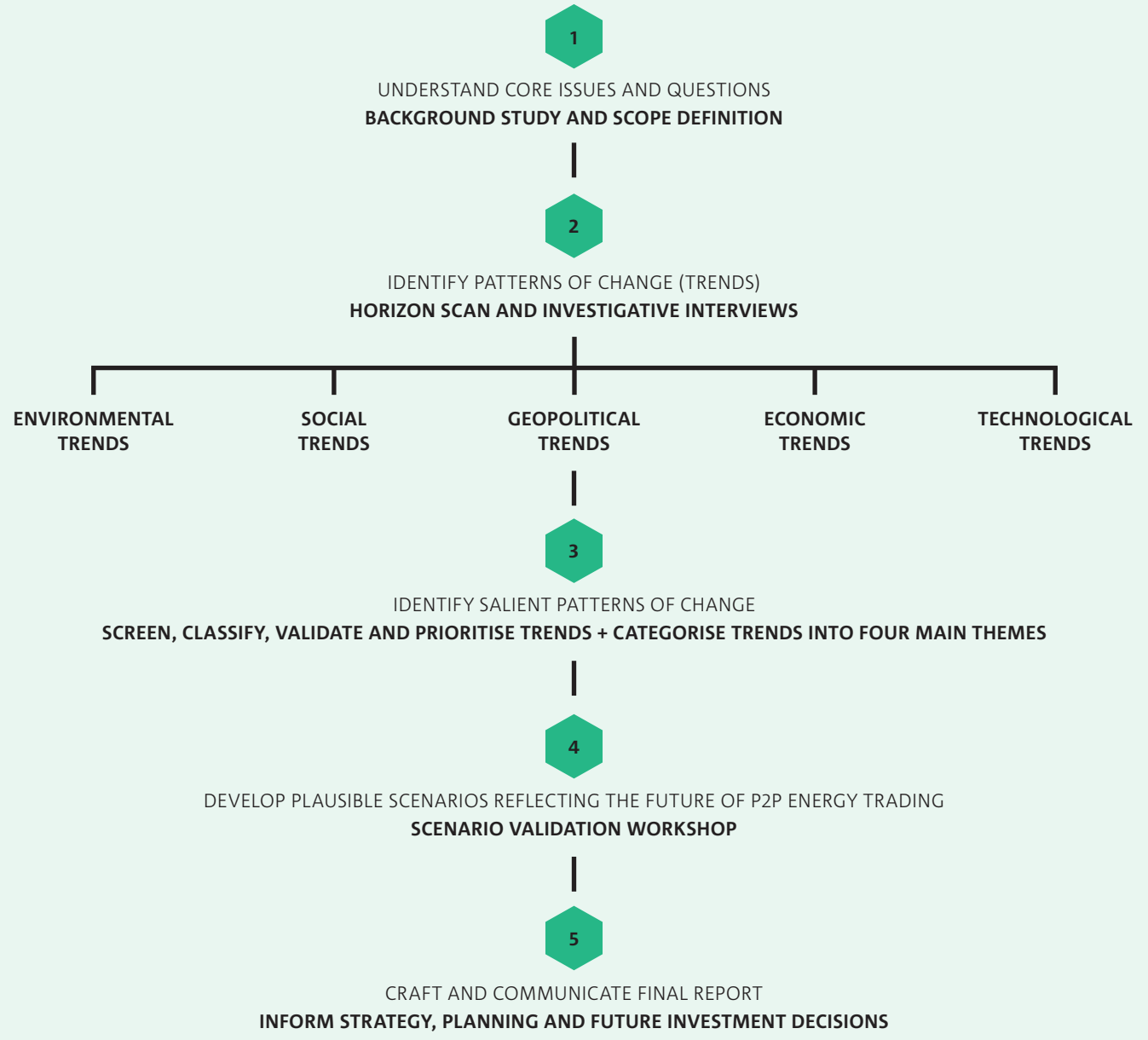


Figure 6. The generic strategic foresight process developed by CSIRO.

THE CHANGING **AGRICULTURAL SECTOR**

The Australian agricultural sector is made up of around 85,000 businesses across a number of diverse industries, each with their own labour needs.[41] The vast grain farms across Western Australia that collectively cover millions of hectares of farmland have markedly different workforce needs compared with the cattle stations and fruit orchards on the east coast.[42] Changes in the agricultural sector—including the aggregation of small farms into larger operations, commodity diversification, and advancements in automation and technology—are already demanding a different set of skills from the existing agricultural workforce. Even though in some instances mechanisation and automation have the potential to substitute for human labour on farms, new technologies are also likely to generate demand for new skills and positions. In addition, the agricultural workforce of the future will likely possess generalist skills from a wide range of disciplines, including human resources, information technology, data science, management, marketing and trade.[7,43] Changing demands across the agricultural workforce could potentially attract a new generation of graduates with a diverse set of technical skills, as well as soft skills such as the ability to collaborate and solve problems.[44,45] The future viability of the sector will depend highly on its ability to embrace innovation, technology and change, as well as to promote agriculture as an attractive career for young people.

Social and demographic impacts

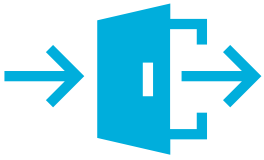
The next generation of farmers is shrinking. Agriculture in Australia has long been based on the foundation of farming families who supply most of the farm labour. However, the number of farming families decreased by 22% between 1986 and 2001, and then by a further 9% between 2001 and 2006.[46,47] In 2016, there were around 87,325 farming families in Australia.[29] The reduction in the number of Australian farming families has been largely due to the migration of youth (many of whom represent the next generation of farming families) from regional areas to major cities, in order to pursue employment and education prospects.[48] This migration pattern, along with the aggregation of farms, has reduced the size of the overall workforce across many regional areas of Australia.[49] Over the past 40 years, broadacre farms have seen an approximate 2.1% reduction in labour use per year on average, while dairy farms saw a slightly higher reduction of around 2.4% per year on average over the same period.[50] Agricultural employment dropped by approximately 20% over the past decade, and is expected to decline further over the next five years.[51] In addition, the number of people enrolled in agricultural education and training programs decreased from around 60,000 enrolments and 15,000 completions in 2014, to around 50,000 enrolments and 12,000 completions in 2017.[51] The regional workforce is impacted by outward youth migration as it reduces the number of people locally available to fill job vacancies.

The agricultural workforce is aging. The average age of Australian farmers is 57 years, and their average years of farming experience is around 37.[41] By comparison, the average age of an Australian worker is 40 years, and the average age of a manager is 46 years.[52] The aging demographic of Australian farmers is concerning, particularly in terms of their ability to innovate and adopt new technologies to improve productivity.[53] However, further analysis of subgroups of the agricultural workforce indicates that aging is not occurring homogenously across the sector. The average age of Australian farm owners seems to correlate with the size of their farm. The oldest group of farmers are among those with smaller farms producing around 6% of total agricultural output, while owner-managers of larger farms, which account for most of the annual national agricultural output, are around five years younger than the average.[53]

THE FIVE KEY REASONS WHY **THE AUSTRALIAN AGRICULTURAL WORKFORCE IS AGING**[23]

As part of intergenerational transfers,

ENTRIES INTO THE AGRICULTURE SECTOR ARE OFTEN TIED TO EXITS.



In addition, aggregation of smaller farms into larger operations reduces the number of opportunities for younger entrants to enter the workforce.

Decreasing profit among smaller farms means that only one generation can be supported at a time. As a result,

INTERGENERATIONAL TRANSFER OF FARMS IS OCCURRING AT A MUCH LATER POINT OF RETIREMENT

rather than having multigenerational families working on the farm together.

Small farms are more attractive to older buyers. Small farms with more capital invested into the residence(s) of the farm rather than the land itself do not tend to attract buyers who are seeking to amalgamate farms. However,

THE HIGH STANDARD OF HOUSING ON SMALL FARMS IS ATTRACTING RETIREES WHO ARE LOOKING FOR LIFESTYLE CHANGES.

YOUNG PEOPLE ARE SPENDING MORE TIME IN EDUCATION,

which is delaying their entry into the farming workforce.

The decline in the number of young women working in agriculture is more rapid than the decline for young men.

THE NUMBER OF 20-YEAR-OLD WOMEN ENTERING AGRICULTURE WAS FOUR TIMES HIGHER IN 1976

compared with those entering in 2006.

Educational challenges in agriculture. There is a sector-wide outcry for quality agriculture graduates with certificates and degrees from reputable universities and colleges.[54] A commonly reported statistic is that for every graduate there are four job vacancies in agriculture.[6] Indeed, the number of agriculture graduates dropped substantially between the 2011 and 2016 census years.[55] However, there is also the issue of high workforce turnover of high-skilled agricultural employees. Over a four-year period, around 40% of those employed as skilled agricultural workers left the sector.[22] Between 2011 and 2016, the number of filled high-skilled agricultural positions increased by around 4,600. However, the number of workers exiting the sector was around 9,600.[1,15,22] This leaves a substantial deficit of approximately 5,000 positions that need to be filled by new entrants to the sector. Over the next decade, the sector's ability to retain its skilled workforce will be crucial for addressing its future workforce demands.

Increasing urbanisation is reducing the size of rural and regional populations. Australia is becoming increasingly urbanised as a growing number of people move to major cities from regional and remote areas. In recent years, more Australians have moved from regional areas to cities than vice versa.[56] Although increased overseas migration has contributed to population growth in major cities like Melbourne and Sydney, data from the Australian Bureau of Statistics showed consistent net positive internal migration into inner regional areas between 2008 and 2015, while major cities, outer regions, remote and very remote areas all experienced net negative internal migration over that period.[57] In terms of absolute numbers, the declines are most pronounced in outer regional areas (see **Table 1**).[58] Across the states and territories of Australia, population decline in regional and remote areas has been the most pronounced in New South Wales and Western Australia, with an approximate 1% decline (see **Figure 7**).[57] Over the next decade, continuing urbanisation is likely to negatively impact the future population, workforce and growth opportunities for rural Australian communities.

Table 1. Net internal migration by remoteness class.[58]

REMOTENESS CLASS	2008–2009 (PERSONS)	2011–2012 (PERSONS)	2014–2015 (PERSONS)
Major cities	–18,236	–11,740	–3,058
Inner regional	22,221	17,833	19,648
Outer regional	–152	–1,579	–8,096
Remote	–2,794	–2,603	–4,178
Very remote	–1,039	–1,911	–4,316

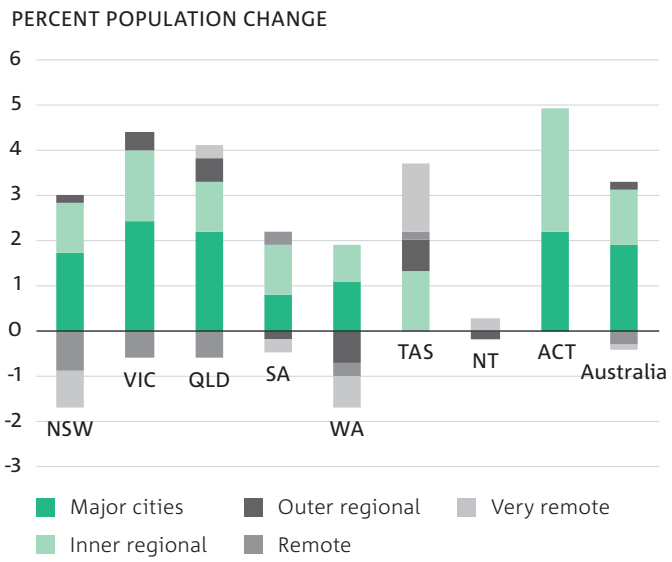


Figure 7. Resident population change across Australian states and territories between 2008 and 2018.[57]

Increasing need to attract and retain regional workers. Regional areas with a decreasing proportion of young people experience associated declines in population and increasingly older demographic profiles. In particular, young women from rural areas are more likely than men to migrate to cities.[23] Young rural women often report having more uncertainty about their ability to maintain a fulfilling career in rural areas, and tend to establish a career in urban areas after completing their education.[59,60] Decreases in population across regional Australia often lead to a decline in key industries and services in those areas, including construction, schools, hospitals, aged care, banks and retail. In turn, these changes are likely to make regional and rural living less attractive to young people, and negatively impact the wellbeing and sustainability of the remaining community.

As key export industries have traditionally served as the engines of economic growth in regional areas, the survival and longevity of Australian regional towns and small cities will depend partly on the long-term sustainability of export-oriented industries, such as agriculture, mining and manufacturing.[61,62] The development of these industries in regional areas, along with the capacity of the regions to establish businesses and attract the next generation of male and female workers, will play a key role in defining the future prosperity of regional communities.

The need for gender diversity is growing. Agriculture has traditionally been a male domain, with women playing crucial yet less visible roles in farm businesses. Recent progress towards improving participation rates of women in agricultural education has resulted in women now representing a larger share of student enrolments than men in agricultural courses across Australian universities.[63] However, this has not yet translated to a similar ratio in the agricultural workforce. An analysis of gender balance across the sector shows that agriculture has one of the lowest levels of employment for women, who make up around 30% of the workforce.[64] Given the large proportion of women now graduating from agricultural education programs across Australia, and the fact that women make up half of the labour force in rural and regional Australia, embracing the benefits of diversity in the agricultural sector is essential for its economic sustainability.[63,65,66]

International consumers demand healthy, safe, and environmentally sustainable food. The geographical proximity of the Asia–Pacific region makes it a key export market for Australia. Consumers in this region are increasingly focused on health, with a survey finding that 93% of Asian respondents would pay more for foods with health attributes.[67] Foods that are fortified, enriched or enhanced to provide health benefits beyond basic nutrition are also popular across the Asia–Pacific, with sales expected to reach around $918 million by 2026.[68,69] Due to the numerous high-profile food-safety scandals in China and its domestic over-reliance on hormones, pesticides and antibiotics, assurance around the quality and provenance of food and nutritional products has also become increasingly important to Asian consumers.[70,71] Australia is well placed to meet this new demand, which could translate into opportunities for specialised agricultural workers at every point along the supply chain. Farms may need to generate more organic produce and high-value 'superfoods', which traditionally require more workers than conventional agriculture.[72] However, increasing automation across the agricultural sector could mean that many of the tasks requiring lower skill levels are performed by automated systems.[73] In addition, organic or other certified agriculture has more complex supply chain needs for inspection, certification, shipping, marketing and distribution, especially when produce is exported internationally.[74] Additional workforces will be required to meet these needs, and are likely to be aided by new supply-chain technologies in the future.

Changing domestic preferences and behaviours. While international consumers are increasingly health conscious, Australian consumers are showing a preference for fast foods and eating out. Meals out and fast foods accounted for 25% of total food expenditure among Australians in 1989 compared with 34% in 2016.[75] This change in consumer preference represents new opportunities for food producers to sell to an increasingly diverse domestic food supply chain, including the food services industry, and may require additional specialised workforces to cater to changing needs and preferences of the domestic market.[75] On the other hand, household expenditure on meat, fish and seafood has declined substantially over time, with recent research indicating that Australia is the third fastest growing vegan market in the world.[75,76] A 2016 survey showed that around 11% of Australian adults reported eating a vegetarian diet all or most of the time—up from around 10% in 2012.[77] Catering to the growing demand for meat substitutes, a number of overseas companies are developing animal-free meat and dairy products.[78,80] The continuation of this trend could threaten the viability of the domestic meat and livestock industry and lead to a decline in the associated workforce. However, these changes also represent new opportunities to grow the domestic workforce in the grain industry and the production of non-animal proteins.

Economic impacts

Aggregation of farms. Over the past few decades, the benefits of economies of scale have resulted in many small farms aggregating into larger operations. The number of broadacre farms in Australia has consistently decreased since the late 1970s, although the gross value of output (receipts) remain similar (in real terms).[81] During the same period, the average land area operated per broadacre farm increased by 30%.[81] The aggregation process, coupled with the out-migration of many next-generation farmers, means that many farmers are increasingly sourcing labour outside of the family.[82] In addition, farm aggregation is also reducing the number of available agricultural jobs in regional areas.[1] Farm aggregation in Australia can be observed in the estimated value of agricultural operations (EVAO) produced by farms and their different sizes (see **Figure 8**).[22] The figure shows the share of EVAO from farms of different sizes for selected years between 1983 and 2016. The trend shows an increasing share of output coming from the largest farms (producing more than a million dollars in value per year), and a declining output share from mid-sized farms.

Corporatisation of farms. Data on agricultural corporatisation are difficult to source, but there is abundant anecdotal evidence that corporatisation is increasing as farm sizes increase.[83,84] Corporate farms, in general, are more likely than family farms to hire more permanent workers from diverse career and cultural backgrounds—with the possibility of attracting skilled younger workforces to agriculture.[84,85] However, corporate farms tend to be less agile when making decisions, and they are generally burdened with multiple levels of management and a larger number of stakeholders. These constraints tend to lead to poorer returns than the more agile family-run units.[86] In terms of foreign ownership, just over 600 businesses with agricultural holdings reported some level of foreign ownership in 2016.[87] This represents less than 1% of all businesses with agricultural holdings in the country.

The morphing agricultural workforce. A decline in the number of farms across Australia over the past decade has reduced the proportion of employers in the agricultural sector.[88] In addition, advancement in new agricultural technologies is demanding different skill sets across the sector.[89] Although technology developments and automation may displace some existing agricultural jobs, jobs around the management, integration and operation of new technologies and machineries are likely to be in increasing demand in the future.[90] These trends, along with the corporatisation of farms, are likely to see the agricultural sector require a workforce from a wide range of industries, including human resources, information technology, data science, management, marketing and trade.[7,43] In addition, soft skills such as emotional intelligence, collaboration and creative problem solving will become increasingly crucial as the sector and its workforce grow and diversify over the next decade.[44,45]

Innovation is changing the future agricultural workforce. Innovation in agriculture, including high-tech protected greenhouses, vertical farming, precision agriculture, drone technology and robotics have the potential to completely change how Australian farmers produce food and fibre in the future.[91–95] Integrating these technologies into existing farm practices will likely increase future demand for a range of technology-related skills.[43] These technologies will also produce an increasing volume of complex unstructured agricultural data, which will generate demand for data scientists to organise and interpret them.[43,96] However, integration could be an important barrier. A 2016–17 ABARES farm survey of 2,200 Australian farmers found that their inability to integrate new technologies into on-farm practices was the main obstacle for adopting new technology, especially among small farm operators.[13] In addition, lack of access to reliable internet and the cost and availability of useful new technologies were also reported as barriers to adoption. As technology advances, combining on-farm experience-based knowledge with the functionality of new agricultural

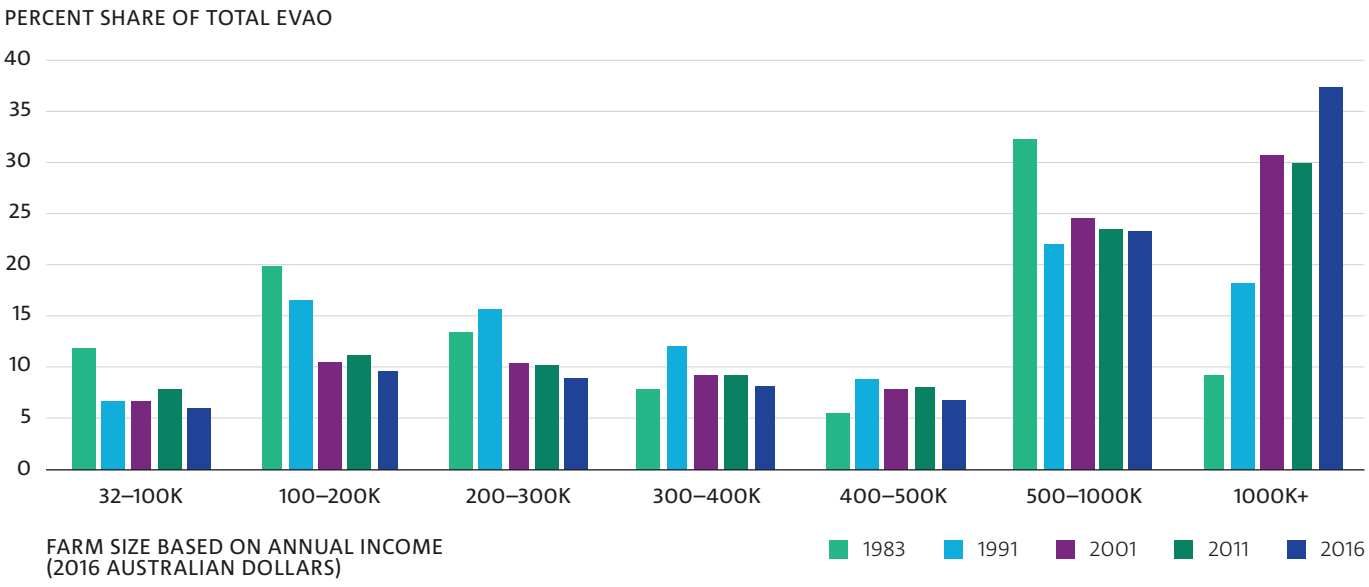


Figure 8. Percent share of total Australian estimated value of agricultural operations (EVAO) produced by farms of different sizes between 1983 and 2016.[22]

technologies will be crucial in strengthening technology uptake to improve efficiency and maximise profitability and production.[97] To fully realise the benefits of new agricultural technologies, developers may need to offer advisory support to farms and modify these technologies to the needs of the operator.[98] In the future, farmers and farm operators may increasingly seek professional services to integrate automation, robotics, sensors, connectivity and data science into their on-farm practices, as well as assist in the repairs and breakdowns of farm technologies.

Technological impacts

Limited internet connectivity across rural communities. Technology is becoming increasingly important to farm operators. A 2017 survey of Australian farmers found that 96% of farmers owned and used information and communications technology assets.[13] However, poor internet coverage and transmission rates across some areas of Australia are major barriers to integrating new agricultural technologies and systems into on-farm practices (e.g. sensors and devices, GPS units and controllers, electronic identification tools) as reported by around one-third of Australian farmers.[13,99]A CSIRO survey of 1,000 producers across 17 industries found that 55% of Australian producers reported relying on mobile phone networks to access the internet, while at the same time 43% reported having patchy or no mobile reception across their property.[100] According to the Australian Digital Inclusion Index (ADII), geography plays a critical role in digital inclusion, with capital cities attracting a ADII score of 62.4 out of 100 in terms of digital ability, internet access and affordability compared to a score of 53.9 for rural areas.[101] As an example, a 2015 survey found that dryland farmers reported the poorest telecommunications access in the country, with the majority reporting poor to very poor internet and mobile phone access.[102]

Access to fast and reliable internet will enable farmers to control a wide range of machinery across their property, which in turn could increase productivity and encourage further technology adoption on farms. Being globally connected allows primary producers and regional businesses to compete on a more level playing field and deliver high quality food and fibre products to both domestic and global markets. Technological companies (e.g. Ericsson and Telstra) are working on the fifth-generation wireless broadband technology, known as 5G. This technology has the potential to offer download speeds of greater than 20 Gb per second. Telstra is currently delivering the 5G network in selected areas of the Gold Coast, and has activated the first 5G mobile base station in Toowoomba.[103,104] The implementation of 5G networks in regional Australia is likely to enable new precision agriculture capabilities on farms. Leveraging real-time connectivity through connected 'Internet of Things' devices could provide Australian farmers with access to real-time data on water and power usage, crop growth, livestock movements, maintenance alerts and market prices.

Over the next decade, a limited access to fast and reliable internet will likely impact the economic output and quality of life among some communities. On the other hand, there is also the possibility that improved connectivity may allow more people to work remotely, thus facilitating the movement of workers to regional areas with better amenities, such as a pleasant climate, access to the ocean or plentiful parks and green spaces.[105] This pattern may negatively impact the survival of regions with fewer amenities.

High-tech agriculture has the potential to attract young people to regional Australia. Advancements in agricultural technologies are transitioning the traditional agricultural workforce into a new era of farming. Innovative farming techniques, including vertical farming, lab-grown agricultural produce and high-tech greenhouse facilities are changing the way food is grown and produced in Australia.[91–94] Other innovations that convert agricultural byproducts into clean energy could substantially reduce the cost of energy on farms while reducing carbon emissions and increasing yields.[106] In addition, new agricultural technologies including remote sensors, microbe-based fertilisers, farm management software, land-surveying drones and weed-zapping robots are transforming the mundane perception of traditional farming into an exciting industry with a wide range of career opportunities.[95] Over the next decade, linking higher education to advances in agricultural technology, coupled with facilitating innovation across a diverse and evolving agricultural sector with a focus on agribusiness and entrepreneurship, could potentially bring young Australians to regional towns or rural areas to pursue a career in agriculture.

Gene editing, a 'game changer'. Meeting future food and fibre demand from a rapidly growing world population will require a variety of new technologies, including genetically modified crops and animal proteins.[107] Although historically farmers have practised selective breeding to increase yields or to produce certain kinds of crops and animals that are resistant to drought, diseases and pests, genetically modified crops have the potential to produce more impressive benefits in the future.[108] For instance, over the past decade, researchers from eight countries have been working on the C4 Rice Project to develop a rice variety using the C4 form of photosynthesis, which efficiently produces as much as 50% more than current rice varieties.[107] Gene editing will enable further development of crop varieties with improved nutrient contents and higher levels of resistance to herbicides and diseases.[109] There are also other projects taking place, such as one aiming to improve nitrogen-fixing cereals that could potentially reduce the need for fertilisers.[110] For Australia, drought- and heat-tolerant crop varieties could help maintain yields even in the face of challenging environmental conditions, thereby preserving workforces that may otherwise shed jobs. In addition, advancements in gene editing may present growing workforce opportunities in biotechnology research, development and sales.

Rise of the robots. Expensive and difficult-to-source labour is a major challenge faced by the agricultural sector.[30,111] However, new robotic systems may be able to replace some human labour, particularly in monotonous and highly manual tasks. Agricultural robotics are currently used in various parts of the world for milking, harvesting and picking crops, autonomous mowing and pruning, phenotyping, sorting and packing, seeding, spraying and thinning.[112,113] These robotics technologies are especially useful in repetitive labour-intensive tasks. For instance, organic farming requires

weeds to be removed manually rather than through spraying pesticide. Robotic systems that can navigate through a field, detect and classify weeds, and kill weeds mechanically have been developed.[114,115] Automation also has major potential to improve productivity and reduce labour costs on farms, and would be particularly valuable to the horticulture industry, where about 50% to 70% of production costs are estimated to come from labour.[116] Increasing automation across Australian farms could also potentially drive a further wave of farm aggregation.[117]

However, although new technologies are emerging, agricultural produce with varied harvesting needs can increase the complexity of automation.[118,119] Adoption of new technologies is also highly dependent on cost. The high cost of technologies could mean that automation is not as cost-effective as using human labour. As such, the transition to automation is likely to be gradual, and dependent on developments in technology and cost structures.

Automation could improve productivity and create new jobs. The agricultural sector has historically drawn on new technologies to improve productivity.[120] Estimates suggest that the value of Australian agriculture could increase by 25% from 2014–15 levels through greater uptake of digital technologies, which would equate to approximately $20 billion increase in gross value of production.[121] In particular, unconstrained application of digital technology across the agricultural sector could potentially see savings of $7 billion from automation, while gaining $3 billion from genetic enhancements, $2 billion from tailoring inputs to needs, and $1 billion from improvements to markets access and biosecurity.[121]

However, the increasing deployment of automation is likely to result in the loss of some agricultural jobs, predominantly low-skilled positions. For example, a 2018 report from the Regional Australia Institute found that agricultural regions with more farm labourers than farm owners are more susceptible to job loss from automation.[73] Continual investment in skills development, which may take the form of formal or informal learning, will be crucial in ensuring that low-skilled employees facing job loss from automation are able to reskill for higher level positions.[73] Without coordinated reskilling efforts, the automation of low-skilled positions could see a large proportion of the agricultural workforce facing unemployment. This is likely to lead to a decline in regional economies, population and wellbeing of entire communities.[102] Nevertheless, the increased efficiency facilitated by technological advancement could also create new high-skill jobs in and adjacent to the agricultural sector. For example, robotics engineers will be in higher demand, as will robotic maintenance technicians. In addition, a new sub-sector could emerge around the need to provide technical support to robotic systems on farms, as well as the need to regularly inspect and maintain these systems and other equipment. Furthermore, adopting automated systems will generate massive amounts of data, which will require skilled data scientists and analysts to unlock their value.[122]

Automation will change the nature of human labour in agriculture. Increasing automation and technological advancements in agriculture are changing the way farmers work. Today, most agricultural tasks still require human skills. However, technology advancements over the next decade are likely to see human–robot collaboration emerge and become more common across the agricultural sector, with humans performing the more complex work requiring judgment and classification, and robots filling in the simpler, more routine tasks. For example, the RASberry project at the University of Lincoln (UK) is developing mobile robots that help human fruit pickers to transport heavy boxes of fruit from picking point to collection point.[118] As the use of, and interaction with, advanced technology becomes more common in agriculture, it will be important to develop technological skills within its workforce.[73] Future farm managers will likely need to possess a combination of skills in decision-making, data analysis and marketing, as well as technological literacy.[123] However, there may also be unintended skill shifts with automation. For instance, farmers may lose the ability to fix equipment, and the breakdowns may have more impact and be harder to manage. These shifts could also lead to new jobs focused on maintaining and repairing automated systems.

The specialist biosecurity workforce is declining. There has been a decline in the specialist workforce crucial to the management of biosecurity, including taxonomy, plant pathology and entomology.[4] Estimates reveal that as much as 50% of Australia's diagnostics capability will be lost by 2028 as the result of fewer people being trained in taxonomy.[4] An independent review revealed that the Australian biosecurity system continues to face challenges, including budgetary issues, declining and uneven capability across biosecurity jurisdictions, frequent leadership changes and a lack of codified practices.[124] Investments in biosecurity have also been struggling to keep pace with the growing challenges faced by Australia.[125] At the workforce level, the shortage and aging demographic of biosecurity experts is a major issue, especially as part-time and seasonal agriculture workers are unlikely to possess sufficient biosecurity skills.[126] In addition, a declining number of postgraduate and postdoctoral researchers also contributes to the shortage of biosecurity workers.[127] A declining specialist workforce in biosecurity has the potential to create substantial gaps in Australia's biosecurity capabilities, and therefore threaten the reputation of Australian produce in the national and global markets.

In response to these potential biosecurity challenges, there is a place for technology to improve practices. For example, blockchain technology integrated with radio-frequency identification and network communication could potentially track produce across the entire supply chain.[128,129] Biosensors fitted on individual organisms (e.g. oysters) can help collect data about their health in real time, and drones can be used to collect data for plant health monitoring and early weed detection.[130,131] In addition, scientists are also using genetic techniques to develop rapid tests for identifying pests and diseases.[4] However, a human biosecurity workforce will still be needed to apply these new technologies and interpret the data. Therefore, while technologies can help to improve biosecurity and fill some of the gaps created by workforce deficiencies, there is still the need to enhance the human biosecurity workforce via succession planning, capability building and strategically designed programs that attract and retain skilled workers.[127]

Environmental impacts

Climate change presents new risks. The impacts of climate change are already being felt in the agricultural sector. Worldwide, climate change-related extreme weather events, such as droughts, floods and increasingly severe storms are some of the main reasons for shocks in farming outputs.[132] Estimates suggest that direct climate impacts on maize, soybean, wheat and rice production involved production losses of up to 43% in 2014.[133] As extreme weather events continue to threaten production, the agricultural sector will need to adapt and become more resilient over the next decade. It will be crucial to develop production systems that can simultaneously meet both production and environmental targets while helping farmers adapt to a range of emerging challenges, such as increasing water shortages and declining yields.[134–136] However, there is also an opportunity here for the Australian agricultural sector to differentiate itself by further developing Australia's 'clean and green' reputation and producing sustainable products for both domestic and export markets.[43]

Water shortages will impact the future agricultural workforce. Around 92% of global annual freshwater withdrawals are used for agriculture, but climate change is likely to decrease water security in Australia and make water shortages and droughts more common.[137,138] Drought decreases farm production and threatens the financial viability of agriculture. The Millennium Drought of 1996–2010 substantially affected rural areas throughout Australia, especially during the particularly dry years in 2002 and 2003.[139,140] During this time, Australia's farm gross domestic product (GDP) decreased by 24%, rural exports dropped by 27% and agricultural income saw a 46% decline.[139] Estimates suggest that approximately 100,000 (or one in four) agriculture jobs were lost as a direct result of the drought between 2002 and 2003.[139] One study found that drought increases the probability of farmers experiencing financial hardship by 10% in drought-affected areas, compared to those in areas of above-average rainfall.[141] Drought is also associated with a higher rate of closure of local services, and lower levels of reported social cohesion in rural communities.[142] Droughts will also impact the viability of agribusinesses and their workforces. Employment rates (excluding farmers) in drought-affected areas are around 5% lower than in above-average rainfall areas (see **Figure 9**).[142] Drought can also mean that farmers are left with a 'stranded' workforce of sponsored workers who cannot work elsewhere. Establishing coordinated workforce data that can be shared between farms could be one way of addressing this issue.

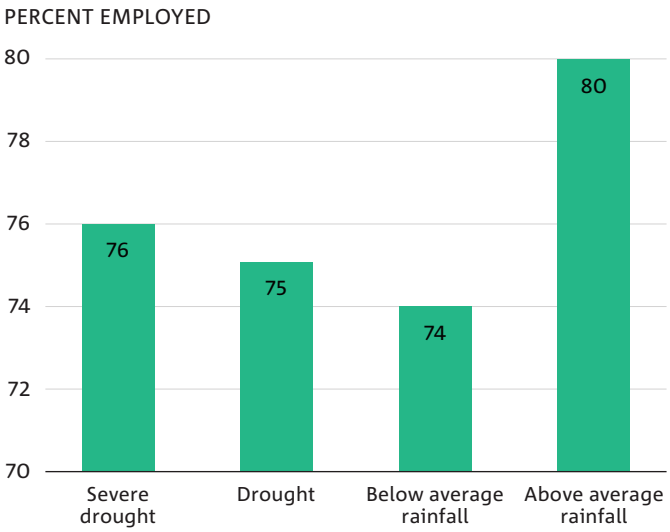


Figure 9. Employment rates in agribusinesses (excluding farmers) by drought definition.[142]

Note: These data use the 'rainfall deficit' definition of drought

Regenerative organic agriculture could potentially build more sustainable soils in the long term. Regenerative organic agriculture adopts a holistic systems approach to agriculture that promotes new innovations for improving long-term environmental sustainability of farms through practices that regenerate degraded soil.[143,144] Increasing industrialisation and intensification of farming practices have substantially increased the overall agricultural production in Australia over the past few decades. Over time, these practices have impacted environmental biodiversity and soil health.[143,145] The Australian Government's most recent national assessment of soil quality found that removing native vegetation in forested and wetland areas for agriculture can lead to carbon imbalances in soil, rising groundwater levels, erosion and increased salinity—all of which affect soil health.[146] Regenerative agriculture could help reduce impacts on biodiversity over time by building soil diversity for ensuring efficient production and improving resilience against the changing climate.[147] However, transitioning to regenerative agricultural practices could reduce yields in the short term and require more farmland to reach the historical output of conventional farming practices. This in turn could lead to more widespread deforestation and loss of biodiversity, therefore offsetting some of the gains that result from soil improvement.[148]
An increasing need to adopt new farming practices for building resilience against droughts and floods while ensuring efficient production over the next decade may see a growing number of agricultural scientists further develop regenerative organic agricultural practices.

THE CHANGING **HORTICULTURE INDUSTRY**

In the financial year ending in 2018, the Australian horticulture industry had a gross value of around $11 billion and employed 72,800 people across the country.[149] The industry feeds a domestic market that has grown by over 2% each year for the past two decades.[75] The Australian horticulture industry remains heavily reliant on human labour, and in particular on a seasonal workforce sourced from overseas temporary visa holders, including working holiday makers (WHM) and seasonal workers sourced from Pacific Island countries. The horticulture workforce is therefore highly vulnerable to immigration and labour policy changes.

Other changes impacting horticultural production, such as climate change or automation and technological change, are also likely to have a significant impact on the horticultural workforce.[150] Horticulture producers are also particularly exposed to supply-chain pressures caused by the dominant market position of large retailers that create narrow margins. Heading into the future, Australia's horticulture producers are likely to be impacted by the availability of labour, water scarcity caused by climate change, and their market position relative to other stakeholders.

INDUSTRY SNAPSHOT[22]

Median weekly income (2016 AUD, total income including off-farm income)

High-skill employees

	Fruit and nut industry	Vegetable and mushroom industry
2001	$850	$720
2016	$1004	$923

Low-skill employees

	Fruit and nut industry	Vegetable and mushroom industry
2001	$595	$563
2016	$688	$699

Median age of owner-managers (years)

	Fruit and nut industry	Vegetable and mushroom industry
2001	51	49
2016	56	51

Gender of owner-managers (%)

	Fruit and nut industry	Vegetable and mushroom industry
Male	71	67
Female	29	33

FRUIT AND NUT INDUSTRY

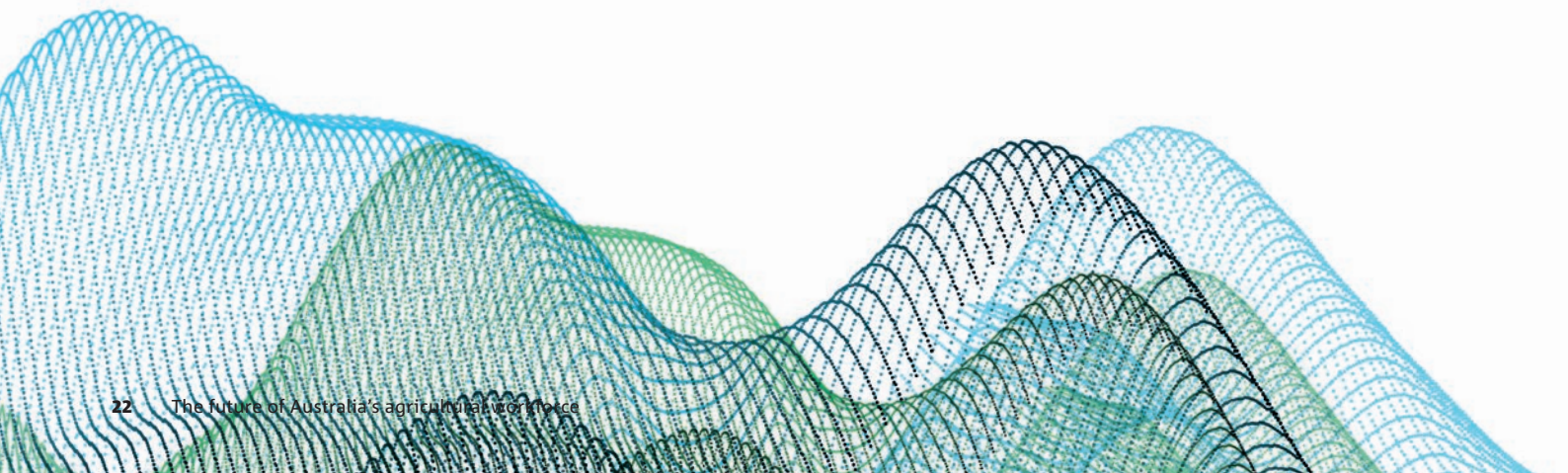
VEGETABLE AND MUSHROOM INDUSTRY

Reliance on undocumented labour. In the horticulture sector in particular, growers tend to rely on undocumented labour, citing a shortage of readily available legal workers.[151] A 2019 national survey of 332 growers found that 40% of those surveyed indicated that they had not been able to hire enough labour, with 63% of this cohort revealing that they had left produce unpicked.[30] The cost of labour on Australian farms is also higher than that of most global competitors and a subset of growers use undocumented workers as a source of cheap labour, paying them less than the award rate.[30] At present, there is an unknown number of undocumented workers across the agricultural sector, with many of them exploited by labour hire companies, underpaid and without workplace rights.[152,153] In the future, creating a new agriculture visa and extending the rights of the seasonal workers program to temporary migrant workers could be the first step towards addressing ongoing issues relating to labour shortage and worker exploitation across the agricultural sector.[7]

Worker exploitation is in the spotlight. A multi-year investigation by the Fair Work Ombudsman involving hundreds of horticulture businesses nationwide found that just over half of Australian horticulture businesses had been involved in a workplace agreement breach, including underpaying staff or failing to keep records.[154] Workers from the Working Holiday Maker (WHM) visa program were more vulnerable to exploitation and over $1 million in unpaid wages was recovered and given to 2,500 workers.[155] Labour hire contractors who supply temporary labour to farms have been identified as a key element of non-compliant labour practices on horticulture farms.[155] Although a Harvest Trail working group has been established in an effort to build a culture of compliance across the horticulture industry, developing effective nationwide regulation, oversight and monitoring of labour hire contractors in horticulture could minimise future exploitation of workers.[30,154]

Working holiday visas make up the majority of the horticultural workforce. The Australian horticulture industry heavily relies on foreign labour, the largest source of which is the WHM visa program. Due to the transient, dispersed nature of the WHM workforce, estimates on its exact representation across the horticulture industry can vary. A 2016 report by ABARES showed that Australian horticultural farms sourced around 44% of their labour from WHM visa holders.[156] A more recent study in 2018 estimated that working holiday makers represent around 60% of the horticultural workforce, while others have made estimates between 50% and 85%.[30] An increasing reliance on variable labour supplied through the WHM visa program may impact the overall productivity and efficiency of Australian horticultural farms in the future.

The workforce from the 417 working holiday visa program is declining. Although the number of 462 WHM visas granted each year has been steadily increasing, the number of 417 WHM visas has been declining since 2013 (see **Figure 10**).[32-37] In 2018, there were around 36,000 fewer 417 WHM visa holders in Australia compared to five years prior.[32,37] In an effort to increase the 417 WHM visa cohort, expansion strategies have been introduced allowing those working outside of northern Australia to qualify for a second year in Australia.[157] In addition, changes have been put in place enabling working holiday makers to extend their stay from six months up to 12 months with one employer.[157] Some countries are also seeing their caps on eligible WHM visa applicants to Australia increased, with the option of staying for a third year.[157] Over the next decade, working holiday visa policies may be subject to external influences over which the agricultural industry has little control. Given that the industry has a high reliance on working holiday makers to maintain core business functions across the Australian horticulture industry, this may increase precariousness and uncertainty.



Growers are becoming increasingly reliant on the seasonal worker program. The Seasonal Worker Program (SWP), established in 2012, brings workers from Pacific Island countries to work seasonally in Australia.[158] The number of seasonal workers employed in Australia has grown each year and over half of the participants work on horticulture farms (see **Figure 11**).[38,158,159] Studies indicate that seasonal workers provide more productivity benefits to farms than workers from WHM visas, largely because work is the primary motivation for seasonal workers to travel to Australia. In addition, seasonal workers are able to return each year to the same farm and therefore require less on-farm training and supervision compared to working holiday makers.[159] A large number of Australian horticulture farms, particularly those across northern Australia, rely on seasonal workers during harvest. A continued lack of interest in seasonal labour work by the Australian workforce means that such programs are imperative to ensuring that Australian horticulture farms remain in business in the future.

Decreasing margins. The increasing market power of the supermarket giants in the Australian food system is creating a challenging environment for many Australian growers. The large retailers have the power to dictate the negotiating terms to obtain suitable produce at low cost.[30] As labour remains the highest cost for growers, there is intense pressure to keep those costs low. However, time constraints, along with short picking and packing seasons in the horticulture industry, mean that workers must be paid overtime and penalty rates. Moving into the future, a continuing market power imbalance between growers and retailers that constrains the price of horticultural products will likely impact the viability of smaller or marginal farms.

Doing more with less. Water scarcity is a constant pressure on Australian horticulture farms and climate change-related impacts are exacerbating these shortages.[138] In addition, climate change is likely to affect the enterprise structure and location of horticulture farms, irrigation and soil management practices, crop selection, and management of pests and diseases.[160] While natural resources are increasingly limited, there is a simultaneous push for growers to produce more food for lower prices.[161] Declining availability of water will likely increase the need for expert advice on irrigation and drought-resistant crop species. At the same time, however, technology advancements are enabling the establishment of enclosed greenhouse farming facilities that ensure optimal growing conditions and resource management.[162] As greenhouse facilities for growing horticultural produce are confined, less land is required to grow an equivalent yield. Therefore, these facilities could potentially operate in a range of areas and climatic conditions, including urban, suburban and rural.[162]

Figure 10. Number of 417 (working holiday) and 462 (work and holiday) visa holders in Australia per year between 2013 and 2018.[32-37]

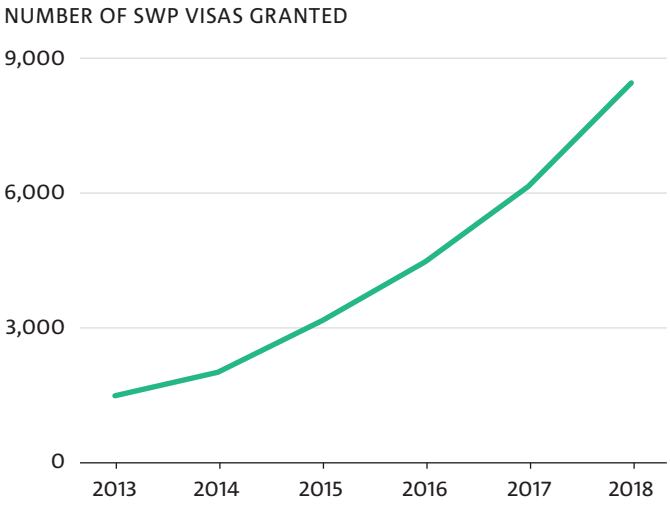


Figure 11. The number of Seasonal Worker Program (SWP) visas granted in Australia each year between 2013 and 2018.[38]

THE CHANGING **LIVESTOCK INDUSTRY**

The Australian livestock workforce is subject to both domestic and international influences. Australians are eating less red meat, but worldwide consumption continues to climb, and Australia has become one of the largest global exporters of beef and sheep meat.[163–166] A competitive international marketplace ensures that there is considerable pressure to increase productivity and improve margins for the export market. As an industry heavily exposed to the international market, the livestock sector will be substantially affected by international market trends and biosecurity risks. At the same time, there is an increasing national demand for smaller scale ethically sourced and environmentally sustainable beef and lamb.[167,168] Technology and data are also transforming livestock farming practices. Technologies such as virtual fencing and electronic tagging have the potential to assist in livestock management and data collection, and boost productivity.

However, the workforce is shrinking and aging, which may pose future challenges. For example, older livestock workers may find it more difficult to adopt new technologies, while labour shortages could pose a significant problem to the industry's future viability. This decline is particularly pronounced in the cattle industry.[22] Over the coming decades, the livestock workforce will need to adapt to the changing landscape and market demands, and a new generation of livestock workers will need to be recruited.

INDUSTRY SNAPSHOT[22]

Median weekly income (2016 AUD, total income including off-farm income)

		BEEF INDUSTRY	SHEEP INDUSTRY
High-skill employees	2001	$787	$830
	2016	$1033	$962
Low-skill employees	2001	$615	$636
	2016	$764	$734

Median age of owner-managers (years)

	BEEF INDUSTRY	SHEEP INDUSTRY
2001	58	53
2016	61	58

Gender of owner-managers (%)

	BEEF INDUSTRY	SHEEP INDUSTRY
Male	73	72
Female	27	28

Aging livestock workforce and labour shortages. The majority of livestock owner-managers and high-skilled employees are over 55 years, which is higher than the median age of those from other agricultural industries.[1,166] As a large portion of the current workforce will imminently retire, there is an immediate need to ensure that there are adequate numbers of incoming skilled workers.[169] This is especially critical for northern cattle farms that on average require more labour compared to southern farms (see **Figure 12**).[170] Public perception of the livestock industry is one of the main barriers the industry faces when trying to attract a diverse and skilled workforce. The public generally perceives the livestock workforce to have low level of education, and the industry to employ a very low proportion of women.[1,166] The future viability of the Australian livestock industry will depend on its ability to attract the next generation of skilled livestock workers. Offering programs and career pathways to a diverse group of workers will help address future workforce demands across the livestock industry.

A declining workforce across the cattle industry. From 2001 to 2017, the number of cattle farms in Australia fell by 25% with the decline predominantly seen in southern Australian regions.[171] While the workforce on sheep farms remained relatively stable over the past two decades, the decline in the number of cattle farms across Australia corresponded with more than 50% decline in the cattle farm workforce between 2001 and 2016 (see **Figure 13**).[22] Despite the decline in the number of cattle farms, the volume of meat produced in Australia remained steady throughout the same period, which could be due to the sizable gains seen in production efficiency (kgs of meat/head of cattle) over that time.[22,172,173] Nevertheless, a continued decline in the number of cattle farms over the next decade is likely to reduce the number of workers in the livestock industry.

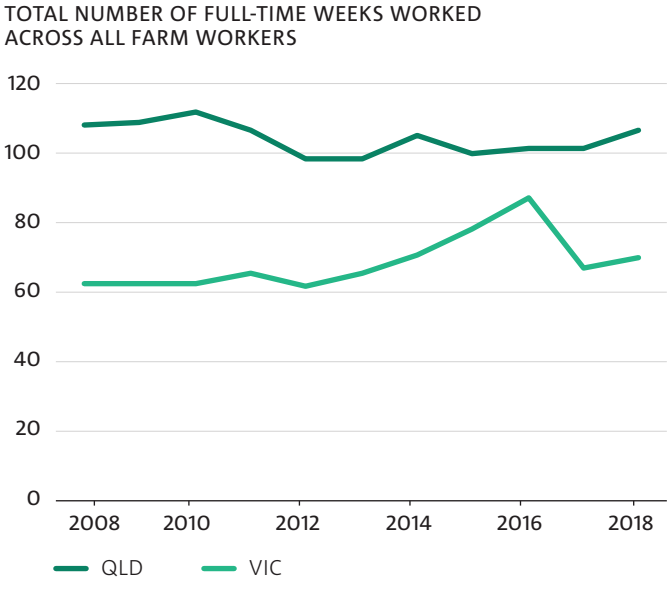


Figure 12. Average number of total weeks worked by all employees per farm, per year, between 2008 and 2018 on northern (Queensland) versus southern (Victoria) cattle farms. Multiple workers mean more than 52 weeks in a single year is possible.[170]

Note: Data show total number of full-time weeks worked by all farm workers including hired labour. If an individual works less than 40 hours in an average week, the estimate is converted into a full-time week equivalent. All estimates are per-farm averages.

Vulnerabilities of export markets. In 2017, Australia exported almost 70% of its beef and sheep meat overseas and was the largest exporter of sheep meat and third largest exporter of beef worldwide.[166] Global meat consumption continues to grow, creating an increasing demand for high-quality Australian meat. Australia's primary beef export markets for premium beef are Japan, China and South Korea, while the United States is the primary export market for hamburger meat (see **Figure 14**).[174] Although increasing global demand for Australian meat provides opportunities for exports, the export market is highly susceptible to external influences. For example, outbreaks of foot-and-mouth disease or other diseases of concern that result in trade bans could potentially shut down livestock exports for years.[175] In addition to disease outbreaks, trade deals could have a severe positive or negative impact on export markets. For example, the China-Australia Free Trade Agreement, signed at the end of 2015, eliminates all tariffs on Australian beef imports in China until 2024.[176] This places Australia in a competitive position to increase beef exports to China. The future state of the export market, under these and other influences, will have a direct impact on the viability of Australian livestock businesses and their workforce.

Australians are not eating as much beef and lamb as they used to. On average, Australians are some of the world's biggest meat eaters—consuming a much greater portion of both sheep meat and beef per capita than global and Organization for Economic Cooperation and Development (OECD) averages (see **Figure 15**).[164] However, the national consumption of beef has dropped around 45% in the past 50 years, while lamb consumption dropped by 52% and mutton by 98%.[163,164] A recent Australian study found that the biggest driver of declining beef and lamb consumption across Australia was the increasing price of meat.[167] As an alternative, consumers are increasing their consumption of less expensive animal protein sources such as chicken and pork.[177] In addition, progress has been made in the development of lab-grown meats, which over the next decade could be available on supermarket shelves.[178,179] If the cost of lab-grown meat becomes comparable to the cost of traditionally produced

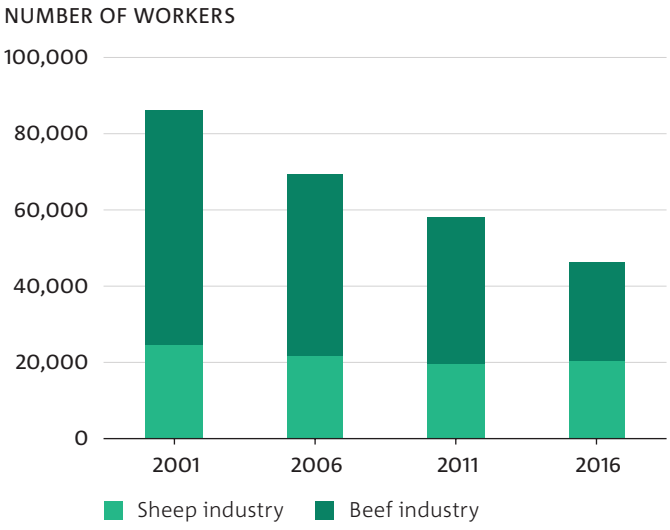


Figure 13. Number of Australian livestock workers employed in Australia between 2001 and 2016.[22]

beef, and consumer values and behaviours favour "cultured meat", further declines in meat consumption could negatively impact the livestock industry. Further decline in domestic demand for meat is likely to negatively impact the viability of smaller livestock operations supplying the domestic market and their workforce.

Riding the technology wave. Technology developments around monitoring and managing herd health, reproduction, location and behaviour have the potential to lead to productivity gains and better animal management in the livestock industry. Integrating monitoring technology, such as weighing stations and electronic tagging, could potentially enable livestock farmers to collect more data with less physical effort. In addition, developments in technology could see new systems being integrated into on-farm practices where, for example, virtual fencing could be introduced, which would reduce the need for hands-on work.[180,181] The shift towards technological adoption on livestock farms over the next decade will likely demand a workforce with the ability to capture, process and utilise data in a meaningful way. However, a lack of tech-related skills to efficiently integrate and use agricultural technologies is likely to deter some operators of smaller livestock farms from adopting new technologies.[13] Establishing ways to educate and strengthen farmers' ability to effectively use technology is likely to enhance their trust in the technology and increase its adoption.[182]

Increasing demand for industry transparency. Increasing interest in the farm-to-table movement, along with environmental and animal welfare concerns, may drive changes to farming practices and the agricultural workforce in the future.[183] New trends such as 'flexitarian' and 'Meatless Mondays' are emerging along with updated nutrition guidelines that encourage Australians to reduce their red meat consumption.[167,168] A shift in consumer attitudes and preferences away from supporting large livestock operations could establish new markets for smaller local farms that operate under strict ethical and environmental transparency standards.[184] Consumers may be willing to reduce meat consumption in order to afford more expensive ethically sourced produce. This movement could create new opportunities for smaller operations throughout Australia that cater to the changing market demand for ethical meat.

Climate change and drought. Climate change is likely to impact productivity, farm profits and jobs over the next decade. In Australia, extensive livestock production systems mean that vast amounts of land and water are required to raise cattle and sheep for food and fibre. Climate change will increase rainfall variability and temperatures and directly impact animals and livestock farming practices.[185] The changing climate is also likely to have an impact on the condition of pastures and decrease the number of animals per unit of land. This may increase the need to provide supplementary feed and affect long-term sustainability of grazing operations. In addition, livestock is also a significant contributor of greenhouse gas emissions—producing more than half of the global agricultural emissions.[186] However, in 2017, Meat and Livestock Australia (MLA) reported that Australia's red meat industry could be carbon neutral within the next decade.[187] In partnership with CSIRO, MLA is developing methods to reduce livestock emissions including breed selection, supplementary feeding, biotechnology and vegetation management.[187] The ability of the livestock industry to develop solutions to deal with the changing climatic conditions, as well as options to reduce its contribution to Australia's greenhouse gas emissions, will determine its growth in the future.

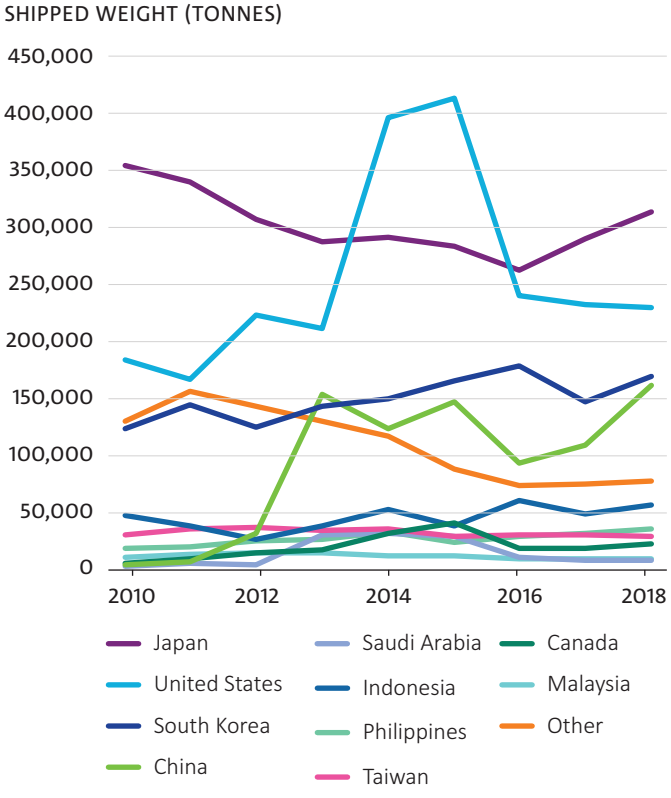


Figure 14. Primary export markets of Australian beef between 2010 and 2018.[174]

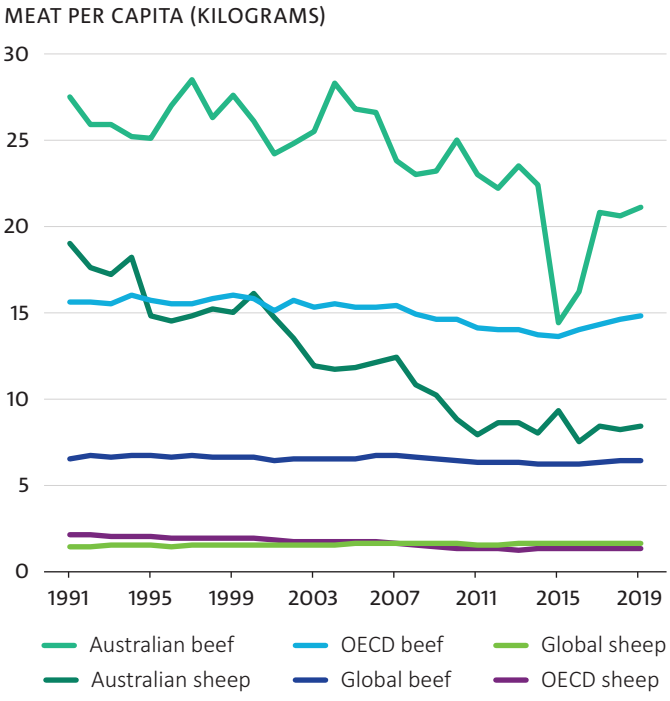


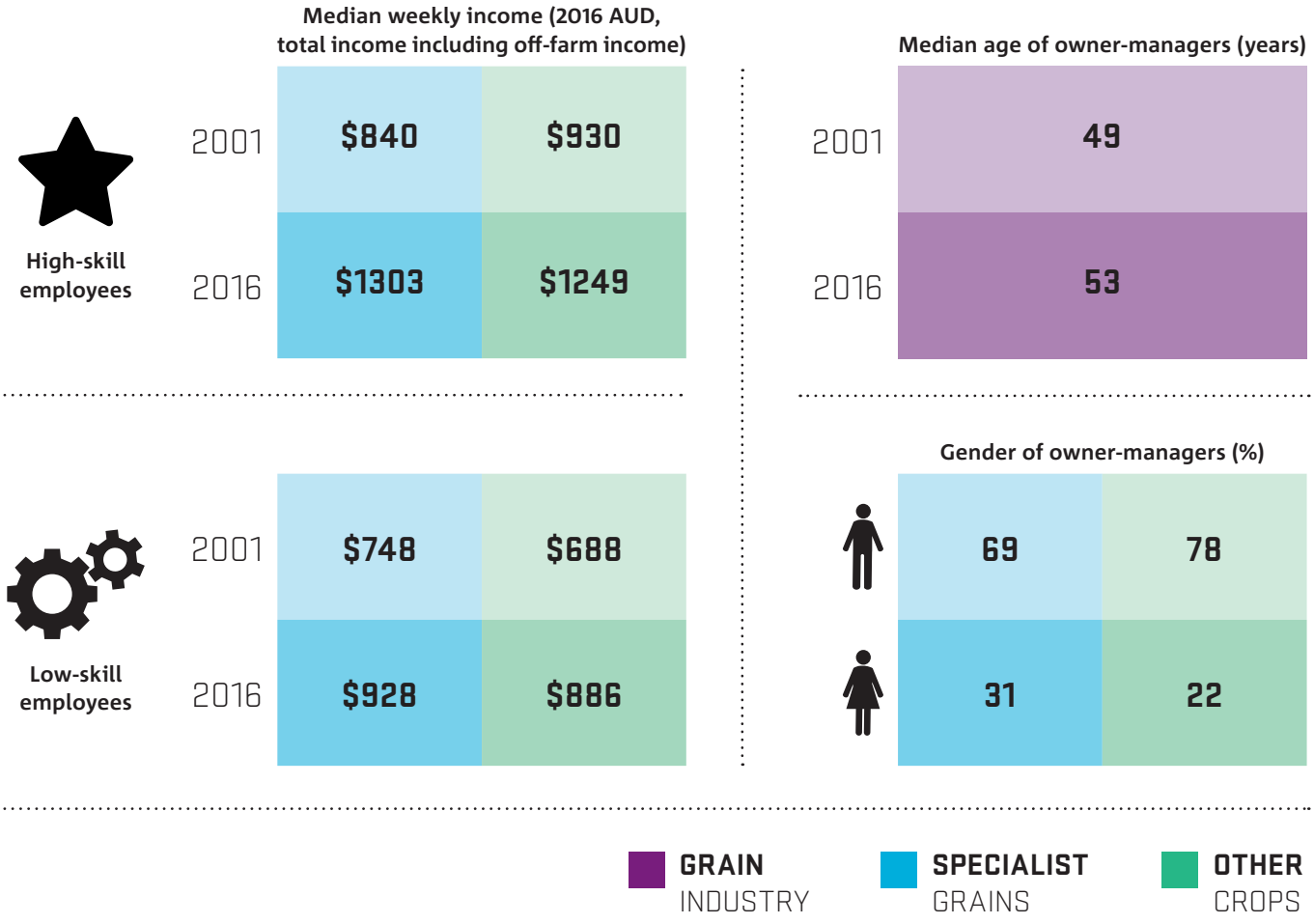
Figure 15. Australian beef and sheep consumption compared to OECD and global averages.[164]

THE CHANGING **GRAIN INDUSTRY**

The grain industry workforce is relatively large compared to many others. Although growth in employment within the grain industry was only around 4% between 2001 and 2016, the industry accounted for the largest sectoral share of employment in comparison to other industries* in 2016 (21%).[1] Due to economies of scale, larger farms are more suited to adopt new technologies. The Australian grain industry is indeed the largest adopter of precision agriculture technologies in sector.[13,188] Increasing global competition for grain exports and the growing size of broadacre farms across Australia are likely to increase the need for new technology developments in precision agriculture.

However, the grain industry is likely to see some loss of low-skilled jobs due to greater automation and adoption of precision agriculture technologies. There is potential for the workforce to move into higher skill occupations. This could be achieved through greater investment in workforce training and skills development. Given the technological, market, and environmental shifts already underway, preparing a workforce with skills to meet the changing demands of the grain industry will be crucial.

INDUSTRY SNAPSHOT[22]



*The other industries included fruit and nuts, beef, dairy, mixed-grain meat, vegetables, sheep, services, nursery, poultry, pigs, other crops and other livestock.

Australia imports wheat due to declining domestic production. Ongoing drought is having adverse effects on grain production across Australia. In particular, drought in the eastern states of Australia saw a 20% decline in grain production in 2018, and a shortage in the overall production of grains is reducing the availability of feed for livestock farmers across Australia.[189] As a result, in 2019 Australia started importing wheat from Canada to meet the growing domestic demand.[189] This can increase biosecurity risks associated with introduction of diseases and weed species from Canada. Effectively managing the transportation of imported grains, along with establishing necessary controls and strict import conditions, will be crucial for minimising the biosecurity risks associated with imported grains.

Increasing global competition. In the global market for wheat, Russia and the United States are Australia's key export competitors. In recent years, the volume of wheat exported from Russia spiked to around 41 million tonnes in 2018, compared to 37 million tonnes from Australia and 10 million tonnes from the United States.[190] Russia is upgrading its infrastructure to accommodate growing wheat exports, and estimates suggest that its wheat production could increase by 60% over the next decade.[191] Currently the export potential for Russian wheat comes from its east coast ports, which allow access to a number of countries, including South Korea. For overland trade, transport routes through locations like Kazakhstan are being built over the next five years, which is likely to increase Russia's future export potential.[191] In response to increasing Russian exports, wheat producers from Canada and the United States are likely to take additional measures to compete in the global wheat market.[191] Over the next decade, this increasing export competition could put further price pressures on Australian wheat exports.

The potential to sell Australian grain in premium markets. The cost of producing Australian wheat is higher than other competing nations including Russia, Ukraine and Argentina.[192] A 2018 study of international wheat markets revealed that the cost of wheat production in Australia is higher than other wheat-exporting nations. However, Australian wheat is benefiting from the value that its clean and green reputation achieves in international markets.[193] Although adopting and integrating precision agriculture could enable some Australian grain producers to compete in low-cost export markets in the future, the cost of producing and distributing Australian grain is likely to remain high for most growers.[194,195] It is therefore important to capitalise on the value of Australian wheat in premium markets, which could bring new opportunities to the Australian grain industry.[193]

Further, over the next decade, technology advancements across the entire supply chain could provide the necessary transparency and efficiency in recording valuable information, such as provenance, grain breed, and construction and storage processes that align with the requirements and expectations of premium export markets.[192,196] Developing the capacity in traceability-related technologies that enable Australian grains to access premium export markets, could demand a workforce capable of developing and operating increasingly sophisticated technology for tracking produce across the supply chain.

Technology is aiding rice crop production. In Australia, rice is grown in fields of ponded water in regions across New South Wales and Victoria. The two main methods for sowing rice crops are aerial (sowing by dropping pre-germinated seed from an aircraft into fields of ponded water) and drill (sowing dry seed into field and applying water at different stages to germinate the rice seed).[197] In addition, Australian rice farmers use laser technology to help them design and level the rice fields, and deploy harvesters for collecting the crop when water levels drop in fields.[197] Over the next decade, new technology advancements have the potential to increase the accessibility of aerial sowing to Australian rice growers, and automate the entire process of growing rice crops from sowing to harvesting. This increased automation will likely improve productivity and demand a workforce that is able to efficiently integrate new technologies to existing practices.

Precision agriculture boosting efficiency. Precision technologies have the potential to boost the overall efficiency of farming operations across the grain industry. These satellite-driven GPS technologies can track farm equipment and usage, and ensure inputs such as water, fertiliser and pesticide are applied only where needed on a schedule that optimises efficiency. As a result, adopting precision agriculture across broadacre farms could potentially minimise overuse of inputs and boost efficiency.[195] In addition to economic benefits, precision technologies can also improve the efficiency and safety of farm management tasks. For example, development in guidance and auto-steer technology reduces operator fatigue and enables operators to multi-task.[194,195] Over the next decade, precision agriculture could therefore have a substantial impact on-farm management tasks and the overall viability of Australian broadacre farms.

Genetic advancement of grains. Traditionally, Australian broadacre farmers have used selective breeding to develop desirable crop qualities. For example, Australian rice species have been bred to thrive in the Australian climate and growing conditions, resulting in an increase of around 50% water efficiency over the past 20 years. Today, Australia is producing greater rice yields per hectare than the large rice-producing countries, including China and India.[197,198]

Technology advancement has also led to new gene-editing techniques that are cheaper and easier to manage than traditional breeding programs.[199] In addition, 'speed breeding' enables up to six generations of crop species in just one year.[200] The Australian Government recently deregulated some gene-editing techniques.[201] Deregulation could potentially spark growing interest in developing new species of grains that require less pesticide, fertiliser and water, which in turn could lower production costs for growers.

Rice, maize and wheat together make up two-thirds of the world's energy intake.[202] Given a growing global population and the challenges of a changing climate, new gene-editing techniques could be crucial in meeting future demands for food. Therefore, over the next decade, technology advancements in gene editing are likely to see a growing workforce that supports this industry, including researchers, geneticists, agronomists and sales staff.

Climate change is putting pressure on wheat yields. In the future, the negative impacts of climate change will likely contribute to declines in yields of wheat as well as other commonly grown broadacre crops. Wheat is a major agricultural crop for the Australian grain industry, both in terms of value and area sown.[203] Developing and adopting new technology and management systems along with increasing engagement with advisory services within the grain industry have substantially increased yields over those of the early 1980s.[13,188] However, a 2017 study showed that wheat yields across Australia declined by around 27% between 1990 and 2015, and estimated that the nationwide average yield of 1.74 tonnes per hectare will likely fall to 1.55 tonnes per hectare by 2041.[204] The yields of other cereal grains, pulses and oilseed crops that require similar resources to wheat are likely to experience similar impacts.[204]

The decline in yields has also contributed towards the aggregation of wheat farms into larger operations. For the Australian grain industry to remain globally competitive and contribute to meeting the increasing global demand for food, it is likely that broadacre farmers will need to rely on tech support services to collect, use and share data in order to improve efficiency and productivity over the next decade.

THE CHANGING **DAIRY INDUSTRY**

Australian dairy farms employed around 27,000 workers in 2016, half of whom were family members of dairy owners.[205] Population growth in Australia and a challenging export environment has seen Australian dairy industry shift its focus towards serving the growing domestic market.[206] Unlike the export-oriented New Zealand dairy industry, the Australian domestic market consumes around two-thirds of Australian dairy.[206]

Over the next decade, increasing domestic consumption could generate more jobs in dairy production and transportation. This may already be underway, with the dairy industry beginning to rely less on family labour. Although technology advancements such as robotics provide productivity benefits in dairy farming, they also require a different labour skill set and high capital investment.[207] As cost of labour is an important overhead for many dairy farms, future challenges may emerge around finding skilled local technicians who are able to repair and maintain the technology.[208,209]

INDUSTRY SNAPSHOT[22]

Median weekly income (2016 AUD, total income including off-farm income)

High-skill employees

2001	$753
2016	$1032

Low-skill employees

2001	$615
2016	$771

Median age of owner-managers (years)

2001	49
2016	52

Gender of owner-managers (%)

♂	66
♀	34

DAIRY INDUSTRY

Limited vacancies due to the role of family workers. Many dairy operators rely on family members for on-farm labour, and thus have less need to recruit workers.[205] A 2016 survey showed that only around 4% of Australian dairy farms had vacant positions, and around 9% recruited workers over the one-year period.[205] Most of the vacant positions were for casual labourers with only one-third looking for full-time workers. Although farms reported no difficulties in hiring casual workers, those hiring full-time workers did. Around 79% of the respondents reported issues around clash of personalities as the main challenge when hiring new workers. Other challenges included lack of skills or qualifications (74%) and insufficient interest in the type of work (71%).[205] The same survey also revealed that around 66% of respondents reported word-of-mouth as an effective hiring method, and 38% indicated that newspaper or internet advertisements had been useful for recruitment.

However, the dairy industry's reliance on family labour may be changing. Indeed, the industry has experienced the largest increase in the share of employment held by employees (as opposed to owner-managers or family members) between 2001 and 2016 (see **Figure 16**).[1,22] Together with the increasing size of dairy farms, it's likely that there will be a growing demand for a reliable workforce outside of the family, and a recruitment process that goes beyond word-of-mouth in the future.

A decreasing number of dairy farms. Drought conditions and shortages in water supply are impacting the Australian dairy industry. The number of dairy farms across Australia has declined substantially over the past decade, from around 7,953 farms in 2008 to 5,699 farms in 2018 (see **Figure 17).**[206] In 2018, around 75,000 dairy cows were culled as part of a downturn in the industry.[210] Difficulties in recruiting both low- and high-skilled labour to work on dairy farms, high labour costs and declines in the global commodity price have all contributed to this downturn.[208]

Despite these constraints, milk production in Australia has been steady over the past decade.[206] Victoria produces more milk than the other states and territories combined.[210] The expected growth in size and changing operation of dairy farms, characterised by digitisation, market and climate volatilities and automation, across large parts of Victoria, could see a growing need for a broad generalist workforce to support these changes.

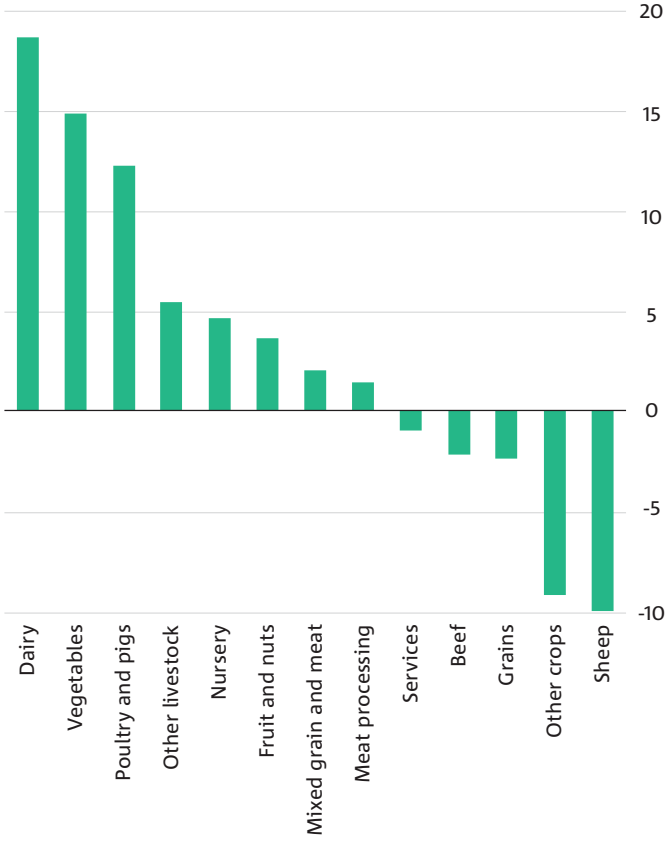


Figure 16. Percent change in employee share of employment by industry in Australia between 2001 and 2016.[1,22]

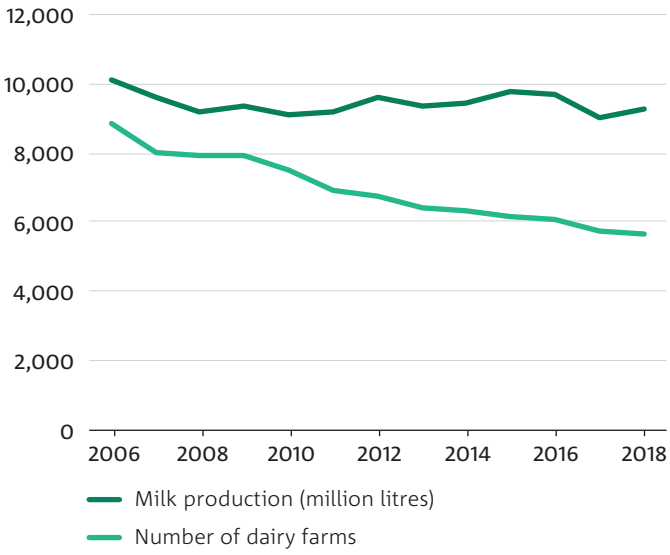


Figure 17. The number of dairy farms and milk production in Australia between 2006 and 2018.[206]

Production is increasing. While the number of farms has declined over the past decade, the remaining farms are growing in size. Also, large farms are employing more workers and producing more milk than smaller ones.[205] In 2016, farms with 350 cows or more, produced on average around 610,000 litres of milk per full-time employee, while farms with fewer than 200 cows produced around 350,000 litres per employee.[205] Consequently, the cost of labour in small farms was 12 cents per litre of milk compared to 9 cents for large farms.[205] Also, smaller dairy farms generally relied more heavily on family as labour compared to larger farms that employed a larger proportion of workers outside the family.[205] In addition to these factors, cost advantages through economy of scale among the larger operators, along with a larger workforce that has the flexibility to specialise, could see more aggregation of Australian dairy farms with an increasingly diverse workforce.[205]

A growing domestic market. Dairy is one of Australia's most important rural industries. Over the financial year ending in 2018, Australia produced over nine billion litres of milk and exported around 36% of its milk production valued at $3.4 billion. Beyond those working on farms, the dairy industry has a total workforce of around 42,600 across Australia.[206] However, dairy farmers face several challenges. Compared to their peers in other countries, including the European Union and the United States, Australian farmers receive lower levels of government support.[211] In addition, drier conditions across farms and a growing need for purchasing supplementary feed and water have pushed up production costs for many dairy farmers across Australia.

Despite these changes, a growing domestic dairy market (due to ongoing population growth in Australia) is presenting new opportunities. In 2002, around half of all the milk produced in Australia was exported, compared to around 36% in 2018.[206] More specifically, domestic consumption of manufactured milk products increased from 26% in 2002 to 37% in 2018, while exports dropped from around 56% to 36% over the same period.[206] In the future, an increasing domestic market for milk and manufactured dairy products could generate economic activity and increase workforce demand in regional areas.

Automated dairy farms. In 2014, around 25 dairy farms across Australia were using robots to milk cows.[112] On robotic dairy farms, electronic tags are used and cows are trained to walk to the milking parlour where they are milked by a robotic arm. As robotic dairies are fully automated and do not require ongoing monitoring of milking sessions, they substantially reduce the need for human labour. The quality and amount of milk produced by individual cows can also be monitored.

Adopting automated milking systems in Australia is likely to increase once early adopters overcome the initial obstacles that come with new technology.[112] Automated milking systems could also potentially improve the working conditions and lifestyles of many dairy farmers, and provide advantages to the Australian economy. In practice, however, farmers are likely to find their work routines changed rather than reduced.[212] In addition, the sparseness of Australian dairy farms, compared to the denser operations in Europe, makes the adoption of automatic milking systems more challenging.[209] Also, widespread adoption of automated milking systems will likely demand technical support and workers with skills in data collection, analysis and storage.[209] Therefore, establishing specialist training for installing and repairing robotic dairies might be crucial to ensure that the benefits of automated farms are fully realised.

CASE STUDIES

Growing regional workforces through refugee resettlement

The town of Nhill, in Victoria's wheat-belt region, has become a centre of resettlement by Karen refugees from camps along the Thai–Burma border. As of 2014, the Karen community comprised approximately 10% of the Nhill population.[213] This migration boosted the local population and labour force participation, and had a number of positive economic and social impacts.

The initiative was started by the general manager of Luv-a-Duck, a Nhill's poultry producer, who made contact with the resettlement agency AMES Australia to recruit workers from the Karen community. Over the course of five years, around 160 Karen people came to Nhill. Of those, 54 adults were employed at Luv-a-Duck and 26 worked across other businesses.[213] Several Karen people also established their own businesses, including a grocery store, an artisan home goods store and a poultry supply business.[213,214] Karen migration has directly increased labour force participation. As of January 2014, an estimated 70.5 full-time equivalent positions had been added to the local economy.[213] As labour supply increased in the area, the measures of gross regional product, employment and household consumption all increased accordingly.[213] The overall economic impact is estimated to be around $42 million over the five financial years between 2009 and 2014.[213]

The resettlement has also had numerous positive social impacts. Importantly, the influx of new residents (many of whom are young adults and families with children) has partially offset Nhill's aging and declining population.[213] The Karen community has also generated demand for new and additional services from the local shire council and other service providers. Their use of local services (e.g. the enrolment of Karen children at local schools) has helped these institutions to secure increased funding.[213] The local Hindmarsh Shire is also planning to use the Karen resettlement in its case to secure more government funding.[213,215] Other positive social impacts include an improved standard of living for the Karen people (compared to Melbourne, where housing is much more expensive), an increase in social interaction and acceptance between the Karen and non-Karen residents of Nhill, and the development of new skills even among non-Karen residents (for example, the Karen language is now taught in a local primary school).[213,216]

Given its uniformly positive economic and social effects, this resettlement initiative could serve as a model for other small rural and regional towns facing the pressures of a declining population, low labour supply, and a struggling economy.

Shrinking regional workforces due to declining water availability

The community of Dirranbandi–Hebel in south-western Queensland, has experienced major population and workforce declines, largely due to the decreasing availability of water for agriculture. The prolonged drought in the area has placed a strain on the agricultural industries and workforce. Furthermore, Dirranbandi–Hebel sources its water from the Condamine–Balonne catchment within the Murray–Darling Basin and has been subject to water buybacks since 2011. The effect of these buybacks has seen a 20% reduction in water available for irrigation.[217] While the early 2000s saw major population increases due to the development of local irrigation farms and the associated need for staff, seasonal workers and support businesses, decreasing water availability and water buyback schemes have seen the closure and departure of many agricultural businesses and their suppliers.[217] For example, the owner of one agricultural supply business lost four major clients overnight when they decided to sell their licences back to the government in 2013.[217]

Work opportunities for agricultural contractors (e.g. cotton and wheat carting) have also diminished in the area. For example, one transport operator earned $170,000 carting cotton out of Dirranbandi in 2011, compared to $8,000 in 2015.[217] When work opportunities disappear, these contractors are unable to engage sub-contractors, which leads to further employment declines. Additional pressures arise from the fact that contractors in neighbouring areas are now competing fiercely for the limited work available.[217]

These developments have had significant impacts on the local population and employment. Between 2001 and 2011, the Dirrabandi population declined by 22%.[217] Most of this decline was in the farming community, which suffered a decline of 96 people (39%). In comparison, the town population fell by 70 people, or 14%.[217] Notably, the town's population also became significantly older over that period, with the share of people aged 45 years and older increasing from 28% to 42%, due to both the aging population and migration of young people away from the town.[217]

A drop in employment simultaneously occurred with declines in population. Employment in Dirranbandi–Hebel is concentrated in the agriculture and agriculture supply sector, which represented 61% of all jobs in 2011. However, employment in this and other sectors has been falling. Between 2001 and 2011, total full-time equivalent employment decreased by 23% (79 jobs), and employment in the agricultural sector decreased by 14% (26 jobs).[217] These declines have also impacted local services. For example, the number of students enrolled at the local school has dropped from 130 to 60.[217] The continued migration of people away from Dirranbandi, especially from the farming community, will further decrease the available workforce and exacerbate the challenges faced by the town.

EXPLORING **THE FUTURE**

The key trends from the previous section of this report identified a range of influencing factors shaping the future of the Australian agricultural workforce. However, the identified trends do not point towards a single future. The data reported in the trends are historic and can only signpost possible impacts in the near term. Relevant uncertainties remain around what the agricultural workforce will look like in 2030 and the factors that will influence its development. Therefore, to analyse the longer term future, multiple alternative futures for the Australian agricultural workforce need to be considered.

Using the trends identified previously as the evidence base, this section describes four plausible scenarios shaping the future of the Australian agricultural workforce in 2030. Scenarios are evidence-based narratives about the future at a set point in time and are an estimation of how the identified trends are likely to unfold over this timeframe. Because the future is uncertain and unpredictable, it is important to consider multiple scenarios.

The scenario planning process requires us to select axes that have the highest level of impact and broad uncertainties relating to the changing demand and supply of agricultural workforce over the next decade. In reality, there are countless sources of uncertainties and impacts buried within trends. The axes do not capture everything that matters in detail, but instead they help to establish a simplified model of a much more complex reality.

Informed by the horizon scan of trends and discussions with stakeholders in interviews and workshop, our analysis identified economic development across Australian small cities and large towns (regional development), and technology advancement and uptake across the agricultural sector as the two continuums of highest level of impact and uncertainty. The extent of regional development over the next decade will play a major role in providing the needed agricultural workforce to meet the growing global demand for food. Regional development refers to infrastructure investment in transport and demographic shifts (e.g. changing migrant resettlement and internal migration patterns). However, as regional development across Australia is likely to vary from one town to the next, there is much uncertainty around the risks and opportunities of development.

Likewise, there is also much uncertainty around the extent of technology advancement and uptake across the agricultural sector. Even though it is likely that technology advancement and adoption will accelerate over the next decade, uncertainties remain around just how quickly this will occur across Australian farms. There is a future where automation and robotic technologies could come to full fruition and replace many agricultural jobs of today. However, there is also a future where technologies fail to deliver on their promises and only some job tasks become automated. These two ends of the spectrum are likely to demand different workforces and skill sets.

Other aspects of the current and emerging workforce-related trends (e.g. social and demographic, economic and environment) are important, but do not have the same extent of both impact and uncertainty. Rather than characterising these aspects as key areas of uncertainty in this report, we explore their impacts on Australian agricultural jobs and employment towards 2030 in the context of the four scenarios.

Representing the two broad continuums of uncertainties as two axes, and crossing them, creates a four-quadrant conceptual scenario model (see **Figure 18**).

In the remainder of this report, we will describe the two axes and the scenarios they create. Each axis endpoint is supported by evidence that validates the plausibility of that future playing out towards 2030. These scenarios collectively represent extremes, though events that transpire within them could be situated anywhere along these axes. Each scenario tells a story of how these uncertainties might interact and shape the agricultural workforce in 2030. Extending beyond the agricultural workforce, the scenario narratives also impact the wider food and fibre systems, including the Australian producers, post farmgate service providers and the natural environment. The value of scenario planning is not in making accurate predictions. Scenarios do not have to be ‘correct’ to be useful, but should shine a light on blind spots and challenge conventional thinking. The aim of developing scenarios is to prompt strategic thinking and conversations around plausible future conditions, and present possible future opportunities, risks and implications.

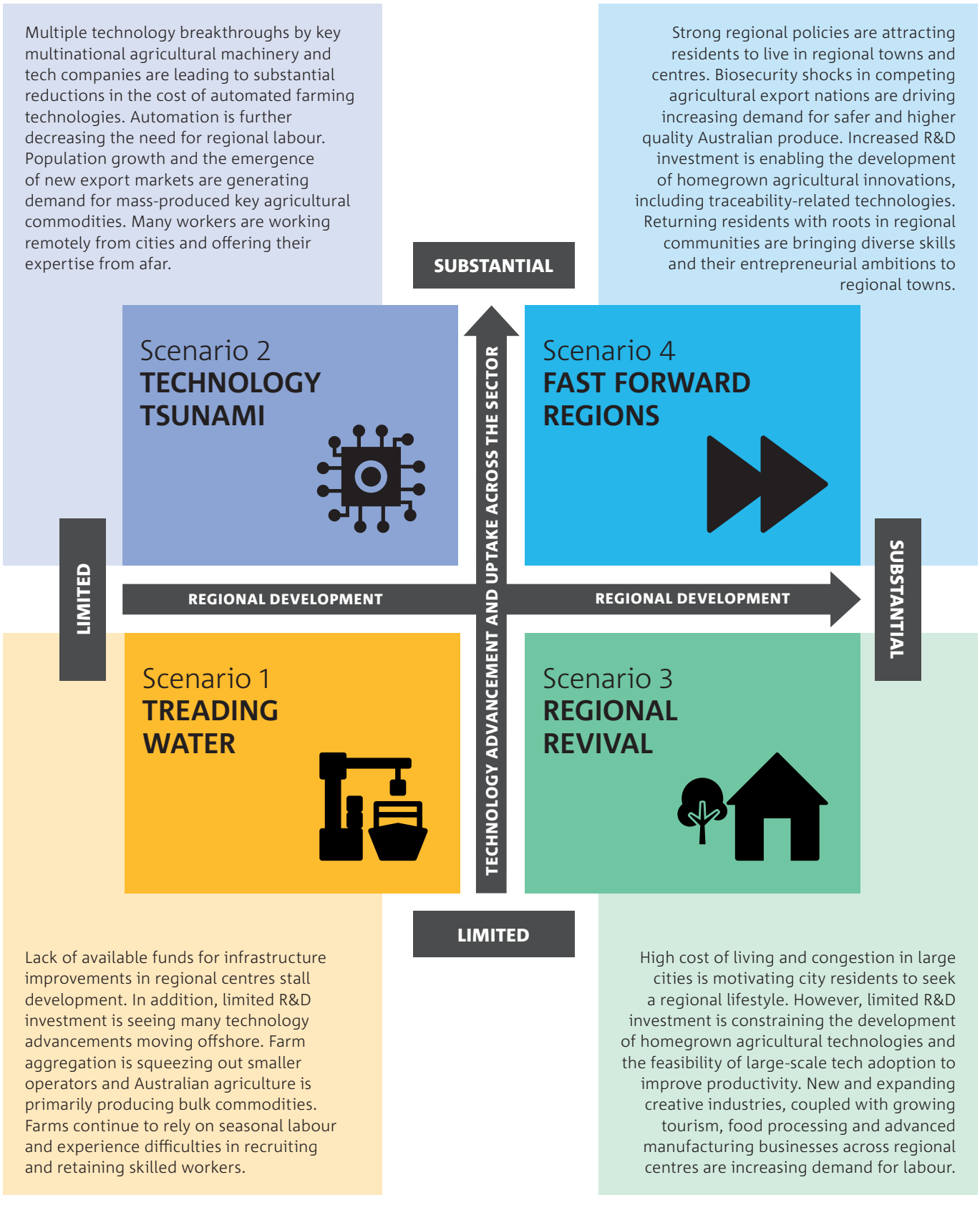


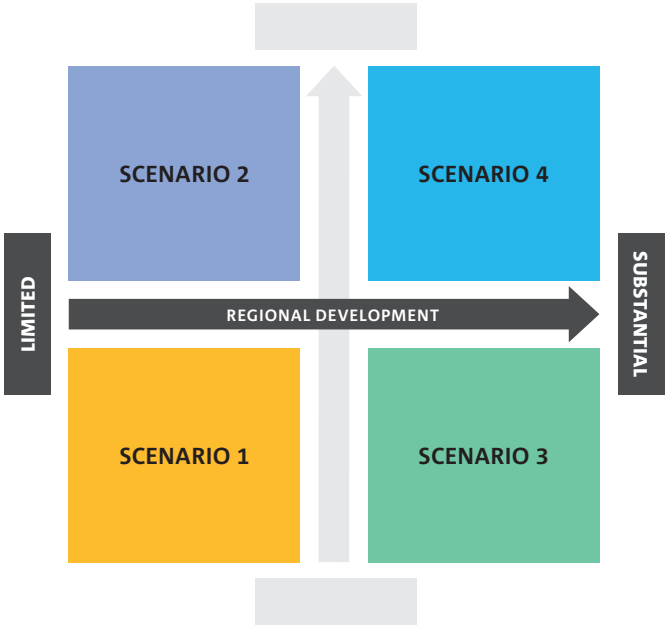
Figure 18. Four plausible future scenarios describing the Australian agricultural workforce in 2030.

HORIZONTAL AXIS
REGIONAL DEVELOPMENT

The horizontal axis highlights the uncertainty around the extent of regional development across Australia over the next decade and how this will likely shape the agricultural workforce. Will urbanisation persist and people continue to move from regional areas to major cities, or will regional centres across Australia become increasingly attractive to those living in the city?

The degree of regional development in small cities and large towns of Australia will play a substantial role in determining the future agricultural workforce. Regional development will be impacted by various factors, including internal migration, population policy, climate impacts on agricultural land, the viability of agricultural businesses, and the ability to attract workforces to regional centres across the agricultural, healthcare, trade, service and education sectors.

It is plausible that there could be substantial development across many regional centres over the next decade. Rising house prices, overcrowded services and traffic congestion create increasing pressure on major city residents to move to small cities and large towns. The slower pace and more affordable lifestyle of regional centres have the potential to attract a socio-economically and culturally diverse Australian workforce motivated to gain access to new job opportunities and markets. On the other hand, if regional residents, especially those from younger generations, continue to leave rural areas for better education and career opportunities in major cities, regional development will likely stall and in turn negatively impact the agricultural workforce and overall productivity of Australian agriculture.



LIMITED REGIONAL DEVELOPMENT

In this future, urbanisation continues across Australia and high-density apartment living remains an attractive and affordable option. Most migrants in Australia choose to move to cities and remain in them. Minimal changes to immigration policy mean that migrants continue to reside in large cities. Extreme heat, fire risks and rainfall events become more common in areas across the country as global temperature rises. These events mean that some regional areas experience water insecurity and become too hot or flood prone to attract new residents or industries, which in turn contributes to stunted regional development. Lack of population growth across regional and rural Australia has led to a shortage in skilled agricultural labour in these areas and has also restricted funding for infrastructure improvements in regional centres. As a result, key industries and services, including construction, schools, hospitals, aged care, banks and retail are moving away from small cities and large regional towns. In addition, family-operated farms find it difficult to attract and retain a functioning workforce as younger generations move away from regional areas in search of better opportunities in major cities. Corporate operations with the resources to source and offer attractive packages to skilled workers are more successful in retaining their workforce and begin to dominate the sector. Increasing aggregation of farms reduces the number of jobs available across the sector. There is also an increasing preference towards contract arrangements for positions in remote locations.

Evidence supporting limited regional development

- Between 2006 and 2016, the rate of exit from the agricultural sector was high among all categories of agricultural employees, ranging from 42.6% among owner-managers to 73.3% among low-skilled employees.[1,22]
- Rural out-migration of youth is an observed phenomenon in Australia, and the proportions of young people leaving home are highest in the drier, remoter, more agriculturally dependent regions.[49] This is driven by a combination of economic and lifestyle factors. Many young people face limited job opportunities in rural and regional areas, but are also enticed by the 'bright lights' of urban living.[49]
- Most migrants moving to Australia tend to reside in large cities and very few of them leave urban areas.[218] The few who do initially move to regional areas tend to out-migrate to cities over time.[218]

- Changes in Australia's climate are likely to make some locations unliveable for many. The Australian Government's State of the Climate 2018 report identified increasing frequency and severity of droughts, bushfires, heatwaves, rainfall and floods across large parts of the country.[136] While cities may be affected by some of these events, there is more infrastructure and services to support city residents during extreme weather events compared to regional Australia.
- Declines in key industries and services, including schools, hospitals and aged care, could be some of the contributing factors towards lower life expectancy and higher rates of disease and injury among rural and remote communities compared to those living in major cities.[219] These declines are also impacting the wellbeing and sustainability of the remaining regional communities, and making rural in-migration less likely.[102]
- Aggregation of farms is evident in the 50% reduction in the number of broadacre farms between 1978 and 2007, and the concurrent 30% increase in the average land area operated per farm.[81]
- The agricultural sector has one of the lowest median personal incomes of any Australian industry, which could discourage people from beginning a career in agriculture.[22]

SUBSTANTIAL REGIONAL DEVELOPMENT

This future sees transformed regional centres with high levels of employment and access to high-quality healthcare and schools. More people moving to regional centres means that there is now an increasing number of people available to take on work in agriculture. However, the agricultural sector is competing with other industries for the available workforce. This need for talent is driving efforts to incorporate agriculture into Australian school curricula. Due to the greater opportunities and education prospects, young people from regional areas are staying in their hometowns and more young city residents are moving to regional areas for career opportunities in agriculture.

Changes to population policy have encouraged new migrants to reside in large regional centres. In addition, rising property prices and the increasing cost of living in large Australian cities have made moving to regional towns more attractive to the younger generation. An increasingly mobile workforce is enabling more professionals to work anywhere. As a result, regional areas with pleasant climate and access to the ocean, as well as parks and green spaces are experiencing a population boom. Infrastructure development across Australia is giving regional residents easy access to healthcare and services. This increased population is supporting workforce growth within agriculture and other industries.

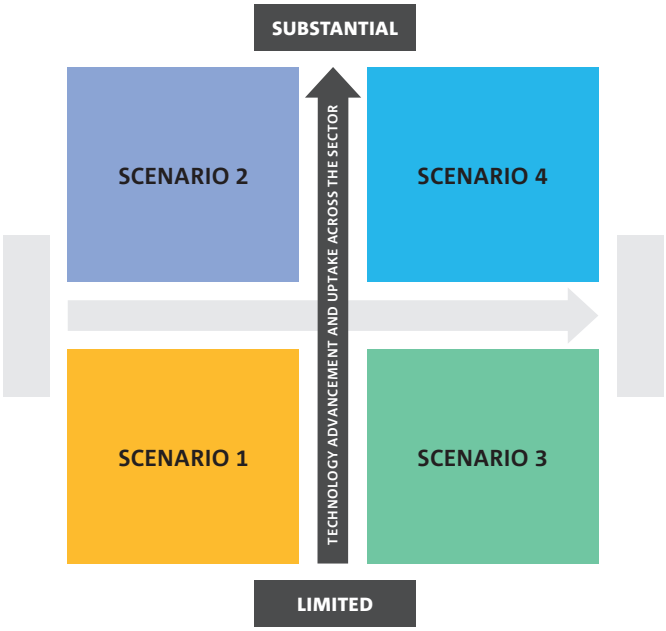
Evidence supporting substantial regional development

- Housing price pressures could be a major driver of regional migration, as house prices have grown in most Australian capital cities since 2011.[220] The cost of housing in many of these cities has been characterised as 'severely unaffordable', particularly in Sydney where house prices relative to incomes are more than double the level of the early 2000s.[221]
- The effect of housing prices on regional migration is already observable. Regional housing markets have recently grown as people move out of major cities to seek more affordable options.[222]
- As the desire to avoid a lengthy commute is one of the main reasons why Australians move house or change jobs, the worsening congestion in every major city could act as another factor encouraging people to leave urban areas.[223,224]
- There have been recent attempts and widespread discussions about immigration policies that emphasise decentralisation. The Australian Government has announced new regional visa programs and tertiary scholarships for international students to study in regional areas.[225]
- Changing business and employment models are supporting an increasingly mobile workforce across Australia.[226] With internet access, teleworking is becoming an increasingly popular option among many Australian workers who are using teleconferencing and videoconferencing, cloud computing and digital platforms as tools to connect with colleagues and work remotely.
- Over the financial year ending in 2017, around 45% of employed Australians had accessed the internet for home-based work.[227] The continuing popularity of teleworking makes rural and regional living more feasible for many professionals.
- Building new infrastructure across regional Australia will further assist with easy travel and opening up the regions for future development. For instance, the Infrastructure Priority List released in February 2019 included numerous projects aimed at improving the capacity and safety of regional transport infrastructure.[228] In particular, the government plans to invest $4.5 billion in the Roads of Strategic Importance initiative, aimed at efficiently connecting agricultural and mining regions to ports, airports and other transport hubs.[229]
- Some regional areas in Australia are already seeing population growth, and these trends could drive further growth and regional development.[57]

VERTICAL AXIS
TECHNOLOGY ADVANCEMENT AND UPTAKE ACROSS THE SECTOR

Technology advancement across the agricultural sector could potentially transition the traditional agricultural workforce into a new era of farming. The vertical axis highlights the uncertainty around technological advancement and adoption across the agricultural sector over the next decade.

Developing and adopting agricultural technologies will be crucial determinants of Australia's future agricultural workforce. Advancements in remote sensor and data-collecting devices are enabling detailed monitoring and efficient management of agricultural resources, such as water, animal health and milk production, without the need for human labour. Innovative farming techniques, including auto-steering, vertical farming, robotic dairies, high-tech greenhouse facilities and lab-grown agricultural produce, are changing the face of modern farming. The next ten years could see these technologies continue to progress and have substantial impacts on the size, demographics and skills of the agricultural workforce. However, agricultural technologies provide competitive advantages only to those capable of adopting them. Without reliable telecommunications infrastructure and a requisite skilled workforce to apply and integrate new technologies to farm practices, the ability of Australian farms to compete in the future could be affected, which could in turn, disrupt the agricultural workforce and the sector as a whole.



LIMITED TECHNOLOGY ADVANCEMENT AND UPTAKE ACROSS THE SECTOR

In this future, large-scale adoption of agricultural technologies across the sector has not been feasible. Minimal investment in research and development (R&D), high costs of technology, difficulties in integrating new technologies into on-farm operations, fear of risks and lack of data sharing have contributed towards limited technological advancement across the sector. Compared to international competitors, Australian farm operators have struggled to optimise outputs through digitisation over the past decade. Although young people are studying science, technology and engineering at school, they are not necessarily acquiring the technological knowledge and skills to efficiently develop, optimise, monitor and repair agriculture technologies. In addition, many regional and rural areas across Australia continue to experience internet connectivity issues. New agricultural technologies are largely developed for and adopted by large corporate operations. Economies of scale and market power are enabling these operations to tailor new technologies to their specific needs.

Evidence supporting limited technology advancement and uptake

- Many farms in Australia still do not have access to reliable internet due to the telecommunications gap between urban and rural areas. On average, capital cities score 8.5 points higher on the Australian Digital Inclusion Index (ADII) than rural areas in terms of digital ability, internet access and affordability, and the majority of dryland farmers report poor to very poor internet and mobile phone access.[101,102]
- Australia's domestic spending on R&D is relatively low. The latest data show that Australia spends 1.9% of its GDP on R&D, compared to the OECD average of 2.4%, which may further limit the technologies available to farmers.
- Where agricultural technologies have been developed, barriers to adoption among Australian farmers include the time-cost of evaluating all the options, and difficulty in integrating technologies into on-farm practices.[230,231]
- Adoption can also be hindered if the technology does not present a clear value proposition, and adopted technology is often quickly abandoned if benefits are delayed.[231,232]
- A 2017 analysis examining the digital opportunities and threats across seven major sectors of the Australian economy found that the agriculture sector was the least digitised sector compared to all other sectors surveyed.[233]
- An absence of well-coordinated national agricultural data for farm operators to access is seeing Australian agriculture lag behind competing nations.[234]

- The cost of technology is also a barrier, especially for smaller farms. Large farms are among those who can afford to adopt new technologies.[13] Larger farms are also more likely to have the ability to integrate technologies into on-farm practices.
- A survey conducted in 2016–17 showed that lack of skills was most commonly reported by owners of small farms as a barrier to technological adoption.[13] These skills are likely to be more prevalent in younger generations who have grown up as 'digital natives'. However, as agricultural education and training enrolments decrease and rural out-migration impacts the next generation of farming families, younger people are less likely to bring these skills to the agricultural workforce.[48,51]
- The availability and management of data presents another possible issue. There is a lack of available farm data on varying soil, climate and weather conditions across Australia.[235,236] Farm operators are concerned about data privacy and ownership, and are therefore less likely to participate in data-sharing schemes.[237]

SUBSTANTIAL TECHNOLOGY ADVANCEMENT AND UPTAKE ACROSS THE SECTOR

This future sees sector-wide development, adoption, management and integration of new agricultural technologies and machineries. Some tech giants that are already flooding the general consumer market with new technology solutions have begun to move into agriculture and are developing and adapting new applications to the varying needs of farm operators. In addition, high-speed internet connections and telecommunications networks have been established across regional and rural Australia.

Technology advancements and increased uptake across the agricultural sector have attracted a skilled workforce for establishing well-coordinated, Australia-wide agricultural data. Farm operators can now access large datasets that provide real-time information on water and power usage, crop growth, livestock movements, maintenance alerts and market prices. In addition, the availability of large agricultural datasets across the supply chain is providing consumers crucial information on the safety and quality of the agricultural produce. The use of technology is extending into classrooms, where agriculture is often one of the applications for science, technology and engineering solutions explored in schools.

At the same time, reliable internet and telecommunication connections are enabling smaller operators to tailor broad-use technology solutions to the needs of their farm. Technology is now carrying out many of the low-skilled and repetitive on-farm tasks, and reducing pressures on the low-skilled labour that was in high demand a decade ago. Further, the adoption of technology-based practices like precision agriculture across Australian farms is increasing agricultural productivity and facilitating the efficient use of precious resources such as water.

Evidence supporting substantial technology advancement and uptake

- Remote sensors and data-collection devices that allow detailed monitoring and management of agriculture resources, such as water availability, animal health and milk production, without the need for hands-on labour have been advancing.[91,92,94,95]
- Large technology companies are investing in startup companies developing new agricultural data platforms. In 2018, Google and Temasek were the key investors in the development of a new business network platform that has the potential to become a 'Google for farmers'.[238]
- Integrating agricultural data across the supply chain can provide food safety assurances to consumers. For example, working with a number of key universities, the United States Food and Drug Administration (FDA) established the 100K Pathogen Genome Project that maps thousands of foodborne pathogens to identify food safety risks.[239]
- In the United States, open data initiatives that provide farm operators access to well-coordinated agricultural input data are enabling data-driven decisions and improving overall farm productivity.[234]
- There have also been major advancements in automated technologies, including auto-steering of farm machinery, robotic dairies and automated greenhouses.[113,162] For example, Sundrop Farms, that was established in 2010, uses renewable energy and high-tech greenhouse facilities that rely on a variety of technologies for growing fruit and vegetables in dry and hot locations where traditional agriculture would not be feasible.[91] In another example, automated milking systems now use robotic arms to carry out traditional manual labour of washing and milking cows.[209]
- Other high-tech agricultural production methods, including indoor vertical farming and lab-grown meat derived from animal cells can lead to production of high-quality agricultural products anywhere and in any climate.[92,93,240]
- Technological advancements and automation have the potential to replace low-skill manual tasks, delivering massive savings by reducing labour costs.[73] High-tech agriculture will demand a new type of agricultural workforce to develop and manage the technology, and has the potential to attract more tech-savvy workers to the sector.
- The agricultural sector also has a long history of using new technologies to improve productivity.[120] In addition, the rollout of 5G internet and other telecommunications infrastructure could further enhance the use of technologies in agriculture.[103,104]

THE **SCENARIOS**

SCENARIO 1: TREADING WATER

KEY TRIGGERS

- Continued migration out of regional centres
- The Australian economy stalling from another global financial crisis
- Increasing cost of investment capital
- Low investment in R&D
- Lack of available funds for infrastructure improvements in small cities and large towns

The Treading Water scenario is a future with limited regional development *and* limited advancement and uptake of technologies across the agricultural sector.

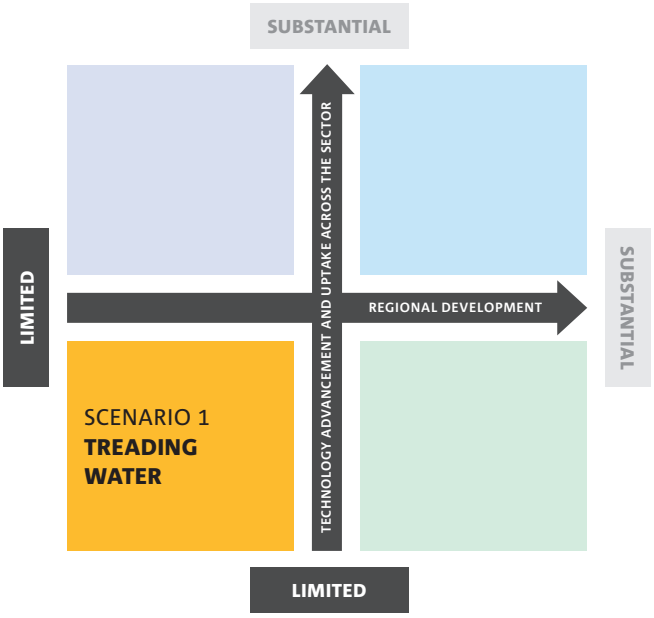
SOCIAL AND DEMOGRAPHIC CHANGES

Urbanisation continues, with many young people moving out of agriculture dependent regions to major cities for better employment, education and lifestyle opportunities. Like most city residents, these people are opting into high-density apartment living as the most affordable and convenient lifestyle.

ECONOMIC CHANGES

Population declines across many regional centres of Australia, coupled with increasing cost of investment capital has restricted the availability of funds for infrastructure improvements in regional towns. As a result, many national industries and services are moving out of regional towns, with only those community and local organisations that have been traditionally embedded in regional networks remaining. Reduced access to a variety of services is impacting the viability of the remaining businesses and the wellbeing of the remaining regional communities.

Many family-operated farms are finding it increasingly challenging to attract and retain suitable workers. However, corporate operations with the resources to source and offer attractive packages to skilled and seasonal workers are more successful in retaining their workforce. As a result, large corporate operations now dominate the sector and are leveraging on economies of scale. Continuous aggregation of farms has resulted in further declines in the number of agricultural jobs available. Consequently, the agricultural workforce in regional areas struggles to grow.



TECHNOLOGY CHANGES

Around the world, there are advancements in remote sensor, robotics and data-collecting devices that enable detailed monitoring and efficient management of agricultural resources without the need for human labour. In addition, new innovative farming techniques, including vertical farming, robotic dairies and high-tech greenhouse facilities, have emerged and are becoming more mainstream across many European countries. However, low investment in R&D in Australia limits further advancement of domestic agricultural technologies and has in turn impacted Australia's ability to compete on the global market. Most small farm operators are finding imported technologies too expensive and time consuming to fully integrate into the unique conditions and practices of their farm. Larger operators with the capital to invest in new agricultural technologies are the main adopters, as economies of scale and market power allow them to tailor new technologies to their specific needs. However, even these operators struggle to find a reliable domestic workforce with the requisite skill set for optimising, developing, monitoring and repairing these new technologies.

In addition, limited internet access in regional areas is presenting challenges when connecting new technologies. There is an absence of well-coordinated long-term weather data that can be used to assist farm operators to generate their own real-time local environmental data and make better informed farm management decisions. Agricultural businesses, faced with uncertainties around future productivity and profits, rely heavily on contract workers. Also, a lack of coordinated farm and production data across the supply chain means that data for gaining access to premium export markets are not transparent. In turn, this limits the potential for developing a workforce in Australia focused on designing and operating increasingly sophisticated technology for tracking produce across the supply chain. As a result, Australia relies on bulk commodities rather than value-add premium produce.

Can the Australian agricultural sector remain globally competitive and viable?

ENVIRONMENTAL CHANGES

Increasing environmental pressures, water scarcity and input constraints are slowing down agricultural production across most Australian farms. Limited adoption of water-saving technologies is seeing declines in water availability. Limited uptake of new technologies mean that existing environmental problems, like nitrogen leaching and greenhouse gas emissions, continue unabated as there are no new effective technological solutions. As technology is not delivering many water-saving techniques or new crop varieties, water availability is the key defining factor determining the success or failure of farms.

Farm aggregation continues as small farms are bought by larger ones

Low-skilled labour is needed as most smaller farm operators find imported technologies too expensive and time consuming to fully integrate into the unique conditions and practices of their farm

Farm operators faced with uncertainties around future productivity and profits, rely heavily on contract workers

IMPACT OF THE **TREADING WATER** SCENARIO ON THE AUSTRALIAN AGRICULTURAL WORKFORCE, PRODUCERS AND POST-FARMGATE SERVICE PROVIDERS

GROUP	IMPACTS
Agricultural workforce	• Struggles to grow in regional areas • Many young people are unaware of the potential opportunities of a career in agriculture • Lower demand for high-skilled workers because of low adoption of technology • Remains highly reliant on seasonal and working holiday labour programs • Limited availability of full-time workforce for farming and regional food-processing industries • Lacks the requisite skill sets for optimising, developing, monitoring and repairing new agricultural technologies
Producers	**SMALL FARM OPERATORS** • Experience more difficulties in boosting production • Face challenges around attracting and retaining suitable workers • Find imported technologies too expensive and time consuming to fully integrate into the unique conditions and practices of their farms • Have limited internet access in regional areas, which presents challenges when connecting new technologies • Find it hard to see the value of integrating various technologies to their on-farm practices **LARGE FARM OPERATORS** • Dominate the agricultural sector • Have the resources to source and offer attractive packages to workers and are more successful in retaining their workforce • Have the capital to invest in new agricultural technologies and are the main adopters. Economies of scale and market power allow large operators to tailor new technologies to their specific needs
Post-farmgate service providers	• Find it difficult to coordinate to provide the necessary transparency to access premium global markets • Have not adopted a sufficient level of technology to support the emergence of high-tech and related service providers

IMPACT OF THE **TREADING WATER** SCENARIO ON THE HORTICULTURE, GRAIN, LIVESTOCK AND DAIRY INDUSTRIES

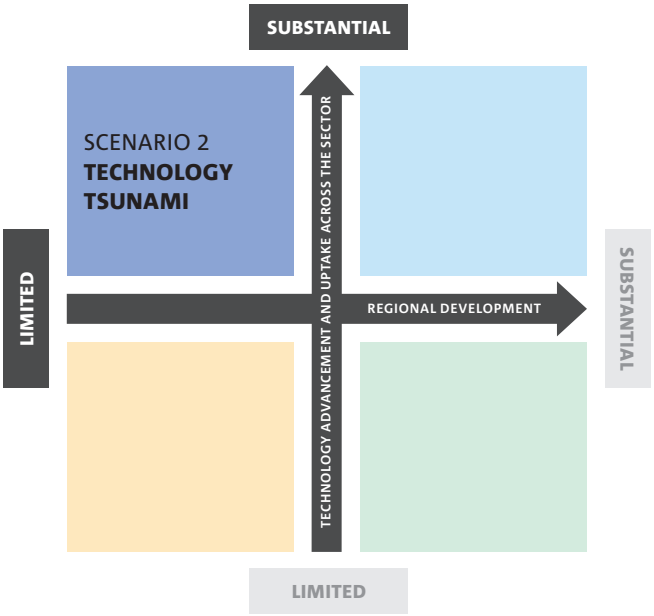
	HORTICULTURE	GRAIN	LIVESTOCK	DAIRY
Industry structure	• Farm aggregation sees many smaller horticulture farms disappear and the surviving small farms find it very difficult to compete for market access. • Australia continues to primarily focus on bulk horticulture commodities and is seeing greater competition from other nations with lower labour costs.	• Rising wheat exports from Ukraine and Russia over the past decade mean that Australian wheat exporters are facing increased competition for existing customers and are struggling to compete on price. • Although most Australian grain growers continue to focus on producing high-quality and reliable bulk exports, some are finding it challenging to compete with lower cost competitors. • To cut down on costs, grain businesses continue to aggregate into enormous operations that require a very small workforce with higher skill levels.	• Heightened consumer concerns over animal welfare and food safety, coupled with a lack of provenance and assurance technologies mean that consumer attitudes are not well disposed towards the livestock industry and its corresponding workforce. • Increasing distance to local abattoirs coupled with consumer concerns over animal welfare are seeing some niche livestock farmers operating their own micro-abattoirs and developing their own branded meat products. • Australia continues to trade as a premium meat seller on the global market, but maintaining this status is becoming increasingly difficult as competing nations develop their own livestock industries.	• Labour costs remain high compared to competing export nations and farms continue to primarily focus on the domestic market. • Struggling dairy businesses supplement income by other means, and there is some trading of water licences with other agricultural businesses. • There is relatively little diversification from the existing bulk production of cheese and milk varieties. • Farm aggregation continues to be driven by the greater productivity-per-cow and lower labour inputs of larger operations.
Technology	• Thin margins on horticulture farms mean investment into new technologies is not attractive to many investors. • Automation technologies have been developed for some horticulture orchards, but the capital investment requirements are too high for most farms to consider implementing them.	• As an industry with high level of automation and technology adoption, Australian grain farms see modest uptake of new precision agriculture technologies. • The larger sizes of farm operations necessitate increased use of on-farm transport infrastructure for harvest.	• Lab-grown synthetic meat products have not entered the market due to the lack of necessary regulatory approval systems and consumer resistance. • Poor connectivity in key grazing regions hampers uptake of electronic tagging systems.	• The uptake of automated milking systems is slow, due in part to difficulties maintaining the technology and finding suitable workers. • The upfront capital investment required proves to be a deterrent to farmers wary of taking on debt in an uncertain market. • There has been some post farm gate development in supply chains, but these improvements are not transformative for farmers or consumers.
Labour supply and demand	• Horticulture farms continue to struggle to access enough local labour and rely heavily on temporary overseas worker programs. • The larger, well-resourced farms are better able to attract and hold on to seasonal workers. • Reduced government services to regional areas make permanent labour pools even scarcer. • Young talent chooses other areas to apply innovative ideas.	• While labour inputs are kept fairly low, high-skilled labour is in demand. However, grain operators are finding it challenging to find high-skilled labour in regional areas. • Grain operations need to recruit from afar and develop strong incentives and packages while competing for available talent. • Farm operations gradually shift to areas with more stable and higher yields of grain.	• With relatively high margins, the beef industry is better positioned to attract high-skilled talent compared to other agricultural industries. • However, competition for labour between livestock businesses is also substantial. • Low-skilled labour is still needed in the meat-processing industry.	• Recruitment continues to be a challenge for dairy businesses. • Changes in labour hire patterns are driven more by farm aggregation than by technological development or automation, with a shrinking proportion of family operations. • The use of both high-skilled and low-skilled labour continues on dairy operations, but other agricultural industries are able to offer more competitive salaries. • Many dairy operations are working to find creative ways to attract and hold on to labour.

SCENARIO 2: TECHNOLOGY TSUNAMI

KEY TRIGGERS

- Multiple technology breakthroughs by key multinational agricultural machinery and tech companies lower the price of automated farming technologies
- Developments in automation and remote-sensing technologies enable more people to work remotely from urban areas

The Technology Tsunami scenario is a future with limited regional development *and* substantial advancement and uptake of technologies across the agricultural sector.



SOCIAL AND DEMOGRAPHIC CHANGES

The increasing aggregation of farms and automation of many on-farm tasks drastically reduces the number of agricultural jobs in regional areas. As a result, many regional residents, especially those from younger generations, move away from rural areas for better education and career opportunities in large cities. Low-skilled workers in regions who cannot afford to move to the city struggle to find work. At the same time, accelerated urbanisation puts increasing pressures on the availability and affordability of housing in large cities. High-density apartment living is now the only affordable option for much of the agricultural workforce living in cities.

ECONOMIC CHANGES

Large population declines in regional and rural areas of Australia result in further cuts to infrastructure funding. Key industries and services, including construction, schools, hospitals, aged care, banks and retail, struggle to make a profit in regional centres. Consequently, many of them either close or move to the large cities. This reduced access to services is impacting the wellbeing of the remaining regional communities, and further reduces rural and regional in-migration.

Although there is a growing domestic market for niche agricultural products, population growth and the emergence of new export markets are still generating demand for mass-produced key agricultural commodities. Most of this produce is grown and processed on regional farms that can now be fully automated and operated remotely from large cities.

TECHNOLOGY CHANGES

The decade leading up to 2030 has seen sector-wide boom in technology and machinery development, adoption, management and integration. Large technology companies and agribusiness corporates carve out out niche opportunities in agriculture by developing hardware and software to boost both pre- and post-farmgate efficiencies. In addition, high-speed 5G internet connectivity and telecommunications networks across regional and rural areas of Australia are allowing farm operators to access real-time data on water, inputs and power usage, crop growth, livestock movements, maintenance alerts and market prices.

In addition, advancements in remote sensor and data-collecting devices are enabling detailed monitoring and efficient on-farm management of water, animal health and milk production without human labour. Farm operators now have access to a variety of applications and tools that draw on large well-coordinated long-term data to optimise inputs and outputs. An increasing certainty around agriculture production is creating more permanent positions across the sector. Also, the automation of many low-skill manual tasks delivers massive labour cost savings to farm operators and lowered pressure on labour supply. However, the profits from these technologies go to the multinational tech companies that developed them, as their effectiveness is in part due to their ubiquity and ability to gather data.

What strategies could be put in place to efficiently transition low-skilled workers to take on high-skilled technology and knowledge-intensive work?

At the same time, innovative farming technologies, including robotics and vertical farming in high-tech greenhouse facilities, have advanced and are integrated across urban areas and are catering for the growing domestic market for niche agricultural products. Agricultural robots adapted for amateur home gardeners are on the shelves of home improvement stores. Supermarkets grow and sell their own niche agricultural produce using enclosed hydroponic farming techniques and are employing more staff to manage this production. The development and integration of agricultural technologies into farm practices, and the changes to food production and distribution, increase the overall size of the agricultural workforce. While many low-skilled jobs have been replaced by automated systems, a larger workforce emerges around the need to develop, control, monitor and maintain automated systems, as well as analyse the data these systems generate. In addition, a more technologically advanced supply chain generates a number of specialised and high-tech jobs. However, because much of the key economic growth from agriculture has not been re-invested into the regions, most of the growth in the agricultural workforce is concentrated in large cities.

Nevertheless, the development and use of agricultural technologies extend into the classroom at all levels of education. Agricultural applications are incorporated into the science, technology engineering and mathematics (STEM) curriculum in both regional and urban schools. Agricultural science courses are now more diverse and are offering young people more specialised areas of study, such as agricultural technology, software development and engineering.

ENVIRONMENTAL CHANGES

New and emerging technologies are increasing productivity within constraints of the changing environment. More investment in agricultural technologies and high rates of adoption are enabling producers to mitigate some impacts of climate change. Adopting precision agriculture across Australian farms is increasing agricultural productivity and ensuring efficient use of water and other resources. In particular, large modern irrigation projects that take advantage of new technologies are substantially improving water use efficiency. However, a lack of improved land management practices to effectively integrate automation and robotic technologies into farms is seeing further degradation of land across some Australian farms.

Population growth and the emergence of new export markets are generating demand for mass-produced key agricultural commodities. Most of this produce is grown on regional farms that can now be fully automated and operated remotely from large cities

Technology is replacing human labour in many of the low-skilled and repetitive tasks across many Australian farms and is thus reducing labour supply pressures

Because much of the key economic growth from agriculture is not being re-invested back into small cities and large towns, the majority of the growth in the agricultural workforce is concentrated in major cities

IMPACT OF THE **TECHNOLOGY TSUNAMI** SCENARIO ON THE AUSTRALIAN AGRICULTURAL WORKFORCE, PRODUCERS AND POST-FARMGATE SERVICE PROVIDERS

GROUP	IMPACTS
Agricultural workforce	• Reduced the demand for low-skilled labour due to automation, but increased demand for high-skilled labour around the need to develop, control, monitor, and maintain automated systems, as well as analyse the data these systems generate • Becomes more concentrated in cities or large towns • Has more high-skilled employees who work in agriculture but mainly reside in cities • Has a relatively small focus on niche products and more emphasis on traditional bulk commodities, which requires a smaller workforce relative to amounts produced and traded • Sees increased certainty around agricultural production, creating more, but still low, permanent positions in some parts of the supply chain • Sees supermarkets employ staff to manage their own niche agricultural produce • Sees a decrease in the reliance on seasonal and working holiday programs • Sees traditional bulk commodities dominate the entire supply chain for niche agricultural products and employ fewer staff to manage their production
Producers	**SMALL FARM OPERATORS** • Continue to shrink in favour of larger operators and are unable to remain viable **LARGE FARM OPERATORS** • Adopt more precision agriculture technologies, increasing agricultural productivity and ensuring efficient use of water and other resources • Use privately owned high-speed 5G internet and telecommunications networks across regional farms, allowing access to real-time data on water, inputs and power usage, crop growth, livestock movements, maintenance alerts and market prices • Increasingly work remotely from cities or large towns
Post-farmgate service providers	• Coordinate operations to provide the necessary transparency for accessing premium export markets • Are concentrated in cities or large towns where farmers increasingly reside

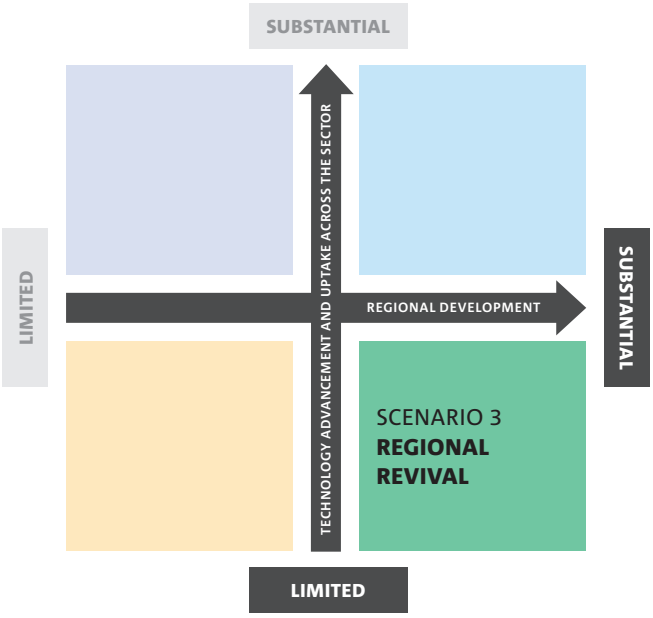
IMPACT OF THE **TECHNOLOGY TSUNAMI** SCENARIO ON THE HORTICULTURE, GRAIN, LIVESTOCK AND DAIRY INDUSTRIES

	HORTICULTURE	GRAIN	LIVESTOCK	DAIRY
Industry structure	• Farm aggregation continues, driven in large part by the productivity gains that large horticulture farms are reaping via technology. • With limited regional development, niche businesses located far from cities or large regional centres struggle to survive. • As regional centres become less attractive destinations, the number of working holiday and seasonal workers has been declining. • Many small family-owned farms have been bought up by larger companies or corporations.	• Australia continues to be an exporter of premium bulk grain products. • The higher cost of labour compared to competing nations like Ukraine and Russia means that Australian grain businesses need to adopt the latest precision agriculture technologies to boost productivity, keep workforce costs down and ameliorate declining yields from the changing climate.	• Australia exports an increasing amount of livestock to markets in Asia. • To compete on the global market, Australian livestock farmers become adept at adopting the latest technologies to boost productivity. • Some livestock farmers take on other initiatives, such as reforestation or external carbon offsets, to obtain a social licence to operate.	• The Australian dairy industry focuses primarily on its domestic market. • Higher labour costs in Australia impact its dairy industry and ability to compete on the global market.
Technology	• Larger farms are the first to automate their on-farm processes. • A reduced need for seasonal labour is giving the larger operators a substantial advantage over their smaller competitors that remain heavily dependent on working holiday and seasonal labour. • Although larger farms are now requiring less labour input due to greater automation, they have more need for high-skilled labour to operate and maintain the technology.	• Advances in technology and its adoption across the entire agricultural sector have established well-coordinated and shared data on agricultural inputs including labour use and skills. • More on-farm technological problems are handled remotely. • Post farm-gate supply-chain activities and food safety processes are now largely automated.	• Australia's ability to export an increasing amount of premium meat has been due to the greater use of tagging and supply-chain provenance technologies. • There are increased competition and price pressures brought about by meat substitutes, such as lab-grown meat. • Grazers are using new monitoring and land-care technologies with more emphasis on sustainable farming. • There is now a greater role for data analysis in boosting productivity.	• Many Australian dairy farms adopt automated milking systems. • A new workforce emerges around the need to operate and maintain automated systems. • Tech companies partner with dairy farms to market and deliver niche dairy products to consumers via various applications on smart devices. • Supply-chain technology advances in biosecurity and provenance are enabling some Australian dairy companies to secure lucrative export opportunities in the rapidly growing and food safety conscious Asian markets.
Labour supply and demand	• Smaller farms are unable to source sufficient local labour during picking seasons and remain reliant on working holiday and seasonal programs. • The extent to which smaller farms find labour during picking seasons depends highly on the global shifts in tourist preferences. • As a result, horticulture farms located closer to attractive tourism destinations can source more working holiday labour than those that are not. • The seasonal worker program fills in labour needs to some degree.	• The grain industry continues to require only low labour inputs. • The additional productivity boosting precision agriculture technologies that are being introduced on farms require an even more skilled and adaptable workforce. • Contractors become more common and help service these labour needs during peak harvesting periods.	• Producing agricultural products with relatively high margins is enabling the livestock industry to better attract skilled labour. • Livestock workers are rarely sourced locally and often engage in long-distance commuting. • Advancements in supply-chain technologies and changing industry demands to stay competitive are requiring the livestock workforce to become more adaptable to the shifting labour demands.	• Automated milking systems are increasing productivity across the dairy industry. • Although automation replaces some low-skilled work, it is now demanding a new set of skills from workers to efficiently operate and maintain the systems. • Competition for labour across other agricultural industries means that the dairy industry needs to develop creative strategies to attract and retain staff.

SCENARIO 3: **REGIONAL REVIVAL**

KEY TRIGGERS

- Continuing growth in house prices and increased cost of living in many cities of Australia
- Small cities and large towns receive investments in key infrastructure (e.g. transport), which improves connectivity between regions and cities
- Limited R&D spend constrains the development of homegrown agricultural technologies and the feasibility of large-scale tech adoption



The Regional Revival scenario is a future with substantial regional development *and* limited advancement and uptake of technologies across the agricultural sector.

SOCIAL AND DEMOGRAPHIC CHANGES

Rising house prices, overcrowded services, growing infill development and traffic congestion in the large Australian cities encourage more city residents to move to regional centres. An increasing number of residents from large cities who have diverse skill sets are attracted to the closeness to nature and more affordable lifestyle that regions offer. They are highly motivated to gain access to new job opportunities and markets in small cities and large towns.

Regional cities and larger towns see substantial development. The added investment in key infrastructure across regional centres, including transport, improves connectivity between regions and large cities and provided residents easy access to high-quality healthcare and schools. Baby boomers are selling up their city properties for a semi-retired lifestyle in regional towns. They have been buying up and running small farms across Australia. The movement of people towards regional centres boosts the regional economy, and creates renewed interest in agriculture as a rewarding and fulfilling industry to consider for career options. Young people from regional areas stay in their home towns, and an increasing number of young people who left in the past decide to move back to their home towns to raise families. Growing regional populations and workforces mean that farm operators closer to regional centres now have easier access to a diverse and readily available supply of labour.

ECONOMIC CHANGES

Farm aggregation continues as an overall trend. However, renewed regional centres and adequate workforce supply contributes to a slowing down of farm aggregation. New opportunities emerge for some small farms to sell locally sourced produce to niche consumers seeking specific quality, local production and/or ethical assurances. As environmentally sustainable and ethically produced agricultural products require labour-intensive practices across the supply chain, more people living in regional centres means that there is more available labour to produce these products. As a result, smaller operations are now thriving alongside larger farms.

At the same time, increased tourism across many regional centres creates more opportunities for the agricultural workforce to take on more off-farm work such as working in tourist accommodation on farms or wineries. Because seasonal workforces now have more employment opportunities outside of the traditional agricultural seasons, they are staying in regional centres and also working in other industries. As a result, there is less of a reliance on migrant labour. However, growing employment opportunities across other regional industries, such as tourism and mining increase competition for labour and talent.

TECHNOLOGY CHANGES

Limited R&D spent over the past decade has constrained the feasibility of large-scale adoption of agricultural technologies across the agricultural sector. Small operators generally cannot afford the upfront costs of adopting and integrating new technologies. Although some large operators that benefit from economies of scale have the market power and capital to invest in technologies, they struggle to find an experienced workforce with sufficient technical expertise to optimise, monitor and repair these technologies. As a result, these large operators have to invest in graduate programs to develop their own workforce. As automation has not substantially altered the composition of the agricultural workforce, Australian labour remains expensive compared to international competitors. Inadequate adoption of technologies across the sector has limited wage growth in agriculture and many farm workers have low-skilled jobs. However, the lower cost of living in regional centres to an extent allows these workers to support their families on lower wages.

Can the agricultural sector compete with other sectors for regional talent?

In addition, many regional and rural areas across Australia still have poor connectivity. Many Australian farms do not have access to reliable internet, which limits their capacity to efficiently manage and use their farm data. However, basic connectivity improvements in regional centres are providing enough coverage for many residents to work remotely much of the time. An increasing number of residents are enjoying the regional lifestyle and have set up home offices.

While increased training and education in agriculture is encouraging a growing number of young people to learn about food and pursue a career in agriculture, students are not equipped with the technical knowledge and skills to develop and manage many of the new technologies. Many regional residents are completing online tertiary and agricultural courses to gain new skills. However, these courses also lack technological content, which in turn limits the extent to which online learners are able to use the learned content to improve farm productivity and efficiency.

ENVIRONMENTAL CHANGES

Increasing regional population is providing the needed hands-on labour, locally, which reduces emissions from long-distance commuting. However, infrastructure and land development in regional cities and large towns reduces the amount of open space and ecological areas. In addition, a growing regional population has increased pressures on water availability. As a result, appropriate government planning policies become an important determinant of the success of both regional and agricultural development. Those able to capitalise on their advantages are the areas that thrive the most. However, areas with inappropriate planning policies see an influx of new residents moving into areas close to large agricultural businesses—generating friction between the agricultural businesses and new residents.

Regional cities and larger towns are seeing substantial development with many city residents moving to regional centres due to rising house prices, overcrowded services, growing infill development and traffic congestion in the large cities

Changing consumer demand for more environmentally sustainable and ethically produced agricultural products that demand labour-intensive practices across the supply chain can now be met more easily

However, there has been added competition for labour and talent from other regional industries like tourism and mining

IMPACT OF THE **REGIONAL REVIVAL** SCENARIO ON THE AUSTRALIAN AGRICULTURAL WORKFORCE, PRODUCERS AND POST-FARMGATE SERVICE PROVIDERS

GROUP	IMPACTS
 **Agricultural workforce**	• Experiences growth as the sector caters to growing consumer preferences for more local, environmentally sustainable and ethically produced agricultural products, which demand labour-intensive practices across the supply chain • Grows in regional areas as youth and middle-aged people opt to stay or migrate to regional areas • Draws more interest from young people, but there are challenges around providing sufficient training for them to efficiently integrate agricultural technologies to on-farm practices • Continues to be served by seasonal and working holiday programs • Sees increased demand from new and expanding creative industries, growing tourism, increasing food processing and advanced manufacturing businesses across regional centres producing niche products for the domestic market • Functions with basic connectivity improvements in regional towns that provide enough coverage for many regional residents to work remotely much of the time
 **Producers**	**SMALL FARM OPERATORS** • Are remaining in large numbers in regional areas but many cannot afford the upfront costs of adopting and integrating new technologies and still rely on human labour • Have increasingly become third-party growers to a greater extent and sell their produce to large operators **LARGE FARM OPERATORS** • Benefit from economies of scale and have the market power and capital to access technologies, but the adoption rate remains limited relative to global competitors • Experience difficulties finding workers with sufficient technical knowledge and skills for optimising and repairing these technologies • Struggle with internet connectivity and data management issues • Invest in internal graduate programs and develop their own workforce
 **Post-farmgate service providers**	• Are able to access the necessary human resources for managing an increasingly complex supply-chain

IMPACT OF THE **REGIONAL REVIVAL** SCENARIO ON THE HORTICULTURE, GRAIN, LIVESTOCK AND DAIRY INDUSTRIES

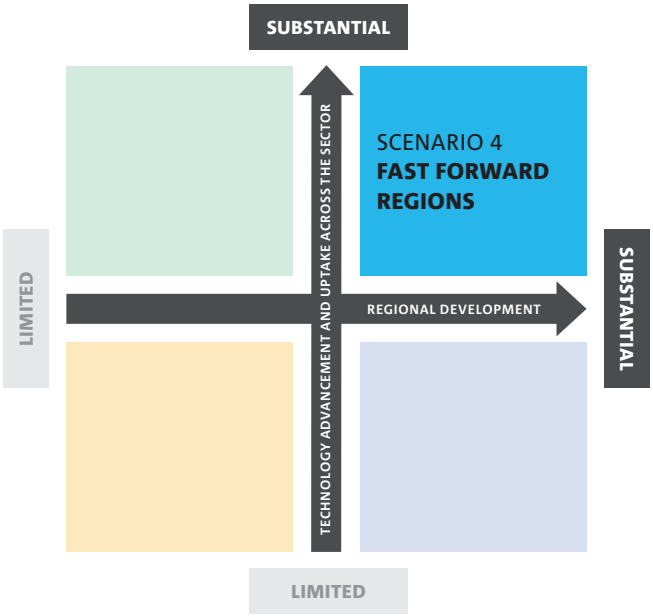
	HORTICULTURE	GRAIN	LIVESTOCK	DAIRY
Industry structure	• Increased demand for locally sourced and niche agricultural products. • Agricultural tourism and accommodation become more common forms of supplementary income for smaller farms. • Farm operators are producing premium agricultural produce that caters to consumers demanding niche or locally produced products. • Some farms are trialling waste-to-energy schemes to source biomass materials from large cities for generating clean energy. • An increasing number of farmers are collecting organic materials and food waste from a wide range of cafes, restaurants, bars and brewers as effective resources to regenerate and nourish soil biology on farms.	• Increased demand for local water resources means reduced availability of water for growing grains. • As some grain-growing areas of Australia have experienced decreasing yields, some key areas of grain production shift to areas with the strongest yields. • As exports increase from competing nations with lower labour costs, Australia's reputation as a high-quality bulk commodity supplier of nutritious grains has become even more crucial than a decade ago.	• Rising meat consumption in countries across Asia increases export market demand for Australian livestock. • The livestock industry is creating high-value premium livestock products for the export market. • The livestock industry implements changes across its supply chains to address issues around logistics and safety. • More homes are being built on grazing land with greater competition for water resources.	• Dairy farms are closer in proximity to residential areas. • Although there is less friction towards dairy farms compared to feedlot operations, some residents who live close to dairy operations have complained about odour and noise. • Some dairy businesses have sold premium land for residential development. • The composition of the dairy industry is changing to one comprising mainly larger operations and a falling number of small farms.

	HORTICULTURE	GRAIN	LIVESTOCK	DAIRY
Technology	• Farms are difficult to automate at a feasible cost for many small operators. • There is still a reliance on low-skilled seasonal labour. • Although there are some developments in supply-chain and provenance technologies, these technologies have been primarily used by larger operators and by those providing off-farm services.	• Grain businesses continue to adopt and integrate new precision agriculture technologies into their on-farm practices. • These technologies have been providing modest efficiency gains but have not been game-changing. • Farm aggregation across the grain industry forces these large operators to invest in infrastructure for grain transport.	• New meat substitute products have not become affordable enough for the general public. • Opportunities to improve the environmental impacts from producing livestock are limited. • Traditional methods that emphasise low-impact grazing and lower stocking rates are used instead of technological solutions.	• The adoption of automated milking systems is limited. • The larger scale farms are the main adopters of automated systems and have been benefiting from greater economies of scale compared to the smaller operators. • New technological solutions for dealing with logistics and quality assurance are limited. • Food safety issues become more common. • The transport needs for dairy products become more complex. • Limited technology to capture changing consumer patterns across the country means that many retailers struggle to accurately forecast consumer demand that could potentially lead to greater food waste or shortages.
Labour supply and demand	• More local labour is now available year-round. • The cost of labour remains high compared to competing export nations. • Other regional industries compete for the available regional labour. • Many small operators are still relying on working holiday and seasonal workers during peak periods. • Those who are relying on the seasonal workforce are concerned about future changes to visa policies that could impact the sustainability of this workforce.	• Gradual adoption of precision agriculture technologies across the grain industry is shifting the workforce demand towards one that has more technical knowledge and skills for optimising and repairing these technologies. • Although there is an increasing number of skilled workers moving to regional centres, there is still a lack of available workers with the technical expertise to more efficiently generate value from precision agriculture technologies. • Some large farm operators are developing their own internal graduate programs and tech-enabled workforces.	• Although there is a shortage in the number of available workers with technology-related skills, a larger regional workforce is seeing many farm operators offering less experienced workers on-farm training and career development opportunities in livestock.	• Dairy operations that have adopted automatic milking systems require a skilled workforce with technical knowledge to operate and analyse production data, as well as the willingness to perform traditional manual tasks. • Many larger dairy operations invest to re-skill their existing workforce in the relevant technologies. • Although increasing regional development is seeing growth in available labour across regional centres, other industries such as the livestock industry are more successful in competing for available labour.

SCENARIO 4: FAST FORWARD REGIONS

KEY TRIGGERS

- Biosecurity shocks in competing agricultural export nations drive an increase in demand for safer and higher quality Australian produce
- Increasing agricultural productivity in other countries puts added pressures on Australian farmers to adopt new technologies
- Strong regional policies attracting Australians to live in small cities and large towns



The Fast Forward Regions scenario is a future with substantial regional development *and* substantial advancement and uptake of technologies across the agricultural sector.

SOCIAL AND DEMOGRAPHIC CHANGES

Regional centres across Australia undergo major transformation and have higher levels of employment. Young people from regional areas are motivated to stay in their home towns and pursue careers in agriculture, while a growing number of young urban residents are also relocating to the regions for more diverse job opportunities and lower cost of living. Those who are tech-savvy and are educated in generalist technology-related fields including robotics, computer science and information technology are applying their knowledge and skills in agriculture. In particular, returning residents with their roots in regional communities are bringing diverse skills and their entrepreneurial ambitions to regional towns.

ECONOMIC CHANGES

Increased investment in infrastructure and transport across Australia is giving regional residents easy access to healthcare and services. Regional residents can now access high-quality healthcare and education through improved infrastructure and transport links to larger cities. In addition, reliable and fast internet connectivity and telecommunications networks across regional centres are enabling residents to access online health and education services. An increasing population in regional centres is supporting workforce growth and diversification across regional centres. Other thriving industries, including construction, mining, education, healthcare, aged care, finance and retail, are attracting some of the available regional workforce. However, as regional residents become increasingly aware of the importance of producing premium agricultural produce in Australia and the growing employment opportunities across many agricultural industries, the sector is attracting an increasing number of workers from other thriving industries.

TECHNOLOGY CHANGES

Increased spending on agricultural R&D over the past decade facilitates the growth of new homegrown agricultural innovations and technologies that deliver new efficiencies, increase production and save on labour costs.

Innovative farming technologies, including precision agriculture, auto-steering, vertical farming within high-tech greenhouse facilities and robotic dairies are efficiently adapted to the changing Australian climate. Substantial adoption of these technologies is driven by the guarantee of cost savings, new efficiencies and productivity gains. Automation and robotic technologies replace much of the low-skilled and repetitive on-farm labour that farm operators struggled to find a decade ago. However, sector-wide development and adoption of new technologies and machineries are demanding a workforce with diverse skill sets to efficiently integrate and manage these technologies, as well as a workforce that provides tech-related services to farm operators. Incorporating agriculture into the Australian school curriculum in the decade leading up to 2030, along with additional technical knowledge skills taught in schools, is establishing a young labour force capable of effectively applying science, information technology and engineering to agriculture.

High levels of technology adoption, increasingly efficient management and integration of homegrown technologies into on-farm practices, and reliable internet and telecommunications networks, are allowing both small and large farm operators to tailor technology solutions that have general application to the specific needs of their individual farms. As a result, farm operators are now growing an increasingly diverse range of agricultural produce in addition to the key commodities. Reliable internet connectivity is enabling farm operators to better coordinate agricultural data to improve productivity. Working with a tech-savvy workforce, farm operators can now access real-time data on water and power usage, crop growth, livestock movements, maintenance alerts and market prices. This system is helping farm operators to predict packing and labour needs, harvesting periods and logistical requirements well in advance. Increasing certainty around agriculture production is creating more permanent positions across the sector.

Can Australia export its homegrown agricultural innovations and devices to recoup its investment costs?

With more reliable internet connectivity, an increasing number of regional residents can work remotely. Some regional residents start to move away from traditional employment models in favour of taking on freelance work and working on digital platforms. The growing workforce across regional areas is helping establish new business models and retail platforms that cater to the needs of busy consumers. In addition, developments in digital technology have also enabled new marketing opportunities in agriculture that are independent of on-farm practices. These new opportunities attract an even more diverse workforce that uses a variety of off-farm technology to effectively advertise the niche offerings of Australian produce to both domestic and global markets. Using new marketing platforms, consumers can now be informed about the authenticity, and the high ethical and environmental standards of Australian agricultural produce.

In a world with increasing concern about biosecurity threats, there is a strong focus on advancing and adopting technologies across the entire agricultural supply chain. These technologies enable efficient and tamper-resistant tracking that records valuable information, including the provenance, breed, production and storage processes of Australian produce. Advancement in traceability-related technologies is enabling Australian growers to access premium export markets, and demanding a workforce capable of developing and operating these increasingly sophisticated technologies.

ENVIRONMENTAL CHANGES

Growing regional population and integration of technologies into on-farm practices is increasing agricultural productivity within the constraints of the changing environment. In addition, developments in agricultural and traceability technologies, along with growing regional population and workforce, are enabling growers to cater to consumer preferences for sustainable and ethical produce. The introduction of lab-grown agricultural produce to the domestic market reduces some of the environmental impact of farming livestock. Water is more efficiently used in farming, but there is an increase in demand for water to maintain parks and amenities in small cities and large towns.

The diverse application of agricultural technologies in science, information technology and engineering has been extended into the classroom. Young people from regional areas are motivated to stay in their hometowns and undertake careers in agriculture, while a growing number of young urban residents are also relocating to small cities and large towns in pursuit of more diverse job opportunities and a lower cost of living

Those from generalist technology-related fields including robotics, computer science and information technology are applying their knowledge and skills in agriculture. In particular, returning residents with their roots in regional communities are bringing diverse skills and their entrepreneurial ambitions to regional towns

Advancement in vertical farming within high-tech greenhouse facilities, precision agriculture and lab-grown agricultural produce is changing the way food and fibre is grown and produced in Australia. Technology is replacing much of the low-skilled and repetitive on-farm labour

Advancements in traceability-related technologies is enabling Australian growers to access premium export markets. However, these growers are needing a workforce capable of developing and operating these increasingly sophisticated technologies

IMPACT OF THE **FAST FORWARD REGIONS** SCENARIO ON THE AUSTRALIAN AGRICULTURAL WORKFORCE, PRODUCERS AND POST-FARMGATE SERVICE PROVIDERS

GROUP	IMPACTS
 **Agricultural workforce**	• Diversifies across regional areas of Australia and low-skilled labour is in less demand due to increases in automation • Relies less on seasonal and working holiday programs • Has high demand for high-skilled workers with diverse skill sets able to manage and maintain new technologies • Witnesses growth in wages as demand for regional workforce increases across industries, including construction, education, healthcare, aged care, finance and retail • Increasingly needs to have the ability to manage traceability-related technologies that enable the access to premium export markets • Needs skilled labour to work in manufacturing and food-processing businesses across regional areas to produce niche products for both domestic and international markets
 **Producers**	• Have high levels of adoption, management and integration of homegrown technologies into on-farm practices • Taking advantage of the increasingly reliable internet and telecommunications networks that are enabling the coordination between the small and large farm operators and allowing them to tailor broad-use technology solutions to the specific needs of their individual farms • Use reliable internet connectivity to better coordinate agricultural input and output data to improve productivity • Adopt precision agriculture to increase productivity and efficiency
 **Post-farmgate service providers**	• Access the necessary human and technological resources for managing an increasingly complex supply chain • See technology-related service suppliers establish their business in regional areas, attracting high-skilled labour • Experience growth in demand for premium commodities, which increases the need to establish packaging, storage, air freight facilities near places of production

IMPACT OF THE **FAST FORWARD REGIONS** SCENARIO ON THE HORTICULTURE, GRAIN, LIVESTOCK AND DAIRY INDUSTRIES

	HORTICULTURE	GRAIN	LIVESTOCK	DAIRY
Industry structure	• Farms are benefiting from automation and cutting down labour costs for low-skill work. • There is greater demand for locally sourced or niche products that both smaller and larger operators are catering to. • Agricultural tourism and accommodation become key earners for some smaller operators. • The horticulture industry is seeing greater diversification as more discerning consumers develop tastes for exotic food commodities.	• Large-scale broadacre grain farms are particularly exposed to the risks relating to the changing climate. • Farmers are now better equipped to optimise outputs and predict risks—leading to more willingness to diversify into growing other grain crops. • With rising competition from overseas competitors, Australian grain businesses are still seeking competitive advantage by being early adopters of precision agriculture technologies.	• Meat-substitute products become more common. • As lab-grown meat relies on new methods of production, industry regulatory bodies struggle to develop appropriate food safety codes fast enough to foster a lab-meat industry. • Although meat substitutes are eating into some parts of the domestic market for livestock, rising demand for meat from Asia is increasing demand for premium and safe Australian meat.	• Consumer preferences for locally sourced, niche dairy products such as cheeses are increasing product diversification. • New opportunities for developing niche products depend heavily on the sophistication and flexibility of food safety and pasteurisation regulations. • While the industry is catering to the domestic market, a growing proportion of producers has secured access to markets in Asia and other rapidly developing regions.

	HORTICULTURE	GRAIN	LIVESTOCK	DAIRY
Technology	• Even for the more difficult to automate horticulture operations, robots are being used or trialled. • The largest farm businesses have been the first movers on this technology due to their greater ability to invest and larger labour costs. • In some remote, dry and difficult-to-reach areas with plenty of electricity, communities set up indoor vertical farms to grow fresh produce instead of transporting produce over long distances. • Some large-scale high-tech greenhouse facilities are generating their own bioenergy using agricultural byproducts.	• Using data from precision agriculture technologies, farmers are relocating their farms to areas of the country that have the potential to produce higher grain yields. • New development in supply-chain efficiencies through automation of grain transport and storage. • Some grain operators start to adopt innovative farming techniques, including high-tech greenhouse facilities and indoor vertical farming for growing specialty grains catering to niche markets. • By combining enclosed and precision agriculture technologies, farm operators are now allocating water, fertiliser and pesticides more efficiently. • New drought-resistant crop varieties are helping to maintain productivity in difficult weather conditions.	• Meat-processing industries become increasingly automated. • Improved tagging and sensor technologies help boost on-farm productivity while supply-chain provenance platforms and improved biosecurity measures help maintain the premium label of Australian meat products in foreign markets. • The increasing diversification of grain varieties, along with the development of vertical farming in high-tech greenhouse facilities across the industry, is seeing some niche livestock farmers adopting these new technologies and growing their feed on their property.	• Automated milking systems are cheaper and better adapted to the Australian environment. • Australian farmers are eager to try new commodities, such as high-quality cheese and yoghurts, supported by technologies that ease the production and commercialisation of these more diverse dairy products. • Australian dairy products are more competitive in overseas markets.
Labour supply and demand	• The increasing adoption of high-tech greenhouse facilities is demanding labour to monitor inputs, outputs, harvest and planting. • The high cost of labour in Australia encourages many operators to automate. • A few smaller operators that cannot afford large-scale automation technologies are still relying on imported labour. • Some horticulture businesses have developed automated technologies for year-round production and are relying on high-skilled labour with the technical knowledge and skills to optimise and manage these technologies.	• There is an increased need for high-skilled workers in areas such as logistics and biosecurity. • Greater reliance on regional-based skilled contractors across many grain farms during times of peak need. • Large operations are now serviced by relatively few staff who have the advanced technical expertise and skills to handle the challenges of servicing large operations.	• Certain key tasks that are only needed at certain times, such as calving or veterinary treatment, are still handled by contractors. • There is an increasing number of data analysts, technology specialists and agronomists being hired as contractors to improve productivity. • Some farm operations are further developing training programs to attract workers to the livestock industry.	• Integrating automated milking systems into traditional dairy operations is helping to reduce some of the cost disadvantage from high labour costs. • Adopting automated milking systems has not removed the need for labour on dairy farms. Instead, these systems are establishing hiring opportunities for people with technical skills and expertise to collect and analyse production data. • To compete for skilled technical labour, many dairy farms are tailoring their recruitment packages to attract applicants. • Many dairy businesses are working with education institutions to showcase the positive aspects of a career in dairy while ensuring skills education is relevant and applicable to the demands of the dairy industry.

FUTURE **OPPORTUNITIES**

The trends explored in this report present a number of crucial risks, challenges, and opportunities for the Australian agricultural workforce over the coming decades. These are explored in detail through the lens of four plausible future scenarios for the year 2030. The scenarios from this report illustrate the range of futures that can be created by various patterns of change, and especially demonstrate that these will unfold differently depending on the social, political, economic, environmental and technological contexts.
The four scenarios explored in this report identify various intersections of regional development and technological advancement, but neither of these two forces is guaranteed to produce a uniform outcome. For instance, substantial regional development will not necessarily lead to improvements in agricultural productivity and efficiency, if technological development and adoption are lagging. Similarly, while major technological advancement has the potential to revolutionise on-farm processes, it may also lead to further aggregation of farming operations and declines in regional populations and workforces.

The scenarios outlined in this report are simplified and condensed, and are not intended as predictions of future states. In fact, it is likely that the world in 2030 will include elements from all four scenarios. The scenarios are rather intended to illustrate a range of plausible future conditions, risks, and challenges. Based on these, we have identified a number of actions that could be undertaken in the present day (or over the coming years) to mitigate risk and enhance opportunities to grow and develop the Australian agricultural workforce.

Raising awareness of career opportunities in agriculture among young people

The number of students enrolled in agricultural courses has declined over the past decade, and many agricultural courses have been discontinued due to poor enrolments. A greater emphasis on equipping students with relevant skills, as well as promoting agricultural knowledge and career opportunities at every stage of education within both regional and urban schools, could help address this issue. Marketing content that showcases the attractive salaries and varied work opportunities available in the agricultural industry (including jobs that use new technologies, take advantage of emerging export opportunities, and go beyond on-farm work) may help boost participation in the future.

Adapting education to the changing farming systems

Using new technologies such as precision agriculture devices and robotics, as well as adding value via their data collection and analysis, is increasingly important to on-farm operations. Education curricula need to adapt and cater to the emerging skills requirements driven by technology. Advancement in innovative farming techniques, including vertical farming within high-tech greenhouse facilities and lab-grown agricultural produce will demand a workforce with science, technology, engineering and mathematics skills. In addition, continuing aggregation of farms across the sector will increasingly demand a workforce with generalist skills from a wide range of disciplines, including human resources, information technology, data science, management, marketing and trade. Actions could include upskilling educators, creating new (or redesigning existing) courses, and providing greater access to skills training for existing or aspiring agricultural workers (e.g. through TAFE and/or distance education systems).

The growing need to collect and update agricultural workforce data

Agricultural jobs and occupations have changed, but the standard industry and occupation classifications do not reflect these changes. This makes it difficult to capture the nature of work being performed across the agricultural sector (especially casual and contract work that make up a large portion) and to determine the actual patterns of change within its workforce. Updating the methods and classifications used to collect data on the agricultural workforce and collecting these data consistently and frequently (e.g. yearly) would help provide a more accurate picture of its current status, trends, challenges and opportunities.

Establishing well-coordinated big data and data governance

Establishing open data initiatives that enable well-coordinated big data on all agricultural inputs to be freely shared between farm operators and stakeholders has the potential to improve overall agricultural productivity over the next decade. However, there is a need to develop an agricultural research workforce with technological knowledge and skills to understand, adapt and efficiently apply big data approaches in agriculture.

Addressing the shortcomings in the current provision of imported seasonal labour

Accreditation for labour providers and consistent monitoring of third parties that help secure seasonal labour for farms would help reduce the likelihood of worker exploitation while serving the needs of Australian farms. There is also a need to grow WHM programs and address barriers that constrain WHMs from working in agriculture. In the longer term, increased opportunities, including jobs, career opportunities and structured mentorship programs, for those living in regional areas, could help build a culture around harvesting and picking seasons that may draw people back to the regions as a local labour force.

Funding trials to test new technologies

There are high risks associated with early adoption of technology. Farmers are wary of the high capital investment, and most technologies do not guarantee a return on this investment. Adopting new technologies could be accelerated if the associated financial risks were mitigated. One way of achieving this could be via funded trials to test new technologies and deal with problems that arise with early adoption.

Moving toward industry-led agricultural research and development

When compared to other developed nations, Australia attracts a fairly small share of private sector venture capital investments.[241] There is scope for Australia's private sector to invest in new and emerging agricultural innovations that have growth potential. This could help improve the responsiveness and usefulness of agricultural technologies in Australia, and thereby drive their increased adoption on farms.

Invest in and promote carbon neutral technologies and practices

To keep pace with increasing societal concerns over climate change that is increasingly changing market and consumer preferences, public and private investments in agricultural mitigation options need to continue and expand in the future. Australian farmers can operate with relatively smaller carbon footprints than some competitors. Therefore, catering to the domestic and international markets that are demanding more 'climate-change-friendly' Australian food and fibre products could offer an avenue for competitive advantage.

CONCLUSION

Shifting consumer preferences and behaviours along with increasing impacts of climate change and rapid advancement in technologies are all driving changes to the Australian agricultural workforce and labour use. Across the horticulture, livestock, grain and dairy industries, a degree of aggregation is occurring, where smaller farms are gradually being replaced by larger operations. Larger farms benefit from economies of scale and are gaining competitive advantage in both domestic and international markets. In addition, technology has reduced the need for human labour in certain areas, such as broadacre farming, but other industries like horticulture remain heavily reliant on imported low-skilled labour and are likely to remain so for the foreseeable future. Other factors, such as migration and aging patterns, are also reshaping the sector.

Over the next decade, the extent and nature of workforce transformation across the horticulture, livestock, grain and dairy industries will vary. However, workforce development across those industries will likely rely on appropriately skilled labour. Future demand for certain skills, as well as availability of labour, will depend on a number of factors. This report highlighted two key factors influencing the future of the agricultural workforce in Australia: 1) the extent of regional development, and 2) technology advancement and uptake across the agricultural sector.

How regional centres will transform and develop over the next decade will be governed by complex factors. On the one hand, urbanisation could continue and limited population growth in small cities and large towns of Australia may restrict the necessary infrastructure improvements needed to increase the agricultural workforce. On the other hand, increasing cost of housing and growing congestion in large cities of Australia, along with changing business and employment models that are supporting an increasingly mobile workforce, could see regional towns and centres transformed in 2030.

Integrating new technologies across the sector could potentially present many benefits in the future, but uncertainties remain around the extent of technology advancement and adoption across the entire sector. Development in remote sensors, robotics and automation has the potential to replace low-skilled human labour and increase demand for a workforce with a range of technology-related skills in the future. However, many farms across Australia still do not have access to reliable internet. In addition, the high upfront costs of new technologies and difficulties around integrating them to on-farm practices present challenges to the feasibility of large-scale adoption across the sector.

This report describes contrasting futures for the Australian agricultural workforce and highlights the key factors driving change in the agricultural workforce and labour demands over the next decade. The report does not aim to predict a single future describing the agricultural workforce and it is possible that the future will include elements from all four scenarios identified above. The degree to which optimal outcomes are achieved will depend highly on the decisions made today by farmers, policymakers, industry bodies and other stakeholders. Looking ahead, developing collaborations, fostering knowledge exchange, and establishing long-term strategic planning and cooperation across government, industries and communities will be crucial in establishing sufficient supply of the requisite labour across the sector. The tools of strategic foresight can be used to foster constructive discussions among diverse stakeholders and identify strategies and policies to effectively navigate future change across the sector. This work is an important step towards informing decisions around future priorities and investments across the agricultural industries for growing their workforce over the next decade.

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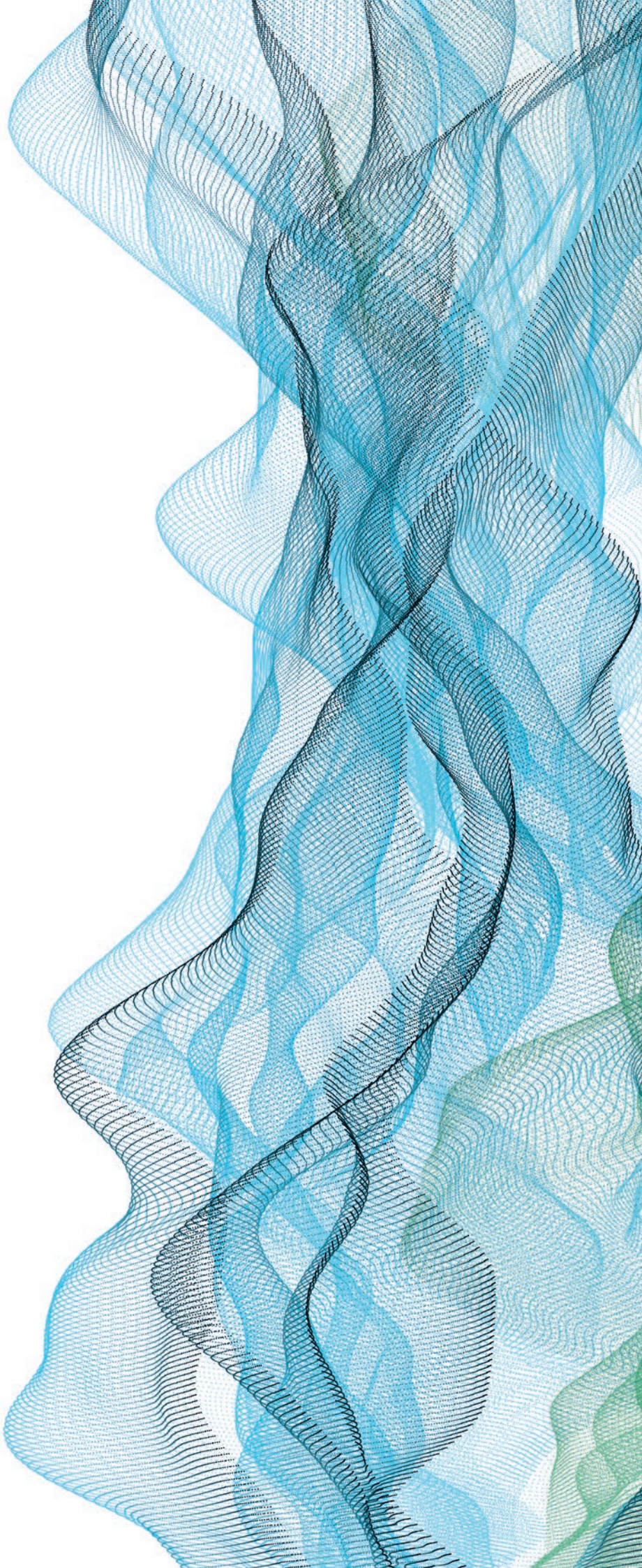

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