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# The Changing Landscape of Protein Production:

Opportunities and  
challenges for  
Australian agriculture

by S Admassu, T Fox, R Heath & K McRobert  
(Australian Farm Institute)

February 2020



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# The Changing Landscape of Protein Production:

Opportunities and challenges for Australian agriculture

February 2020

Animal-sourced



Plant-sourced



Non-traditional



## Foreword

**Animal agriculture is under more community scrutiny than ever before. Social license issues have arisen on everything from livestock's contribution to climate change through to shifting animal welfare expectations. These institutional risks are driving industry change. Understanding consumer trends towards alternative proteins and industry implications are key to proactively engaging with, and responding to, these changes.**

The shift towards alternative proteins has gathered momentum over the past 18 months, with large-scale food retailers promoting plant-sourced meat to mainstream consumers. The impact of growth in vegetarian, veganism and flexitarian consumer segments is often debated in industry circles.

This study focuses on the implications for Australia's agriculture and fisheries sector in response to the opportunities and challenges of the emerging market for alternative (i.e. non-traditional) proteins.

The research, undertaken by the Australian Farm Institute, for the first time not only outlines the size of the alternative proteins trend but also unpacks the likely implications for the sector. The research tells us that despite the trend towards alternative proteins, large opportunities exist for animal proteins into the future. Whether an industry will benefit from the alternative protein trend or not, there are critical policy and regulatory issues that need to be addressed.

Consumer preferences and trends will undoubtedly continue to change and adapt over time and we know that a future-thinking sector needs to be responsive and capitalise on opportunities where possible. This work ensures industries are armed with information to understand the impacts of the increasing trend towards alternative proteins and, in response, make sound, timely production and marketing decisions.

While the trend to alternative proteins offers a modest opportunity in Australia, the sector also needs to be mindful of the magnification of small shifts in consumer and community trends in the media and on social media. Providing clear, independent research is critical to understanding the true impact from changing trends with an eye to regions like America and Europe to identify trends early and respond appropriately.

This report has been produced under AgriFutures Australia's National Rural Issues Program. It is an addition to AgriFutures Australia's diverse range of over 2000 research publications and it forms part of our National Challenges and Opportunities arena, which aims to identify and nurture research and innovation opportunities that are synergistic across rural sectors.

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John Harvey  
Managing Director  
AgriFutures Australia

## About the authors

The Australian Farm Institute (AFI) is an agricultural policy research organisation that has been established to develop and promote public policies that maximise the opportunity for Australian farmers to operate their business in a profitable and sustainable manner.

To do this, the Institute carries out or contracts leading academic and consultants to conduct research into farm policy issues that the Institute's Research Advisory Committee has identified as being of high strategic importance for Australian farmers. The Institute has a commitment to ensuring research findings are the conclusion of high, quality, rigorous and objective analysis. The AFI promotes the outcomes of the research to policy-makers and the wider community.

The authors of this report are: Dr Samuel Admassu, Researcher; Teresa Fox, Researcher; Richard Heath, Executive Director and Katie McRobert, General Manager.

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## Executive summary

The Australian agriculture, aquaculture and fisheries industries supply the animal and plant-based protein needs of many people domestically and globally. This study focuses on the implications for Australian agriculture of the opportunities and challenges of an emerging market for alternative (i.e. non-traditional) proteins<sup>1</sup> in the coming decade.

The rise of alternative proteins in the food market has garnered attention over the past 18 months, with large-scale food retailers promoting plant-sourced meat analogues to mainstream consumers. Investments in and production of alternative proteins such as insect proteins, meat, dairy, egg and fish analogues and cultured meat are showing increasing growth, albeit with a very small market share.

While the impact of growth trends in vegetarian and flexitarian consumer segments on animal agriculture is often debated in industry circles, analysis presented here demonstrates continued and stable demand for traditional (animal-sourced) protein sources. Animal agriculture<sup>2</sup> plays a significant role in the Australian economy and is likely to continue to do so. Indeed, the factors impacting consumers' protein preferences discussed herein are driving increased demand for protein from all sources, traditional and alternative.

However, animal agriculture is subject to community scrutiny related to changing animal welfare expectations and external pressure due to the environmental impacts of some livestock production systems.

Animal agriculture will struggle to supply the world's growing demand for protein using the finite resources available in current production systems as the production of animal-

sourced foods generally has a greater impact on land use, freshwater consumption and greenhouse gas (GHG) emissions than plant-sourced foods. However, this is a very broad generalisation and within every system (plant and animal-sourced) there are production methods that can have positive or negative environmental implications.

Recent reports have quantified the aggregate opportunities of an alternative proteins market yet lack the specific implications of the growth trend of these markets for Australian producers, value chain actors and investors. This study aims to fill this gap by performing a sector-by-sector economic analysis of the potential impacts and opportunities of alternative proteins to Australian agriculture to provide a quantitative overview.

A desktop review of recent literature was also conducted to ascertain the current protein production landscape in Australia and identify emerging alternative protein product segments. Key informants were interviewed using a semi-structured questionnaire to obtain insights into current market benefits and challenges.

This investigation concluded that there is room for both animal-based and alternative proteins in the Australian market. **Forecast global demand for protein is strong and will accommodate growth in both sectors.**

<sup>1</sup>For this report, 'alternative protein' is defined as protein which is not sourced from animal stock.

<sup>2</sup>Incorporating livestock, eggs and dairy production, aquaculture and fisheries





While alternative protein substitution of animal protein will continue to increase in the next 10 years, the levels and rate of substitution will not present a material threat to the viability of animal agriculture by 2030. Producers of plant-sourced protein (e.g. pulses) also stand to gain from increased market share; however, new demand for animal-sourced protein from a rising population will outweigh any additional market share that alternative proteins may gain in the near future.

To ensure producers and industry actors can capitalise on these opportunities, it will be important for Australian agriculture to present a united front in the aim of producing sufficient protein for the growing population. Segregation and competition between traditional and alternative proteins providers could do more harm than good for all markets.

Enabling traditional and alternative protein producers to work in collaboration (such as using the by-product of insect farmers as feed for chicken, pork and fish) could also provide a mutual sustainability benefit for the industry.

This report finds that a business-as-usual (BAU) estimation of the **additional opportunity for the protein market in 2030 is estimated at A\$19.9 billion**, of which **A\$3.1 billion is for alternative protein** categories. The production of alternative protein offers opportunity for Australian agriculture, provided that:

- The industry is mindful of the **limited natural capital** which can be used for protein production in a resource-constrained future, and makes informed decisions on the most efficient and sustainable use of this capital.
- Australian agriculture presents a **united front in** the aim of producing sufficient protein for the growing population.
- The industry **monitors the marketing language** used by some alternative protein companies to ensure accurate representations of both plant- and animal-sourced proteins are presented to consumers.

Overall, the emerging market for alternative proteins should be seen not as a threat to existing production systems but as a means of diversifying choices for producers, processors and consumers to fill the growing gap between global protein demand and supply.

# Objectives

The main objective of this study is to identify and quantify the opportunities and challenges to the Australian agricultural industry posed by the rise in alternative protein sources.

## Report structure

- 01** Section 1 presents a brief introduction.

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- 02** Section 2 provides an overview and context of alternative proteins in the market.

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- 03** Section 3 details the changing protein landscape; for example, factors driving the trend in alternative proteins market growth and possible impacts on animal and plant agriculture.

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- 04** Section 4 offers case studies which demonstrate some benefits of and barriers to alternative protein production in Australia.

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- 05** Section 5 details a sector-by-sector economic analysis of potential opportunities (and related impacts) of alternative proteins to Australian agriculture.

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- 06** Section 6 canvasses options to realise potential gains and mitigate impacts of changing protein markets for Australian agricultural participants.

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- 07** Section 7 concludes with recommendations on potential strategies for Australian agriculture to remain competitive in the changing global protein market.

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## Methodology

A desktop review of recent literature was conducted to ascertain the current protein production landscape in Australia and identify emerging alternative protein product segments.

To build a qualitative industry-level perspective about the opportunities and threats of the rise of alternative protein sources in the Australian market, key informants from selected RDCs and other stakeholders were interviewed using a semi-structured questionnaire. Participants in alternative protein production were also interviewed for insights into current market benefits and challenges.

A sector-by-sector economic analysis of potential impacts and opportunities of alternative proteins to Australian agriculture was performed to provide a quantitative overview.

A person wearing a dark hat and a plaid shirt is walking away from the camera through a field. The field is covered with rows of crops, and there are irrigation systems visible, with water spraying from nozzles. The scene is set during sunset or sunrise, with a warm, golden light. A red arrow points from the left towards the person.

**The main objective of this study is to identify and quantify the opportunities and challenges to the Australian agricultural industry posed by the rise in alternative protein sources.**

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The rise of alternative proteins in the food market has garnered significant attention over the past 18 months, with large-scale food retailers promoting plant-sourced meat analogues to mainstream consumers, global reports calling for meat-reduced diets and media headlines declaiming “the end of meat”. Concurrently, investments in and production of alternative proteins such as insect proteins, meat, dairy, egg and fish analogues and cultured meat are showing increasing growth, albeit with a very small market share.

Whilst the continued expansion of the middle-income global population segment implies a stable demand for traditional protein sources, questions have arisen on whether the simultaneous growth trend of the vegetarian and flexitarian consumer segment could offset these gains.

In Australia, animal agriculture plays a significant role in the economy. The production of animal protein – red meat, poultry, pork, eggs, dairy and fisheries – contributes to Australian GDP, exports, employment and underpins the viability of many regional communities.

However, animal agriculture is under more community scrutiny and external pressure than ever before. Social licence issues have arisen from concern about the contribution of livestock production systems to climate change and from emerging animal welfare expectations, and these institutional risks are focusing attention on the need for industry change.

While the ‘meat vs plant’ debates played out on social media are often reductive and lack insight into the complexity of protein production systems and comparative nutritional value, ‘prosumers<sup>3</sup>’ are increasingly perceiving alternative sources of protein as the more ethical food choice over those produced through traditional livestock farming methods.

Recent published reports on the issues (e.g. from FIAL, CSIRO and Food Frontier) have quantified the aggregate opportunities yet lack the specific implications of the growth trend of alternative proteins market for various animal and plant protein sources. This study aims to fill this gap by identifying the potential opportunity (or threat) for Australian agriculture arising for each protein sector.

In order to build an industry-level perspective about the opportunities and threats of the rise of alternative protein sources for Australian agriculture, key informants from selected RDCs and other stakeholders were interviewed<sup>4</sup> using a semi-structured questionnaire. The interview participants were asked to provide their perspectives about the present and expected future impact of alternative proteins in their respective industries, and to comment on any industry-specific alternative protein strategies to avert risk and maximise gains.

<sup>3</sup>A consumer who is proactively involved with customising - or vocally calling for the design of - desired products to their own unique specifications

<sup>4</sup>Stakeholders contacted for interviews included representatives from Meat & Livestock Australia, Cattle Council of Australia, Australia Pork Limited, AEGIC, Grain Growers, Dairy Australia, Australian Chicken Meat Federation, Eggs Australia, AgThentic, CSIRO and supermarkets.



## Section 2

## Overview of alternative proteins

## 2.1 Understanding proteins

Alternative proteins are foods that act as a substitute for traditional animal-sourced protein diets, i.e. that which is not sourced from animal stock. In general, protein sources can be categorised as **animal-sourced**, **plant-sourced** and **non-traditional proteins**; plant-sourced protein substitutes and non-traditional sources are therefore categorised as alternative proteins (**Figure 1**).

**Animal-sourced**

Meat: beef, lamb, mutton, chicken, pork, goat

Dairy: milk, yoghurt and cheese

Eggs

Fisheries: wild catch fisheries, aquaculture

**Plant-sourced**

Grains & pulses: wheat, rice, chickpeas, lupins

Nuts

Fruit & vegetables

Plant-sourced meat, dairy and egg substitutes

**Non-traditional**

Insects

Algae & seaweed

Cultured meat: e.g., Memphis Meats

**Figure 1**  
**Protein source categories**

Source: Authors' compilation

Animal-sourced proteins include meat, dairy, eggs and fish / seafood. This category also includes hybrid plant and meat products which are currently emerging in the marketplace.

Plant-sourced protein is the largest source of protein globally (Henchion et al., 2017), particularly in countries such as India with a high percentage of vegetarians. Plant-sourced proteins include traditional grains, pulses, fruit, vegetables, nuts as well as plant-sourced analogues<sup>5</sup> for meat, dairy, egg and fish.

<sup>5</sup>A food made from vegetarian ingredients which can be substituted for a meat product.



## Overview of alternative proteins

The number of plant-sourced meat analogues is rising both globally and domestically. Plant proteins (e.g. soy and pea) are being used to create meat-like characteristics in products such as burger patties. Although products like these have been available in the market for decades<sup>6</sup> targeting vegetarians and vegans, many of these new products – which have more advanced ‘meat-like’ characteristics and are not directly comparable to traditional alternatives – are designed to appeal to carnivores and flexitarians<sup>7</sup>.

Non-traditional protein sources include cultured or cellular meat, insects and algae. In Western culture, insects and algae have low levels of uptake as food products consumed by humans and currently have a very small market share. However, these protein sources have potential as feed for livestock.

Cultured meat refers to meat grown in a laboratory using cells from an animal, rather than raising and slaughtering animals for consumption. Several companies across the globe are in development stages of products such as these, which are not yet available to consumers. The marketing strategies of these

companies are usually based on highlighting the perceived environmental and animal welfare benefits of cellular meat compared to traditional animal farming. Consumer acceptance and the health effect of these products are relatively unknown, given products are not yet commercially available (van der Weele et al., 2019).

Protein is an important requirement for a healthy diet. As such, discussion about how to sustainably source the world’s protein needs is gaining significant attention with academics, media and in policy circles. Although proteins can be gained from different sources, the protein quality and other nutrient content varies between those sources. As seen in **Table 1**, the source with the highest level of protein is algae, followed by insect and myco-protein<sup>8</sup>. However, humans are not sustained by protein alone. The digestibility and amino acid completeness of the protein in the diet are important, as are other important aspects of food, such as carbohydrates, fibre, lipids, minerals, and micronutrients, all which are required to make up a healthy diet.

**Table 1**

### Nutrient contents in 200 kcal of different protein sources

Animal-sourced	Grams	Protein(g)	Plant-sourced	Grams	Protein(g)	Non-traditional	Grams	Protein(g)
<b>Beef</b>	83	20.89	<b>Wheat</b>	60	5.79	<b>Insect</b>	43	27.49
<b>Pork</b>	67	17.3	<b>Nuts</b>	33	6.43	<b>Algae</b>	69	39.63
<b>Chicken</b>	140	24.39	<b>Bean</b>	157	13.65	<b>Cultured beef</b>	83	20.89
			<b>Pea</b>	247	13.38			
			<b>Tofu</b>	241	24.05			
			<b>Myco-protein</b>	235	25.88			
			<b>Jackfruit</b>	211	3.62			

Source: (World Economic Forum, 2019)

<sup>6</sup>New products have more advanced product characteristics and perhaps may not be directly comparable to traditional plant-meat analogues.

<sup>7</sup>A person with a primarily vegetarian diet who occasionally eats animal protein.

<sup>8</sup> Mycoprotein is a source of dietary protein and fibre derived from fungus and is made in fermenters similar to those found in a brewery.



The World Economic Forum (2019) conducted an in-depth analysis of the amount of nutrients in each source of protein (see Appendix 1). Although alternative proteins have equivalent or more protein content than animal protein sources, there are differences in other nutritional components in food. In addition, the quality of protein as measured by the FAO's

digestible indispensable amino acid score (DIAAS) system ranks animal protein as excellent quality and more digestible than other protein sources (**Table 2**). These studies and systems highlight that while protein is crucial in diets, many factors determine the best source and type of protein for each diet.

**Table 2**

**DIAAS Protein quality ratings of Animal and Plant Proteins**

<b>Animal Protein</b>	<b>DIAAS</b>	<b>Plant Protein</b>	<b>DIAAS</b>
Beef	111	Almonds	40
Chicken	108	Chickpeas	83
Eggs	113	Lentils (red)	50
Milk	114	Lentils (yellow)	73
Milk protein concentrate	118	Pinto beans	70
Whey protein isolate	109	Pea protein concentrate	82
		Red kidney beans	58
		Soybean	99.6
		Soy protein	91.5
		Tofu	52

*Note: DIAAS >100 is high-quality protein; DIAAS >75 is a good quality protein; and DIAAS <75 is a low-quality protein.  
Source: (Marinangeli & House, 2017)*

**In Western culture, insects and algae have low levels of uptake as food products consumed by humans and currently have a very small market share. However, these protein sources have potential as feed for livestock.**

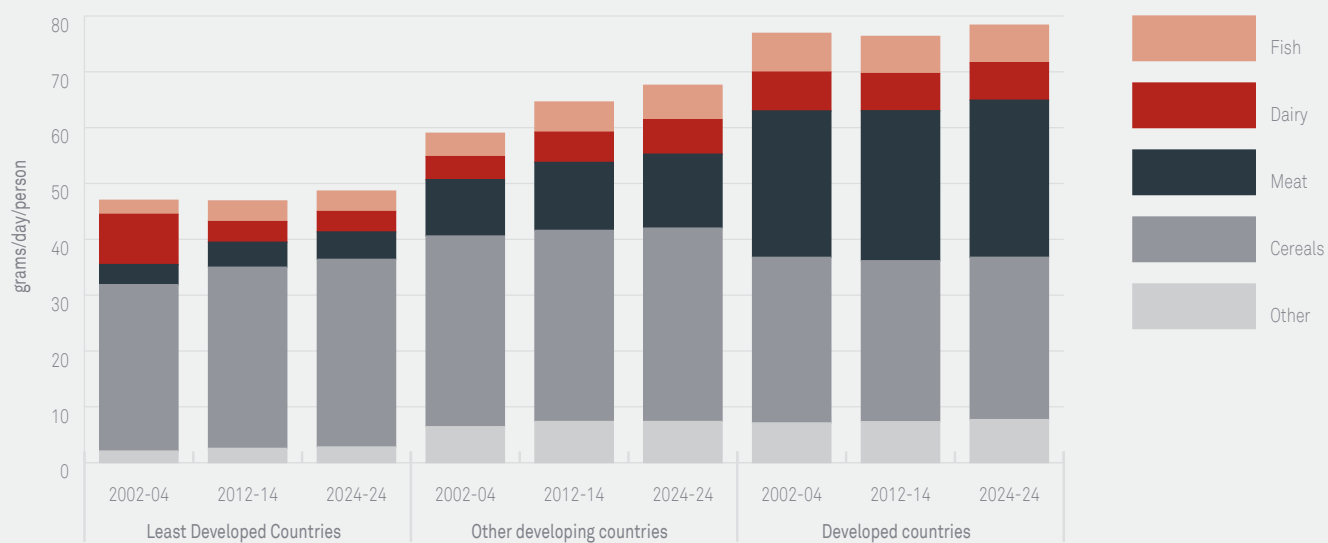
## Overview of alternative proteins

**Table 3**

**The average daily protein intakes of Australians**

Age (years)	Female (g/capita/day)	Male (g/capita/day)
14-18	77	101
19-70	79	107
71+	72	83

Source: (Noakes, 2018)



**Figure 2**

**Protein intake per capita in developed / developing countries**

Source: (OECD & FAO, 2015)



**The estimated daily protein intake of Australians in daily grams per capita averages between 72 – 79 g for females and from 83 – 107 g for males, on par with other developed countries and well ahead of developing countries.**

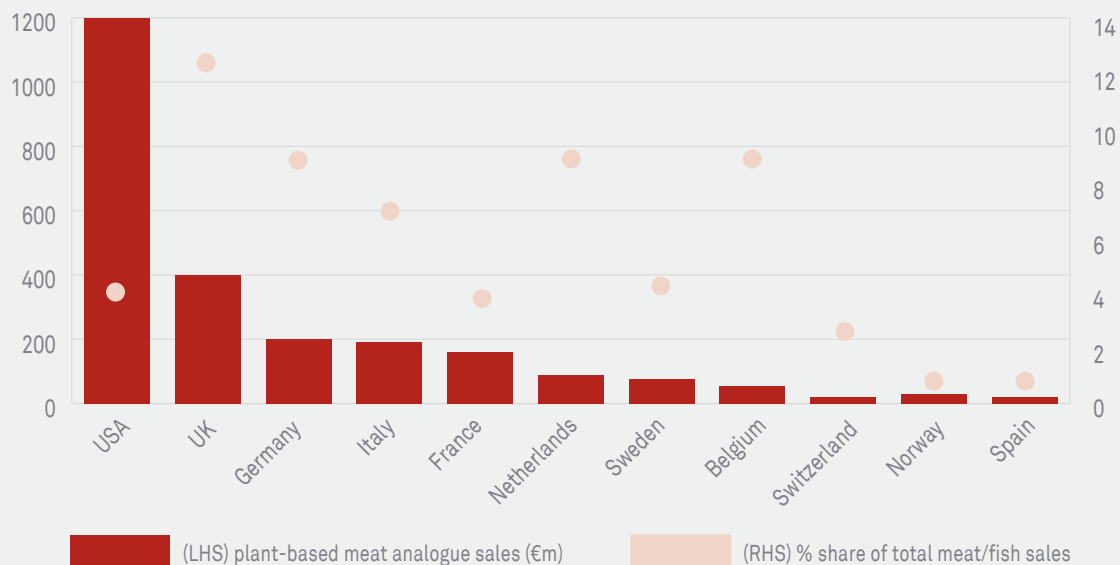
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## Overview of alternative proteins

### 2.2 The alternative proteins market

The US remains the largest market for plant-sourced meat analogues and is three times the size of the next largest market (UK) as shown in **Figure 2**. Plant-sourced meat analogues are leading growth for the food sector in the US, with sales value growing by 31% over the past two years. However, although plant-sourced meat analogues have seen strong growth, their market share is still very small. The biggest market share for alternative proteins is for dairy milk analogues, which account for 13% of the market share of total US retail milk sales and less than 9.2% of the Australian market<sup>9</sup>.

In terms of market size, Europe is substantially smaller than the US. However, European countries typically have a higher market penetration for plant-sourced meat analogues. The market penetration in the UK is 12%, which is three times that of the US at 4% (**Figure 3**). Growth in Western Europe has remained relatively stable for this sector over the last three years at around 10% (FAIRR, 2019).



**Figure 3**

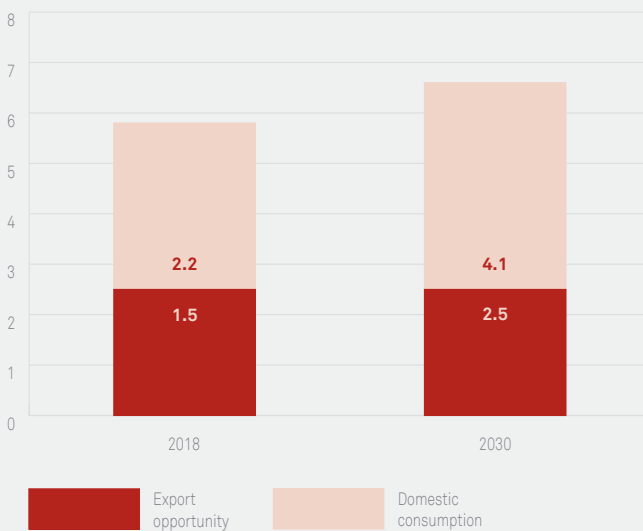
#### Sales (in million euros) and market share of plant-sourced meat analogues in 2018

Source: (FAIRR, 2019)

Global market figures show that in 2019 alternative proteins held a marginal share of \$2.2 billion of the overall meat market of \$1.7 trillion (Bashi et al., 2019). The global market is becoming increasingly favourable for alternative protein products as exhibited from the fast growth in sales values, although they remain very small in comparison to traditional protein sources.

A recent report by Food Innovation Australia Limited (2019) revealed that the size of the Australian protein market is projected to range between A\$67 billion to A\$122 billion depending on the assumptions made. However, the current

market share of alternative proteins is very small, albeit with a rapid sales growth rate. The market size of alternative protein in Australia is also projected to have robust growth. For example, CSIRO (2019) estimated the size of the domestic and export markets for alternative proteins to be approximately \$4.1 billion and \$2.5 billion respectively by 2030, excluding environmental savings (**Figure 4**). This is a collective growth of \$2.9 billion from the 2018 market size of \$3.7 billion. This economic analysis utilised the assumptions that consumers of alternative protein products would be dominated by those who were predominately vegetarian. It also assumed an annual growth rate of vegetarians of 3.5% and a 1.5% population growth rate.



**Figure 4**  
**Estimated growth of the alternative protein sources market (A\$ billions)**

Source: (Wynn & Sebastian, 2019)

Food Frontier is a think tank and industry accelerator for plant-sourced meat analogues and cellular meat. In 2019, Food Frontier released a report entitled *Meat the Alternative*, which included economic modelling conducted by Deloitte on the future of the plant-sourced meat analogue market in 2030 in Australia (Lawrence & King, 2019). The modelling showed that under a moderate growth scenario, plant-sourced meat analogues will generate an additional \$A2.9 billion in domestic sales in Australia by 2030. It also estimated that more than 6,000 jobs will be created (directly and indirectly) through the manufacturing of plant-sourced meat analogues. Food Frontier also released a report entitled *Hungry for Plant-Based* (conducted by Colmar Brunton) in 2019, which noted that one in three Australian consumers are consciously limiting their consumption of traditional (animal-sourced) meat, primarily due to health concerns (Food Frontier & Life Health Foods, 2019).

The moderate growth scenario predicted by Food Frontier relies on several assumptions, including that Australians will consume on average 6.1 kg of plant-sourced meat analogues annually and the proportion of the population identifying as flexitarian will increase to 40% in 2030.

Although the *Meat the Alternative* report notes there will be potential opportunities for Australian farmers to supply crops (such as lupins, faba beans, lentils and chickpeas) into the plant-sourced meat analogue market, the majority of the direct opportunities and gains are identified as being directed towards manufacturing, processing and supply chain areas.

### 2.3 Factors driving the changing landscape

Changing social, market and technological conditions are impacting the animal protein market in both positive and negative ways, sometimes simultaneously. For example, the growing population and rise in wealth in developed and developing countries is driving an increasing demand for all protein sources (including animal protein). However, affluent consumers tend to be more concerned about health and sustainability issues which contributes to growth in the alternative proteins market (at the expense of animal proteins).

Technology improvements are lifting the productivity of producing animal protein leading to inexpensive and plentiful supply (particularly in intensive animal industries such as Pork and Chicken). However, technology development is also leading to new and more efficient ways of producing alternative protein products.

Similarly, while environmental factors in the production of animal protein such as GHG emission, water and land use issues are factors contributing towards alternative protein demand, there is a growing awareness that animal protein production can be a sustainable and practical way of managing some agricultural landscapes (Ghahramani & Moore, 2015; Vinnari, 2008).

Several of these issues are discussed in the following 'PESTLE' analysis (**Table 4**), which places the macro view of the wider political, economic, social, technological, legal and environmental context against the possible impacts of these factors on production of protein.

<sup>9</sup>Only soy and pea milk have equivalent protein to dairy milk; other analogues contain very low protein. Pea milk is almost non-existent on the market while soy accounts for 50% of the alternative market.

## Overview of alternative proteins

**Table 4: PESTLE analysis**

		Macro view: Australian Agriculture	Impact on protein production
P	Political	Australian govt. policy is increasingly focused on agricultural productivity & sustainability in the face of a changing climate & growing population. Policy mood affects regulation on trade, labour, environment, consumer protection, transactions and data use.	Protein production will become increasingly focused on improving sustainability in conjunction with increasing productivity instead of the solely productivist mindset previously adopted by government/industry.  Potential political implications from unclarified terminology of 'plant-sourced meat analogues' in free trade agreements.
E	Economic	Australia's agricultural output as a proportion of the economy has declined from 25% of GDP in the first half of the 20th century to just 2% in 2015 – still amongst the highest in the OECD (Hughes et al., 2015). Providing 93% of domestic food supply, the agricultural industry comprises more than 85,000 farm businesses, 99% of which are wholly Australian-owned (NFF, 2018). Australia exports more than \$30 billion worth of food annually, daily providing food for more than 36 million people outside the country (Bellotti, 2017). Drought and severe weather events (i.e. floods) have impacted recent sector profitability.	Climate change and natural disaster such as drought will impact both animal and plant-sourced protein production systems.  Protein producers will need to become more resilient to overcome these economic challenges, for example by seeking opportunities to value-add or pursuing alternative and supplementary incomes streams through alternative protein channels.  The economic analysis presented in this report shows there is room in the protein market for both traditional and alternative protein sources.
S	Social	Socio-cultural expectations of agriculture are shifting towards more consciously sustainable production and consumption.	Social expectations are leading to changes in the way we consume and purchase food, including protein. New food categories are emerging, albeit with small market share. Supermarkets are changing store layout and the types of products stocked.
T	Technological	Unconstrained implementation of digital technology in agriculture has been projected to boost GVP by 25% (Keogh, 2018; Perrett et al., 2017) but significant barriers still remain to adoption, including physical infrastructure limitations.	Farmers will become increasingly reliant on technology to produce protein in a sustainable and profitable manner.  There will be an increased presence of cell-grown protein sources in the market as technology solutions become more scalable.  Technology is enabling the extraction of protein from sources such as off-grade pulses, and the combination of plant and animal proteins to create new food products.

<b>L</b>	<b>Legal</b>	<p>Climate, culture and risk are now mainstream governance issues in agriculture and natural resource management (Guerin, 2019). Farm businesses in Australia are subject to a vast and complex array of regulations. At each stage of the agricultural supply chain regulations include land acquisition and preparation, capital and labour use, transport of inputs and outputs, marketing and product sales. The number and complexity of these regulations means that the cumulative burden of regulation on farmers is substantial (Productivity Commission, 2016).</p>	<p>Regulation of labelling and terminology use may have a positive or negative impact on the agricultural sector. Any regulatory decisions should be underpinned by robust, independent research.</p> <p>Cellular food will need to be carefully monitored to ensure regulatory and food safety standards are robust and complied with, e.g. allergen testing.</p> <p>The legal categorisation of hybrid or new products could impact trade deals with exporting partner countries.</p>
<b>E</b>	<b>Environmental</b>	<p>Any degradation of natural resources (e.g. from impacts of climate change) impairs the sustainable development of farmers, businesses and nations and imposes external costs on society and future generations (FAO, 2015).</p>	<p>Environmental and sustainability concerns are a large driver for alternative proteins. As the animal-sourced agricultural sectors seek to improve their positive environmental impacts, gains in this area will need to be proactively promoted to consumers to avoid misconceptions.</p> <p>Alternative proteins will also need to continually improve environmental footprints as resource scarcity increases in the future.</p>

Source: Authors' Compilation

### 2.3.1 Rising population

Australia's population is increasing, ensuring consistent demand and creating new outlets in the protein market. The global population is also projected to rise to 9.7 billion people by 2050, fuelling a doubling of demand for protein products (WEF, 2019). This increase will place significant pressure on traditional agriculture practices to satisfy the growing demand for protein.

Globally, the proportion of middle-income consumers who can afford to buy higher-valued food products is rising (Belbağ et al., 2019). As incomes rise in developing countries, particularly in Asia, demand for more animal-sourced protein is predicted

to grow. The estimated global consumption of protein in 2018 is 71.2 grams per capita per day, which is expected to rise to 90.4 g per capita per day in 2025 due to the growth in the consuming class (Food Innovation Australia Limited, 2019).

The rise of global demand for protein has already been witnessed in countries such as China, where dairy consumption per capita has increased from near zero in the late 1980s to 30 kilograms annually in 2016 (Henchion, et al., 2017). Given the significant export nature of Australia's agricultural industry, this increase in global demand for protein presents a notable opportunity for domestic protein producers.

## Overview of alternative proteins

### 2.3.2 Sustainability and animal welfare

Consumer perceptions about food system sustainability challenges are a strong driver in the rise of alternative protein market share. This changing sentiment is being influenced in part by global studies (such as those from the World Economic Forum, 2019) which indicate that beef has the greatest adverse effects on the environment compared to other sources of proteins, and hence its substitution is likely to produce the greatest environmental benefit. However, while easily communicated to a receptive audience, studies like these are problematic as the findings are often not directly transferable to different production systems around the world.

In general, the production of animal-sourced foods is more impactful in terms of land use, fresh-water consumption, and GHG emissions than plant-sourced foods (Ranganathan et al., 2016). However, this is a very broad generalisation and within every system (plant- and animal-sourced) there are production methods that can have positive or negative environmental implications. Table 5 highlights the range of GHG emissions and land use implications of various protein sources. It is evident that for each product there is extreme variation in the potential impact depending on production system used and other factors.

**Table 5**  
**Carbon footprint and land use per kilogram of protein**

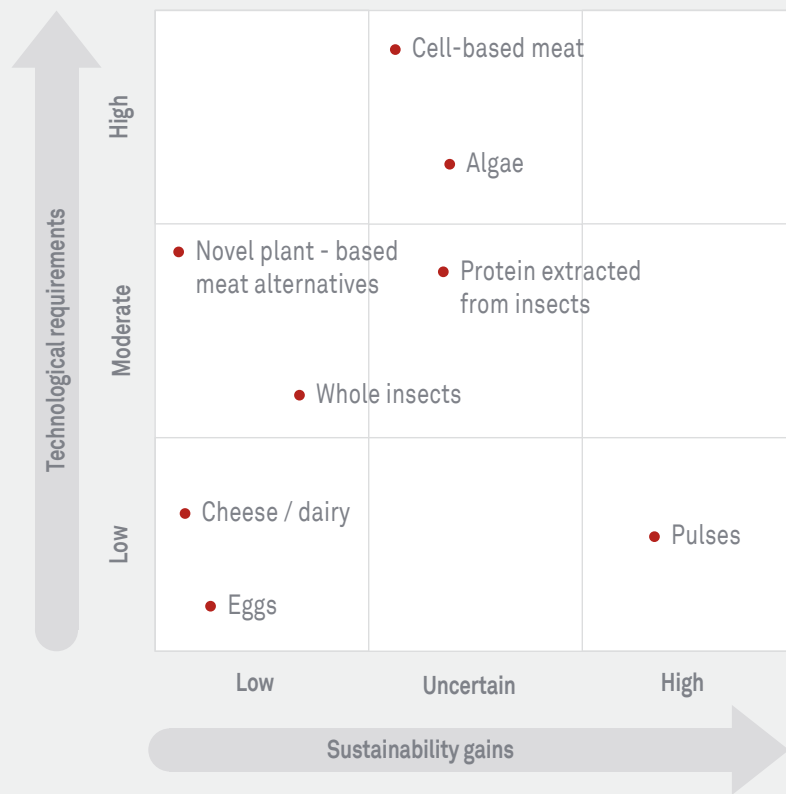
Product (%protein)	GHG kg CO <sub>2</sub> -eq kg <sup>-1</sup> protein	Land use m <sup>2</sup> y kg <sup>-1</sup> protein
Beef (20%)	45–640	37–2100
Industrial systems	45–210	75–143
Meadow systems, suckler herds	114–250	164–788
Extensive pastoral systems	58–643	1430–2100
Culled dairy cows	45–62	37
Pork (20%)	20–55	40–75
Poultry (20%)	10–30	23–40
Eggs (13%)	15–42	29–52
Mutton and lamb (20%)	51–750	100–165
Milk (3.5%)	28–43	26–54
Cheese (25%)	28–68	26–54
Seafood from fisheries (16–20%)	4–540	N/A
Seafood from aquaculture (17–20%)	4–75	13–30
Meat analogues containing egg - or milk protein (15–20%)	17–34	8–17
Meat analogues, 100% vegetal (8–20%)	6–17	4–25
Pulses, dry (20–36%)	4–10	10–43

Source: (Nijdam, Rood & Westhoek, 2012) compilation of cradle to retail LCA of several studies



Meat & Livestock Australia (MLA) are positioning the domestic red meat industry to be at the forefront of best practice for sustainability with a target to make the sector carbon neutral by 2030. Nevertheless, global sustainability factors will remain a large contributor to change in protein markets. In Iteration 10 of MLA's Project Daisy survey (discussed in 2.3.3), the primary drivers of decreasing red meat consumption were found to be cost and health. However, environmental concerns by consumers were still apparent.

Different types of meat substitutes have differing sustainability gains and variable technology innovation requirements (Figure 5). For example, plant-sourced proteins such as pulses require low technological innovation and offer high sustainability gains, while the sustainability gain for cultured meat and algae is uncertain and the technological requirement is high. Similarly, the plant and insect protein used to substitute for meat products requires moderate technology and results in a moderate sustainability gain (van der Weele et al., 2019).



**Figure 5**  
**Sustainability gains and required technological innovation of alternative proteins**

Source: Author's compilation based on van der Weele et al., 2019

Society is becoming more concerned about the conditions in which livestock are reared, transported and slaughtered (Animal Welfare Institute, 2019; Seng & Laporte, 2005). Concern regarding the welfare of farmed animals is a common driver for consumers in choosing a vegetarian or vegan diet,

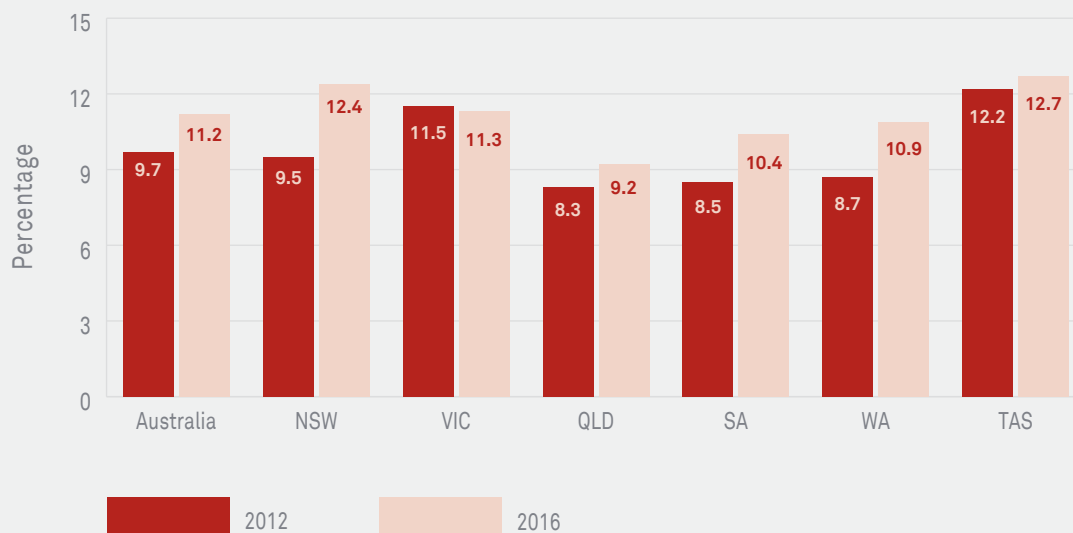
and also when evaluating the ethical profile of brands of protein products. However, welfare is less of a concern for those looking to reduce their meat consumption or who identify as 'flexitarians' compared to those who cut animal-sourced products from their diets altogether.

## Overview of alternative proteins

### 2.3.3 Changes in consumer preferences

The proportion of the Australian population making all or almost all vegetarian food choices rose from 9.7% in 2012 to 11.2% in 2016<sup>10</sup> (Figure 6). A 2019 survey reported that in addition to an approximate 10% of vegans/vegetarians, 12% of Australians identify as 'meat-reducers' and 20%

as 'flexitarians' (Food Frontier & Life Health Foods, 2019), indicating an increasing domestic market for alternative protein products. Meat consumption trends are discussed in further detail in Section 3.



**Figure 6**  
Australian population making vegetarian / mostly vegetarian food choices 2012-16

Source: (Roy Morgan Research, 2016)

Malek, Umberger & Goddard (2019) surveyed a nationally representative sample of Australian meat eaters in 2016 and found that 46% of respondents were committed meat eaters, 22% were willing to reduce their meat consumption, 15% were classed as prospective vegetarians or vegans and willing to stop eating meat (with the remaining 17% undecided). Although the majority of Australian consumers are committed meat eaters, meat reducers, flexitarians and vegetarians represent a significant market niche to be targeted as consumers of alternative protein products.

MLA's Project Daisy has assessed consumer sentiments since 2010 to explore the metropolitan community's understanding of and concerns about the red meat industry. The Project Daisy

survey has shown that the primary drivers behind the reduction in per capita red meat consumption since 2010 have been cost and health, while animal welfare and environmental concerns ranked significantly lower with the respondents surveyed (Cooney, 2019).

A recent report by Food Frontier and Life Health Foods (2019) found that 60% Australians have tried or are interested in trying plant-sourced meat analogues. It should be noted that curiosity can play a role in consumers' willingness to try some products and does not directly correlate with consumers continuing to purchase products regularly as part of their diets. Care should be taken when interpreting statistics which focus on willingness to try alternative protein products so as not to directly mean continued consumption of these products.

<sup>10</sup> These figures do not include the growing number of flexitarian and meat-reducing consumers.

A number of similar studies across the globe have investigated consumer preferences in relation to alternative proteins, particularly comparing acceptance when varying levels of information are provided. Van Loo, Caputo, & Lusk (2019) conducted a nationwide survey of 1800 US consumers, noting their purchasing patterns under various scenarios. When price was held constant 72% of respondents chose farm-raised beef, 16% chose pea-protein plant-sourced meat analogues, 7% chose animal-like plant-sourced meat analogues and 5% chose cultured meat. The study also showed when brand names were added<sup>11</sup>, more consumers chose the farm-raised beef option (80%). Providing environmental and technical information made very minor changes to the respondent's choice.

A recent Danish study has suggested that product perception of plant-sourced meat analogues can be improved when the precise protein type<sup>12</sup> is highlighted in the ingredients list (Aschemann-Witzel & Odile Peschel, 2019). This is an important finding for food manufacturers and processing businesses when deciding on the particular protein type to secure for developing new products.

Non-traditional protein sources such as cell-grown, insects and algae have much lower acceptance by consumers, particularly in western cultures, compared with traditional animal-sourced proteins (Sogari, Bogueva & Marinova, 2019; van der Weele et al, 2019; Van Loo, Caputo & Lusk, 2019; Wilkinson et al., 2018).

Wilkinson et al (2018) found that taste, appearance, safety and quality were the greatest factors influencing Australian consumers' willingness to try insects as food. Utilising insects as an ingredient in familiar products such as biscuits increased their appeal with the consumers surveyed. Witchetty grubs (followed by ants, grasshoppers and crickets) were the most common insects consumed by the 21% of respondents who had previously eaten insects.

In summary, the amount and type of information provided to consumers can influence their preferences and decisions. Although animal-sourced meat remains the most popular protein choice, the amount of plant-sourced meat analogues being consumed is rising (Lawrence & King, 2019). The ability of these products to better mimic the taste of traditional meat may see them attract more consumers in the future, particularly those who identify as meat reducers or flexitarians.

International sales data confirms that nutritional profile rather than claims of sustainability and animal welfare issues can be more significant drivers of choice in some protein markets (Lusk, 2019). For example, Fairlife Milk – an ultrafiltered, branded milk product with more protein and less sugar than regular milk – is the highest selling milk brand in the US. In this case it is the technology-enabled nutritional profile as opposed to sustainability/animal-welfare claims that is the major driving force for market dominance (Lusk, 2019).

Consumer preferences were a common theme in the stakeholder interviews undertaken as part of the research process. The key takeaway message from these discussions was that **while there are major and real trends driving an increase in alternative protein consumption, many consumer purchasing decisions will come down to familiarity, taste and cost.**

Stakeholders noted that for some consumers, food is more than just a fuel, and can be a culturally significant experience in some cases. They also noted that although some will purchase alternative proteins for ethical or emotional reasons, for many it will come down to how the product tastes and how sensitive they are to price points.

The consensus from stakeholders consulted was that consumer perceptions of alternative proteins as a healthy alternative to animal-sourced protein are changing, and that more consumers are concerned about potential health issues with highly processed food products (which includes some alternative protein products) – a conclusion consistent with the MLA's Project Daisy consumer survey data.

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**Non-traditional protein sources such as cell-grown, insects and algae have much lower acceptance by consumers.**

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<sup>11</sup> The brand names added in the survey were Certified Angus Beef, Beyond Meat, Impossible Foods and Memphis Meats.

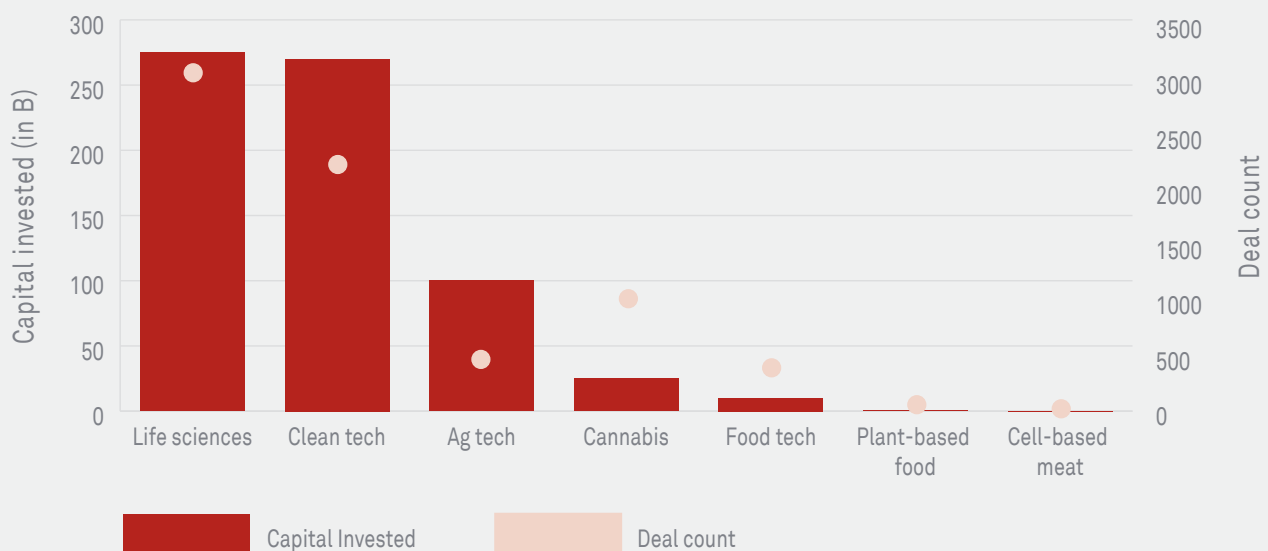
<sup>12</sup> For example, potato protein, soybean-based protein or faba bean-based protein.

## Overview of alternative proteins

### 2.3.4 Investment

The amount of investment into companies producing alternative proteins continues to secure significant media attention, especially with high profile individuals and companies making significant investments<sup>13</sup>. Despite the

hype and attention, the investment received by alternative protein companies is still significantly less than other food-related innovation industries such as agriculture technology and cannabis (**Figure 7**).



**Figure 7**  
**Funding invested in various industries in 2018**

Source: (The Good Food Institute, 2019) compilation from PitchBook

The Good Food Institute (2019) analysis on plant-sourced meat analogue market investment in the US found that \$US673 million was invested in total into the industry in 2018, with 43% of the total deals being venture capital funded. The analysis also included the cultured meat market, which had fewer deals

and less total money invested than the plant-sourced meat analogue market over the same time period. Food technology investment totalled approximately \$10 billion compared with cultured meat companies securing less than \$100 million in the same time period.

<sup>13</sup>For example, Microsoft co-founder Bill Gates, actor Leonardo DiCaprio, former McDonald's CEO Don Thompson, venture capital firm Kleiner Perkins Caufield & Byers LLC and Twitter co-founder Ev Williams's Obvious Ventures are all invested in Beyond Meat (Mulvaney & Hytha, 2019).



Despite the hype and attention, the investment received by alternative protein companies is still significantly less than other food-related innovation industries.

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## Section 3

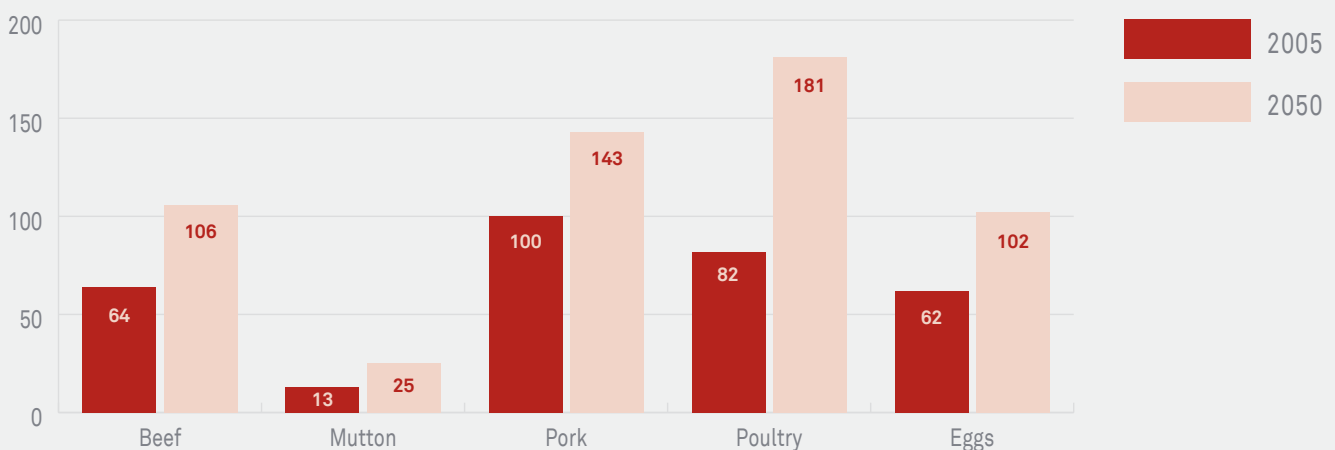
# The impact of the changing protein landscape

### 3.1 Animal agriculture

Animal agriculture will struggle to supply the growing demand for protein using the finite resources available in current production systems (Alexandratos & Bruinsma, 2012). The Human Appropriation of Land for Food index shows that plant and alternative protein production requires less land than animal protein production (Alexander et al., 2017), and changing conditions will in turn create competition for resources between animal and alternative protein production. Alexander et al. (2017) also claim that, given the rising global trends for meat consumption, meeting the demand of diets based on high proportions of animal products will be impossible in 2050 using existing methods and systems without severely degrading the environment, potentially beyond repair.

Under the business as usual (BAU) scenario baselined at the 2005 level (Figure 8), global meat demand in 2050 is significantly increased. More water, feed and land will be needed to meet this demand - however, shortages of water

and land are already serious issues for global production even now at existing volume production. To meet the upcoming demand for protein, the agricultural industry cannot rely on traditional systems alone.



**Figure 8**  
Business as usual global demand for meat 2005 vs 2050 (million tonnes)

Source: (Alexandratos & Bruinsma, 2012)



**Animal agriculture will struggle to supply the growing demand for protein using the finite resources available in current production systems.**

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## The impact of the changing protein landscape

The scarcity (and hence increasing opportunity cost<sup>14</sup>) of land, water and feed combined with limiting environmental factors will require that animal agriculture limits herd numbers while increasing productivity in order to produce sustainably. Drought, and the subsequent increase in feed cost, are already forcing Australian producers to decrease the herd size (MLA, 2019).

Global agriculture will continue to face increased resource scarcity in the future in sustainably supplying the growing demand for protein. Both animal and plant production will need to increase productivity to overcome this challenge. The utilisation of technology and breeding techniques which enable the production of more protein with fewer resources will be vital in ensuring environmental stewardship and global food security.

Consistent themes relating to the impact on animal agriculture from alternative proteins emerged from the stakeholder interviews conducted as part of this research.

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### Stakeholders do not consider alternative proteins a significant threat but believe they should not be dismissed.

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Many stakeholders interviewed noted that plant-sourced protein substitutes have been in the marketplace for several decades; the difference with newer protein substitute products is that many taste better than previous iterations. The consensus of interviewees was that there is room for alternative protein products alongside traditional protein in the market, and that these alternatives provide an improved range of product choice for consumers.

Although the growth in market share of alternative proteins was perceived as noteworthy by the agricultural industry, several stakeholders noted there are much more pressing issues which could impact on future demand for animal-sourced proteins, such as competition with other exporting countries. Many suggested that any substitution of traditional protein in the market by alternative proteins will be insignificant compared with the increased demand for all protein from a growing population. This was also affirmed by the empirical analysis in **Section 5**.

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### The primary concerns arising from stakeholder interviews related to the marketing and labelling of alternative protein products.

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Stakeholders interviewed noted that marketing of alternative protein products can be misleading and drive misconceptions about traditional animal-sourced protein sources. An example includes plant-sourced chicken meat analogue companies promoting their product as 'free from hormones', falsely inferring that chicken growers use hormones in production. Stakeholders from the chicken meat sector also advised they had received complaints from consumers who had mistakenly purchased plant-sourced chicken substitute products instead of animal-sourced chicken. Earlier in 2019, consumers in New Zealand complained to their Commerce Commission about a limited edition 'burger pizza' which was made with – but not advertised as – plant-sourced meat analogue, resulting in a warning for the company for a potential breach of the Fair Trading Act (Lai & Becher, 2019). However, according to Colmar Brunton's consumer analysis (Food Frontier & Life Health Foods, 2019) 91% of Australians have never mistakenly purchased a plant-sourced product when intending to purchase animal-sourced products (or vice versa).

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#### 3.1.1 The meat industry

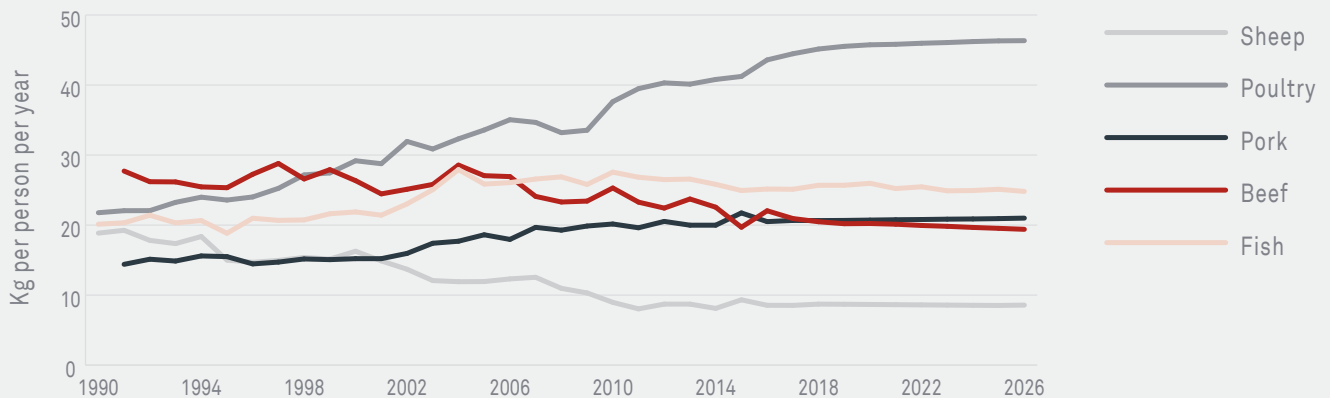
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Australians are consuming less red meat in favour of white meat, significantly reducing the per capita red meat consumption over recent decades (**Figure 9**). Total meat consumption in Australia has continued to rise since the 1960s as the population has grown. However per capita consumption (at more than 100kg per annum) has remained relatively stable over the same time period. Global meat consumption increased by 58% from 1998 to 2018 to reach 300 million tonnes, with 85% of the rise attributed to consumption in developing countries. Chinese consumption increased by 72%, accounting for 34% of total global consumption growth (Whitnall & Pitts, 2019). Meat production in Australia continues to rise, mainly due to this global demand, with roughly 70% of Australian red meat production destined for export.

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<sup>14</sup>Land and water used for animal production cannot be used for something else that might be more environmentally efficient in providing protein using the same resources, resulting in opportunity costs.





**Figure 9**

### The change of annual per capita consumption of meat type in Australia

Source: Authors' compilation based on OECD data

Factors triggering the decline of red meat per capita consumption include high prices and concerns for human and environmental health. While emerging beef substitutes such as Beyond Burger are strategically marketed to compete with the red meat sector, they currently account for less than 1% of Australia's meat market<sup>15</sup> (Lawrence & King, 2019). Plant-sourced meat analogues account for less than 0.1% of the \$1.7 trillion global market for meat, fish and dairy (Friend, 2019).

The rising middle-income global population and the strong domestic demand for red meat means that even if the per capita domestic consumption declines, the overall demand for red meat will remain high.

Much of this change in the type of meat consumed by Australians can be attributed to changes in price. The historic retail meat prices show a steep rise in the price of lamb, goat, beef and veal, a modest rise in pork while the price of chicken meat has remained relatively stable for several decades (Figure 10).

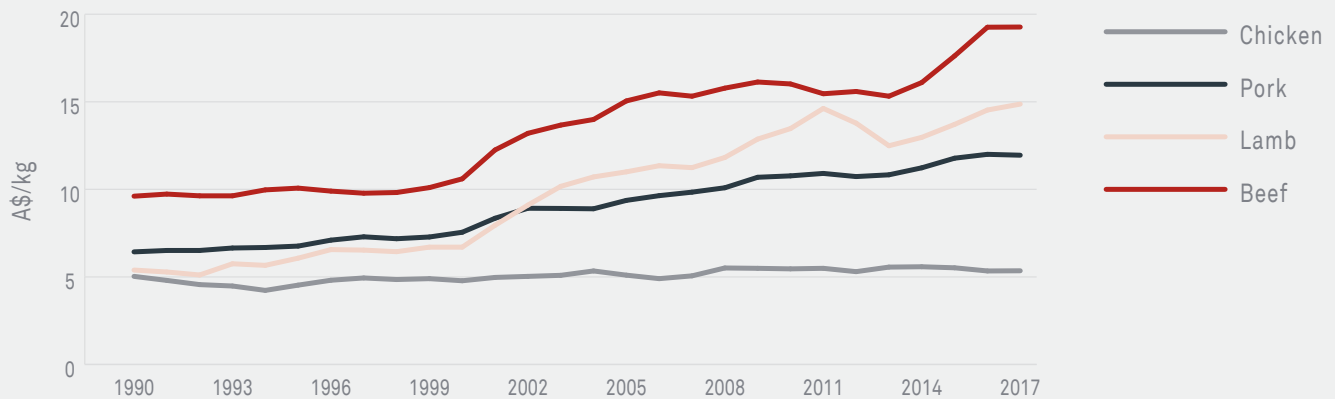
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**Australians are consuming less red meat in favour of white meat, significantly reducing the per capita red meat consumption over recent decades.**

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<sup>15</sup>The total meat market being the sum of all animal-based and plant-based meat analogues sold in Australia.

## The impact of the changing protein landscape



**Figure 10**  
**Australian retail prices of meat**

Source: Authors' compilation based on Department of Agriculture data

### 3.1.2 The dairy industry

The introduction of plant-sourced milk alternatives such as soy and almond are not new in the global and Australian milk markets. However, the market share of animal-sourced milk is decreasing with new plant-sourced products entering the market and taking an increasing share of total sales. Milk substitutes now constitute about 9.2% of the dairy market in Australia (Dairy Australia, 2019). **Figure 11** compares the sales growth of animal and plant-sourced dairy products in the US supermarkets from April 2018 to April 2019. Growth of animal-sourced milk and yoghurt products has declined by over 3% over this time.

It should be noted that high growth can provide a false impression of size of the market if the growth is coming from a relatively small base line. Sales growth is useful for

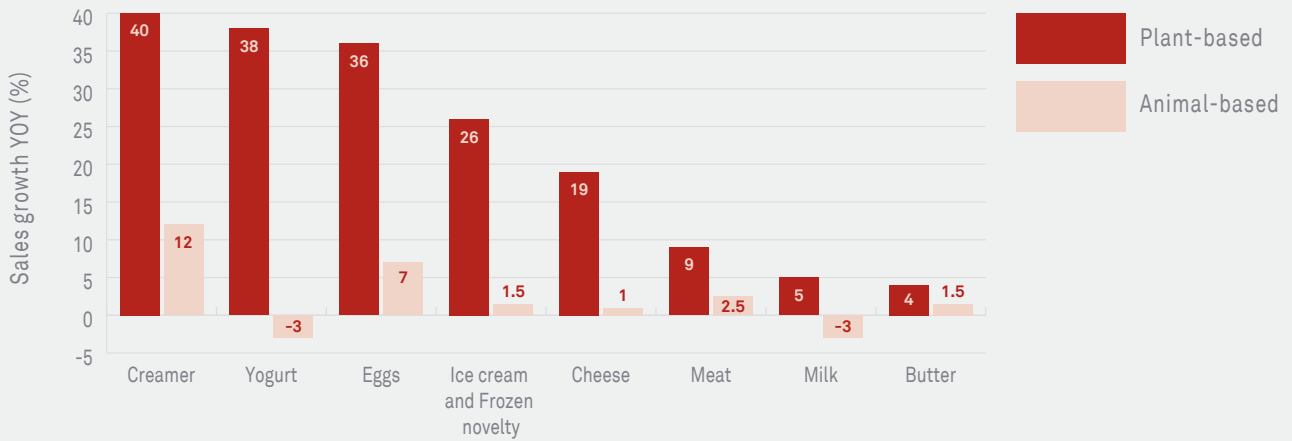
understanding trends in consumer behaviour however the size of the market needs to be considered in determining whether such trends pose a material threat to the existing market. Plant-sourced animal protein analogues are currently taking a \$2.2 billion share of the \$1.7 trillion global animal-sourced protein market.

It should also be noted that Australian purchasing behaviours differ to that of the US, meaning the figures outlined in **Figure 11** should not be inferred as indicating likely patterns in the Australian market.

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**Plant-sourced animal protein analogues are currently taking a \$2.2 billion share of the \$1.7 trillion global animal-sourced protein market.**

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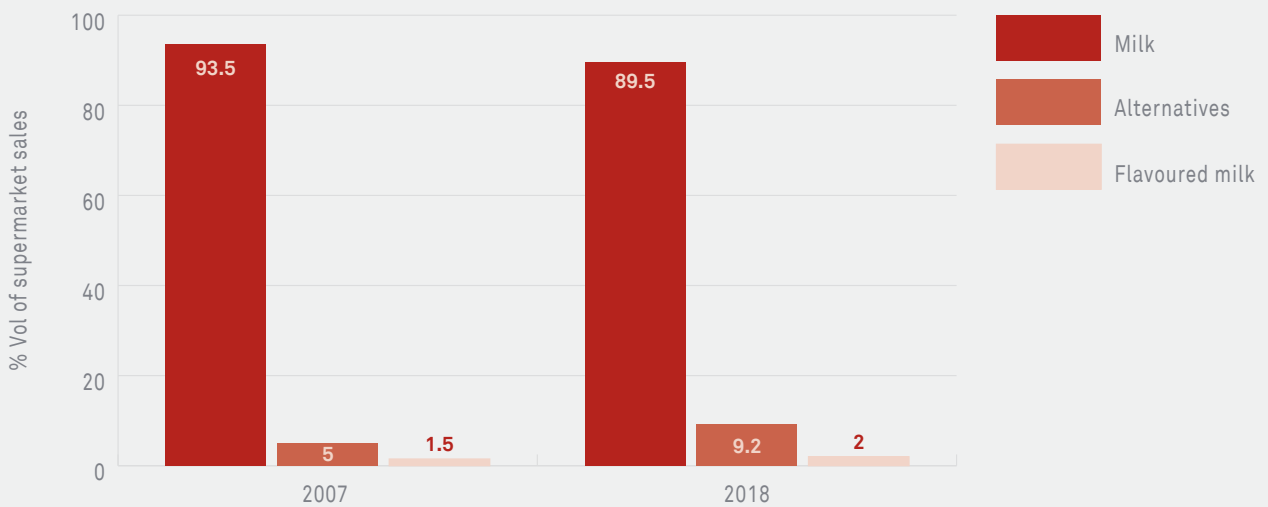


**Figure 11**  
**Change in sales of plant and animal-sourced dairy products in US supermarkets, April 2018-19**

Source: (The Good Food Institute, 2019)

In Australia, supermarket sales of dairy milk alternatives have grown steadily over the past decade. Approximately 63% of milk sales is through supermarkets with remaining sales occurring through other outlets such as food service, petrol

stations and hospitals. As of December 2018, approximately 136 million litres of milk alternatives were sold at Australian supermarkets with alternative dairy products being sold at a higher price point than their traditional counterparts.



**Figure 12**  
**Percentage volume of Australian supermarket sales of milk in 2007 and 2018**

Source: (Dairy Australia, 2019)

## The impact of the changing protein landscape

Although plant-sourced alternatives are now close to a \$337 million-market in Australia, dairy milk still accounts for approximately 89.5% of total volume of supermarket milk sales with alternatives only accounting for approximately 9.2% and flavoured milks sales the remaining volume (Figure 12). In 2018/19, there was a 0.9% drop in volume sales of white milk, while non-dairy milk sold grew 10.9% in supermarkets. In terms of sales (\$), white milk sales grew by 2.5% while the sales (\$) of non-dairy beverages grew by 7.6%. Therefore, while consumption of alternative milk is growing, dairy milk still holds the majority market share and sales continue to grow<sup>16</sup>.

Dairy substitutes, particularly plant-sourced milk, have been present in the market for a longer time period than substitutes for meat due to the low technological innovation requirement to produce plant-sourced dairy substitutes when compared to substitutes for meat products such as cellular meat. While the sustainability gains from switching to plant-sourced dairy from animal-sourced dairy are quite low (van der Weele et al., 2019), consumers often make the switch for ethical (e.g. animal welfare) or health reasons.

The labelling and marketing of alternative proteins are significant concerns highlighted in the dairy stakeholder interviews conducted for this project. It was also noted that plant-sourced milks are functionally equivalent but not nutritionally equivalent to traditional animal-sourced milks. A Dairy Australia report notes that a French study conducted in 2017 found that six out of 10 people erroneously believed that plant-sourced drinks can replace cow's milk in terms of nutrition. Similarly, a survey conducted by Dairy Australia in 2017 indicated that 54% of those who purchase dairy alternatives did so as they believed it was a healthier option.

The dairy industry is concerned over the nutritional claims made on the packaging of alternative products which could mislead consumers into believing alternatives are either the healthier option or nutritionally equivalent. Table 6 highlights the differences in vitamins and minerals between regular cow milk and several alternatives. When focusing on protein, only pea and soy milk are comparable to cow milk in grams per serve.

**Table 6**

### Nutritional values of traditional dairy compared to plant-sourced alternatives

Vitamins/minerals	Cow's milk	Soy	Rice	Oat	Almond	Pea
Calcium*	34%	36%	22%	39%	21%	38%
Phosphorus*	23%	17%	5%	10%	3.5%	25%
Riboflavin*	31%	4%	0%	0%	4%	29%
Vitamin A*	17%	2%	0%	0%	0%	18%
Zinc*	7%	3%	1%	6%	2%	0%
Magnesium*	8%	16%	8%	13%	10%	0%
Protein**	8.8g	9.3g	1g	3.5g	1.5g	8.3g
Price***	A\$1.58	A\$2.42	A\$2.5	A\$2.95	A\$3.39	A\$4.00

Note: \*%RDI; \*\* gram per serve; and \*\*\* price per litre. The shaded figures represent added nutrients during processing.

Source: (Dairy Australia, 2019)

Several stakeholders interviewed for this project identified a marketing opportunity to re-brand animal-sourced dairy proteins, such as milk, and promote their benefits to consumers. They noted a potential competitive advantage for

industry to be proactive in portraying the nutritional benefits of animal-sourced dairy products rather than reacting against misconceptions about functionally similar products.

<sup>16</sup>Soy, almond, coconut, rice and oat milks are the alternatives to dairy milk included in this data.

### 3.1.3 The aquaculture and seafood industries

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Aquaculture is the fastest-growing protein sector globally relative to other meat sectors. Seafood consumption per capita in developing countries has risen strongly in recent years, while consumption in the developed world has remained steady during the same period. Currently, Australia's consumer demand for seafood exceeds the supply from domestic production and continues to grow (Wright, 2016) and about 95% of Australians eat seafood (FRDC, 2019). The volume of fisheries and aquaculture production increased by 4% between 2006–07 and 2016–17, while the pattern of production has shifted from wild-catch stocks towards farmed aquaculture products (ABARES, 2017).

Given the increasing trend in consumer preference for fish and seafood and the rising per capita consumption, the overall growth in the protein market represents an opportunity for the fisheries sector.

Fish and seafood offer consumers a unique combination of high-quality protein and important nutrients (Bogard et al, 2019). The leading drivers of seafood consumption in Australia are health (particularly for finfish such as Atlantic salmon), taste and convenience. Barriers to consumption include expense, quality concerns, inadequate availability and a lack of confidence in selection and preparation (Christenson et al., 2017).

In terms of sustainability, aquaculture is drought-proof in marine environments and land-based systems can accommodate climate change impacts. In addition, studies show that seafood has a very low GHG footprint (González, Frostell, & Carlsson-Kanyama, 2011).

However, social licence issues based on depletion of stocks in wild-caught fisheries and fish welfare in aquaculture are a concern for the sector. For example, while intensive farming that increases yields by farming more fish per cubic metre of seawater could meet rising demand for product, community opposition to intensive fish farming poses a threat to expansion.

There are few seafood substitutes introduced in the market at present and their market share is still very small. BlueNalu is a company based in the United States working towards producing cellular aquaculture. They use living cells of fish and other seafood to create fresh and frozen fish products in laboratories (BlueNalu, 2019). Although there are no cultured seafood products yet commercially available in the market, there are several plant-sourced alternatives already available for consumers to purchase, such as New York-based Good Catch which produces plant-sourced tuna and other seafood products. The 'tuna' products use a blend of plant proteins including soy, pea, lentil and chickpea (Wild Catch, 2019). Plant-sourced mimics of seafood have better shelf life than animal-sourced products.

Companies currently selling alternative seafood and fish products do not appear to be receiving the same hype or attention as products targeting other meat sectors such as beef and chicken. This may be attributed to heightened concerns of the environmental impacts of red meat compared with seafood and aquaculture. However, concerns over sustainable fishing and depletion of wild stocks could drive increased attention towards alternatives to traditional fish and seafood products.

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**Aquaculture is the fastest-growing protein sector globally relative to other meat sectors.**

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## The impact of the changing protein landscape

### 3.1.4 The feed market

Alternative proteins such as insects have potential not only for human consumption but also as feed for livestock such as poultry, fish, pigs and pets. The increasing costs and limited availability of conventional feed resources (such as soymeal and fishmeal) are cause for concern to the feed industry. In addition, the sustainability of using grains and pulses to feed livestock has been questioned as a responsible use of natural capital. Insect farming has potential to provide part of the solution to these problems (Makkar et al., 2014).

Multiple insect products – for both human food and animal feed – produced by small start-ups are already available for consumers to purchase in Australia. The domestication of edible insects is relatively simple and economical (Melgar-Lalanne et al., 2019; van Huis, 2015) as:

- most insects can be easily reared in small spaces or containers;
- their life cycle is short;
- they can eat forest<sup>17</sup> or agricultural waste instead of grains;
- insect farming can be carried out in both urban and rural areas; and
- short-term financial returns are possible.

Insect farming for animal feed is a promising method of protein production given the nutritional properties of insects, high feed-conversion efficiency and the possible environmental benefits (Sogari et al., 2019). However, consumers' perceptions in developed economies of using insects as a feed source for farmed animals and pets are relatively unknown.

Multiple insect farms now operate in Australia (Rohrlach, 2019), with the Edible Bug Shop and GoTerra<sup>18</sup> two of the most noteworthy in terms of operating size and output. Given their commercial success, house crickets and yellow mealworms are the most widely farmed insects in the world, and these are mainly used as pet food (Sogari et al., 2019).

The use of insects as feed (which is already underway in Australia) has potential to stabilise feed costs and enable agriculture to support traditional animal protein production at a lower price.

### 3.2 Plant protein production

Market share of plant-sourced alternative protein is increasing year-on-year. However, with a total retail value in the US in 2018 of around \$3.7 billion (The Good Food Institute, 2019), this is still approximately only 0.6% of the total retail food market<sup>19</sup>.

The increasing number of vegetarians and flexitarians means that demand for protein from plant sources is increasing. In the US, the retail sales of plant-sourced meat analogues grew by \$700 million in 2018<sup>20</sup> (The Good Food Institute, 2019). On a global scale, plant-sourced proteins account for 66% of protein consumption (Food Innovation Australia Limited, 2019).

Protein fractionation of pulses is a significant value adding opportunity that is attracting global investment. Protein extracts from pulses are now being used in meat analogues, protein juices, protein bars and other similar products. This trend is creating alternative markets for low quality, off-grade pulses that are usually destined for animal feed. The market is currently small, but as more plant protein extraction investments are made, there is potential for pulse protein to become a more mainstream market.

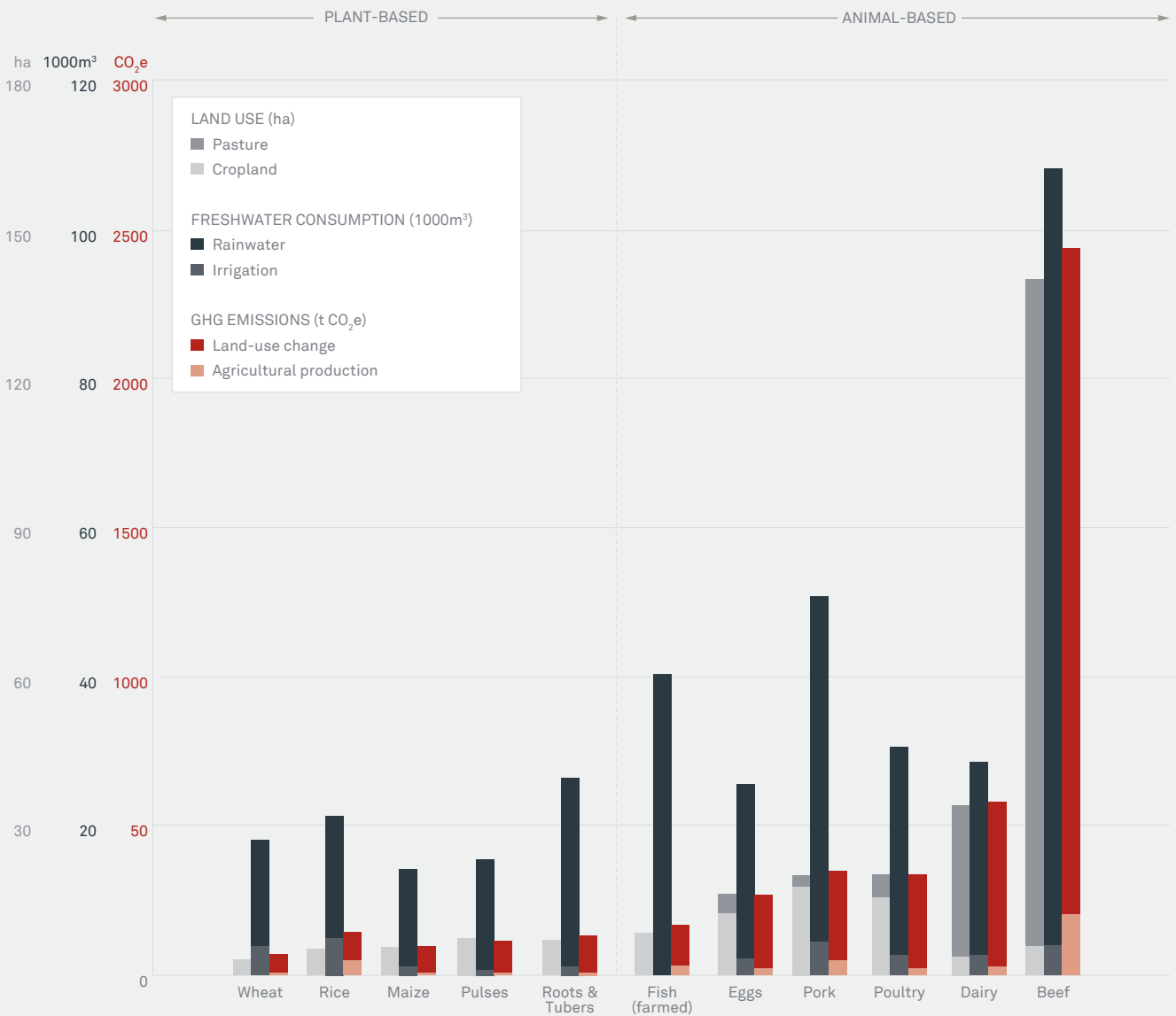
The efficiency of plant-sourced protein production in terms of GHG emissions, land and water use compared to animal protein means that plant protein will likely become increasingly more attractive to investors and consumers in the near future (**Figure 13**).

<sup>17</sup>The organic waste from the production of forestry products which is discarded (i.e. the portion not used as biofuel or compost) can be used as a feed for insects (Varelas & Langton, 2017).

<sup>18</sup>Other edible insect producing companies in Australia include The Rebel food Tasmania, The Cricket Bakery, Grilo, GrubsUp, Hoppa Foods, and Leap Protein.

<sup>19</sup>Traditional food stores in the US sold \$648 billion of retail food and non-food products in 2016 (USDA, 2018).

<sup>20</sup>Total growth in the US retail food market in 2018 was \$12 billion.



**Figure 13**  
**Resource intensity of different sources of protein**

Source: (Ranganathan et al., 2016)

The utilisation of off-grade grains for plant protein powder extraction can reduce waste, stabilise price and offer additional revenue. These opportunities are perceived to be of greater benefit in the processing sector rather than agricultural production.

The bigger driver for opportunity in Australian grains is likely to be the increasing per capita consumption of plant protein in predominantly vegetarian countries (such as India).

One of the key findings from the stakeholder interviews conducted for this research was that **there may be some economic opportunities to plant-sourced agriculture from the rise of alternative proteins, but they will be niche.**

Several Australian businesses currently producing alternative protein products were interviewed to inform this research. The focus of these case studies is to highlight the benefits and barriers of producing alternative protein products in Australia and to identify related opportunities and challenges for producers of traditional (animal) protein.

#### 4.1 Australian plant protein

Australian Plant Protein (APP) is a business founded by the EAT Group, an Agricultural Investment Management company based in Melbourne. APP use a hybrid wet/dry extraction process to remove high quality protein powder from grains (predominantly pulses however other grains are being explored). The process can use second-grade crops which are usually sold as livestock feed. The extracted powder is a versatile ingredient containing 85-90% protein and can be used in products such as drinks, protein bars and plant-sourced meat analogues.

APP have received investment to fund the establishment of a commercial protein extraction facility in the regional Victorian town of Horsham, with a timeline to be operational by mid-2020. The company aims to expand into South Australia and Western Australia in the future. The company currently has a small research and development facility near Melbourne where they conduct trials and create samples of the extracted protein product.

The opportunity for plant protein extraction was first identified by the EAT Group in 2015 when a supplements company enquired about the availability of plant-sourced protein. The opportunity to build a commercially viable process to extract high value protein from legumes, pulses and grains was then identified in Horsham through discussions with growers. Trials were undertaken from January 2017 until November 2018 to refine the methodology of the extraction process and produce new products.

Over the four years APP has been operating, the drivers for demand of their product have shifted from being mainly focused on health benefits of plant protein to now including sustainability and environmental concerns.

Basing the processing facility in Horsham will likely bring both direct and indirect job opportunities to the Wimmera area, as well as opportunities for growers in the area to sell their product through this channel.

APP believes their product provides an innovation story which is attractive for many of their clients. There are also additional sustainability benefits of APP using a hybrid wet/dry extraction process rather than the traditional method which utilises extensive amounts of water.

APP's aim is to be a "niche and nimble" product and target consumers who are willing to pay a premium price for their high-quality protein powder. They have currently formed relationships with global manufacturing companies in the United States, Canada and Europe and aim to have a high export focus as they grow.

APP has encountered barriers in finding a suitable R&D facility. After exploring several options APP then partnered with CSIRO through the Kick-Start program to optimise the production of their protein powder, but eventually established their own R&D facility through private investment funding. Although there were difficulties in using CSIRO facilities, APP notes they benefited from the highly regarded CSIRO brand when showcasing their samples to potential overseas customers.



**Key takeaways from APP:**

- There are opportunities stemming from the alternative proteins market for grains, pulses and oilseeds growers, however they will be likely to be in the form of a secondary market for off-grade grains rather than a market opportunity for a price premium.
- The direct opportunities for farmers will likely be small, niche and in specific locations until the industry expands further. Processors also have options to import grains from elsewhere in the world, meaning that the opportunity will be pegged to global grains markets, as is the case for most grain products in Australia.

## Case studies

### 4.2 v2food

An Australian company which produces plant-sourced meat analogues, v2food started as a joint venture between CSIRO, Competitive Foods and Main Sequence Ventures. The company was set up in January 2019 and has recently released their first product, the Rebel Whopper, across Hungry Jack's stores throughout Australia. This product has been a success for the business with all sales targets being met so far.

Due to lack of availability of Australian ingredients, v2food are currently importing soy as the main ingredient in their plant-sourced products. However, the company is in the process of developing methods to utilise Australian ingredients and hopes to be producing 100,000 tonnes of plant-sourced meat analogues within three years.

Although the Rebel Whopper is their first commercial product, the business is planning to launch into other food channels in the very short-term. The plant-sourced meat analogue product is very versatile and can be utilised in variety of food ingredients such as sausages, mince, pies and burgers. V2food is planning to launch products into higher-end restaurants and aim to begin exporting within the next three years.

The business has strong values based on sustainability and is currently undertaking life-cycle assessments on the carbon footprint of their supply chain. V2food believes it will have a market advantage being an Australian business and eventually utilising 100% Australian ingredients.

Being less than 12 months old, the company is still early into its product journey. As it has been moving so quickly, it has faced a limited number of barriers so far. However, several barriers to growth have been identified, some of which are indicated below.

- **Negative consumer experiences with competitor products:** With an increasing number of plant-sourced meat analogue products available to consumers, the quality of these products is far from consistent across the market. V2food could be impacted in the future through consumers unwilling to try their product due to a negative experience consuming and inferior competitor's product.
- **Regulation on the use of terminology:** Policies which regulate the use of terminology such as 'meat' on plant-sourced meat analogue products would be a barrier v2food may have to overcome in the future. They believe Australian agriculture should be presenting a united front and avoid segregation.
- **Barriers to export:** Due to the fast growth of the business, there is little knowledge thus far on export, which is a barrier v2food will need to overcome to sell into overseas markets in the future. It is also unknown if there will be any implications on trade agreements as to what category plant-sourced meat analogues will fall under.

#### Key takeaways from v2food:

- Sustainability is also a concern for plant-sourced meat analogues, not just animal protein.
- Regulation of use of terminology such as 'meat' and safety issues could be a possible barrier for businesses in marketing these products.
- The potential trade barriers in exporting plant-sourced 'meat' analogues are relatively unknown.

## 4.3 Perfectly Balanced

Perfectly Balanced is a brand of food products introduced in 2018, produced by meat manufacturing company BE Campbell<sup>21</sup>, made with a combination of vegetables, lentils and meat ingredients. The brand is exclusively available at Woolworths supermarkets in the chilled meat section and currently has two products in its range: beef, sweet potato and kale meatballs and beef and carrot chipolatas.

The products are marketed as the 'perfect blend of meat and vegetables', targeting the growing segment of flexitarians looking to increase vegetable intake while retaining a relatively familiar diet. Through market research, BE Campbell identified the drivers for the rise in consumers identifying as flexitarians<sup>22</sup> and vegetarians and further narrowed the target market down to 'conscious mums' and those trying to get more vegetables into their children's diets.

BE Campbell believes the benefits of developing and launching the Perfectly Balanced products have extended throughout the business. It has increased their capacity to develop a wider range of products, including those which are not traditionally produced by a meat-based company. While a change in strategic direction of branded products within Woolworths will see these two products change their placement in stores in 2020, investigation of alternate channels will be conducted. The experience has increased BE Campbell's knowledge and ability to handle and create hybrid meat products as well as source new and novel ingredients.

BE Campbell experienced several hurdles in developing the flexitarian-targeted products, including:

- **Selling the idea to a major supermarket during the establishment stage:** BE Campbell states that at the time of pitching, Woolworths was aware of the trend of flexitarians but did not have a lot of detail on the opportunity. BE Campbell and Woolworths proactively worked together to develop the concept and bring the offering to life. BE Campbell utilised independent market research and provided significant support to the brand in its establishment through marketing and promotion. This included the development of a standalone website, marketing through social media and other promotional activities such as stalls at food shows and events.

- **Quality Assurance during the product development stage:** Like many new product developments, multiple trials were required through the development stage in order to maintain high quality and maximise shelf life. Challenges such as discolouring vegetables and meat oxidation as well as developing the right mouth feel and taste had to be overcome in the early stages of the product design and development.
- **Competitor activity during the business growth stage:** The most recent challenge faced by the business is the launch of competitor products into the market, e.g. Woolworths launching their own hybrid product. BE Campbell is optimistic the Perfectly Balanced brand will continue to be sold through other channels and sees growth of competitor products as a strong sign for the flexitarian trend.

### Key takeaways from Perfectly Balanced:

- The alternative proteins market is growing with a rising number of competitors introducing products directed at meat reducers.
- While there are benefits to processors in pursuing alternative protein production, opportunities and direct benefits to farmers are limited, however diversification of ingredient mix mitigates business risk for processors and offers alternate market niches for both plant and animal producers.
- The percentage of vegetables and legumes used in the products is quite small - when looking at a whole-of-business approach of the costs of ingredients this would account for a miniscule proportion of ingredient procured.

<sup>21</sup>The company was established in 1969 and has several facilities across NSW: a beef abattoir in Young, a pork de-boning site in Wetherill Park and a tray packing facility in Arndell Park.

<sup>22</sup>At this time, the term flexitarian was loosely defined and had a very broad range of applications including those who were reducing the number of meals containing meat they ate (e.g. meat-free Mondays) and those who were reducing their portion sizes of meat but still including it in their meals.

## Case studies

### 4.4 Goterra

Based in the ACT, Goterra is a waste management solution business using insect farms which are run largely on automation. Household and commercial food waste is collected and fed to maggots, with the mature insects used as a sustainable source of animal feed.

Founder and CEO Olympia Yarger, whose background is in a sheep farming, first identified the opportunity for the business through the need for a sustainable and low-cost alternative feed for livestock. Through developing the idea and business, she then realised the main outcome of the business would be a sustainable waste management solution.

The main customers for the insect feed are currently pet stores as a source for dog food. Although this may not be their target market, the business currently does not have production capacity to supply commercial livestock farmers. However, they are hoping to continue to grow and suspect their customer base will change as they continue to expand.

Ms Yarger says Goterra has experienced exponential growth of 500% quarter-on-quarter since its official establishment in 2016 across multiple facets of the business, including production, colony size, waste management intake and technology, meaning the business has had to adapt and learn to overcome difficulties quickly.

While aiming to raise production capacity and colony size to continue providing a decentralised waste management solution across regional areas of Australia, Goterra also hopes to expand overseas in 2020.

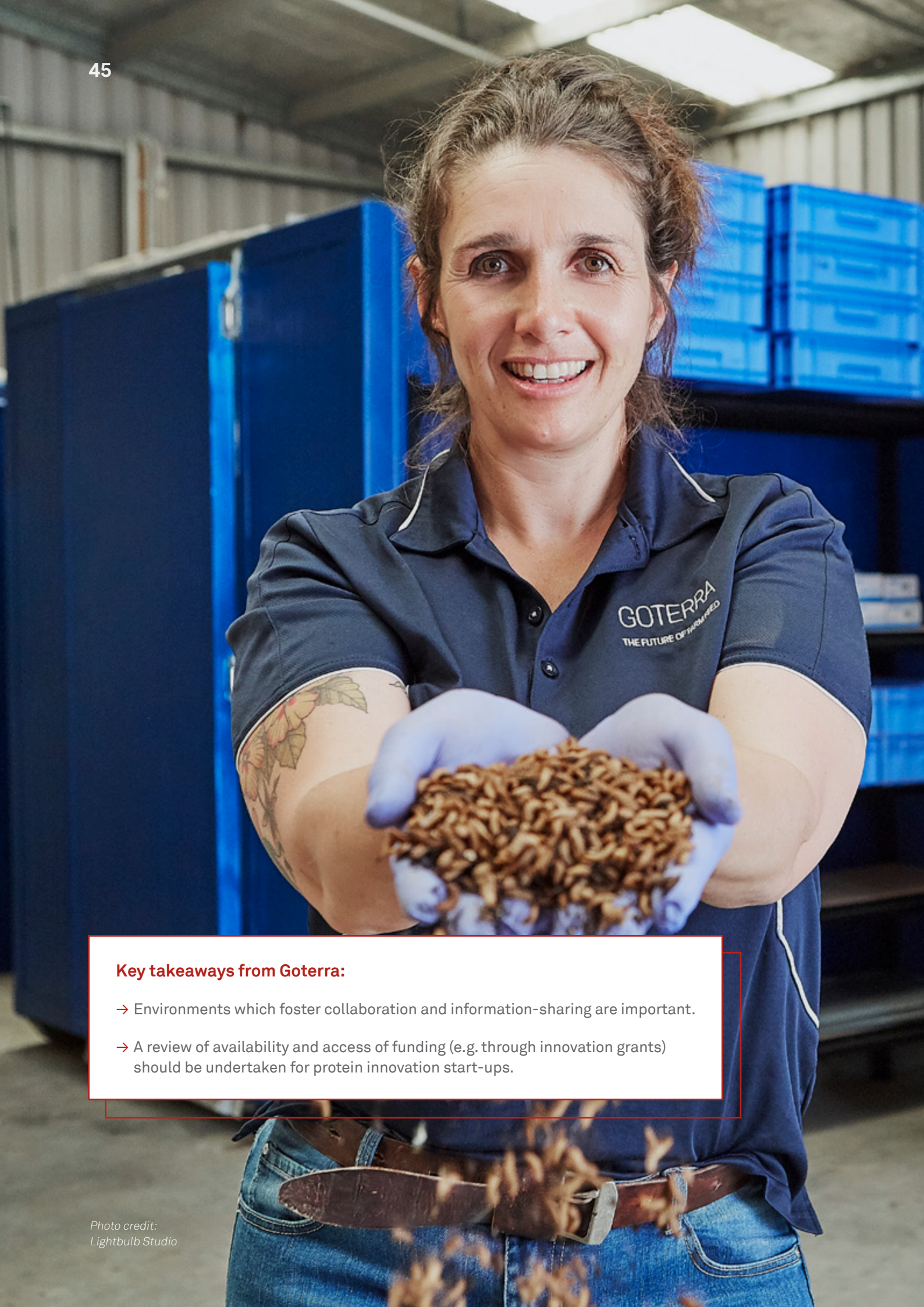
Ms Yarger sees the main benefit of their business as its ability to integrate across multiple industries. Waste management solutions are required in a diverse range of areas and in the process of providing a solution, the business produces a useable and sustainable source of feed.

Goterra has experienced several barriers through establishing and growing the business, some of which have been overcome while others remain a challenge, for example:

- **Lack of available innovation funding:** Goterra found it difficult to access small grants to turn the idea into a commercial opportunity and functioning business model. Very few innovation grants existed at the time of establishment without the need for co-contribution or needing to match the funding provided. However, Goterra

was able to secure an innovation grant in the ACT which did not require needing to match funding. Ms Yarger noted that many start-ups would fail to get off the ground without access to funding through innovation grants and highlighted the lack of funding as indicative of a cultural failure to nurture early innovation in Australia.

- **Fighting preconceived notions:** When establishing and developing her business, Ms Yarger faced challenges in re-educating people who had preconceived notions of the purpose of insect farming. Many mistook her model as being in the business of protein production rather than waste management. Communication of the business value proposition is ongoing.
- **Limited information of production of insects:** Goterra faced multiple barriers to producing and upscaling both the business structure and the maggot colony. Very limited industry information is available on maggot farming, which led to working with many (often incorrect) assumptions. Ms Yarger noted the insect industry is 'closed off' and much less willing to share information compared to those in traditional farming. She also added that start-ups often struggle to find the balance of working in the confines of intellectual property and collaborating with industry to solve problems. Goterra logs all changes in production to ensure they can see historical changes in their production systems and analyse the subsequent impacts. Overcoming production barriers has mainly been through experimentation and processes of trial and error. Ms Yarger has tried to foster a culture that embraces collaboration with peers in the industry and promotes information sharing.
- **Consumer perceptions of insects:** A surprising barrier Goterra needed to overcome was from some consumers who were concerned over the maggots' feelings in the production process. Although not a significant barrier compared with those mentioned above, Goterra overcame this barrier by putting thought into the language used and the narrative they convey to their customers. Ms Yarger stated that human consumption of insects is more of a cultural challenge.



### Key takeaways from Goterra:

- Environments which foster collaboration and information-sharing are important.
- A review of availability and access of funding (e.g. through innovation grants) should be undertaken for protein innovation start-ups.

## Section 5

## Estimation of potential opportunity in 2030

### 5.1 Volume of additional protein demand

The dietary needs of a growing population will inevitably result in increased demand for protein. By 2030 the Australian population is forecast to be 29.17 million (ABS,2018), an increase of 4.17 million from 2018. Assuming that Australian protein production will be sufficient to meet the needs of domestic consumers, the total volume demand will then depend on how much export opportunity can be realised. Population growth and changing dietary preferences driven by increased wealth in Australia's export markets will effectively mean that the demand for protein in those countries will be significantly larger than can be supplied from Australian production alone.

Many factors may impact on the economic opportunity and relative performance of the domestic market compared to export markets for protein production. These include but are not limited to: policies impacting on ability to import and trade protein products; social licence conditions (such as acceptance of live exports and continued use of important agricultural chemicals); changes to transport infrastructure impacting economics of agricultural product movement; consumer preferences within animal-sourced protein production systems (e.g. grain-fed versus grass-fed red meat); and changes in feed conversion efficiencies. For the purpose of this report, which takes a high-level view of threats and opportunities, assumptions have been confined to those which are more directly related to macro trends.

The assumption made for this estimation of potential opportunity, therefore, is that the proportion of exports to domestic consumption will stay approximately the same as it is now, ranging from as low as 3% of products exported (poultry) to as high as 75% of products exported (mutton and goat meat) with an average across total agricultural production of around 33% domestic consumption and 66% exports.

Maintaining these export ratios would result in an additional 10.47 million (4.17 million Australian and 6.3 million overseas) protein consumers being supplied by Australian protein sources in 2030 compared to 2018.

Using FAO statistics for Australian per capita consumption of protein from different food sources (an average of 106g of total protein per day from all sources<sup>23</sup>) and converting for the percentage of protein contained in each food type, it is estimated that Australian agriculture will need to produce 33.1 million tonnes of food to satisfy domestic consumption needs for protein by 2030. If similar export ratios are experienced in 2030 this would equate to a total domestic and export demand for Australian agricultural products to meet protein consumption requirements, of 65.1 million tonnes. This is an additional demand of 8.65 million tonnes compared to domestic and export demand in 2018 (**Table 7**).

<sup>23</sup>The assumption of 106 g per capita per day is based on FAO's data of protein supply available for Australia. The figure shows only the supply of the available protein and doesn't mean that all is consumed as part of it could also be wasted.



By 2030 the Australian population is forecast to be **29.17 million**.

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## Estimation of potential opportunity in 2030

**Table 7**

### Demand for Australian agricultural products required to meet protein consumption

Variable	Year	Products required (million tonnes per year)
(a) Annual domestic and export demand	2018	56.44
(b) Annual domestic and export demand	2030	65.09
(c) Total additional demand in period (b-a)	2030	8.65

Source: Authors' calculation.

FIAL estimate that more than 80% of additional protein demand will be derived from population growth (Food Innovation Australia Limited, 2019) and while the quantum of the forecast in this report of additional demand is based primarily on population growth, there are many other factors such as changes in dietary preferences which could also provide additional demand. The analysis also assumes a scenario where there will not be significant technological, environmental and preference changes such as a cultured meat capable of fully replacing meat and consumer acceptance of non-traditional proteins.

### 5.2 Value of additional protein demand

The value of additional protein demand in 2030 was estimated for a range of protein sources under two different scenarios (Figure 14 and Table 8).

In the first scenario, a business as usual (BAU) with animal protein substitution analysis was performed which assumed that protein consumption patterns would remain similar to those observed today apart from some substitution of animal protein with alternative protein products. The amount of animal protein substitution that was forecast was 9% for meat products, 15% for dairy, 2% for fish and 1% for eggs. In this scenario it was also assumed that 2% of grains used for animal feed would be substituted with alternative protein (predominantly insects).

These assumptions are based on:

- **Meat** – A report from Barclays Research (Barclays Research, 2019) estimated that by the end of the decade alternative meat will become a \$140 billion industry (10% of the \$1.4 trillion global meat industry). Current market share for meat alternatives is around 1%.

- **Dairy** – Dairy Australia data indicates that the current market share of dairy alternatives in Australia is 9.2%. In the US, 13% of the retail milk market is dairy alternatives (The Good Food Institute, 2019). Given the rise in annual sales growth, it is justifiable to assume 15% share by 2030.
- **Fish** – Alternatives are now at the introduction stage with a range of products such as tuna substitutes on the market. Two percent market share by 2030 is assumed as product development and consumer preference evolves.
- **Eggs** – Similarly to fish, there are egg replacement products on the market although their current market penetration is very small.
- **Feed grains** – Similarly to fish and eggs, while there are commercial insect protein animal feed products available and there is rapid growth in the market, the current market penetration is very small.

It was assumed that the potential value for alternative proteins would be equal to the value lost from animal protein sectors, as consumers would look to make cost neutral substitutions.

In this scenario there is a reduction in growth for feed grains by 2030 (compared to a scenario where there is no animal protein substitution) however this reduction is offset by an increase in demand for pulses to supply plant-sourced proteins for manufacture of alternative protein products. These balancing market factors essentially mean that the forecast for grains opportunity in 2030 is similar regardless of the amount of animal protein substitution that occurs.

A second scenario was modelled which analysed the potential opportunities and threats related to a more significant change in dietary patterns. In January 2019 the EAT-Lancet Commission released a report which proposed a Planetary Health Diet that would deliver improved health outcomes for people and the planet

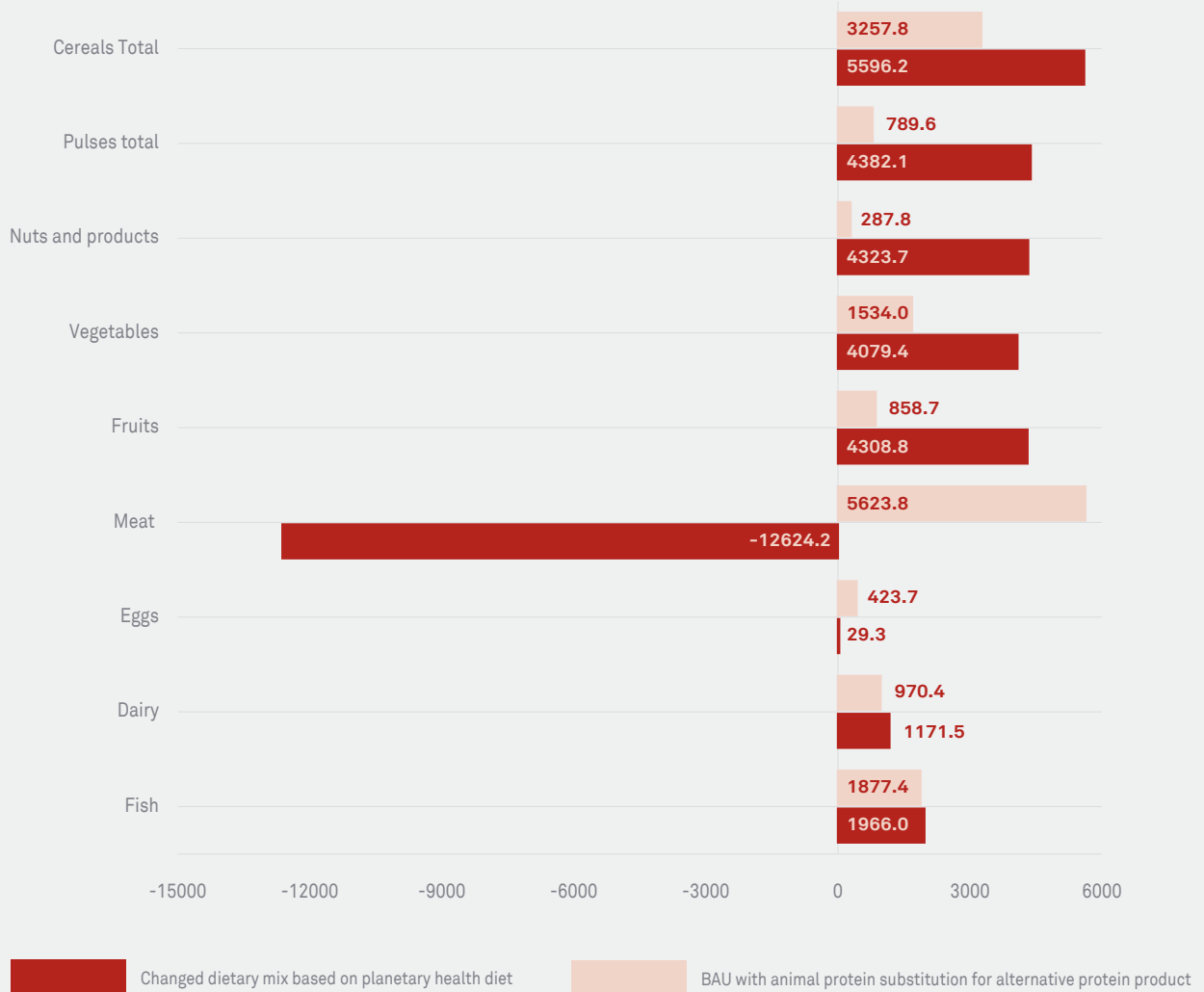


(Willett et al., 2019). The report recommends a significant shift towards a plant-sourced diet with dramatic reductions in animal products. Many of the factors that are leading consumers towards alternative proteins, such as health and sustainability impacts of animal protein, are referenced in the EAT-Lancet report.

Although there has been significant criticism of the practicality of producing the food that would be required if the Planetary Health Diet was fully adopted, it provides a point of reference for analysis of the implications if consumers were to change

behaviour and purchasing habits to fully reflect health and sustainability concerns.

In the second scenario alternative proteins are not forecast as a separate protein sector. The planetary health diet does not specifically recommend alternative protein products however it can be assumed that given the switch to plant-sourced proteins that is recommended is so significant that there would be significant opportunity for plant-sourced meat analogues.



**Figure 14**  
**Estimated value of additional protein demand in 2030 (\$ million)**

Source: Authors' calculation based on FAO Food Balance statistics, assumed trends and planetary health diet guidelines (see Table 8).

## Estimation of potential opportunity in 2030

**Table 8**

**Estimated value of additional protein demand in 2030 (\$ million)**

Protein type	Scenario 1: BAU with animal protein substitution for alternative protein products.	Scenario 2: Changed dietary mix based on planetary health diet.
Wheat	2753.07	5366.47
Rice	404.45	-105.54
Maize	61.80	92.12
Rye	38.48	243.13
<b>Cereals (total)</b>	<b>3257.80</b>	<b>5596.18</b>
Peas	573.15	2742.11
Soybean	43.41	425.87
Pulses, Other	173.04	1214.17
<b>Pulses (total)</b>	<b>789.6</b>	<b>4382.15</b>
<b>Nuts</b>	<b>287.77</b>	<b>4323.74</b>
<b>Vegetables</b>	<b>1534.03</b>	<b>4079.39</b>
<b>Fruits</b>	<b>858.68</b>	<b>4308.84</b>
<b>Miscellaneous</b>	<b>294.74</b>	<b>-127.78</b>
<b>Plant sourced (total)</b>	<b>7948.86</b>	<b>22562.52</b>
Bovine	2795.56	-6790.03
Mutton and goat	1437.28	-3534.55
Pork	342.60	-824.08
Poultry	768.51	-847.27
Other meat and offal	279.86	-628.22
<b>Meat (total)</b>	<b>5623.81</b>	<b>-12624.15</b>
Eggs	423.67	29.31
Dairy	970.39	1171.45
<b>Dairy and eggs</b>	<b>1394.07</b>	<b>1200.76</b>
<b>Fish</b>	<b>1877.43</b>	<b>1965.96</b>
<b>Animal sourced (total)</b>	<b>8895.31</b>	<b>-9457.43</b>

**Table 8 cont.**

Protein type	Scenario 1: BAU with animal protein substitution for alternative protein products.	Scenario 2: Changed dietary mix based on planetary health diet.
Grains for animal feed	926.24	
Meat alternatives	2196.25	
Dairy alternatives	621.36	
Egg alternatives	14.18	
Fish alternatives	130.07	
Insects for animal feed	101.56	
Insects and algae	3.16	
<b>Alternative proteins (total)</b>	<b>3066.58</b>	

Source: Authors' calculation based on FAO Food Balance statistics, assumed trends and planetary health diet guidelines.

The analysis estimates that with animal protein substitution assumptions reflecting current trends and forecasts there will still be an additional opportunity for the animal protein sector in Australia of \$8.9 billion by 2030. The additional

opportunity for traditional plant-sourced proteins is estimated to be \$7 billion and alternative protein products are estimated to deliver a \$3.1 billion dollar opportunity to Australian agriculture.

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**The analysis estimates that with animal protein substitution assumptions reflecting current trends and forecasts there will still be an additional opportunity for the animal protein sector in Australia of \$8.9 billion by 2030.**

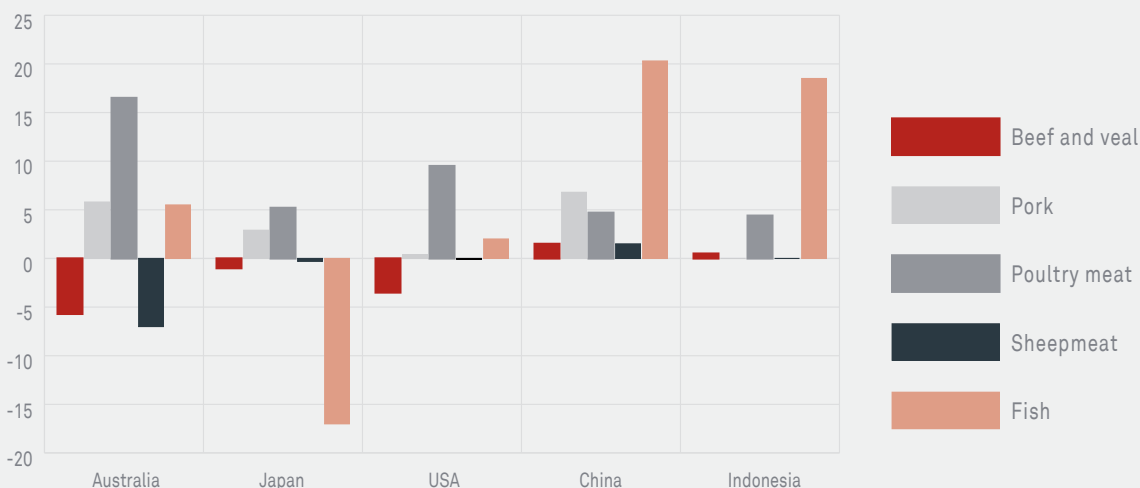
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## Estimation of potential opportunity in 2030

### 5.3 Changes in red and white meat consumption

Globally, white meat consumption per person is growing. Per capita fish consumption is also growing in China and Indonesia, and to some extent in Australia. Poultry consumption is showing growth in all countries, with the highest growth being observed in Australia, and pork consumption is also increasing, notably in Australia and China. Red meat per capita consumption is declining in Australia, US and Japan, although it shows a small increase in Asian countries such as China and Indonesia (Figure 15).

In terms of volume of red meat demand, the growth of red meat consumption in high population countries is more than offsetting the decline in consumption in other countries. For example, the increase of 1 kg per capita of red meat consumption in China equates to a demand increase of 1.34 million tonnes while the decline of 5.1 kg per capita in Australia equates to a reduction of 0.13 million tonnes.



**Figure 15**  
Changes in meat consumption in selected countries, 1998 to 2018

Source: (Whitnall & Pitts, 2019)

Consumer preferences are evidentially moving away from red meat in favour of white meat proteins. In Australia, yearly per capita animal-protein consumption is composed of 25 kg of beef and veal, 9 kg of sheepmeat, 49 kg of poultry meat, 28 kg of pork and 14 kg of fish (Whitnall & Pitts, 2019).

The relatively cheap prices of chicken and pork mean that consumption is expected to rise, while per capita consumption of red meat is expected to decline due to comparatively higher prices. However, while chicken and pork will likely gain in terms of value from volume increases, the red meat sector will continue to sustain value through rising market prices. Meanwhile, fish per capita consumption is rising while prices remain high, implying favourable growth conditions for the sector in the future.

The production of chicken, pork and fish for human consumption also requires high protein stock feed, and the increased needs of the livestock feed industry are likely to create market opportunities for high protein grains, pulses, insects and algae.

There are currently no cultured meat products commercially available. While production costs per kilogram for cultured meat have significantly reduced in the past 18 months, it is still not a commercially viable product at retail scale. Once cultured meat is available to consumers, it is likely to primarily substitute for mince-based products rather than the array of different cuts and products available to consumers of animal-sourced meat. Issues of scalability, potential adverse health impacts and unknown consumer acceptance are potential obstacles for companies producing cultured meat.

## 5.4 Discussion

Our analysis shows that the market for the traditional provision of proteins from plant and animal sources will remain stable. The rising demand for animal protein in Asian countries represents not just continued BAU for animal protein production but also additional market opportunities. Opportunities are also apparent for plant protein producers in the increasing per capita consumption of plant protein in predominantly vegetarian countries, in supplying feed for the increasing animal production sector and in the niche market of value-added hybrid or alternative protein products for discretionary consumers.

The directional indication from our findings is comparable with recent related studies. Our BAU estimation of the **additional opportunity for the protein market in 2030 is about A\$19.9 billion**, of which **A\$3.1 billion is for alternative protein categories (Table 8)**.

Food Innovation Australia (FIAL) indicated that the total market value of protein for Australian agriculture could be from A\$67 billion under the BAU scenario (and up to A\$122 billion with unlikely technological changes) in 2025. Given the estimated market opportunity of A\$56 billion in 2018, the additional opportunity for the total protein market ranges from A\$11 billion up to A\$66 billion in 2025 (Food Innovation Australia Limited, 2019). While the FIAL report did not analyse the specific market value of plant-sourced animal protein substitutes, it did model the effect of the non-traditional sources of protein (insects, micro algae and cultured meat) indicating that their value share is almost zero compared to traditional protein. Within this category, insect protein had higher market value than algae and cultured meat.

The CSIRO (2019) estimated an additional opportunity for alternative proteins could reach up to A\$2.9 billion by 2030 (excluding environmental benefit gains). Similarly, Food Frontier estimated the opportunity of meat alternatives to be up to A\$3 billion (Lawrence & King, 2019).

Given the projected market share of alternative proteins (from A\$2.8 - 6.6 billion) in relation to the projection of total protein market (A\$67 - 122 billion), alternative proteins will not be a major threat to Australian animal agriculture.

Although competition between alternative proteins and animal-sourced proteins appears to be a zero-sum game<sup>24</sup>, this analysis indicates that - even with significant substitution of alternatives - growth in the overall market provides ongoing opportunity for all protein sectors. Global protein consumption rose 40% between 2000 and 2018, with more than half of that increase driven by Asian consumers (Food Innovation Australia Limited, 2019)<sup>25</sup>. The primary factor driving increased protein demand is global population growth, amplified by changes in socio-economic elements such as rising incomes, increased urbanisation, and ageing populations<sup>26</sup>.

There is no doubt that the rapid growth in technological sophistication of production of alternative proteins driven by considerable investment and media focus will lead to the ongoing development of new and affordable alternative protein products. These products will find a ready home with many consumers either on the basis of taste and cost advantages or because of perceptions about the health, environmental and welfare aspects of animal-sourced protein. However, animal-sourced protein production is also subject to technological advancement and advances in feed efficiency and production systems are resulting in cheaper and more environmentally sustainable animal-sourced protein.

Customer familiarity will remain a market advantage for animal protein in the future and will likely drive continued domination of the market (Bashi et al., 2019). As such, there is an opportunity for continued and/or expanded production of quality protein from whole foods such as lean meat, poultry, eggs, legumes and dairy products in Australian agriculture.

Forecast global demand for protein is strong and will accommodate growth in both sectors at the same time. In fact, it is more likely that the scarcity of resources required to produce more traditional protein will be the limiting factor, rather than a demand constraint. Supply constraints associated with animal-derived protein production - such as land use and GHG emissions - will be the significant challenges for livestock production in the coming decades, rather than threats from increased demand for alternative proteins.

<sup>24</sup>i.e. a situation in which each stakeholder or participant's gain or loss is balanced by the losses or gains of the other participants.

<sup>25</sup>For example, in China, dairy consumption per capita has increased from nearly zero in the late 1980s to 30 kg per year in 2018.

<sup>26</sup>The protein requirements of people increase with age.

## Estimation of potential opportunity in 2030

However, this analysis is underpinned by the significant assumption that predicted changes in consumer demand will occur organically, not influenced by market or policy distortions. The same supply constraints that will limit the ability of animal agriculture to supply the protein needed for a growing population are influencing consumer perceptions, policy discussion and ultimately regulation of agriculture globally.

The second scenario modelled based on the Planetary Health Diet recommended by the EAT-Lancet Commission provides an alternative future for which animal agriculture would decline significantly. The practicality of this diet being achieved on a global scale is debatable; nevertheless, the EAT-Lancet report has received considerable attention. Policy recommendations of this report have been discussed at governmental levels around the world and regulatory change for agriculture based on these recommendations is a possibility. As an example, the New Zealand Ministry of Health is encouraging the health sector to actively incorporate sustainability practices and reduce emissions in part by reducing meat and dairy when procuring food for patients, visitors and staff (NZ Ministry of Health, 2019).

Animal agriculture in Australia would suffer a \$9.5 billion decline by 2030 (Table 8) if the Planetary Health Diet was widely adopted. This outcome is unlikely without regulatory intervention - even the 9% animal protein substitution modelled in the BAU scenario would require significant cultural shifts. However, many groups around the world are actively campaigning for intervention of this nature and the impacts of these potential outcomes must be considered.

In summary, in the absence of disruptive regulatory intervention the threat from alternative proteins to Australian agriculture will not be significant up to 2030, due to the fundamental supply and demand aspects of the global protein market.

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**Animal agriculture in Australia would suffer a \$9.5 billion decline by 2030 (Table 8) if the Planetary Health Diet was widely adopted. This outcome is unlikely without regulatory intervention - even the 9% animal protein substitution modelled in the BAU scenario would require significant cultural shifts.**

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A photograph of a group of sheep in a metal pen. A red arrow points from the left towards the text. The background shows a building with a window and a door.

**...in the absence of disruptive regulatory intervention the threat from alternative proteins to Australian agriculture will not be significant up to 2030, due to the fundamental supply and demand aspects of the global protein market.**

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## Section 6

# Unlocking potential opportunities

### 6.1 Plant protein production

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As the challenge to meet the protein requirements of an expanding population continues to grow, demand for plant-sourced proteins is also growing. Indeed, both BAU dietary requirements and changing consumer trends are creating increased demand for plant-sourced protein sources. Emissions, water and nitrogen footprints of plant production are often lower than those of livestock farming, and these high sustainability gains combined with low technology requirements make plant proteins an attractive investment for producers and processors.

Many beans and pulses are rich in protein, such as lupins and soybean which can contain between 35-40% protein (Day, 2013). Markets are emerging in Australia and overseas for off-grade or low-quality legumes to be utilised in protein extraction for addition to various products. These opportunities could provide floors for commodity prices due to their forecasted increased demand, which were formerly only suitable for livestock feed.

Globally, several companies are investing in plant-sourced protein production to produce high-quality protein products which attract price premiums, such as protein bars and drinks (Table 9).

High protein pulse products, including pulse flours and protein extracts and concentrates (such as those Australian Plant Proteins plans to produce) from pulses such as faba beans, could be used in a wide range of foods and beverages including cereals, protein bars, snacks, meat analogues, liquid breakfasts, or even as a vegan protein supplement.

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**Globally, several companies are investing in plant-sourced protein production to produce high-quality protein products which attract price premiums, such as protein bars and drinks.**

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## Unlocking potential opportunities

**Table 9**  
**Major industrially produced protein ingredients from plant sources**

Plant source	Protein products	Protein content	Major manufacturer and/or supplier
Soy	Soy protein concentrates (SPC)	65–70%	<a href="http://www.solae.com">www.solae.com</a>
	Soy protein isolates (SPI)	>90%	<a href="http://www.adm.com">www.adm.com</a>
	Texturised soy proteins	60%	<a href="http://www.cargill.com">www.cargill.com</a>
Wheat	Vital wheat gluten (VWG)	75–80%	<a href="http://www.manildra.com.au">www.manildra.com.au</a>
	Isolated wheat protein (IWP)	90%	<a href="http://www.mgpingredients.com">www.mgpingredients.com</a>
	Texturised wheat proteins		<a href="http://www.cargill.com">www.cargill.com</a>
	Enzyme hydrolysed protein	>90%	
Rice	Rice protein concentrate	~80%	<a href="http://www.foodchem.cn">www.foodchem.cn</a>
	Rice protein isolate	90%	
Maize/corn	Zein	88–96%	<a href="http://www.zeinproducts.com">www.zeinproducts.com</a>
Peas	Pea protein concentrate		
Pea protein isolate	85–90%		<a href="http://www.nutripea.com/company.htm">www.nutripea.com/company.htm</a> <a href="http://www.roquette.com/">www.roquette.com/</a> <a href="http://www.burcon.ca">www.burcon.ca</a>
Canola	Canola protein isolate	90%	<a href="http://www.bioexx.com">www.bioexx.com</a>
	Hydrolysed protein	83%	<a href="http://www.burcon.ca">www.burcon.ca</a>
Potato	Potato proteins		<a href="http://www.avebe.com/producten/solanic/">www.avebe.com/producten/solanic/</a>
Faba beans	Protein powder extract	>80%	Australian Plant Protein (APP)
Chickpea	Protein isolate	90%	<a href="http://www.chickpea-protein.com/">http://www.chickpea-protein.com/</a>
	Protein concentrate	70–85%	

Sources: (CSIRO, 2019; Day, 2013)

As demand for animal protein increases globally, demand for plant protein such as soybean to feed livestock will also continue to increase. As more plant protein product such as soybean meal moves up the value chain towards human consumption and away from livestock feed, a void in the feed

market could become apparent (McGill et al., 2019). This void would need to be filled either by increased plant protein production or by alternative protein sources, which could offer opportunity for Australian croppers and insect farmers.



### **Key opportunities for plant protein production:**

- Potential for alternative / additional income streams from protein extraction of crops previously only suitable for livestock feed.
- Increased demand for plant protein for livestock feed as global consumption of meat rises.
- Potential export opportunities of niche plant-sourced protein products.
- Increased consumer appetite for niche plant protein products.

## Unlocking potential opportunities

### 6.2 Animal protein production

The most significant opportunity for animal agriculture sectors from the rise in alternative proteins will be differentiating their products from other protein products in the market.

Animal production is an integral part of the agricultural system. It can utilise non-arable land to convert plant material which humans cannot consume into a beneficial protein and produces biodiversity and carbon sequestration benefits to the environment. As the number of alternative protein products available in the market rises, the potential for misconceptions regarding the sustainability of the animal protein industry is also likely to rise. Marketing strategies which capture the sustainability improvements animal agriculture industries have made and highlight the health benefits of whole, unprocessed foods could present an opportunity to increase demand for animal-sourced protein products beyond the BAU trendline.

As mentioned previously in this report, the unique protein quality of animal products provides consumers with higher levels of essential amino acids compared to plant-sourced protein sources. In addition, the highly processed nature of some plant-sourced meat analogues (**Table 10**) suggests a growing opportunity for animal-sourced protein sources to be marketed as 'natural' and 'unprocessed'. As consumers become increasingly concerned regarding the quality and health aspects of their food, creating marketing strategies which promote the health benefits of an animal protein will be an opportunity to increase their overall demand.

**Table 10**  
**Ingredients of several commercially available plant-sourced meat analogues**

Meat alternative	Start-up Origin	Ingredients	Source
<b>Sunfed Chicken Free Chicken</b>	New Zealand	Water, Pea Protein, Rice Bran Oil, Pea Fibre, NZ Pumpkin, Natural Yeast Extract, NZ Maize Starch.	<a href="https://sunfedfoods.com/">https://sunfedfoods.com/</a>
<b>Impossible Burger</b>	US	Water, Soy Protein Concentrate, Coconut Oil, Sunflower Oil, Natural Flavours, 2% or less of: Potato Protein, Methylcellulose, Yeast Extract, Cultured Dextrose, Food Starch Modified, Soy Leghemoglobin, Salt, Soy Protein Isolate, Mixed Tocopherols (Vitamin E), Zinc Gluconate, Thiamine Hydrochloride (Vitamin B1), Sodium Ascorbate (Vitamin C), Niacin, Pyridoxine Hydrochloride (Vitamin B6), Riboflavin (Vitamin B2), Vitamin B12.	<a href="https://faq.impossiblefoods.com/hc/en-us/articles/360018937494-What-are-the-ingredients-">https://faq.impossiblefoods.com/hc/en-us/articles/360018937494-What-are-the-ingredients-</a>
<b>Beyond Burger</b>	US	Water, Pea Protein Isolate, Expeller-Pressed Canola Oil, Refined Coconut Oil, Rice Protein, Natural Flavours, Cocoa Butter, Mung Bean Protein, Methylcellulose, Potato Starch, Apple Extract, Salt, Potassium Chloride, Vinegar, Lemon Juice Concentrate, Sunflower Lecithin, Pomegranate Fruit Powder, Beet Juice Extract	<a href="https://www.beyondmeat.com/products/the-beyond-burger/">https://www.beyondmeat.com/products/the-beyond-burger/</a>

Opportunities for animal-sourced protein in Australia include the production and marketing of meat-plant hybrid products (e.g. 'Perfectly Balanced'), branding to attract premiums for sustainable products (e.g. carbon-neutral beef), and

diversifying feed systems (e.g. using insect and algae proteins as feed for chicken, fish and pigs to reduce livestock production costs).

#### **Key opportunities for animal protein production:**

- Implementing marketing strategies which target promotion and education of the environmental and health benefits of consuming traditional animal-based protein as part of a healthy diet.
- As technology increases and companies scale up production, utilising alternative protein sources for livestock feed has the potential to reduce environmental impacts and lower costs.
- Hybrid meat and plant products which target meat-reducers and flexitarians represent a small but increasing market. Opportunities for export of these products should be investigated.

### **6.3 Non-traditional protein production**

Non-traditional protein sources have several sustainability, technological and institutional factors affecting their feasibility as suitable protein alternatives. Specifically, the production of cultured meat and algae proteins are mainly in the research and development stage and not available for purchase by consumers. Current insect protein production is small-scale and labour intensive (van der Weele et al., 2019).

While consumers appear willing to try them, market interest in insects and cultured meat appears to be low. The potential future of cultured meat, algae and insects is not yet clear due to issues related to consumers' acceptability, technological challenges and regulations (van der Weele et al., 2019).

#### **Key opportunities for non-traditional protein production:**

- Opportunities for increased growth in non-traditional protein sources will be highly dependent on consumer preferences in the future.
- Algae and insect production will have emerging opportunities in the livestock feed market.

## Unlocking potential opportunities

### 6.4 Strategies, regulations and policy options

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This study indicates that the market size of protein demand is enough to accommodate both traditional and alternative protein sources. However, the task of unlocking market potential will require both subsector-specific strategies, regulations and policies and industry-wide strategy to ensure Australia agriculture capitalises on the opportunities of alternative proteins in the global protein marketplace.

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In order to increase the benefits and opportunities from the growing protein market, proactive approaches to marketing the health and environmental benefits of livestock-sourced proteins should be adopted by industry.

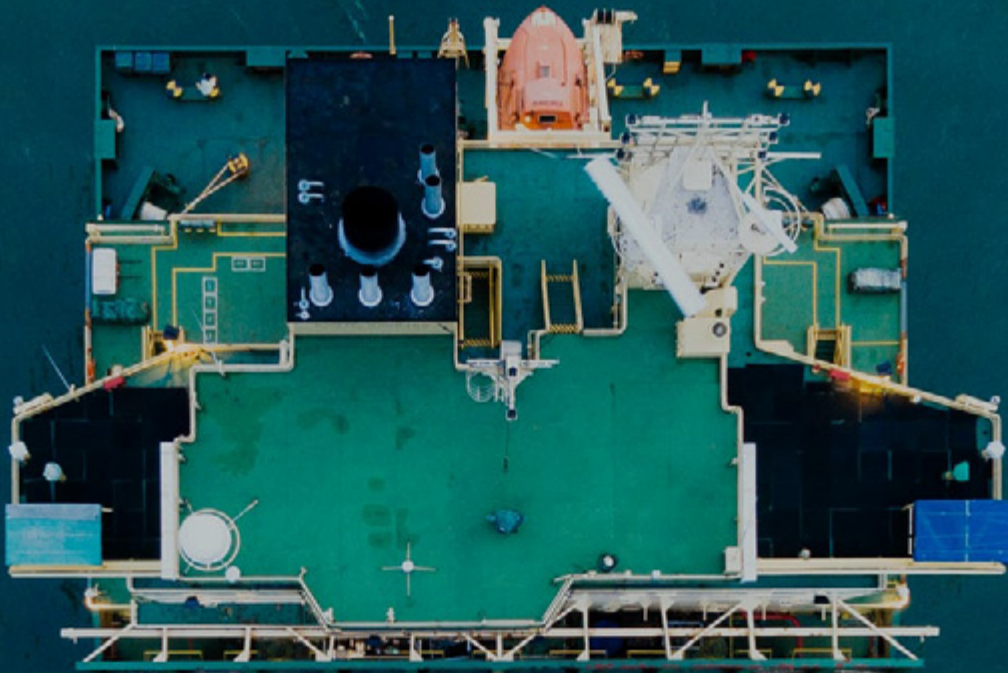
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Clear strategies need to be in place to counter any negative portrayal of animal-sourced Australian agriculture by alternative protein companies.

Since alternative protein products are produced using different methodologies and practices to traditional protein products, government officials and regulatory bodies need to ensure food safety, allergen testing, and biosecurity regulations are appropriately covering emerging products.

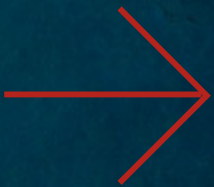
Given Australia's highly regarded export status, opportunities to grow global sales of Australian alternative protein products (such as plant-sourced meat analogues using Australian pulses) should be explored by industry. Implications to export arrangements and free-trade agreements should be considered with any regulation on the use of terminology such as 'meat' and 'milk' in alternative protein products.





**Given Australia's highly regarded export status, opportunities to grow global sales of Australian alternative protein products ... should be explored by industry.**

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**In the absence of disruptive regulatory intervention, the impact of alternative proteins on Australian agriculture will not be significant in the next decade.** Due to the fundamental supply and demand aspects of the global protein market, there is room for both animal-sourced and alternative proteins in the Australian production market.

While global protein demand is rapidly growing due to population growth coupled with changes in socio-economic factors (such as rising incomes, increased urbanisation and ageing populations), the market for the traditional provision of protein from plant and animal sources will remain stable until 2030 under business as usual conditions. There is no foreseeable threat that alternative proteins will substantially reduce animal protein demand up to 2030, and there are potential gains for producers of plant-sourced protein (e.g. pulses). New demand for animal protein from a rising population will outweigh any additional market share that alternative proteins may gain in the near future.

Given the projected market value of alternative proteins (A\$3 - \$6.6 billion) relative to the total value of the protein market (A\$67 billion - \$122 billion), alternative protein will not displace or significantly disrupt existing Australian traditional protein markets. Rather, **the emergence of a small market for alternative products (such as substitutes which require plant ingredients to produce meat, dairy and egg analogues) offers new opportunities** for farmers to supply the required crop varieties.

**Animal protein will likely continue to dominate the market to 2030**, due to factors such as the rising demand in Asian countries and customer familiarity with existing products. As such, the continued and/or expanded production of quality protein from whole foods such as lean meat, poultry, eggs, legumes and dairy products presents an opportunity for Australian agriculture.

In general, the production of animal-sourced foods is more impactful in terms of land use, fresh water consumption, and GHG emissions than plant-sourced foods. While this is a very broad generalisation - and within every system (plant and animal-sourced) there are production methods that can have positive or negative environmental implications - it is important for the industry to be mindful of the limited natural capital which can be used for protein production in a resource-

constrained future, and to make informed decisions on the most efficient and sustainable use of this capital. **Supply constraints will be the significant challenge for livestock production in the coming decade**, rather than threats from increased demand for alternative proteins.

Both government regulators and private industry should monitor the marketing language used by alternative protein companies, as some tend to portray traditional proteins in a negative manner. Strategies should be adopted by industry to **foster a proactive approach in promoting the benefits of particular protein products** (especially animal-sourced products) and ensure misconceptions do not threaten the industries' image.

It will be beneficial for Australian agriculture to present a united front in the aim of producing sufficient protein for the growing population.

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**Segregation and competing with alternative proteins companies could do more harm than good for all markets.**

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Lessons should be learnt from overseas cases, such as in the US and NZ Beef+Lamb, where reactive comments to alternative proteins have adversely impacted the image of the agricultural industry.

Overall, the emerging market for alternative proteins should be seen not as a threat to existing production systems, but as a means of **diversifying choices for producers, processors and consumers** to fill the growing gap between global protein demand and supply.



## Recommendations

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- 01** Protein producers should be proactive in differentiating their products, particularly in promotion of health or environmental benefits, rather than reactive against a competitor's perceived threat.

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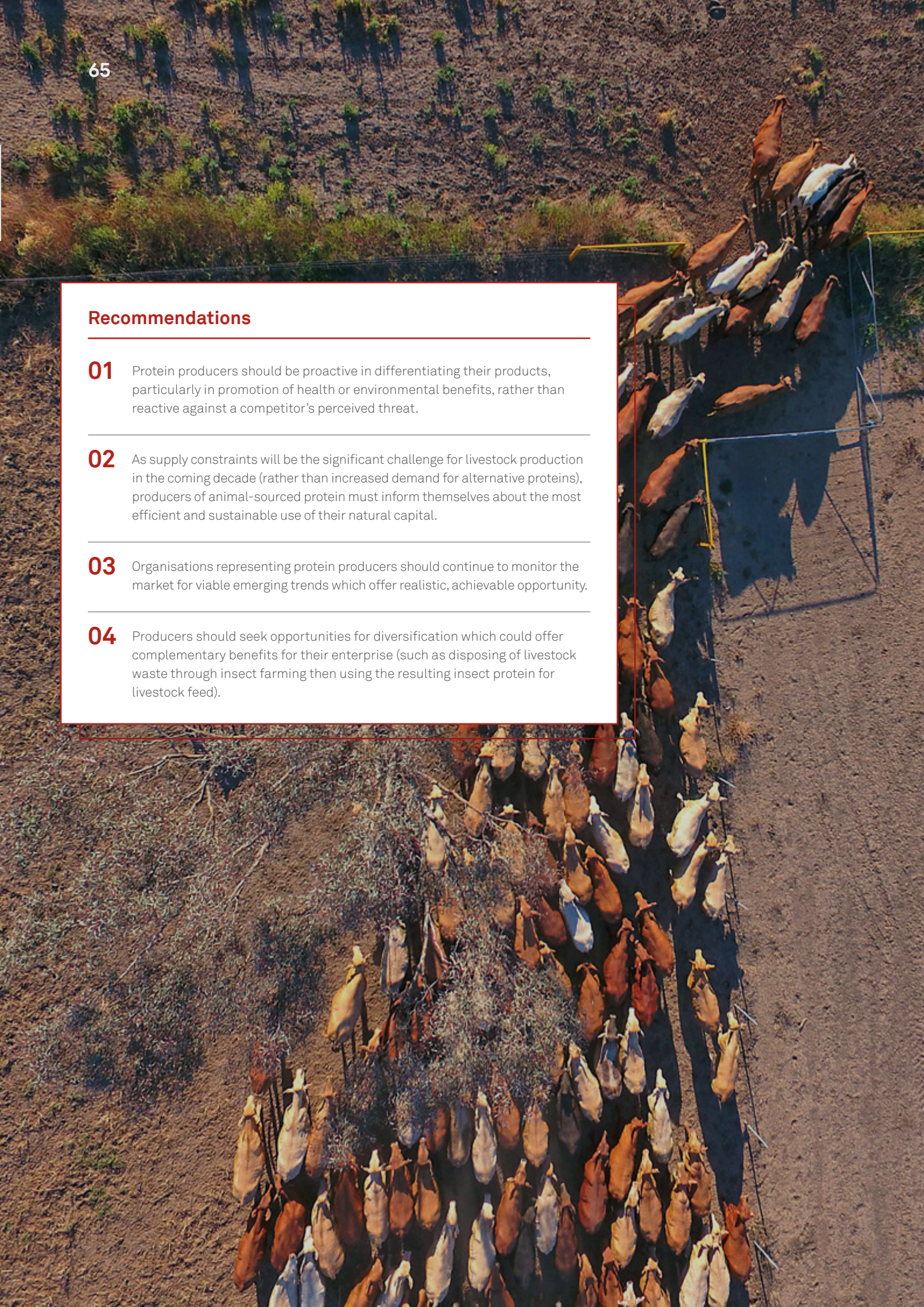
- 02** As supply constraints will be the significant challenge for livestock production in the coming decade (rather than increased demand for alternative proteins), producers of animal-sourced protein must inform themselves about the most efficient and sustainable use of their natural capital.

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- 03** Organisations representing protein producers should continue to monitor the market for viable emerging trends which offer realistic, achievable opportunity.

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- 04** Producers should seek opportunities for diversification which could offer complementary benefits for their enterprise (such as disposing of livestock waste through insect farming then using the resulting insect protein for livestock feed).



## Section 8

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## Appendices

### Appendix A

**Figure 16**

**Nutrient contents in 200 kcal of meat and meat substitutes.**

Nutrient (g)	Beef	Pork	Chicken	Wheat	Nuts	Bean	Pea	Tofu	Myco-protein	Jackfruit	Insect	Alga	Cult. beef
Calories (kcal)	200	200	200	200	200	200	200	200	200	200	200	200	200
Grams	83	67	140	60	33	157	247	241	235	211	43	69	83
<b>Protein</b>	<b>20.89</b>	<b>17.30</b>	<b>24.39</b>	<b>5.79</b>	<b>6.43</b>	<b>13.65</b>	<b>13.38</b>	<b>24.05</b>	<b>25.88</b>	<b>3.62</b>	<b>27.49</b>	<b>39.63</b>	<b>20.89</b>
Carbohydrates	0.52		0.06	44.87	7.39	35.91	35.68	2.84	7.06	48.95	2.89	16.48	0.52
Sugar				0.61	1.65	0.50	14.00	1.71	1.18	40.17		2.14	
Fibre				7.89	2.11	11.65	14.07	2.41	14.12	3.16	2.89	2.48	
Fat	12.11	13.99	11.33	1.17	17.63	0.79	0.99	12.67	6.82	1.35	8.68	5.32	12.11
Sat. fatty acid	4.67	5.20	3.22	0.26	2.64	0.11	0.18	2.21	1.41	0.41	2.89	1.83	2.33
Mon. fatty acid	5.33	6.23	5.05	0.17	11.38	0.06	0.09	3.18	1.18	0.33	1.47	0.47	5.33
Poly. fatty acid	0.41	1.26	2.11	0.70	3.25	0.43	0.46	6.40	4.24	0.20	3.97	1.43	2.74
Transfats			0.09		0.01								
Cholesterol mg	70.00	63.30									131.64		70.00
Calcium mg	20.83	14.81	8.39	19.88	28.67	44.09	61.73	679.52	100.00	50.53	65.10	82.76	20.83
Iron mg	2.23	0.87	1.15	2.23	1.23	4.63	3.63	4.92	1.18	0.48	2.54	19.66	2.23
Heme mg	0.78	0.44	0.52										0.78
Magnesium mg	18.33	16.16	29.37	70.48	74.79	70.87	81.48	84.34	105.88	61.05	52.08	134.48	18.33
Phosphorus mg	177.50	152.19	248.95	194.58	144.32	223.62	266.67	267.47	611.76	44.21		81.38	177.50
Potassium mg	294.17	243.77	730.07	237.35	211.86	634.65	602.47	313.25	235.29	943.16	438.34	940.00	294.17
Sodium mg	70.83	49.16	83.92	1.81	1.32	3.15	12.35	9.64	11.76	4.21	175.05	722.76	70.83
Zinc mg	5.16	2.16	2.06	1.78	1.34	1.69	3.06	2.58	21.18	0.27	7.59	1.38	5.16
Copper mg	0.07	0.03	0.09	0.29	0.50	0.38	0.43	0.48	1.18	0.16		4.21	0.07
Vitamin C mg		0.47			0.26	1.89	98.77			28.84	0.43	6.97	
Thiamin mg	0.04	0.48	0.15	0.18	0.10	0.25	0.66	0.12		0.22		1.64	0.04
Riboflavin mg	0.15	0.15	0.34	0.11	0.13	0.09	0.33	0.12	0.54	0.12	1.44	2.53	0.15
Niacin mg	4.74	2.83	7.80	3.22	2.05	0.91	5.16	0.58	0.82	1.94	3.25	8.84	4.74
Pantothen. mg	0.57	0.35	1.53	0.61		0.35	0.26	2.03	0.59	0.49	3.62	2.40	0.57
Vitamin B6 µg	0.32	0.26	0.72	0.12	0.12	0.19	0.42	0.20	0.29	0.69		0.25	0.32
Folate µg	7.50	4.04	1.40	16.87	19.77	204.72	160.49	21.69		50.53		64.83	7.50
Vitamin B12 µg	2.28	0.36	0.78								3.62		2.28
Vitamin A µg	5.83	1.35					93.83			10.53		20.00	5.83

Abbreviations: Cult., cultured; Sat., saturated; Mon., monounsaturated; Poly., polyunsaturated.; pantothen., pantothenate.  
Source: (World Economic Forum, 2019)

## Appendices

### Appendix B

**Table 11**

#### Outlook, preconditions and implications of meat alternatives

Dimension	Cultured meat	Algae	Insects	Plant-based meat alternatives	Pulses
<b>Environmental sustainability potential</b>	Complexity of technology, hygiene requirements and estimated high energy input likely to limit sustainability gains.	Potentially high energy requirements due to necessary processing (dewatering, breaking cell walls). Production of crops at sea reduces pressure on land use. Potential environmental impacts at sea.	Overall efficiency depends on amount of processing. Protein extraction processes usually imply significant protein losses. No energy gains expected compared to beef.	Energy use depends on amount of processing. Using less purified materials is promising.	High potential gains, no processing apart from cooking, gains for soil through symbiosis with nitrogen-fixing bacteria
<b>Technological</b>	Substantial R&D needed for cell and tissue development, scaling up, finding growth medium and product development	Substantial R&D needed for harvesting, protein extraction (digestibility) and de-greening	Scaling up and mechanisation and R&D for increasing energy efficiency	R&D to allow for less purified materials and improved mimicking of meat	Well established. Yield, resistance and induced flatulence could be improved through breeding and agronomy
<b>Organisational and institutional</b>	Significant investments and organisational coordination needed for product quality and safety; potential disruption of traditional meat production systems.	Significant investments needed, also for optimisation of main and side products. Complex organisation for scaling up. Food safety regulation.	Stable and competitive value chains need to be formed	Can use established organisations and institutions. Markets to be developed with novel products.	Well established
<b>Potential future supporters and opposition</b>	Part of meat industry extending their product portfolio. Consumer support depends on framing. Possible resistance from animal-based meat producers and farmers.	Algae for food probably remote until digestibility issues solved.	Consumer acceptance of whole insects very challenging	Part of meat industry extending their product portfolio. Push-back from meat producers likely if perceived as threat to market share.	Broad but relatively marginal coalition. Initiatives for increased consumer support. Outright opposition unlikely.

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