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CATALYST FOR GROWTH



PROTEIN MARKET: SIZE OF THE PRIZE ANALYSIS FOR AUSTRALIA

March 2019

THE GLOBAL PROTEIN LANDSCAPE TODAY AND IN 2025

PROTEIN DEMAND



Global protein consumption **rose 40%** between 2000 and 2018. More than **50%** of this increase was driven by Asia.



Globally, each person was estimated to **consume 26kg** of protein per year on average in 2018. Fuelled by the growth of the consuming class, this is projected to **grow by 27% to 33kg** in 2025.



Indonesia and Sub-Saharan Africa are forecast to see the highest protein demand growth rates of **up to 3.6%** per year between 2018 and 2025.

PROTEIN SUPPLY



In 2018, plant-based proteins accounted for **66%** of global protein consumption supply, and is likely to remain as the dominant source of supply in 2025.



In value terms, the global protein market could be worth **up to A\$513 billion** in 2025, **40%** of which could come from meat proteins.



China is projected to be the largest market across all protein categories, except plant-based proteins. The country alone could account for **35%** of global protein market value in 2025.

IMPLICATIONS FOR AUSTRALIAN PRODUCERS



Shifting Australia's protein production mix to match projected global consumption for **high-value proteins** could create an **additional A\$55 billion** in 2025, as compared to business-as-usual approaches.



Strengthen partnerships in high-potential markets by taking advantage of existing free trade agreements and forming commercial collaborations.



Deepen collaborations across players in the value chain to harness business opportunities beyond food production.

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An important macro-nutrient that is critical to almost every bodily function, protein has been characterised as the building block of life. Found in a wide spectrum of foods and increasingly recognised by consumers as a critical source of nutrition, the presence and role of protein in food markets across the world are becoming more significant.

Indeed, many consumers are increasingly basing their food purchasing decisions on the nutritional value of the products, with a recent survey finding that 58 percent of consumers purchase food products based on the amount of their protein content.¹ This implies that, to capture their hearts (and wallets), food businesses must be kept up-to-date with the latest trends on health and nutrition.² In particular, a market strategy underpinned by an intimate understanding of the drivers behind consumers' protein demand could lead to valuable new insights for food businesses.

This study undertakes a first-of-its-kind in-depth analysis of 50 protein types in 11 regional markets to

help Australian food and agribusinesses shed light on the major demand and supply trends of global protein consumption. The aim of the study is to trigger a national call to action for industry to adopt new thinking around protein and help position Australia as a leading supplier of the world's proteins. This approach will strengthen the overall competitiveness of the country's food and agribusiness industry, and provide greater longer term returns to growers and producers.

In the context of a rising global population, it is no surprise that global protein consumption has risen 40 percent since 2000. Globally, people are estimated to consume about 26 kilogrammes (kg) of protein per year on average today. Going forward, the rising affluence of the rapidly expanding consuming class is likely to drive another surge in protein demand, with **global per-capita consumption projected to rise by 27 percent** to 33kg in 2025. Likewise, the advent of technological breakthroughs is likely to facilitate major shifts in protein production that were previously unfeasible due to production constraints.

THE KEY FINDINGS INCLUDE:

Protein demand is likely to continue to grow quickly in the future, but the drivers of this demand will potentially be different from the past.

1

The structure of global protein supply will evolve, with slowing growth rates in meat supply expected to be offset by increasing plant-based protein and aquaculture production.

2

There are three strategic imperatives for Australian producers to unlock new opportunities in the global market.

3

EXECUTIVE SUMMARY

1. Natural Products Insider (2019). Deep dive report: The plant-based protein market. Available at: <https://www.naturalproductsinsider.com/functional-foodsbeverages/deep-dive-plant-based-protein-market>
2. Natoli S (2018). "2019 Key Health and Nutrition Trends". FIAL Knowledge Hub.

1

Protein demand is likely to continue to grow quickly in the future, but the drivers of this demand will potentially be different from the past. Global protein consumption has risen 40 percent since 2000, with over half of the increase driven by Asia. Though population growth was the key driver of protein demand in the past – accounting for about 80 percent of global protein demand growth since 2000, the growing consuming class and urbanisation rates may increasingly replace population growth as the key factors fuelling future protein demand. As compared to 2018 levels, global protein demand is projected to grow by up to 20 percent by 2025.

2

The structure of global protein supply will evolve, with slowing growth rates in meat supply expected to be offset by increasing plant-based protein and aquaculture production. Since 2000, plant-based and meat protein have dominated the protein market by volume and value respectively. Going forward, four key trends – dietary shifts for health and ethical reasons, government regulations, environmental constraints and technological advances – are expected to trigger a shift towards increased plant-based and aquaculture consumption. Within the non-traditional protein category, insects are the largest and fastest growing protein type, but the market remains small in absolute terms. At a regional level, China will be the biggest market across all protein categories in 2025, with the exception of plant-based protein.

3

There are three strategic imperatives for Australian producers to unlock new opportunities in the global market. First, if Australian producers were to restructure their food production mix and **shift into higher value protein categories** such as aquaculture or differentiate their offering through the adoption of new technology and innovations to match global protein consumption, they could capture up to A\$55 billion more in production value in 2025 as compared to a business-as-usual trajectory. While a complete transformation of the Australian food and agribusiness industry to reflect global protein demand is challenging in this short timeframe, Australian producers can still put in place mechanisms today to capture some of this future value. Second, Australian producers should seek to **strengthen partnerships in high-potential markets** by taking advantage of existing free trade deals and forming commercial collaborations with local players in these markets. Third, in order to harness business opportunities beyond food production, Australian producers should explore **deeper collaborations with other players across the value chain** such as food processors, researchers, nutritionists and technology providers.



A three-part analysis was conducted to understand the evolution of the global food and agribusiness market related to proteins, in order to identify potential opportunities for Australian businesses and position Australia as a leading supplier of the world's protein. Specifically, this analysis involved:

1. Demand Analysis

Total protein consumption demand today (2018) and in the future (2025) were sized for all protein categories, and broken down by the identified 11 regional markets which, together, make up the global market. 'Protein consumption demand' is defined as protein that is demanded for human consumption only. This excludes demand for protein due to other reasons, such as use for animal feed.

2. Supply analysis:

The sources of protein consumption across the 11 regional markets were further analysed for today (2018) and in the future (2025), based on the 50 protein types identified. Potential shifts in consumption across the different protein types were analysed for the future scenario, taking into account trends relating to consumer dietary choices, technology, environmental constraints and regulations.

3. Implications analysis:

Based on the above estimates of current and future protein consumption patterns, and Australia's current protein production structure, the implications for Australian producers and potential opportunities in the protein market were analysed.

PROJECT APPROACH

PROTEIN TYPES AND THEIR CLASSIFICATION

Analysis throughout the project was conducted for 50 protein types which are classified into 6 protein categories (see Exhibit 1 for the full list and classification). With the exception of the 3 protein types under 'non-traditional proteins', all protein types were taken from the FAO's 'Food Balance Sheets' dataset. The 3 protein types under 'non-traditional' proteins – insects, micro-algae and lab-grown meat – were identified based on analysis of the latest market research.³ All 50 protein types were classified into the 6 categories based on AlphaBeta analysis.

COUNTRY CLASSIFICATION UNDER 11 IDENTIFIED REGIONAL MARKETS

Countries across the world were categorised into 11 regions, with more granularity being accorded to Australia and the Asian countries to allow for a deeper understanding of opportunities from these areas. The 11 regions are as follows:

1. Australia
2. China
3. Europe
4. India
5. Indonesia
6. Japan
7. Latin America
8. Middle East and North Africa ('MENA')
9. North America
10. Rest of Asia Pacific
11. Sub-Saharan Africa

The classification of countries under multi-country regions, which include 'Europe', 'Latin America', 'MENA', 'North America', 'Sub-Saharan Africa' and 'Rest of Asia Pacific', was based on the United Nations' 'M49 Standard Country or Area Codes for Statistical Use'.⁴ 'Rest of Asia Pacific' includes all countries in Asia and Oceania (based on the same classification lists from the United Nations), less Australia, China, India, Indonesia, Japan and countries that fall under MENA (i.e. Western Asia).

3. Sources include Research Nester (2018). Edible insect food market; Global Market Insights (2018). Edible insects market size; Persistence Market Research (2017). Global market study on microalgae; Mintel Global New Products Database (2018); Markets and Markets (2018), Cultured meat market worth 20 million USD by 2027; CoBank (2017). Lab-grown cultured meat – a long road to market acceptance.

4. Based on M49 Standard by UN Statistics Division. Available at: <https://unstats.un.org/unsd/methodology/m49/>

EXHIBIT 1:

Taking reference from FAO's protein classification, analysis was done based on 50 protein types under 6 protein categories



Source: Traditional protein types and categories (i.e. plant-based, meat, eggs & dairy, wild catch and aquaculture protein) are based on FAO classifications; non-traditional proteins based on latest market research

Population growth has fuelled most of the 40 percent increase in global protein consumption since 2000. This upward trend is expected to continue to 2025, driven by the rising consuming class and rapid urbanisation in cities. The highest growth rates in total protein consumption will be seen in regions with the largest increases in the consuming class such as Asia and Sub-Saharan Africa. Conversely, developed regions such as Europe and North America will experience the slowest growth rates in protein consumption, while a decline in total protein consumption is projected in Japan. However, due to their relatively higher consumption of high-value proteins, coupled with higher protein prices, developed regions will still dominate in terms of value per tonne of protein.

DEMAND ANALYSIS

KEY DEMAND INSIGHTS

1. Global protein consumption has risen 40 percent since 2000, with more than half of the increase being driven by Asia



Over the past 18 years, global protein consumption demand has grown by around 40 percent, rising from 162 million tonnes in 2000 to 226 million tonnes in 2018 (Exhibit 2). This is equivalent to an increase from around 75 grammes to around 82 grammes of protein consumed per person daily on average. With the exceptions of Japan and Australia, which respectively saw a decline and flat growth, protein consumption demand increased across all other regions. Asia (excluding Japan) was the key driver, contributing to 57 percent (or around 37 million tonnes) of the total global increase in protein demand. In particular, China (26 percent), India

Over the past 18 years, total annual global protein consumption increased by 40%, mostly driven by Asia.

(14 percent) and Rest of Asia Pacific (13 percent) were among the top five contributors of increased demand, with Sub-Saharan Africa (17 percent) and Latin America (11 percent) also being important sources of the global increase in protein demand.

2. Population growth accounted for about 80 percent of global protein demand growth between 2000 and 2018



Population growth was the key driver behind the rise in protein consumption demand between 2000 and 2018. As seen in Exhibit 3, population growth accounted for 80 percent of global protein demand growth, while the

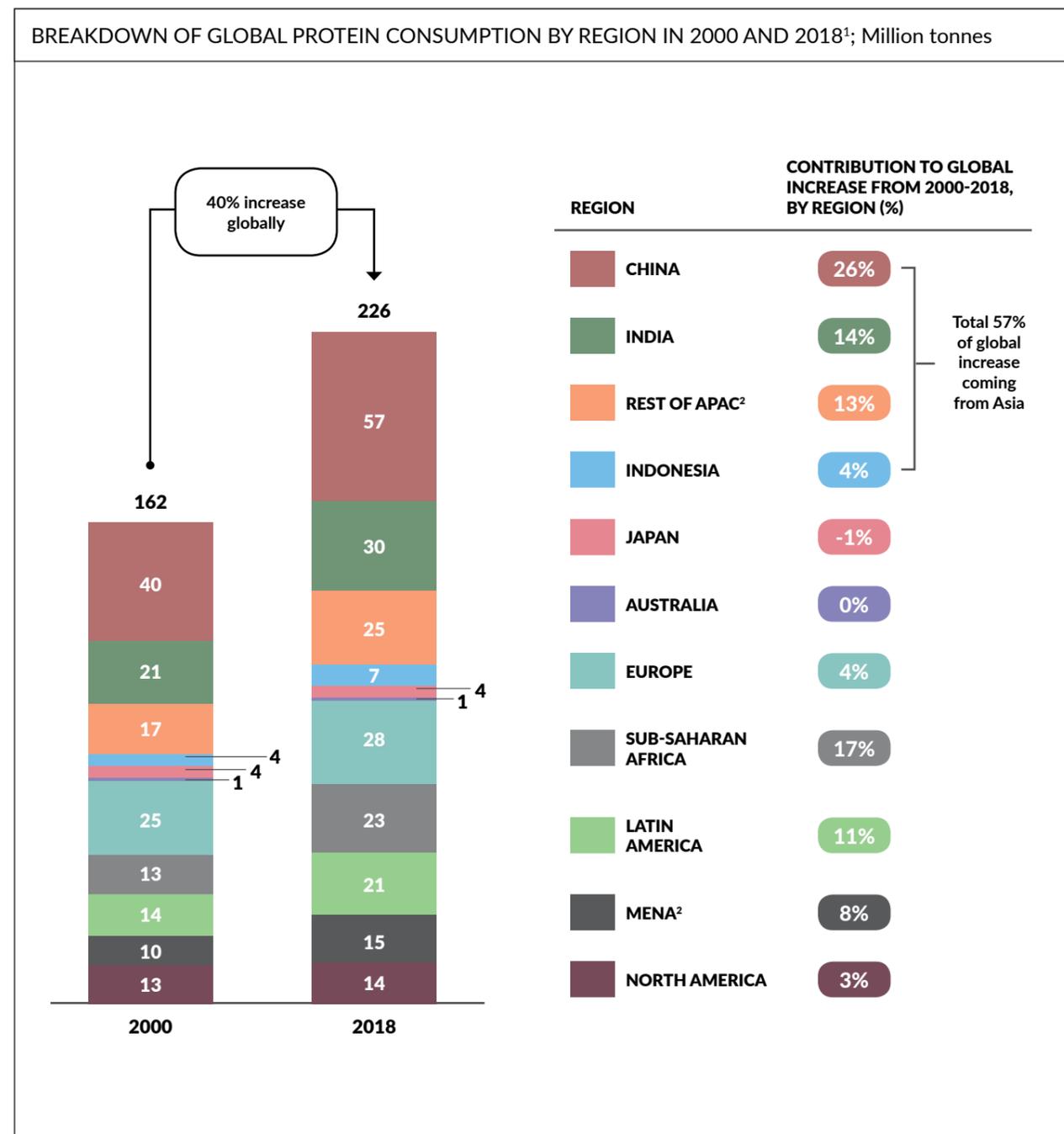
Population growth drove 80% of the global increase in protein demand between 2000 and 2018 - the population effect is strongest in North America, MENA and Sub-Saharan Africa.

increase in per capita consumption accounted for the remaining 20 percent. There is significant variance in population and per capita consumption effects across regions. For example, 31 percent of the increase in protein consumption demand in China and Europe were due to higher per capita consumption. This contrasts with North America, MENA and Sub-Saharan Africa, where population growth accounted for over 90 percent of the increase in protein demand in those regions. An anomaly is Japan, where overall population decline led to a negative population effect.



EXHIBIT 2:

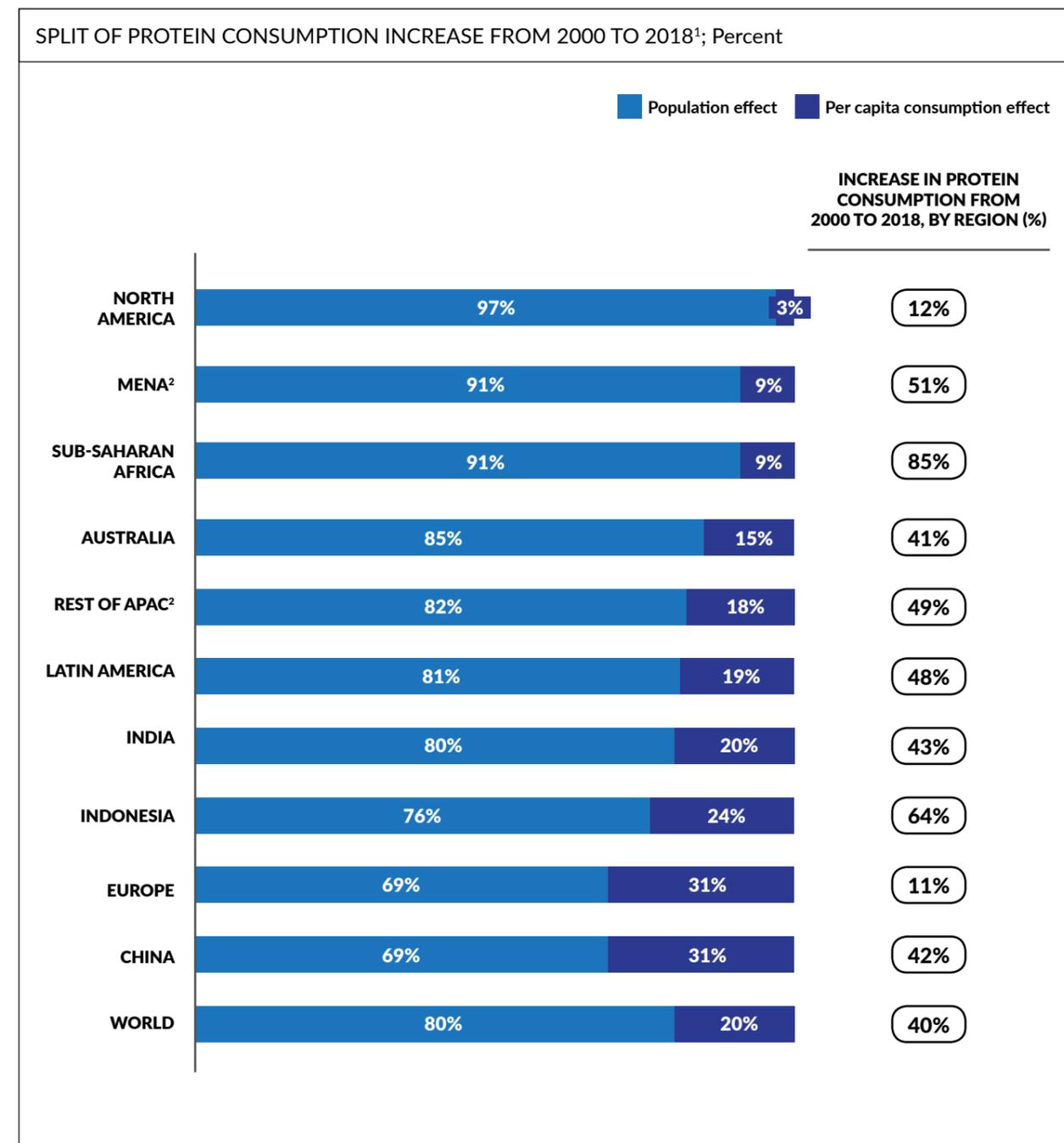
Global protein consumption has risen 40% since 2000, with more than half of the increase being driven by Asia



1. Latest FAO data point is 2013. 2018 estimated using historical growth rates (i.e. 5-year CAGR).
 2. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan; MENA consists of Middle East and North Africa.
 Note: Figures may not sum due to rounding.
 Source: FAO statistics; AlphaBeta analysis

EXHIBIT 3:

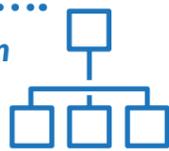
Population growth accounted for about 80% of global protein demand growth between 2000 and 2018



1. Japan is not shown in this graph as Japan is projected to experience a decline in protein consumption of 8% between from 2018 to 2025, while this graph illustrates the drivers of projected increases in protein consumption across regions. The decline in Japan's protein consumption is likely to be due to the projected decrease in its population during this period.
 2. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan; MENA consists of Middle East and North Africa.
 Note: Figures may not sum due to rounding.
 Source: FAO statistics; AlphaBeta analysis



3. Five major drivers will impact global protein consumption demand between 2018 and 2025, with the growth of the consuming class and urbanisation expected to replace population growth as the key drivers going forward



This research has identified five major drivers of global protein consumption (Exhibit 4):

- 1. Population growth.** Faster population growth leads to a higher increase in protein demand. Between 2000 and 2018, the average yearly increase in global population was 90 million but is projected to decline to 79 million annually between 2018 and 2025. Hence, population growth is expected to have a smaller positive impact on global protein consumption demand between 2019-2025 relative to 2000-2018.
- 2. Consuming class growth.** Faster growth in the global consuming class, defined as people with per capita incomes between \$10 and \$100 (measured in 2005 purchasing power parity terms) per day⁵, will lead to a higher increase in protein demand. This is consistent with various studies that show

a typical transition towards more energy-dense foods (i.e. meat proteins) as income increases.⁶ Between 2000 and 2018, 108 million people were added to the global consuming class each year. This annual growth is expected to accelerate to 290 million annually between 2019 and 2025, indicating that the rise in consuming class would likely have a larger positive impact on global protein consumption demand going forward.

- 3. Urban population growth.** Academic research has shown that increased urbanisation has led to an increased number of people having greater access to a wider variety of food options.⁷ As a result, faster growth in the global urban population will lead to higher protein demand growth.⁸ Between 2000 and 2018, 74 million people moved into urban cities on average each year. Going forward, the average annual addition to the global urban

5. Homi K (2017). *The unprecedented expansion of the global middle class: an update*. Brookings Institute.

Available at: https://www.brookings.edu/wp-content/uploads/2017/02/global_20170228_global-middle-class.pdf

6. Kearney J (2010). *Food consumption trends and drivers*. Phil. Trans. R. Soc. B. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935122/pdf/rstb20100149.pdf>

7. ADM Capital Foundation (2017). *Charting Asia's protein journey*. Available at: <https://www.admcf.org/research-reports/charting-asias-protein-journey/>

8. Henchion M., Hayes M., Mullen A. M., Fenelon M., & Tiwari B. (2017). *Future protein supply and demand: strategies and factors influencing a sustainable equilibrium*.

Foods (Basel, Switzerland). Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5532560/pdf/foods-06-00053.pdf>



population is projected to rise to 79 million people between 2019 and 2025 – implying that urbanisation would likely have a larger positive impact on future global protein consumption.

- 4. Growth in share of population over age 65.** Older adults tend to consume less protein than younger adults, primarily due to reduced energy needs.⁹ For example, a survey in Australia found that people in the age group of 51 and above on average consumed 145 grammes of meat, poultry and fish per day, which is 20 percent lower than the average of 177 grammes consumed per day by people in the age group of 19 to 50 years.¹⁰ The share of people aged over 65 out of global population is expected to increase from 8 percent in 2018 to more than 10 percent in 2025. This implies that ageing population will likely have a larger negative impact on future global protein consumption.
- 5. Change in dietary preferences.** Health and ethical concerns are likely to have implications on future protein consumption, although the exact impact is uncertain across time and geography. This will directly affect the demand for foods with heavy

27% of survey respondents in Europe intend to eat less meat over the next 5 years.

protein content. For example, consumer surveys show that 27 percent of respondents in Europe intend to eat less meat over the next 5 years;¹¹ while in Japan, meat consumption has been rising relative to plant consumption.¹² The impact of these dietary preferences is most likely to be felt on changing demand for different sources of protein, rather than impacting overall protein demand.

Exhibit 5 shows an assessment of future relative to historical impacts of the key drivers of protein consumption demand for each region. While all the drivers will continue to play a role in determining protein consumption demand, consuming class growth and urban population growth are expected to have the largest incremental impacts (relative to their historical impacts), replacing population growth as the key drivers of future protein consumption demand.

9. Volpi E et.al (2012). *Is the optimal level of protein intake for older adults greater than the recommended dietary allowance?* *The Journals of Gerontology*.

Available at: <https://academic.oup.com/biomedgerontology/article/68/6/677/873141>

10. Sui Z., Raubenheimer D. and Rangan A (2017). *Consumption patterns of meat, poultry and fish after disaggregation of mixed dishes: secondary analysis of the Australian National Nutrition and Physical Activity Survey 2011-12*. Available at: National health and nutrition examination survey.

Available at: <https://bmcnutr.biomedcentral.com/articles/10.1186/s40795-017-0171-1>

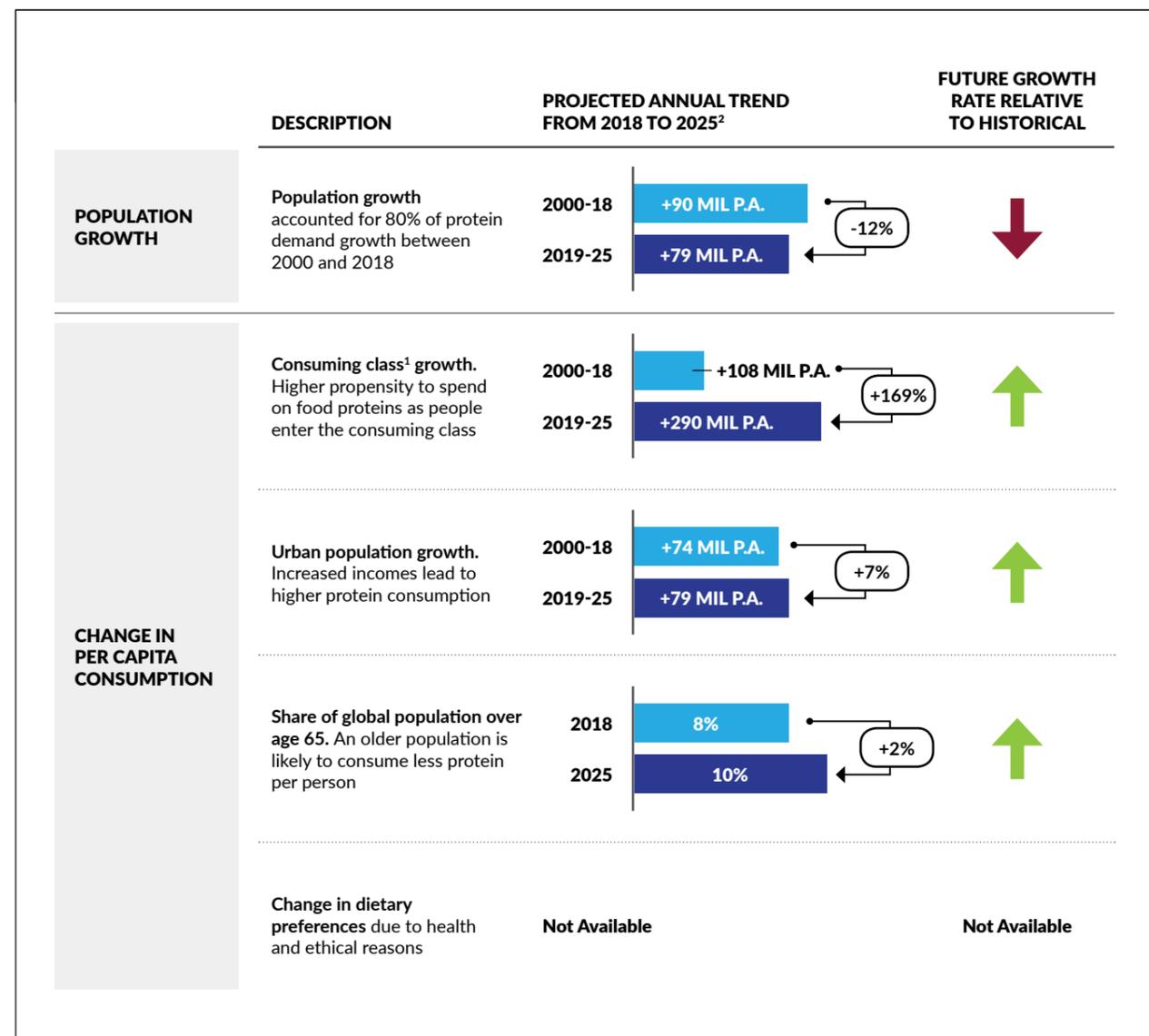
11. Mintel (2017). *The move away from meat infiltrates Asia Pacific: 39% of Indonesians consumed more non-animal sources of protein in 2017*.

Available at: <http://www.mintel.com/press-centre/food-and-drink/the-move-away-from-meat-infiltrates-asia-pacific>

12. Japan Times (2012). *Japanese eat more meat, fewer vegetables than decade ago: official data*.

Available at: <https://www.japantimes.co.jp/news/2012/12/07/national/japanese-eat-more-meat-fewer-vegetables-than-decade-ago-official-data/#.XBikKVwzPY>

EXHIBIT 4:
Five major drivers may impact global protein consumption demand between 2018 and 2025



1. "Consuming class" refer to people in the middle class, which is defined by Kharas (2017) from Brookings Institute as households with per capita incomes between \$10 and \$100 per person per day (pppd) in 2005 PPP terms. This implies an annual income for a four-person middle-class household of \$14,600 to \$146,000.
 2. The bar charts in this column reflect the historical (2000-18) and projected (2019-25) annual average increase in absolute terms for all drivers except "share of global population over age 65". "P.A." in each of the bar charts for these drivers refer to "per annum". For the driver "share of global population over age 65", the bar chart displays the absolute percentage shares of individuals aged over 65 of global population in 2018 and 2025.
 Source: UN Population Division; Brookings Institute; AlphaBeta analysis

EXHIBIT 5:
The growing consuming class and urbanisation could replace population growth as the key drivers of protein consumption

REGION	POPULATION GROWTH ²	CONSUMING CLASS GROWTH ²	URBAN POPULATION GROWTH ²	GROWTH IN SHARE OF POPULATION ABOVE AGE 65 ²	CHANGE IN DIETARY PREFERENCES ³
CHINA	Light Blue	Dark Green	Light Blue	Red	Grey
INDIA	Light Blue	Dark Green	Dark Green	Light Blue	Grey
REST OF APAC ²	Light Blue	Dark Green	Dark Green	Light Blue	Grey
INDONESIA	Light Blue	Dark Green	Dark Green	Light Blue	Grey
JAPAN	Red	Red	Red	Red	Grey
AUSTRALIA	Light Blue	Light Blue	Dark Green	Light Blue	Grey
EUROPE	Red	Light Blue	Light Blue	Red	Grey
SUB-SAHARAN AFRICA	Dark Green	Dark Green	Dark Green	Dark Green	Grey
LATIN AMERICA	Light Blue	Light Blue	Light Blue	Light Blue	Grey
MENA	Light Blue	Dark Green	Dark Green	Light Blue	Grey
NORTH AMERICA	Light Blue	Red	Dark Green	Light Blue	Grey

1. This refers to the comparison of growth rates between the two time periods: 2000-2018 and 2019-2025.
 2. Based on comparison between historical and projected change on a yearly basis (simple average over 2000-2018 and 2019-2025): "Increase protein consumption at faster rate than historical" refers to when yearly projected change is positive and is more than that of historical yearly average; "Increase protein consumption at slower rate than historical" refers to when yearly projected change is positive but is less than that of historical yearly average; "Absolute decline" refers to when the yearly projected change is negative; "Unknown effect" when future impact is unclear.
 3. This driver refers to other factors that alter dietary preferences. For example, widespread adoption of popular diets such as the Keto diet could alter overall protein consumption.
 4. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan; MENA consists of Middle East and North Africa.
 Source: FAO statistics; literature review; AlphaBeta analysis

4. The rising consumer class could drive global total protein demand to increase at an annual rate of 2.7% from now till 2025 which is faster than historical growth



Protein consumption demand was modelled for three scenarios:

1. **Population growth.** The 'population growth' scenario assumes that people in each region maintain their per capita protein consumption till 2025, and that protein demand is purely driven by population growth;

2. **Historical growth.** The 'historical growth' scenario assumes that per capita protein consumption grows at the historical rate till 2025;

3. **Consuming class.** The 'consuming class' scenario assumes an additional increase in protein consumption above the historical growth rates for people entering the consuming class.

The Appendix contains a more detailed description of each scenario and the underlying assumptions. Exhibit 6 shows that future demand would grow annually by 2.7 percent under the 'consuming class' scenario, as compared to 2.4 percent and 0.9 percent under the 'historical growth' and 'population growth' scenarios respectively. Under the consuming class scenario, the total volume of protein consumption demand is projected to grow from 226 million tonnes in 2018 to 271 million tonnes in 2025. This is equivalent to a 20 percent increase from 2018.

In the 'consuming class' scenario, global protein consumption is projected to rise by 271 million tonnes in 2025 - a 20% increase from 2018.

5. The highest growth rates in protein consumption will likely be experienced in Asia and Sub-Saharan Africa, while Japan, Europe and North America could see the lowest growth from today's levels

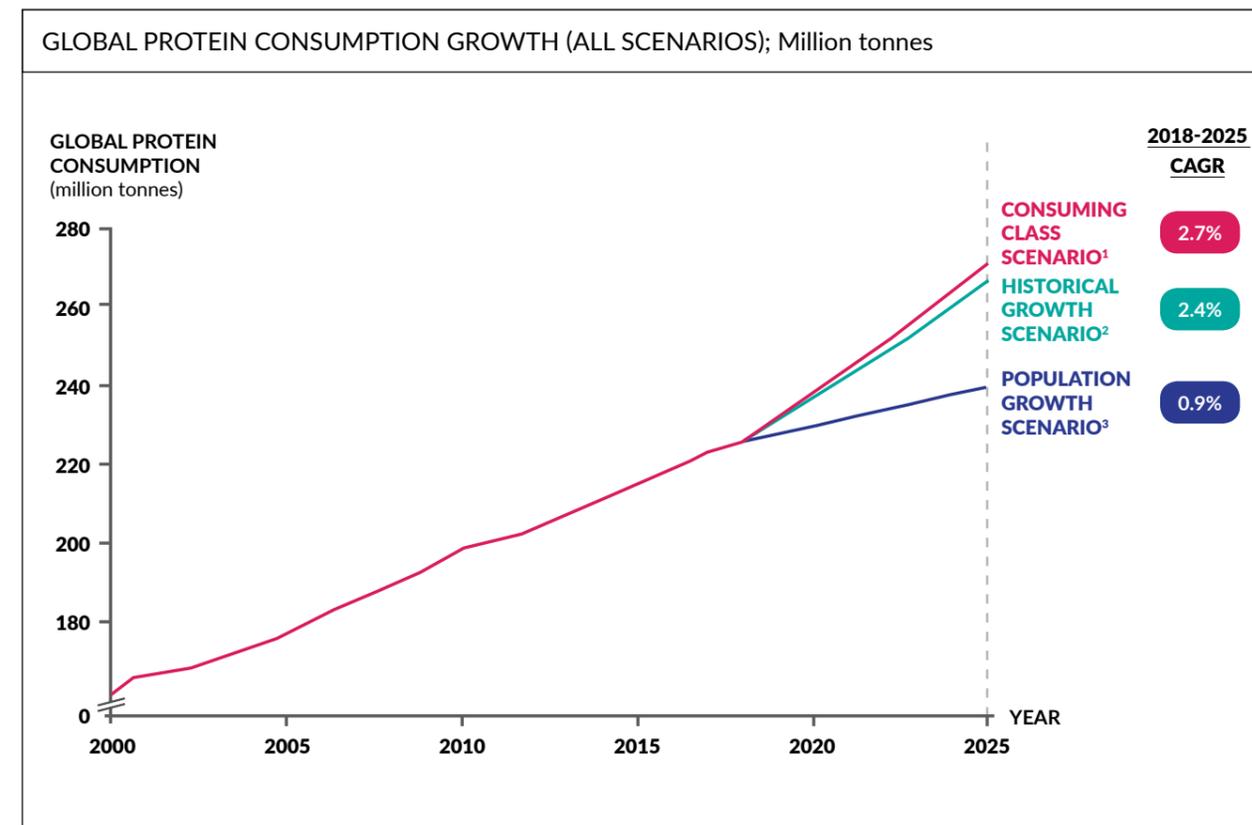


Exhibit 7 shows the projected growth rates of protein consumption demand by region, under the "consuming class" scenario. While all regions are estimated to have positive demand growth, the regions with the fastest growing demand are in the relatively less developed areas such as Indonesia and Sub-Saharan Africa, where both are forecast to grow at 3.6 percent annually between 2018 and 2025. Conversely, more developed regions such as Europe and Japan are forecast to grow by less than 1 percent annually over the same time period.

At 3.6% annual growth, Indonesia and Sub-Saharan Africa are projected to be the fastest growing protein markets worldwide.

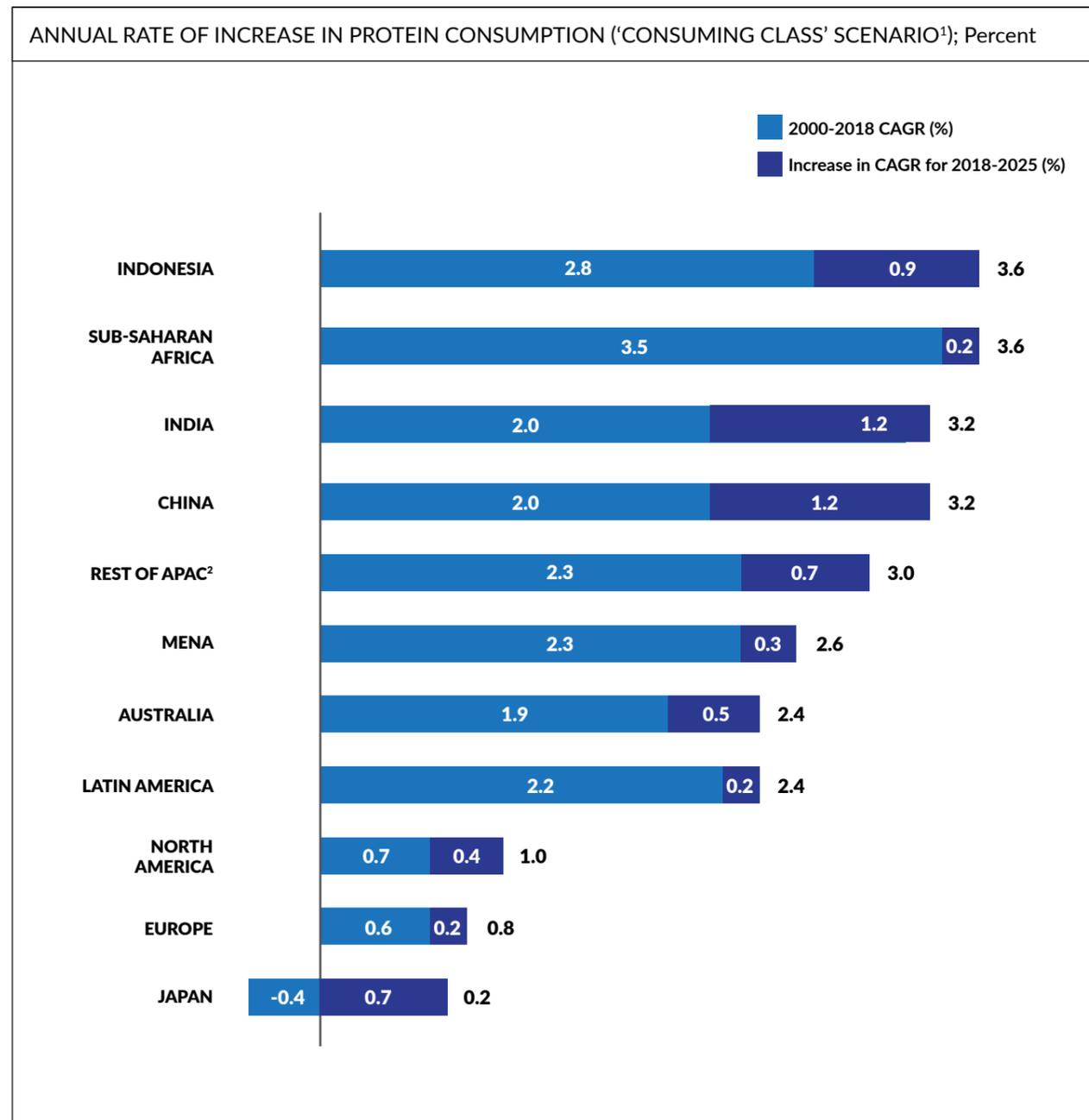
EXHIBIT 6:

The rising consumer class could drive global total protein demand to increase at an annual rate of 2.7% from now till 2025 - faster than historical growth



1. This refers to the scenario in which protein consumption demand grows at a higher rate for the consuming class, while protein consumption demand of those outside the consuming class grows at historical rates.
 2. This refers to the scenario in which protein consumption demand follows per-capita historical growth trend on a per capita basis.
 3. This refers to the scenario in which there is no growth in protein consumption demand on a per capita basis, with demand only being driven by population growth.
 Source: FAO statistics; AlphaBeta analysis

EXHIBIT 7:
The highest growth rates in protein consumption will likely be experienced in Asia and Sub-Saharan Africa, while Japan, Europe and North America could see the lowest growth from today's levels



1. Latest FAO data point is 2013. 2018 estimated using historical growth rates (i.e. 5-year CAGR), 2025 estimated using consuming class scenario. This refers to the scenario in which protein consumption demand grows at a higher rate for the consuming class, while protein consumption demand of those outside the consuming class grows at historical rates.
 2. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan; MENA consists of Middle East and North Africa.
 Note: Figures may not sum due to rounding.
 Source: FAO statistics; AlphaBeta analysis

6. The largest share of global protein consumption will likely continue to be in China; this region may also potentially account for the highest share of the global increase to 2025



Consistent with their respective regional growth rates, the largest increase in protein consumption demand in absolute terms is projected to be in Asia and Sub-Saharan Africa (Exhibit 8). Among the 11 regional markets, China is expected to continue having the highest share of global protein consumption demand – with protein consumption in the country growing from 57 million tonnes in 2018 (25 percent of global consumption) to 70 million tonnes in 2025 (26 percent of global consumption). Moreover, the country's potential contribution to global increase in protein

consumption between 2018 and 2025 will also likely be the largest when compared against the other 10 regional markets, at 31 percent (Exhibit 8). Together with India which could potentially contribute 16 percent to this global increase during this timeframe, the two Asian countries could collectively account for almost 50 percent of the potential increase in global protein consumption demand.

Conversely, Europe and Japan could see a decline in their respective shares of global demand. Europe's protein consumption was 28 million tonnes in 2018 (equivalent to 12 percent of global consumption) and projected to be 30 million tonnes in 2025 (11 percent of global). As for Japan, the country's protein consumption level was 4 million tonnes in 2018 (2 percent of global) and projected to stay at the same approximate amount in 2025 (1 percent of global).

China and India could account for almost 50% of the future increase in global protein demand to 2025.

7. While Japan and Australia rank last in consumption demand among the 11 regions, values per tonne of protein in these two markets are the highest

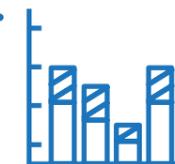


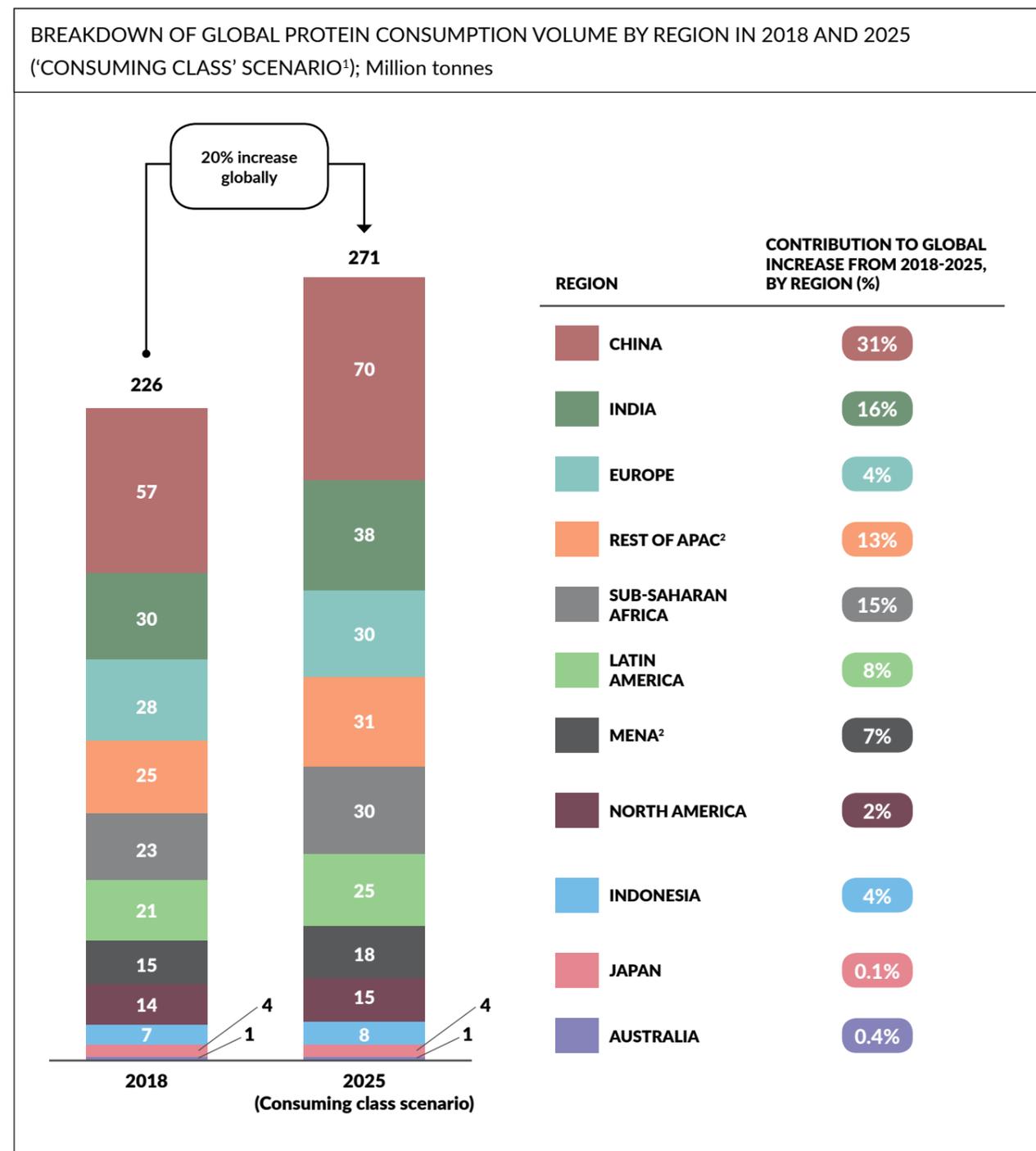
Exhibit 9 shows that a comparison of the total demand for protein in volume terms versus value terms. For certain markets, this can lead to very different conclusions in terms of their global importance. For example, Japan and Australia may be the two smallest markets in terms of volume demand for protein but are the most expensive on a per tonne basis. However, China is the key market regardless of the metric used – not only does it rank first on both volume and total market value,

China is a key protein market to focus on: it ranks first globally on both volume and value.

it also ranks third on value per tonne, driven by the high prices of beef and pork it faces.

EXHIBIT 8:

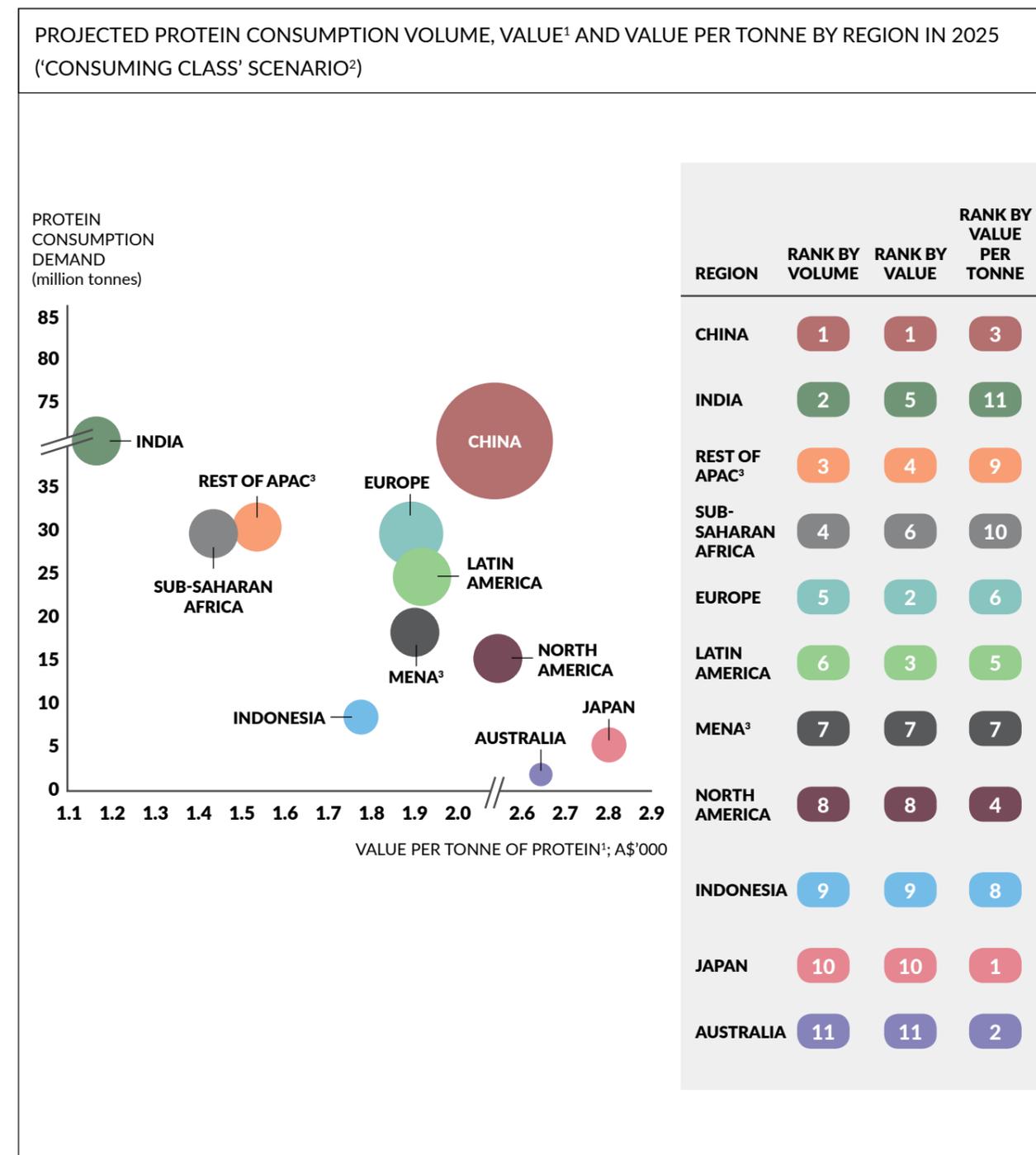
The largest share of global protein consumption will likely continue to be in China; this region may also potentially account for the highest share of the global increase to 2025



1. Latest FAO data point is 2013. 2018 estimated using historical growth rates (i.e. 5-year CAGR), 2025 estimated using consuming class scenario. This refers to the scenario in which protein consumption demand grows at a higher rate for the consuming class, while protein consumption demand of those outside the consuming class grows at historical rates.
 2. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan; MENA consists of Middle East and North Africa.
 Note: Figures may not sum due to rounding.
 Source: FAO statistics; AlphaBeta analysis

EXHIBIT 9:

While Japan and Australia rank last in consumption demand among the 11 regions, values per tonne of protein in these two markets are the highest



1. Based on 2017 prices: FAO producer price data to proxy for plant-based, meat, eggs, and dairy prices; GlobeFish European Fish Report for aquaculture and wild catch fisheries; available market research for non-traditional proteins.
 2. 2025 figures are taken for the scenario in which protein consumption demand grows at a higher rate for the consuming class, while protein consumption demand of those outside the consuming class grows at historical rates.
 3. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan; MENA consists of Middle East and North Africa.
 Source: FAO statistics; AlphaBeta analysis

Since 2000, plant-based foods have supplied the largest amount of protein consumed in volume terms. However, protein supply by other sources such as aquaculture and non-traditional proteins are growing at considerably faster rates. Future protein supply may be influenced by four key trends – dietary shifts due to health and ethical reasons, governance and regulations, environmental constraints and technological advances. These trends are expected to trigger a shift towards plant-based diets and increased aquaculture production. Based on these trends, three scenarios were constructed to understand how protein supply could look like in 2025. Across all scenarios, plant-based protein will likely remain the dominant protein source in volume terms, while meat-based protein will be the largest category by value. Aquaculture and non-traditional proteins are expected to see the largest growth in value terms, though the latter will remain small in absolute terms. At a regional level, China will likely be the largest market across all categories except plant-based proteins.

SUPPLY ANALYSIS

KEY SUPPLY INSIGHTS

1. Since 2000, plant-based protein has been the biggest category by volume, but growth has been faster in other categories.



Since 2000, plant-based foods have supplied the largest amount of total protein consumed in volume terms. In 2018, plant-based foods supplied around 66 percent of global protein consumed. As seen in Exhibit 10, the volume of protein supplied by plant-based foods is about three times that of the second largest protein category – meat – in both 2000 and 2018. However, the growth in the volume of proteins supplied by plant-based foods for this period was lowest across other food categories, except wild catch fisheries. Non-traditional proteins and aquaculture, in particular, have experienced increases of

Plant-based foods supplied around **66% of global protein** consumed in 2018. However, its growth rate since 2000 lags behind all other protein categories except wild catch fisheries.

872 percent and 74 percent respectively between 2000 and 2018. The large increase in non-traditional proteins is due to the emergence of the insects and micro-algae protein markets during this period.

2. Going forward, four major trends will lead to shifts in the sources of protein consumption



Four key trends will shape the future demand of different sources of protein:

1. **Dietary shifts due to health and ethical reasons.** Increased focus on the detrimental health impacts and rising awareness of ethical issues linked to meat consumption (in particular, concerns about

animal welfare and farming practices) have led to an increasing shift towards plant-based diets.¹³ This shift is perceptible across many regions. Regional surveys reflect, for example, that 27 percent of Europeans¹⁴ and 33 percent of Americans intend to eat less meat over the coming years,¹⁵ 14 percent of Australians are making concerted efforts to avoid red meat,¹⁶ and 34 to 39 percent of urban Indonesians and Thais consumed less animal-based proteins over the past two years.¹⁷ While the largest plant-based protein sources are rice and wheat, other sources such as chia seeds, flaxseed and quinoa are experiencing high rates of growth, although their absolute market

14% of Australians are making concerted efforts to avoid red meat.

13. Natural Products Insider (2019). Deep dive report: The plant-based protein market. Available at: <https://www.naturalproductsinsider.com/functional-foods/beverages/deep-dive-plant-based-protein-market>

14. ING Bank (2017). The protein shift: will Europeans change their diet? Available at: <https://www.theguardian.com/world/2016/jun/20/chinas-meat-consumption-climate-change>

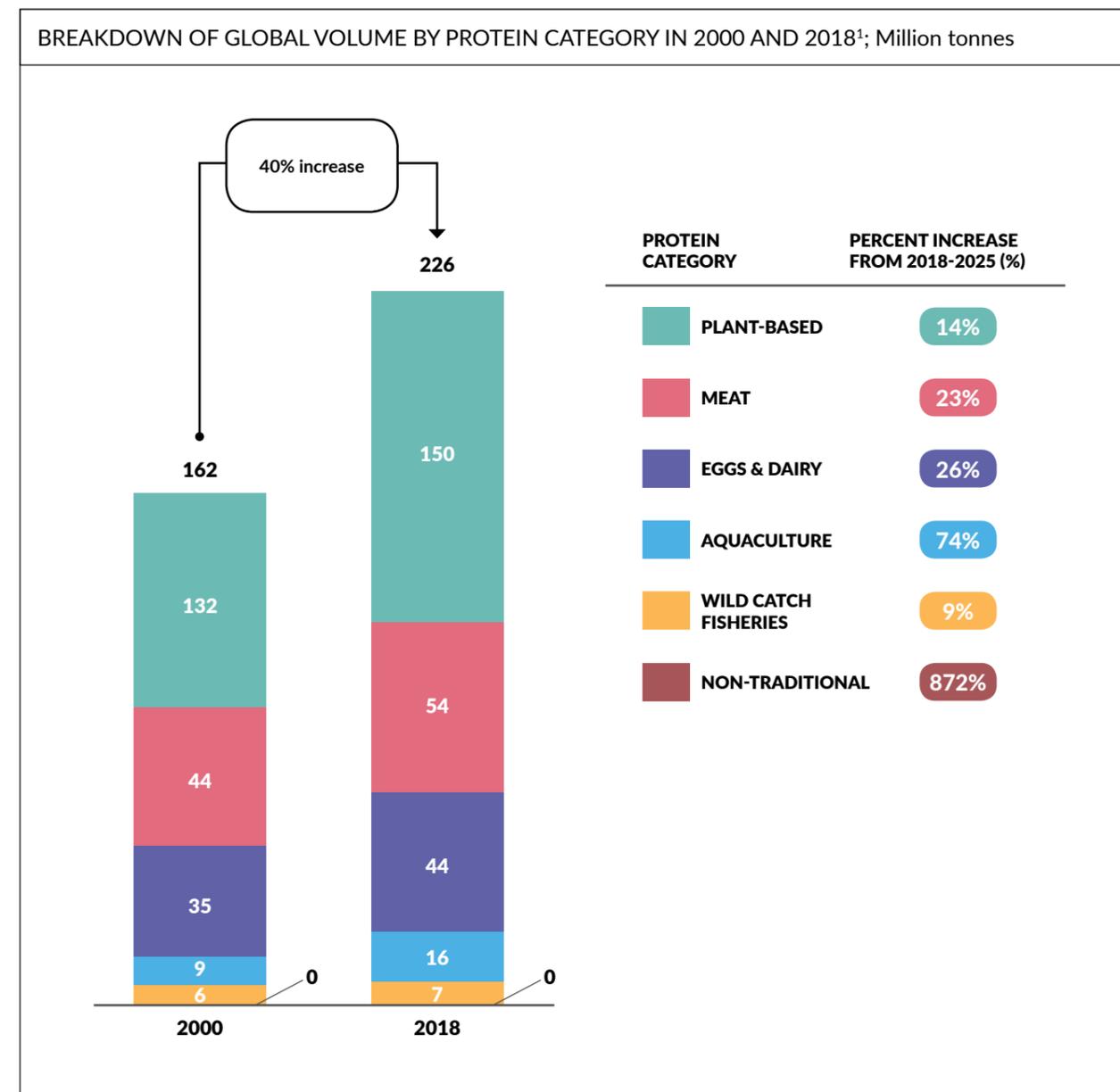
15. Live Mint (2018). "No vegetarianism is not growing in India". Available at: <https://www.livemint.com/Politics/dWUqT4epdPTHNAYuKYVThK/No-vegetarianism-is-not-growing-in-India.html>

16. Australian Bureau of Statistics (2016). "Australian health survey: consumption of food groups from the Australian Dietary Guidelines, 2011-12". Available at: <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4364.0.55.012~2011-12~Main%20Features~Lean%20meats%20and%20alternatives~13>

17. Mintel (2017). The move away from meat infiltrates Asia Pacific: 39% of Indonesians consumed more non-animal sources of protein in 2017. Available at: <http://www.mintel.com/press-centre/food-and-drink/the-move-away-from-meat-infiltrates-asia-pacific>

EXHIBIT 10:

Since 2000, plant-based protein has been the biggest category by volume, but growth has been faster in other categories



1. Latest FAO data point is 2013. 2018 estimated using historical growth rates (i.e. 5-year CAGR). Note: Figures may not sum due to rounding. Source: FAO statistics; AlphaBeta analysis

sizes remain relatively small.¹⁸ Some sources also suggest a shift towards pescatarian diets, in which meat consumption is reduced in favour of seafood consumption, largely for health reasons.¹⁹

2. **Governance and regulations.** In many countries, there has been increased government advocacy of plant-based over animal-based diets. In 2016, the Chinese government drew up new dietary guidelines recommending citizens to halve their meat consumption in order to improve public health and reduce greenhouse gas emissions.²⁰ Other governments that explicitly push for plant-based diets over meat consumption in their dietary guidelines include Germany, Brazil, Sweden and Qatar.²¹ The Swedish guidelines, for example, encourage citizens to eat at least 500 grammes of fruit and vegetables a day and limit their consumption of red and processed meat to no more than 500 grammes a week.²² In addition, some non-traditional proteins currently face regulatory hurdles in their journey to launch to market. While the US is currently home to a number of lab-grown meat start-ups, these companies face potential regulation by the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA).²³ Research has shown that the production of meat and dairy uses 83 percent of farmland and produces 60 percent of greenhouse gas emissions arising from agriculture; in addition, even the lowest-impact meat and dairy products still cause more environmental harm than the least sustainable farmed vegetables.²⁴ Pricing of carbon

Swedish citizens are encouraged to consume a weekly maximum of 500g of red and processed meat.

emissions and other resources (such as water) could thus also have significant impacts on different forms of proteins, potentially increasing their costs by up to 450 percent.²⁵

3. **Environmental constraints.** The supply of certain proteins could be reduced due to environmental constraints such as their impact on greenhouse gas emissions, limited arable land stock and declining wild fish populations. A recent report by the World Resources Institute estimated that ruminant livestock (cattle, sheep and goats) use two-thirds of global agricultural land and contribute roughly half of agriculture's production-related emissions.²⁶ The FAO has also warned that about 90 percent of the world's fish stocks are now fully or overfished, increasing the need for aquaculture production to overtake wild catch fisheries as the main source of fish consumption moving forward.²⁷ Research reflects that on the whole, plant protein production results in a lower environmental impact than animal protein production through reduced energy consumption, emissions, land usage and water consumption.²⁸

90% of the world's fish stocks are now fully or overfished.

18. Natural Products Insider (2019). *Deep dive report: The plant-based protein market.*

Available at: <https://www.naturalproductsinsider.com/functional-foodsbeverages/deep-dive-plant-based-protein-market>

19. Blank C (2016). "Pescatarianism a fast-growing trend to watch", *Seafood Source*.

Available at: <https://www.seafoodsource.com/news/foodservice-retail/pescatarianism-a-fast-growing-trend-to-watch>

20. Millman O and Leavenworth S (2016). "China's plan to cut meat consumption by 50 percent cheered by climate campaigners", *The Guardian*.

Available at: <https://www.theguardian.com/world/2016/jun/20/chinas-meat-consumption-climate-change>

21. Fisher C and Garnett T (2016). *Plates, pyramids, planet – developments in national healthy and sustainable dietary guidelines: a state of play assessment.*

Food and Agriculture Organization of the United Nations. Available at: <http://www.fao.org/3/a-i5640e.pdf>

22. Fisher C and Garnett T (2016). *Plates, pyramids, planet – developments in national healthy and sustainable dietary guidelines: a state of play assessment.*

Food and Agriculture Organization of the United Nations. Available at: <http://www.fao.org/3/a-i5640e.pdf>

23. Bunge J (2018). "Lab-grown meat raises regulatory questions", *The Wall Street Journal*.

Available at: <https://www.wsj.com/articles/lab-grown-meat-raises-regulatory-questions-1538532420>

24. Poore J and Nemecek T (2018). *Reducing food's environmental impacts through producers and consumers.* *Science*, Vol 360, Issue 6392.

Available at: <http://science.sciencemag.org/content/360/6392/987>

25. McKinsey Global Institute (2011). *Resource Revolution: Meeting the world's energy, materials, food, and water needs.*

Available at: <https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution>

26. World Resources Institute (2018). *Creating a sustainable food future.*

Available at: <https://www.wri.org/our-work/project/world-resources-report/world-resources-report-creating-sustainable-food-future>

27. FAO (2016). *The state of the world's fisheries.* Available at: <http://www.fao.org/3/a-i5555e.pdf>

28. Natural Products Insider (2019). *Deep dive report: The plant-based protein market.*

Available at: <https://www.naturalproductsinsider.com/functional-foodsbeverages/deep-dive-plant-based-protein-market>

4. **Technological advances.** Breakthroughs in research and development will lead to alternative and more productive methods of supplying high-demand food. For example, numerous start-ups have recently been established to fulfil the demand of ethically-conscious meat-eaters by developing lab-grown meat, which refers to meat grown in a laboratory from cultured cells without killing animals.²⁹ Aquaculture productivity has also experienced significant increases due to innovations in genetic breeding, disease management and fish feed.³⁰ In Vietnam, a breakthrough in catfish breeding in 2000, coupled with widespread adoption of high-quality pelleted feed, allowed catfish production to grow from 50,000 tonnes in 2000 to more than 1 million tonnes in 2010 – even though the country's total catfish pond area only doubled during that time.³¹

An analysis of the impact of each of the above trends on the future supply of each protein category (Exhibit 11) points towards two possible shifts: a shift towards plant-based diets with a corresponding decline in meat consumption, and increased aquaculture production. Both are explained as follows:

- **Shift towards plant-based diets.** Precipitated by consumers' shifting dietary choices due to health and ethical reasons, government advocacy and environmental constraints, the consumption of plant-based proteins is projected to increase – offset by corresponding declines in meat.
- **Increased aquaculture production.** Aquaculture production is projected to increase due to wild catch fisheries being constrained by declining wild fish populations, as well as increasing technological advances that will improve aquaculture productivity. This is offset by corresponding declines in meat.

Based on analysis of the above four trends and their possible impacts on different protein categories moving forward, three scenarios for the future structure of global protein supply in 2025 were constructed. Total global protein consumption across all scenarios is capped at the same figure modelled under the "consuming class" scenario in the demand analysis – at 271 million tonnes. The three supply scenarios differ in the breakdown of total protein consumption by the six different protein categories – both globally and regionally.

The three supply scenarios are as follows (Exhibit 12):

1. **Business-as-usual.** Under this scenario, protein supply in 2025 is modelled based on projected population and consuming class growth rates, as well as the historical growth of per capita protein consumption.³² This scenario is taken as the baseline scenario to compare against Scenarios 2 and 3.
2. **Shift towards plant-based diets.** The supply of plant-based proteins increases in this scenario, offset by corresponding declines in animal-based proteins (meat, aquaculture and wild catch fisheries).
3. **Technological breakthroughs in aquaculture and non-traditional protein sources.** Due to technological advances in aquaculture production and the development of alternative protein sources, the supply of aquaculture and non-traditional proteins both increase in this scenario, though the latter is from a low existing base. Increases in aquaculture production is offset by declines in meat consumption due to dietary shifts away from meat for health and other reasons.

29. Schafer G (2018). "Lab-grown meat: meat produced without killing animals is heading to your dinner table", *Scientific American*.

Available at: <https://www.scientificamerican.com/article/lab-grown-meat/>

30. FAO (2019). *Aquaculture Technology.* Available at: <http://www.fao.org/fishery/technology/aquaculture/en>

31. Waite R et al (2014). *Improving productivity and environmental performance of aquaculture.* Available at: <http://science.sciencemag.org/content/360/6392/987>

32. This is similar to the 'consuming class' scenario in the demand analysis.

EXHIBIT 11:

These trends will likely trigger a shift towards plant-based diets and increased aquaculture production

TRENDS	DIETARY SHIFTS DUE TO HEALTH AND ETHICAL REASONS	GOVERNANCE & REGULATIONS	ENVIRONMENTAL CONSTRAINTS	TECHNOLOGICAL ADVANCES
PLANT-BASED				
MEAT				
AQUACULTURE				
WILD CATCH FISHERIES				
EGGS & DAIRY				
NON-TRADITIONAL				

1. This refers to the comparison of growth rates between the two time periods: 2000-2018 and 2019-2025.
Source: Literature review; AlphaBeta analysis

EXHIBIT 12:

Based on these trends, there are 3 possible scenarios for the future of protein supply

#	SCENARIO	RELEVANT TRENDS	DESCRIPTION AND BRIEF METHODOLOGY	DATA SOURCES
1	Business-as-usual 	All	Protein consumption is projected based on growth of population, historical per-capita consumption and consuming class	FAO database
2	Shift towards plant-based diets 	<ul style="list-style-type: none"> Dietary shifts due to health and ethical reasons Governance and regulations Environmental constraints 	Ramp up in plant-based protein, with corresponding decline in animal-based protein (which includes meat, aquaculture and wild catch fisheries) due to a combination of health, environmental and ethical concerns	Market estimates and surveys
3	Technological breakthroughs in aquaculture and non-traditional protein sources 	<ul style="list-style-type: none"> Dietary shifts due to health and ethical reasons Environmental constraints Technological advances 	Ramp up in aquaculture consumption enabled by technological breakthroughs, with accompanying declines in meat consumption. Non-traditional protein will also increase, but from current low base	FAO Fish to 2030 Report; market estimates

Source: AlphaBeta analysis



3. Across all scenarios, plant-based protein will remain the dominant source of consumption in volume terms



Across all three scenarios, plant-based proteins will represent the largest component of protein supply in 2025 in volume terms (Exhibit 13). In fact, plant-based protein in 2025 will still likely be three times as large as the second largest component – meat.

Under the “plant-based diets” and “tech breakthroughs” scenarios, the gap between meat and aquaculture supply narrows as compared to 2018. In both scenarios, aquaculture and non-traditional proteins consistently account for the highest estimated growth rates from 2018 till 2025 – at 5 to 12 percent and 38 percent per annum respectively.

4. In value terms, meat-based protein will likely be the largest category in a ‘business-as-usual’ scenario



The composition of the global protein supply market will look very different when viewed through a “value” lens. In this regard, meat-based protein will likely

Meat could account for 20% of the global protein market in 2025 by volume, and an even higher 44% by value .

dominate due to its relatively higher price. Under the ‘business-as-usual’ scenario, meat is projected to account for 44 percent of the total global protein market in 2025 (compared to 20 percent in volume terms), which is valued at A\$513 billion (Exhibit 14). Similarly, while aquaculture represents around 6 percent of the protein market in volume terms, it is expected to account for 16 percent of the total global market value for protein consumption in 2025.³³

33. At A\$7.89/gramme, the global average price of aquaculture is almost eight times as much as that for plant-based protein – at A\$1.14/gramme. These prices refer to the global average prices of all proteins within the specific category (e.g. meat, plant-based, aquaculture) across the 11 regions. Prices are based on 2017 prices; refer to Appendix for sources and full methodology.



5. Aquaculture and non-traditional proteins have the highest growth rates in value terms across all scenarios, but non-traditional proteins’ overall market value is expected to remain small in 2025



Exhibit 15 shows that aquaculture and non-traditional proteins are projected to have the fastest growth by market value between 2018 and 2025. Under the “technological breakthroughs” scenario, the market value of aquaculture is expected to grow at an annual rate of 12 percent, leading to a substantial rise of its share of the total protein market (from 12 percent in 2018 to 21 percent in 2025). Conversely, even though non-traditional proteins are projected to grow by the fastest rate at 35 percent per annum across all scenarios, their share of the global protein market in 2025 would still be minuscule across all scenarios (at less than 1 percent).

The projected high growth in the non-traditional protein category is largely fuelled by the insects market, which is expected to experience a per-annum growth of 45 percent across all scenarios. The UN’s Food and Agricultural Organisation (FAO) advocates the consumption of edible insects for their high level of nutrition, environmentally-friendly rearing and harvesting processes and potential contributions to economic livelihoods.³⁴

While the fastest growth is projected for non-traditional proteins – insects in particular, its market size in 2025 is expected to be less than 1% of the global protein market.

However, this market is not without its challenges. At best, the global insects market is worth A\$1.3 billion in 2025, which constitutes less than 1 percent of the estimated global protein market value. This limited market size is due to three reasons. First, there is an absence of clear regulation and norms guiding the use of insects as food.³⁵ For example, insects are considered a ‘novel food’ in Europe and therefore cannot be sold for human consumption unless overridden by national legislation.³⁶ Second, customer acquisition costs are also currently high due to low rates of consumer acceptance.³⁷ Third, there is also the issue of scalability: rearing insects in large numbers requires the development of automation processes which could be costly.³⁸

34. FAO (2013). Edible insects: future prospects for food and feed security. Available at: <http://www.fao.org/docrep/018/i3253e/i3253e.pdf>

35. FAO (2013). Edible insects: future prospects for food and feed security. Available at: <http://www.fao.org/docrep/018/i3253e/i3253e.pdf>

36. Michail N (2015), “The challenges of selling insects in Europe”, Food Navigator.

Available at: <https://www.foodnavigator.com/Article/2015/07/27/The-challenges-of-selling-insects-in-Europe>

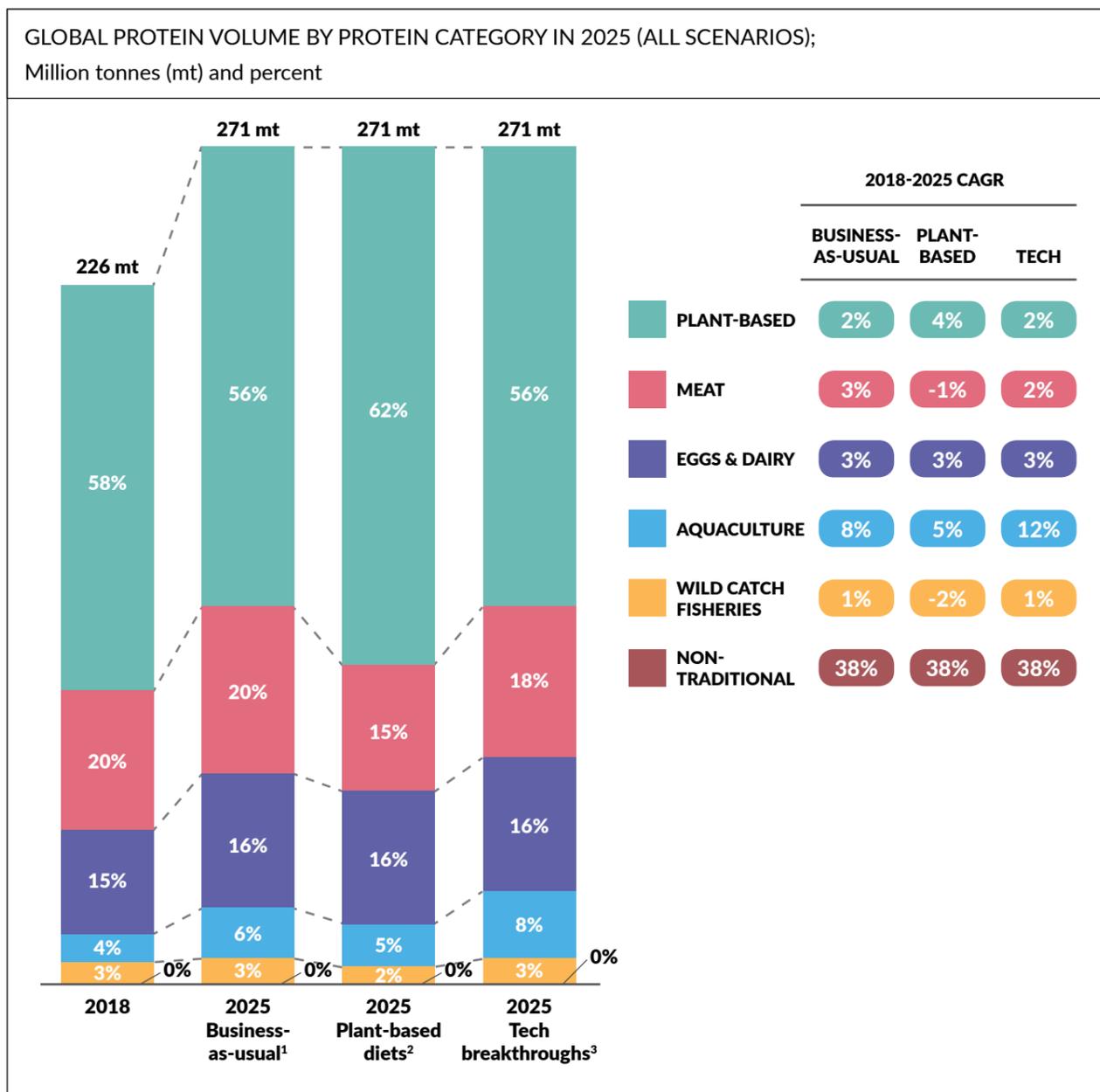
37. Sources include Wilkinson K et al (2018), Australian consumers’ awareness and acceptance of insects as food, National Center for Biotechnology Information, available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6023301/>; House J (2016). Consumer acceptance of insect-based foods in the Netherlands: academic and commercial implications. available at: <https://www.sciencedirect.com/science/article/pii/S0195666316302902>

38. FAO (2013). Edible insects: future prospects for food and feed security. Available at: <http://www.fao.org/docrep/018/i3253e/i3253e.pdf>

38. FAO (2013). Edible insects: future prospects for food and feed security. Available at: <http://www.fao.org/docrep/018/i3253e/i3253e.pdf>

EXHIBIT 13:

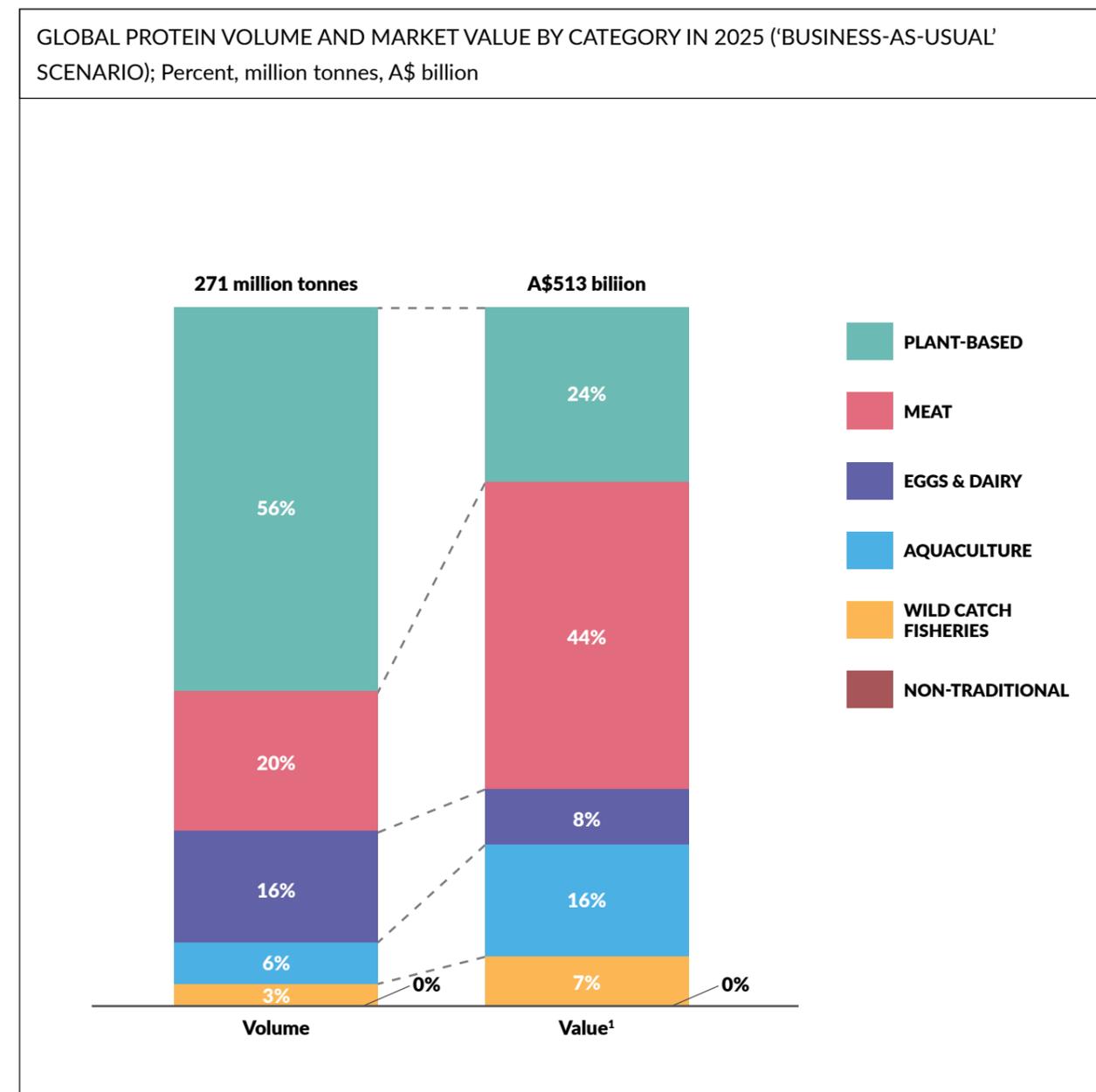
Across all scenarios, plant-based protein will remain the dominant source of consumption in volume terms



1. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 2. In this scenario, a ramp-up in plant-based protein consumption with equivalent declines in meat, aquaculture and wild catch fisheries consumption was assumed based on regional data on expected vegetarianism rates.
 3. In this scenario, aquaculture consumption was increased based on projections of productivity improvements due to technological innovations in the literature, with accompanying declines in meat consumption.
 Note: Figures may not sum due to rounding.
 Source: FAO statistics; AlphaBeta analysis

EXHIBIT 14:

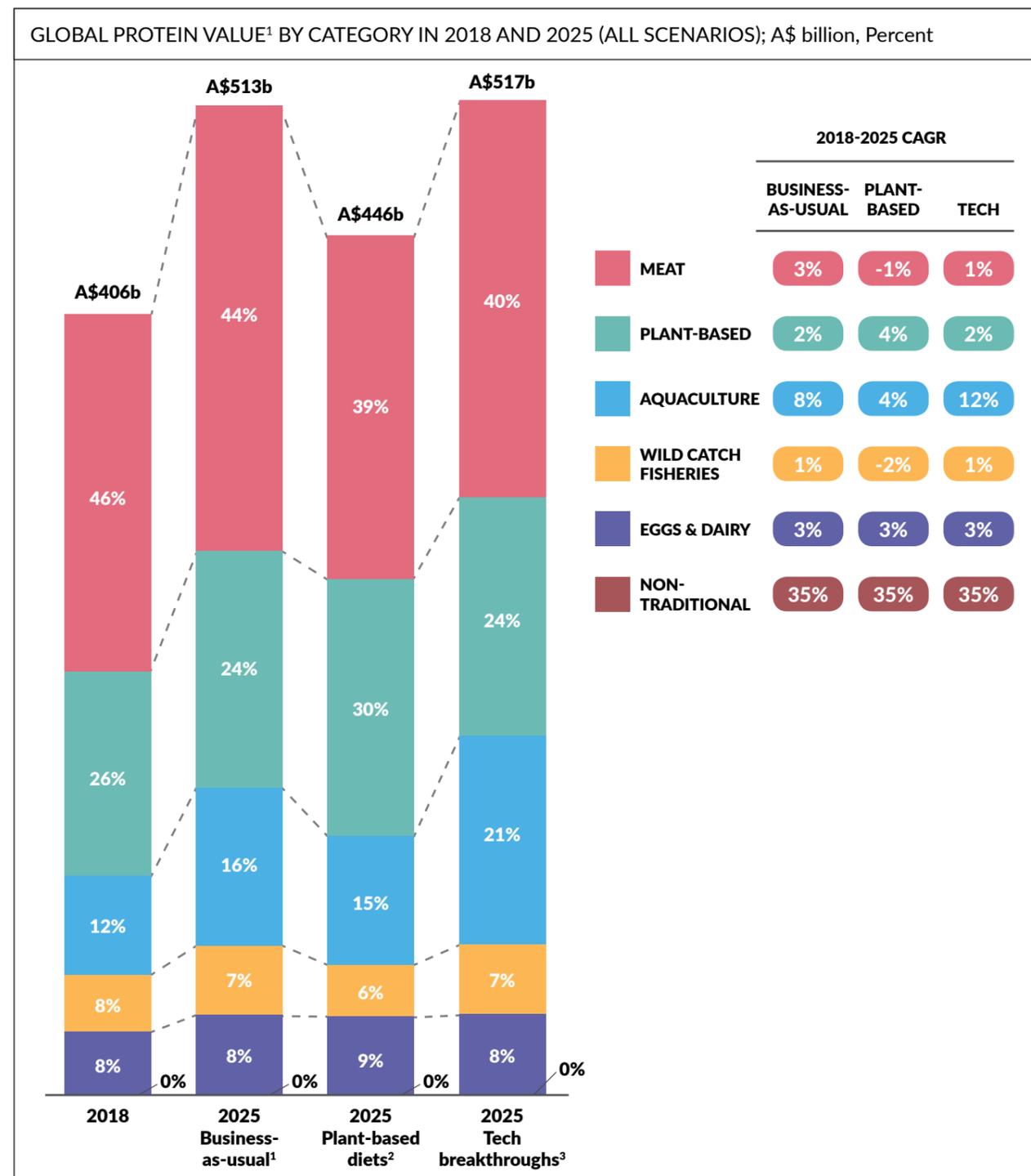
In value terms, meat-based protein will likely be the largest category in a 'business-as-usual' scenario



1. Based on 2017 prices: FAO producer price data to proxy for plant-based, meat, eggs, and dairy prices; GlobeFish European Fish Report for aquaculture and wild catch fisheries; available market research for non-traditional proteins.
 Source: FAO statistics; AlphaBeta analysis

EXHIBIT 15:

Across all 2025 scenarios, aquaculture and non-traditional proteins have the highest growth rates in value terms, but non-traditional proteins' overall market value will likely remain small



1. Based on 2017 prices: FAO producer price data to proxy for plant-based, meat, eggs, and dairy prices; GlobeFish European Fish Report for aquaculture and wild catch fisheries; available market research on non-traditional proteins.
 2. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 3. In this scenario, a ramp-up in plant-based protein consumption with equivalent declines in meat, aquaculture and wild catch fisheries consumption was assumed based on regional data on expected vegetarianism rates.
 4. In this scenario, aquaculture consumption was increased based on projections of productivity improvements due to technological innovations in the literature, with accompanying declines in meat consumption.
 Note: Figures may not sum due to rounding.
 Source: FAO statistics; AlphaBeta analysis

6. In all scenarios, the top 3 protein types by value do not differ



Drilling deeper into how individual protein types rank on value terms, this analysis finds that beef, poultry and pork consistently rank as the top three protein sources across all scenarios – consistent with their relatively higher prices and consumption demand.³⁹ Exhibit 16 additionally shows that beyond the top 3 protein types

by market value, there is some variation in rankings. For example, under the 'tech breakthroughs' scenario, freshwater fish and crustaceans rank 4th and 5th respectively, while demersal fish (10th) is also part of the top 10 list.

7. Within non-traditional protein types, insects are the largest and fastest growing sub-category, but remain small overall in value terms



Exhibit 17 shows the three highest-valued protein types for each protein category. The high growth rates projected for non-traditional proteins will largely be driven by insects (44 percent growth annually), though this market, valued at A\$1.3 billion in 2025, is likely to remain small relative to the highest-valued protein types in other categories. In fact, the market value of insects in 2025 (under the "business-as-usual" scenario) is only 0.03 percent of the global protein market value.⁴⁰

In comparison, the projected per annum growth rates of other non-traditional proteins, micro-algae and lab-grown meat, are lower at 4.6 and 4 percent respectively.⁴¹ The widespread production of microalgae is limited by its high production costs, harvesting access and rights, seasonality, and geographical location of the algae and time-consuming and expensive protein-isolation processes.⁴² Similarly, growth in the production of lab-grown meat is currently restrained by high mass production costs (in 2018, the cost of producing a quarter-pounder patty from lab-grown meat was about A\$800), regulatory barriers (e.g. faced by the FDA and USDA due to issues surrounding the safety of such food products and their economic impact on the existing meat market), low consumer acceptance in markets outside of developed regions and late market entry (the first commercial products are only expected to be launched from 2021 onwards).⁴³

The insects market is forecasted to grow at 44% annually to 2025 – but its expected market size is only 0.03% of the global protein market.

39. At A\$6.38/gramme and A\$3.29/gramme respectively, the average global producer prices of beef and pork are higher than the average producer price of all proteins (excluding non-traditional proteins, the prices of which are extremely high given their nascent stage of development) at A\$3.08/gramme. Consumption demand for beef and pork constitute a substantial 25 and 30 percent of total protein consumption in volume terms under the 'business-as-usual' scenario. For poultry, although its average global price is generally lower than the average price of other proteins types, its consumption demand in volume terms is 45 percent under the 'business-as-usual' scenario. These prices refer to the global average prices of all proteins within the specific category (e.g. meat, plant-based, aquaculture) across the 11 regions. Prices are based on 2017 prices; refer to Appendix for sources and full methodology.

40. Based on AlphaBeta analysis. See Appendix for methodology and sources.

41. Sources include Persistence Market Research (2018). Global market study on microalgae; Markets and Markets (2018). Cultured meat market worth 20 million USD by 2027.

42. Natural Products Insider (2019). Deep dive report: The plant-based protein market.

Available at: <https://www.naturalproductsinsider.com/functional-foodsbeverages/deep-dive-plant-based-protein-market>

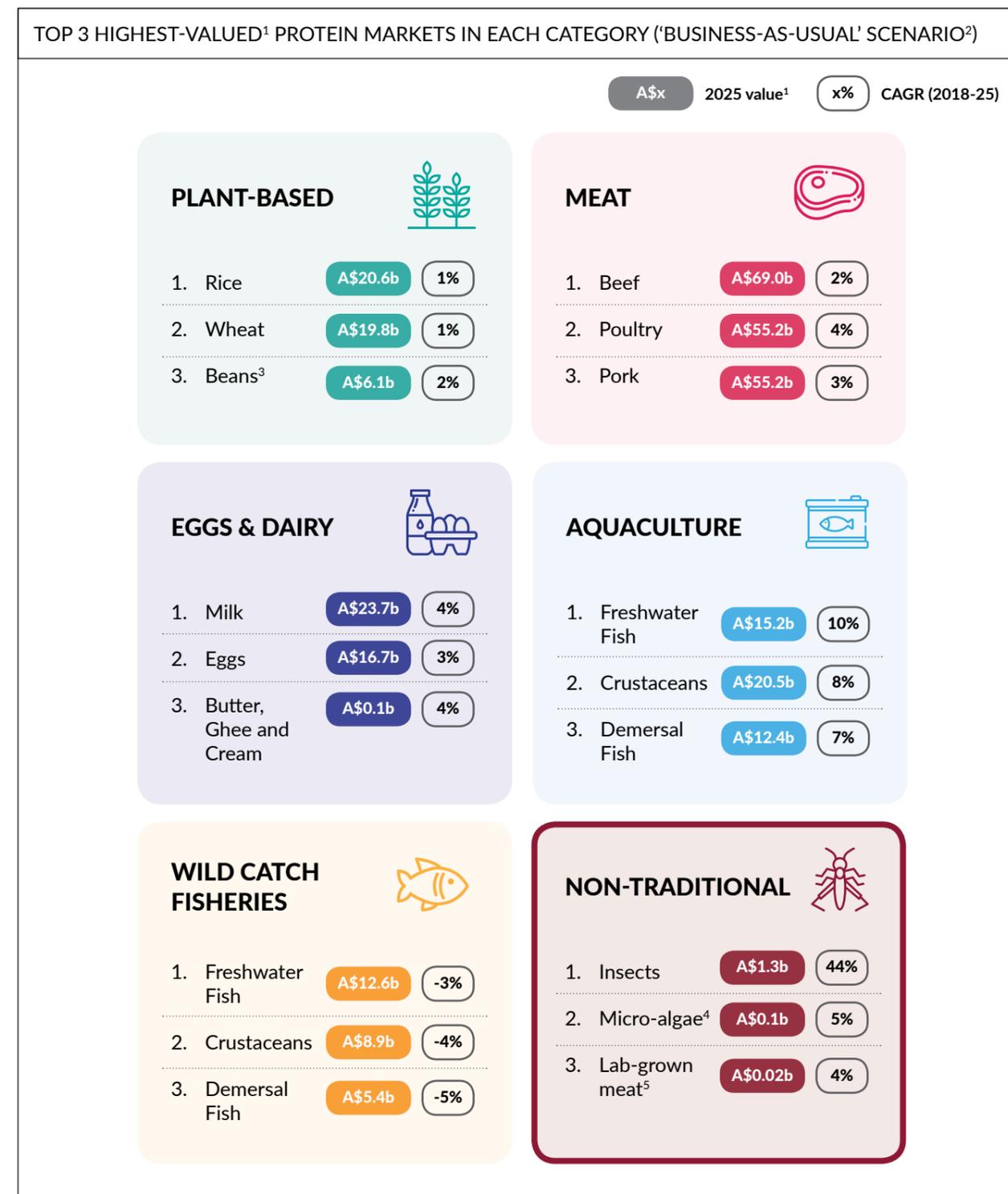
43. Sources include: Amen (2017). Scientific American (2018), "Lab-grown meat: meat produced without killing animals is heading to your dinner table"; CoBank (2017). Lab-grown cultured meat – a long road to market acceptance; Mosa Meat (2018); Supermeat (2018); Future Meat Technologies (2018).

EXHIBIT 16:
In all scenarios, the top 3 protein types by value do not differ

■ Plant-based ■ Meat ■ Eggs & Dairy ■ Aquaculture ■ Wild Catch Fisheries ■ Non-traditional						
RANK	2025 (BUSINESS-AS-USUAL ¹)	VALUE ² A\$ BIL	2025 (PLANT-BASED DIETS ³)	VALUE ² A\$ BIL	2025 (TECH BREAKTHROUGHS ⁴)	VALUE ² A\$ BIL
1	Beef	69	Beef	53	Beef	63
2	Poultry	55	Poultry	43	Poultry	51
3	Pork	55	Pork	41	Pork	49
4	Freshwater Fish	29	Milk	24	Freshwater Fish	38
5	Milk	24	Freshwater Fish	23	Crustaceans	27
6	Rice	21	Rice	22	Milk	24
7	Crustaceans	21	Wheat	22	Rice	21
8	Wheat	20	Eggs	17	Wheat	20
9	Eggs	17	Crustaceans	15	Eggs	17
10	Mutton	15	Mutton	12	Demersal Fish	16

1. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 2. Based on 2017 prices; FAO producer price data to proxy for plant-based, meat, eggs, and dairy prices; GlobeFish European Fish Report for aquaculture and wild catch fisheries; available market research for non-traditional proteins.
 3. In this scenario, a ramp-up in plant-based protein consumption with equivalent declines in meat, aquaculture and wild catch fisheries consumption was assumed based on regional data on expected vegetarianism rates.
 4. In this scenario, aquaculture consumption was increased based on projections of productivity improvements due to technological innovations in the literature, with accompanying declines in meat consumption.
 Source: FAO statistics; AlphaBeta analysis

EXHIBIT 17:
Within non-traditional protein types, insects are the largest and fastest growing sub-category, but remain small overall in value terms



1. Based on 2017 prices. FAO producer price data for plant-based, meat, eggs, and dairy proteins; GlobeFish European Fish Report for aquaculture and wild catch fisheries proteins; available market research for non-trad proteins.
 2. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 3. Beans' constitutes one of the proteins in the list of proteins defined by FAO; it is separate from 'soya beans', which is another protein in the FAO list.
 4. Micro-algae market growth projected by Persistence Market Research (2018) to be at 4.6% between 2017 to 2026 due to prohibitively high costs of mass production.
 5. Lab-grown meat market growth projected by Markets and Markets (2018) to be 4% between 2021 and 2027, due to prohibitively high costs of mass production, late market entry only in 2021, regulatory barriers and low consumer acceptance in markets outside of Australia, Europe, MENA and North America.

8. Except for plant-based protein, China is expected to be the biggest market across all protein categories in 2025



China's protein market value of A\$177 billion in 2025 is the largest by far – more than triple the size of the second largest market, Europe, which is valued at A\$56 billion.⁴⁴ In other words, China alone will account for around 35 percent of the global protein market by 2025, in value terms. Exhibit 18 shows the rank of each region within each protein category under “business-as-usual” scenario in 2025. China emerges as the top market across all protein categories, except for plant-based protein which India outperforms. This is unsurprising given that India has the world's highest vegetarianism rate, which has been estimated to be between 30 to 38 percent of its population.⁴⁵ In 2018, the share of plant-based protein in the Indian diet

Apart from plant-based proteins, China is expected to be the largest market across all protein categories in 2025.

accounted for about 78 percent of per capita protein consumption, as compared to China's 56 percent.⁴⁶

Exhibit 19 shows the projected top 3 protein types by market value in each region in 2025.⁴⁷ This differs significantly across regions, but three trends emerge:

1. Beef, poultry and/or pork consistently feature as one or more of the three largest protein markets in the developed regions (North America, Europe, MENA, Japan and Australia).
2. Seafood proteins – in particular, freshwater fish and crustaceans – have larger market values in Asia Pacific than in the rest of the world.
3. Plant-based proteins, in particular, rice and wheat, have larger market values in developing regions such as India, Indonesia and Sub-Saharan Africa than in the rest of the world.



44. Figures are based on the 2025 'business-as-usual' scenario.
 45. World Atlas (2017). "Countries with the highest rates of vegetarianism". Available at: <https://www.worldatlas.com/articles/countries-with-the-highest-rates-of-vegetarianism.html>
 46. Based on AlphaBeta analysis; estimated based on FAO statistics.
 47. Based on the 2025 'business-as-usual' scenario.

**EXHIBIT 18:
 Except for plant-based protein, China is likely to be the biggest market across all protein categories in 2025**

TOTAL PROTEIN MARKET VALUE¹ BY REGION IN 2025 ('BUSINESS-AS-USUAL' SCENARIO²); A\$ billion

	TOTAL MARKET VALUE	RANK OF REGION BY MARKET VALUE ¹ OF PROTEIN CATEGORY IN 2025					
		PLANT-BASED	MEAT	EGGS & DAIRY	AQUA-CULTURE	WILD CATCH FISHERIES	NON-TRADITIONAL
CHINA	177	2	1	1	1	1	1
EUROPE	56	6	3	3	2	2	2
LATIN AMERICA	48	7	2	5	7	7	5
REST OF APAC ³	48	4	7	2	3	3	7
INDIA	45	1	8	4	8	8	4
SUB-SAHARAN AFRICA	43	3	6	8	4	4	3
MENA ³	35	5	5	7	10	10	8
NORTH AMERICA	32	10	4	6	6	6	6
INDONESIA	15	8	9	10	5	5	9
JAPAN	11	9	10	9	9	9	10
AUSTRALIA	3	11	11	11	11	11	11

1. Total protein market value in each region is computed based on total protein consumption volume multiplied by respective protein prices in market. Prices are based on 2017 prices, and taken from FAO producer price data for plant-based, meat, eggs, and dairy proteins; GlobeFish European Fish Report for aquaculture and wild catch fisheries proteins; available market research for non-traditional proteins.
 2. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 3. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan. MENA consists of Middle East and North Africa.

EXHIBIT 19:

The ranking of protein types is likely to differ significantly across regions

TOP THREE PROTEIN TYPES BY MARKET VALUE¹ IN 2025 ACROSS REGIONS
(‘BUSINESS-AS-USUAL’ SCENARIO²)



1. Based on 2017 prices: FAO producer price data to proxy for plant-based, meat, eggs, and dairy prices; GlobeFish European Fish Report for aquaculture and wild catch fisheries; available market research for non-traditional proteins.

2. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.

3. Rest of Asia Pacific excludes Australia, China, India, Indonesia, and Japan. MENA consists of Middle East and North Africa.

Source: FAO statistics; AlphaBeta analysis

Understanding trends in the nutritional intakes of consumers through a protein-first approach may help the Australian food and agribusiness sector unlock new opportunities in the global market. There are three strategic imperatives for Australian producers:

1. Shift into higher-value protein categories.

Restructuring Australia's protein production mix to match projected global consumption, with the corresponding shifts into higher-value protein categories (such as aquaculture), could lead to an additional production value of A\$55 billion as compared to business-as-usual approaches. While such a transformation in the production mix may be unlikely by 2025, this upside potential should spur Australian producers to explore higher value protein categories.

2. Strengthen partnerships in high-potential markets.

With 3 of the 5 largest contributors to the projected increase in global protein consumption between 2018 and 2025 projected to come from the Asia Pacific region, Australia is well-situated to capture the opportunities in these markets. Capturing this geographical prize requires Australian producers to take advantage of existing free trade agreements and form commercial partnerships with local players in these markets.

3. Deepen collaborations across players in the value chain.

To fully harness future gains, Australian food producers should explore deeper collaborations with other players across the value chain such as food processing companies, researchers, nutritionists and technology providers. Past FIAL research has identified 16 business opportunities relevant to proteins across the value chain, ranging from food safety to precision farming.

IMPLICATIONS FOR AUSTRALIAN PRODUCERS

OPPORTUNITY 1: SHIFT INTO HIGHER-VALUE PROTEIN CATEGORIES

A greater focus on higher-value protein categories such as aquaculture could unlock an additional A\$55 billion in production value for Australia



Exhibit 20 shows that the global protein consumption market could increase by up to A\$111 billion between 2018 and 2025. Regardless of the demand scenario, aquaculture is primed to account for the highest share of the value gap between 2018 and 2025 (e.g. 55 percent of the value increase under the “tech breakthroughs” scenario). Aquaculture’s high contribution rate to the overall value increase of the market is driven by the relatively high growth rates of aquaculture protein demand, and results in aquaculture making up between 16 and 21 percent of the total market in 2025 (Exhibit 21).

Proteins supplied by aquaculture foods could account for over 50% of the projected gap between global protein consumption in 2018 and in 2025.

Australia’s current food production structure appears to be underweight in respect to aquaculture production, with this protein category accounting for only 2 percent of the country’s total production value (Exhibit 21). This has implications on the total production value earned by Australia producers as the average per tonne value of aquaculture is about 7 times higher than that of plant-based crops.⁴⁸

To understand the future trajectories of Australian protein production, two production scenarios were analysed:

a. **“Ride the market” scenario:** Australian food producers simply increase the production of each protein category at their respective projected growth rates till 2025.

b. **“Match the global demand” scenario:** Australian food producers undertake a significant restructure of their food production to match the composition of projected global demand for proteins in 2025.

As reflected in the “match the global demand” scenario in Exhibit 22, if Australia were to restructure its protein production mix to match projected global protein consumption in 2025 and correspondingly focus more on higher-value protein categories such as aquaculture, the country’s food production value could be as high as A\$122 billion. This is A\$55 billion higher than if producers were to follow current approaches, as depicted by the “ride the market” scenario. It should be noted that the values in Exhibit 22 should not be compared to Exhibit 20 as the former focusses on the total value of protein-containing foods, whereas the latter focuses on just the value of protein inputs into food. This difference is due to the availability of data at the global versus national levels for protein production and consumption.

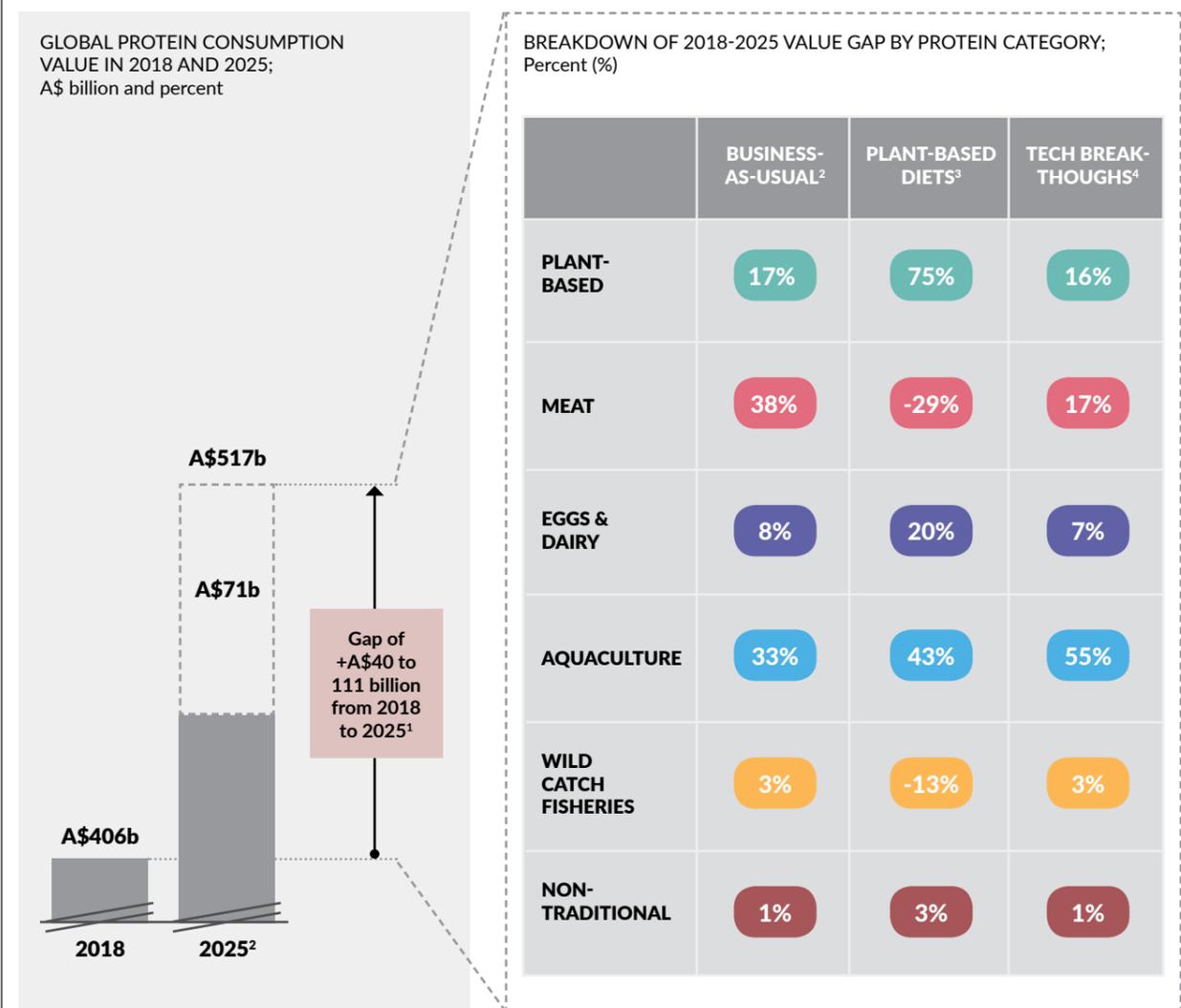
While a complete transformation of Australia’s production mix to reflect global protein demand is unlikely in this time period, Australian producers should still put in place mechanisms that may help them capture some of this future value.

Restructuring Australian production to match projected global protein consumption in 2025 could create an additional production value of A\$55 billion, as compared to a business-as-usual approach.

48. The average per tonne value of aquaculture in 2017 is A\$7,890, while that for plant-based crops is A\$1,146. These estimates were calculated based on FAO data (FAO producer price database and FAO GlobeFish seafood prices report).

EXHIBIT 20: Aquaculture could account for over 50% of the projected gap in global protein consumption value between 2018 and 2025

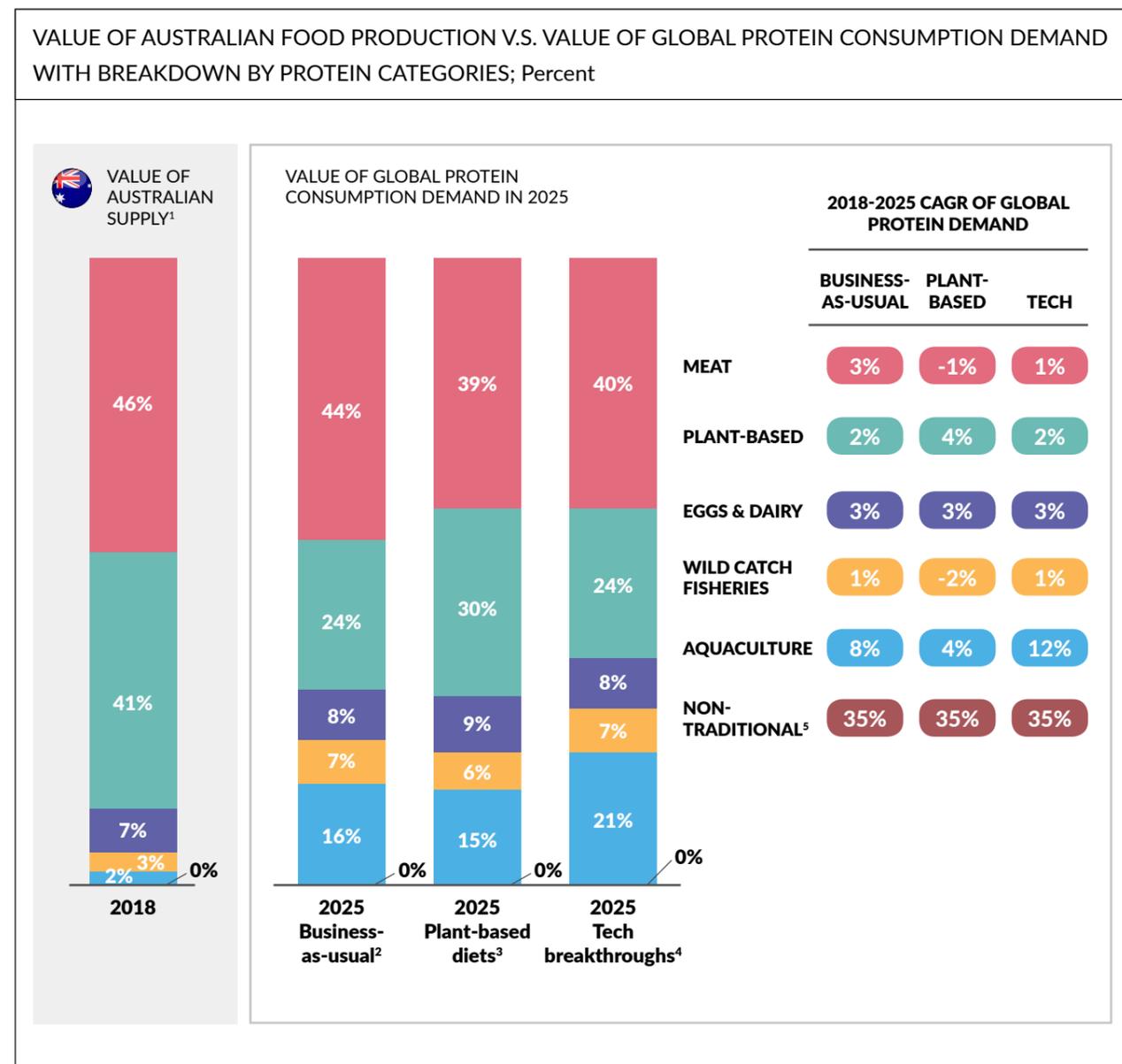
2018-2025 GAP IN GLOBAL PROTEIN CONSUMPTION VALUE AND BREAKDOWN BY PROTEIN CATEGORY (ALL SCENARIOS); A\$ billion and percent



1. Values for all three 2025 scenarios are reflected in this chart. This value ranges from A\$446 billion under the ‘plant-based diets’ scenario, to A\$517 billion under the ‘technological breakthroughs’ scenario. Between these upper and lower bounds, there is a difference of A\$71 billion. Hence, the gap between 2018 and 2025 ranges from A\$40 billion to A\$111 billion.
 2. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 3. In this scenario, a ramp-up in plant-based protein consumption with equivalent declines in meat, aquaculture and wild catch fisheries consumption was assumed based on regional data on expected vegetarianism rates.
 4. In this scenario, aquaculture consumption was increased based on projections of productivity improvements due to technological innovations in the literature, with accompanying declines in meat consumption.

EXHIBIT 21:

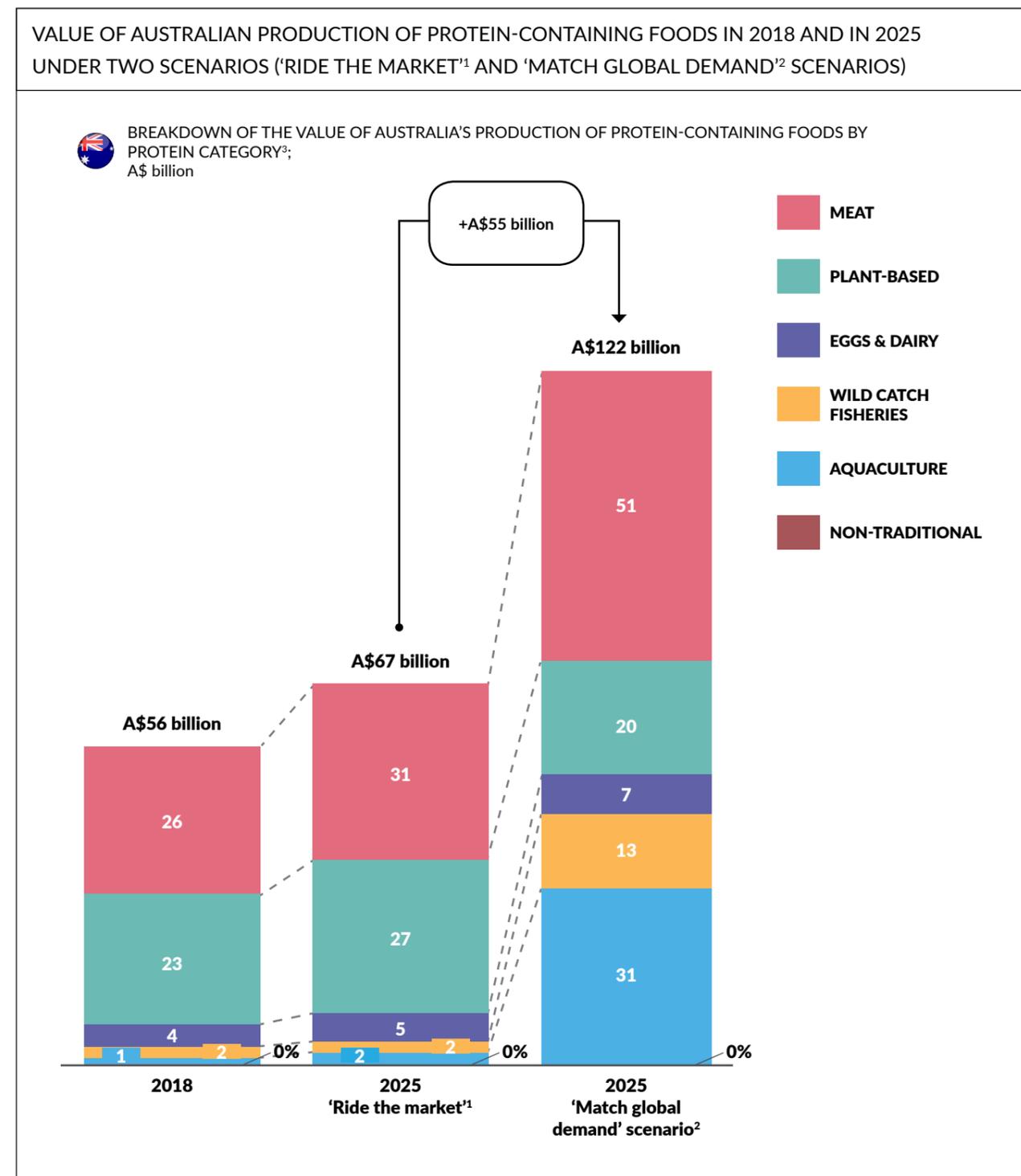
Australia's current production structure appears to be underweight aquaculture – a rapidly growing protein category which could make up 21% of the global market in 2025



1. Refers to Australian production of food with protein content, and not solely to protein content. Data is based on latest available figures from FAO and Australian Government Department of Agriculture and Water Resources.
 2. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class.
 3. In this scenario, a ramp-up in plant-based protein consumption with equivalent declines in meat, aquaculture and wild catch fisheries consumption was assumed based on regional data on expected vegetarianism rates.
 4. In this scenario, aquaculture consumption was increased based on projections of productivity improvements due to technological innovations in the literature, with accompanying declines in meat consumption.
 5. Growth in non-traditional proteins is largely fuelled by the insects market, which will experience a CAGR of 45% across all scenarios. Source: Data from FAO and Department of Agriculture and Water Resources; AlphaBeta analysis.
 Note: Figures may not sum due to rounding.

EXHIBIT 22:

By shifting towards higher-value protein categories, Australia could capture A\$55 billion more in producer value in 2025



1. 'Ride the market' scenario: In this scenario, the projected growth rates in global protein consumption demand for each protein category were applied to current (2018) Australian production of foods containing protein. These growth rates were based on the 'business-as-usual' scenario under the supply analysis.
 2. 'Match global demand' scenario: In this scenario, the total production volume of Australian protein-containing foods was pegged to the total volume under the 'ride the market' scenario. The breakdown of this total volume by protein category was then modelled to mirror the projected breakdown of global protein consumption demand in 2025 under the 'business as usual' scenario in the supply scenario.
 3. Note that the values presented in this exhibit reflect the value of protein-containing foods, and should not be compared against the earlier-presented values of protein consumption, which relate to the value of pure protein consumption (and not the foods they are present in).
 Source: Data from FAO and Department of Agriculture and Water Resources; AlphaBeta analysis



The potential gains to Australian food businesses could be even higher with increased emphasis on value addition within protein types



Australia has historically been a volume player in the industry. The bulk of its sales are in low-value commodities such as grains, animals, fruits and first-stage processed products, while the country's production of higher value-added foods is limited.⁴⁹ Value addition in the context of food is defined as transforming food in its original or raw form (i.e. commodities) into a state which is perceived as more valuable to the end consumer (i.e. products), thereby accruing higher margins to the producer.⁵⁰ Value addition and take place through a variety of approaches including food processing and consumer-centric product curation (e.g. convenience, healthy and environmentally-friendly foods).⁵¹ The latter requires a deeper understanding of the consumers' needs and wants, as well as their willingness to pay for different products.

Examples of value addition within protein types include:

- **Meat proteins:** While beef is a key export for Australia that accounts for 70 percent of the country's total meat exports by value in 2016, 72 percent of Australia's beef exports by volume were frozen beef, of which 84 percent was grass-fed.⁵² Such beef is considered to be of lower grade and is typically used for patties, as compared to chilled grain-fed beef, which is typically used for premium steaks.

In 2016, 72% of Australian beef exports were frozen beef, of which 84% was grass-fed. There is a strong opportunity to move into higher-grade beef of the chilled grain-fed variety.

49. Gidley M (2018). "Value-added foods – leveraging Australian attributes", University of Queensland.

Available at: <https://qaaf.uq.edu.au/article/2018/03/value-added-foods-%E2%80%93-leveraging-australian-attributes>

50. Boland M (2009). "How is value-added agriculture explained?", Agricultural Marketing Resource Center.

Available at: <https://www.agmrc.org/business-development/getting-prepared/valueadded-agriculture/articles>

51. Boland M (2009). "How is value-added agriculture explained?", Agricultural Marketing Resource Center.

Available at: <https://www.agmrc.org/business-development/getting-prepared/valueadded-agriculture/articles>

52. FIAL (2017). Australia's recent meat export performance. Available at: https://fial.com.au/Attachment?Action=Download&Attachment_id=48



- **Plant-based proteins:** Australia largely remains an exporter of grain as a bulk commodity, and investment in grain value-adding, such as grain processing, has been limited.⁵³ There is an opportunity to move into higher value-added grain products such as quick rolled oats (which allow for instant cooking without compromising on nutritional value) as compared to steel-cut oats (which require longer cooking time), as well as niche high-protein food products such as cauliflower-based rice and zucchini and sweet potato-based pasta.⁵⁴
- **Eggs and dairy:** While Australia's dairy industry is relatively high in terms of value-add with its variety of food products ranging from cheeses,

yoghurts to dairy desserts, there is an opportunity to shift towards more 'free-from' and functional dairy products such as lactose-free milk and probiotics-fortified yoghurt.⁵⁵

- **Aquaculture:** With the majority of Australian aquaculture companies undertaking only basic processing activities (cleaning, filleting and packaging), there is scope for significant product transformation in this market.⁵⁶ Examples include the development of smoked fish products, live seafood for exclusive export markets such as Japan, and convenience products such as ready-to-cook, boneless and skinless white-flesh fillets.⁵⁷

53. Hemphill P (2016). "Australian exports: decreasing value means ag needs to specialise". Available at: <https://www.weeklytimesnow.com.au/agribusiness/decisionag/australian-exports-decreasing-value-means-ag-needs-to-specialise/news-story/9db42df9e9a4bd3d85de797131af0e41>

54. Nuffield Australia (2016). Opportunities for value-added vegetable production. Available at: <http://nuffieldinternational.org/live/Report/AU/2016/michael-vorrasi>

55. Sources include Australian Dairy Industry Council (2014). Australian dairy industry, available at: <https://www.aph.gov.au/DocumentStore.ashx?id=3feacfad-4533-4c04-aeb7-ca6d81f24f92&subld=252580>; CSIRO Futures (2017). Food and agribusiness: a roadmap for unlocking value-adding growth opportunities in Australia, available at: <https://www.csiro.au/en/Do-business/Partner-with-our-Business-Units/Do-business-Agriculture-Food/Food-innovation-centre/Our-expertise/Dairy>

56. Dundas-Smith P and Huggan C (2006). An overview of the Australian seafood industry.

Available at: <http://aaa.ccpit.org/Category7/mAttachment/2006/Dec/13/asset000070002007202file1.pdf>

57. Joint Select Committee on Northern Australia (2015). Inquiry into opportunities for expanding the aquaculture industry in Northern Australia.

Available at: <https://www.aph.gov.au/DocumentStore.ashx?id=1d27b2ea-1f2a-4561-b0d4-519080353e93&subld=350751>

OPPORTUNITY 2: STRENGTHEN PARTNERSHIPS IN HIGH-POTENTIAL MARKETS

With 3 of the 5 largest contributors to the potential increase in global protein demand from 2018 to 2025 expected to come from the Asia Pacific, the region holds great potential for Australia



The Asia Pacific region holds great potential for Australia, with three of the five largest contributors to global protein demand between 2018 and 2025 coming from this region (Exhibit 23). These include China, India and Rest of Asia Pacific, which together comprise 60 percent and 64 percent of this increase by volume and value respectively. In these markets, meat and plant-based proteins consistently rank as the top protein category by value.

3 of the 5 largest contributors to the projected increase in global protein consumption between 2018 and 2025 expected to come from Asia Pacific.

Australia's food and agribusiness industry could offer targeted and unique value propositions to each of the three key archetypes of the world's regional markets for protein: high-value-high-volume, high-value-low-volume and high-volume-low-value



The world's protein markets may be categorised into three archetypes:

1. High-volume, high-value markets (e.g. China)
2. High-value, low-volume markets (e.g. Japan)
3. High-volume, low-value markets (e.g. India, Rest of Asia Pacific)

Taking into consideration their unique attributes, Australian food businesses could offer targeted value propositions for each of these archetypes. For example, a high-volume, high-value market such as China is likely to have a wide range of consumers, from those who are mainly concerned with fulfilling their basic nutritional requirements to more sophisticated consumers that

are willing to pay a premium for products with high value-add attributes such as organic products, premium packaging and sustainable sourcing. This could lead to a two-pronged strategy, where no-frills food commodities are targeted at the basic consumer, while products with significant customisation and value addition are used to serve the changing demand profiles of more sophisticated consumers. Conversely, consumers in high-volume, low-value markets such as India would likely be interested in competitively-priced primary food commodities in bulk quantities with minimal value-add. Regardless of market archetype, an effective market strategy will require Australian producers to stay close to their current and potential customers in order to understand both the overall trends in nutritional profiles, as well as shifts in consumer preferences (e.g. gluten-free diets) that are often highly context-specific.

Capturing these regional opportunities will require Australian producers to take advantage of free trade deals and form critical commercial partnerships



In the large potential markets of China and Rest of Asia Pacific, Australia has existing free trade agreements (FTA) which could help facilitate the export of Australian food products to these regions. The ASEAN-Australia-New Zealand FTA (AANZFTA), which entered into force in 2010, promotes certainty for Australian service suppliers and investors through extensive tariff reduction commitments, certain legal protections for investment in ASEAN territories and regional rules of origin which enable Australian exporters to tap into international supply chains in ASEAN.⁵⁸ The China-Australia FTA, which entered into force in 2015, also provides a base for advancing further food exports from Australia to China. This will be particularly supported by the progressive elimination of tariffs on Australian beef imports (ranging from 12 to 25 percent) by 2024 and on Australian dairy imports (ranging from 10 to 19 percent) by 2022.⁵⁹ However, a recent survey of Australian firms also show that 40 to 50 percent of businesses are not

A recent survey reveals that due to a lack of awareness, 40% to 50% of Australian businesses do not take advantage of existing free trade agreements to export to key markets.

taking advantage of these free trade agreements, with the main reason being linked to a lack of awareness.⁶⁰

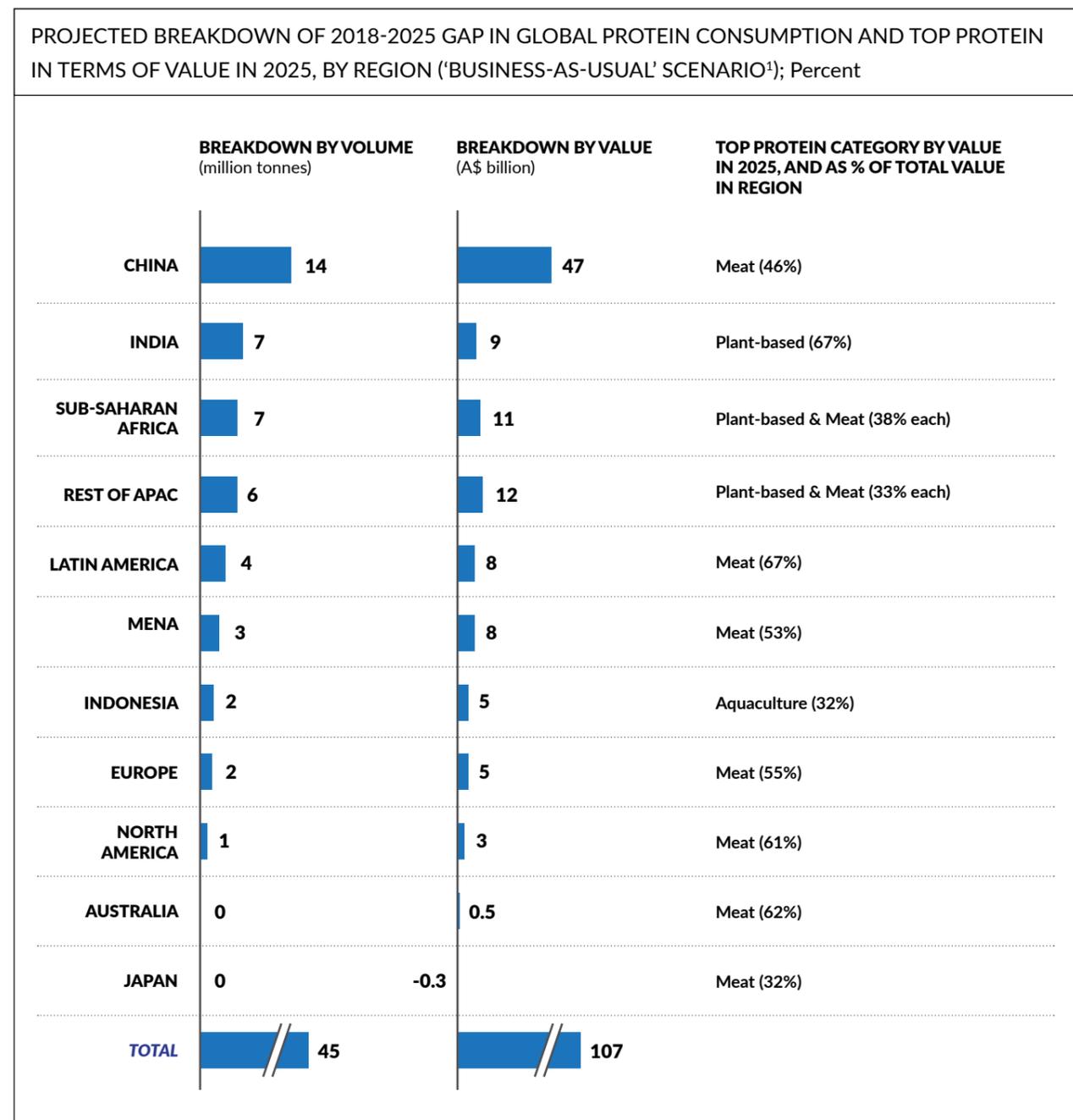
It will also be critical for Australian producers to form strong commercial partnerships in these priority markets that build a detailed understanding of the operating environments. Organisations such as Austrade and the various Australian Chambers of Commerce could provide critical support to Australian producers in this regard.



58. Department of Foreign Affairs and Trade (2019). "Background to the ASEAN-Australia-New Zealand Free Trade Agreement". Available at: <https://dfat.gov.au/trade/agreements/in-force/aanzfta/Pages/background-to-the-asean-australia-new-zealand-free-trade-area.aspx>
 59. Department of Foreign Affairs and Trade (2019). "ChAFTA fact sheet: Agriculture and processed food". Available at: <https://dfat.gov.au/trade/agreements/in-force/chafta/fact-sheets/Pages/chafta-fact-sheet-agriculture-and-processed-food.aspx>
 60. AustCham ASEAN (2017). Australian business in ASEAN survey 2017. Available at: https://cdn.ymaws.com/www.austcham.org.sg/resource/dynamic/blogs/20170814_022451_24139.pdf

EXHIBIT 23:

With 3 of the 5 largest contributors to the potential increase in global protein demand from 2018 to 2025 expected to come from Asia Pacific, the region holds great potential for Australia



1. In this scenario, protein consumption was projected based on growth of population, historical per-capita consumption and consuming class. Source: FAO statistics; AlphaBeta analysis

OPPORTUNITY 3: DEEPEN COLLABORATIONS ACROSS PLAYERS IN THE VALUE CHAIN

Food producers should explore opportunities to collaborate with other players across the value chain to reap potential gains



Other players in the food and agriculture value chain such as technological providers, researchers and logistics providers also have important roles to play to create value for the food industry. For example, the application of new technologies including using big data techniques to optimise crop yield, fitting tractors with global-positioning-systems (GPS) and multispectral sensors (to allow precise application of nitrogen), drone technology, and advanced robotics⁶¹ could lead to a further 40 percent improvement in large-scale farm production (over 2 hectares in size) yields over the next 20 years.⁶² The expertise of researchers and nutritionists are critical in product reformulation and functional foods – increasingly important market categories that target the health conscious future consumer. In addition, certain consumer segments are becoming increasingly aware of issues such as sustainable sourcing and direct-from-farm

Application of various technologies could improve large-scale farm production yields by 40% over the next 20 years.

sales, raising their willingness to pay for food products that fulfil these criteria. Accessing these value adding opportunities may require the use of Internet of Things (IoT) applications to improve supply chain traceability and support logistical innovations in last-mile delivery. In areas where there is a lack of know-how, food producers should actively explore collaborations with partners that could help value-add to their core offerings in order to access new opportunities.

The 16 opportunities identified in past FIAL research remain highly relevant to most protein categories



As mentioned earlier, there are multiple stakeholders in the food and agriculture value chain, and opportunities in global protein markets available to Australia may be harnessed in a range of activities beyond food production. Past FIAL research sized the potential values of 16 opportunities in the food and agribusiness space for 2025, and the relevance of each of these were mapped to the different protein categories. As shown in Exhibit 24, opportunities such as health and wellness

(e.g. organic and 'free-from' foods), food safety (e.g. food safety testing and pathogen control procedures) and supply chain transformation (e.g. Internet of Things-enabled food supply chain traceability) are highly relevant across most or all protein categories.⁶³ These trends are also interesting to consider when identifying opportunities or strategies to target the three archetypes of regional protein markets, as mentioned above.

61. The Economist (2016). "The future of agriculture". Available at: <https://www.economist.com/technology-quarterly/2016-06-09/factory-fresh>
 62. McKinsey Global Institute (2011). Resource Revolution: Meeting the world's energy, materials, food, and water needs. Available at: <https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution>
 63. FIAL (2017). Food and agribusiness: size of the prize analysis for Australia. Available at: <https://fial.com.au/size-of-the-prize-report>

EXHIBIT 24:
The 16 opportunities identified in past FIAL research remain highly relevant to most protein categories

LARGEST OPPOTUNITIES	VALUE 2025 ¹ A\$ BILLION; 2015 VALUES	RELEVANCE FOR PROTEIN CATEGORY					
		PLANT-BASED	MEAT	EGGS & DAIRY	AQUA-CULTURE	WILD CATCH FISHERIES	NON-TRADITIONAL
GLOBAL CONSUMING CLASS	2,730-3,640		✓	✓	✓	✓	
HEALTH AND WELLNESS	3,400	✓			✓	✓	✓
ENERGY SMART FOOD	250-785		✓	✓	✓		✓
FOOD WASTE	465-775	✓	✓		✓	✓	
TARGETED EATING	695-770	✓			✓	✓	
URBAN AGRICULTURE	185-395	✓					
SUSTAINABLE AGRICULTURE	240	✓					
SUPPLY CHAIN TRANSFORMATION	135-200	✓	✓	✓	✓	✓	
DIRECT TO CONSUMER MODEL	160-195	✓		✓			
PRECISION AGRICULTURE AND BIG DATA	110-135	✓			✓		
ADVANCED BREEDING AND FERTILISATION	125	✓	✓		✓		
SUSTAINABLE INPUT	105-110	✓	✓	✓	✓		
ANIMAL FEED AND HEALTH	75-90		✓	✓	✓		
FOOD SAFETY	60-90	✓	✓	✓	✓	✓	✓
SOIL AND LAND MANAGEMENT	65-85	✓					
SUSTAINABLE PACKAGING	10-80	✓	✓	✓	✓	✓	✓

1. Based on estimated savings or projected market sizings in each area. Rounded to nearest A\$5 billion.
 Source: Past FIAL work on "Food and agribusiness: size of the prize analysis for Australia"; AlphaBeta analysis



APPENDIX – METHODOLOGY FOR SIZING ESTIMATES IN DEMAND, SUPPLY AND IMPLICATIONS ANALYSES

Demand Sizing

Protein consumption volumes and values for 2018 and 2025 were sized for each of the 50 protein types and in each of the 11 regions.

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
PLANT-BASED, MEAT, EGGS AND DAIRY, WILD CATCH FISHERIES AND AQUACULTURE PROTEINS		
PROTEIN CONSUMPTION DEMAND VOLUME: 2018 ESTIMATES		
This relates to the sizing of traditional protein consumption demand in volume terms for 2018, for all 11 defined regions.	Method to estimate 2018 consumption demand Data from the Food and Agricultural Organisation of the United Nations (FAO) on the amount of protein consumption from 1990 to the latest available year, 2013, was extracted for all protein types in all countries across the 11 regions. 2018 protein consumption for each protein type in each region was estimated by computing the 5-year historical CAGR in protein consumption volume (or CAGR based on the latest available data where 2013 data was not available), and growing 2013 consumption levels to 2018 based on this CAGR.	FAO Food Balance Sheets database (2018) ⁶⁴
	Split between aquaculture and wild catch fisheries For the years 1990 to 2013, the split of seafood consumption between aquaculture and wild catch fisheries was derived from FAO data. 2018 consumption volumes for both categories were estimated using the same method as above – i.e. growing based on historical 5-year CAGR.	FAO Fishery Statistical Collections (2018) ⁶⁵
PROTEIN CONSUMPTION DEMAND VOLUME: 2025 ESTIMATES		
This relates to the forecasting of traditional protein consumption demand in volume terms for 2025 (all scenarios), for all 11 defined regions.	The following methods were used to estimate 2025 protein consumption for each protein type in each region under the three scenarios: 1. Population growth scenario ('Low'): 2018 consumption volumes were grown at 2018-2025 region-specific population growth rates forecast by the UN, with per capita consumption volumes held constant at 2018 levels. 2. Historical growth scenario ('Mid'): Per capita protein consumption was grown from 2018 to 2025 based on historical 5-year (2013-2018) CAGRs. To obtain total consumption volume for 2025, the derived per capita protein consumption was multiplied by the respective region's projected population in 2025 forecast by the UN.	UN Population Division ⁶⁶

64. Food and Agriculture Organization of the United Nations, Food Balance Sheets (2018). Available at: <http://www.fao.org/faostat/en/#data/FB>

65. Food and Agriculture Organization of the United Nations, Fishery Statistical Collections (2018). Available at: <http://www.fao.org/fishery/statistics/global-production/en>

66. UN Population Division (2018). Available at: <http://www.un.org/en/development/desa/population/publications/database/index.shtml>

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
PLANT-BASED, MEAT, EGGS AND DAIRY, WILD CATCH FISHERIES AND AQUACULTURE PROTEINS		
PROTEIN CONSUMPTION DEMAND VOLUME: 2025 ESTIMATES		
This relates to the forecasting of traditional protein consumption demand in volume terms for 2025 (all scenarios), for all 11 defined regions.	3. Consuming class scenario ('High'): Kharas (2017)'s definition of the consuming class as households with per capita incomes between US\$10 and US\$100 per person per day in 2005 PPP terms is applied here. Based on data from the FAO and World Bank, individuals entering the consuming class consume on average 24 percent more animal-based protein. A 24 percent increase in protein consumption for the protein types under the categories of meat, eggs and dairy and seafood (wild catch fisheries and aquaculture) was hence applied to the 'mid' scenario for entrants to the consuming class between 2018 and 2025. For the rest of the population, per capita protein consumption using the figures from the 'mid' scenario were taken. Data on the size of the consuming class in each region for 2018 and 2025 were taken from Kharas's paper.	<ul style="list-style-type: none"> • Kharas (2017)⁶⁷ • World Bank (2018)⁶⁸ • FAO Food Balance Sheets database (2018)⁶⁹

PROTEIN CONSUMPTION DEMAND VALUE: 2018 AND 2025 ESTIMATES		
This relates to the forecasting of traditional protein consumption demand in value terms for 2018 and 2025 (all scenarios), for all 11 defined regions.	The value of consumption demand in 2018 and 2025 for each of the 50 protein types in each of the 11 markets was derived by multiplying consumption volume with the respective protein price in the region.	
	Prices of plant-based proteins, meat, and eggs and dairy Prices were derived from producer price data from FAO, based on the latest year available (2017). In each region, the price of each protein type was taken as an average of all prices for that protein type in 2017 within the region.	FAO Producer Price database (2018) ⁷⁰
	Prices of wild catch fisheries and aquaculture proteins The prices of protein types under wild catch fisheries and aquaculture were taken from the FAO GlobeFish European Fish Price Report (June 2018). For each protein type, an average of the prices of all relevant protein sub-types was taken (e.g. the price of the protein type 'marine fish' was taken as an average of relevant protein sub-types including salmon, trout and cod).	FAO GlobeFish European Fish Price Report (June 2018) ⁷¹

NON-TRADITIONAL PROTEINS		
PROTEIN CONSUMPTION DEMAND VOLUME AND VALUE: 2018 AND 2025 ESTIMATES		
This relates to the sizing of non-traditional protein consumption demand in volume terms for 2018 and 2025, for all 11 defined regions.	As there is no data available from FAO on non-traditional proteins, the latest market research containing projections of global market sizes, regional distribution and time of market entry was used to size 2018 and 2025 protein consumption. Insects. Global Market Insights (2018) estimates that the global edible insects market was worth US\$55 million in 2017, and will grow based on CAGR of 43.5 percent to 2024. Research Nester (2018) estimates that the Europe	<ul style="list-style-type: none"> • Global Market Insights (2018)⁷² • Amazon (2018)⁷³

67. Homi K (2017). The unprecedented expansion of the global middle class: an update. Brookings Institute. Available at: https://www.brookings.edu/wp-content/uploads/2017/02/global_20170228_global-middle-class.pdf

68. World Bank GNI database (2018). Available at: <https://data.worldbank.org/indicator/NY.GNPATLS.CD>

69. Food and Agriculture Organization of the United Nations, Food Balance Sheets (2018). Available at: <http://www.fao.org/faostat/en/#data/FB>

70. FAO Producer Price database (2018). Available at: <http://www.fao.org/faostat/en/#data/PP>

71. FAO (2018). GLOBEFISH European fish price report – June 2018. Available at: <http://www.fao.org/in-action/globefish/publications/details-publication/en/c/1148793/>

72. Global Market Insights (2018). Edible insects market size. Available at: <https://www.gminsights.com/industry-analysis/edible-insects-market>

73. We used prices of cricket protein powder as a proxy for insect prices, retrieved from [Amazon.com](https://www.amazon.com) in December 2018

DESCRIPTION SIZING ASSUMPTIONS SOURCES

NON-TRADITIONAL PROTEINS

PROTEIN CONSUMPTION DEMAND VOLUME AND VALUE: 2018 AND 2025 ESTIMATES

This relates to the sizing of non-traditional protein consumption demand in volume terms for 2018 and 2025, for all 11 defined regions. and Asia Pacific markets are estimated to reach US\$46 million and US\$270 million by 2024. Protein consumption in volume terms was computed by dividing the estimated market values by the benchmark price for edible insects. This benchmark price was computed by taking an average of retail prices found for 3 key insect-based foods in market research: flour, snacks and bars. Region-level estimates of insect protein consumption volume were computed based on their respective share of traditional protein consumption volume in 2018. 2025 estimates for each region were grown based on the estimated 43.5 percent CAGR for the global market. 2018 and 2025 consumption values were derived by multiplying the estimated consumption volumes by the benchmark price.

- Research Nester (2018)⁷⁴
- Grilo Protein (2018)⁷⁵

Micro-algae. Persistence Market Research (2017) estimates the global micro-algae market to be growing at CAGR of 4.6 percent from 2017 to be worth at least US\$75 million in 2026. Protein consumption in volume terms was computed by dividing the estimated market values by the benchmark price for micro-algae. This price is assumed to be equivalent to the price of spirulina, a common micro-algae source. FAO estimates the price of spirulina to range from EUR70/kg to EUR200/kg; and the benchmark price was computed by taking an average of both values. Mintel Global New Products Database (2018) estimates that Europe, Asia Pacific, North America, MENA and Latin America accounted respectively for 70 percent, 14 percent, 10 percent, 5 percent and 1 percent of global launches of micro-algae food products. These were used to proxy for the 2018 estimates for micro-algae consumption in these regions. Outside of these regions, 2018 estimates were computed based on the remaining regions' share of global plant-based protein consumption. 2025 estimates for each region were grown based on the estimated 4.6 percent CAGR for the global market. 2018 and 2025 consumption values were derived by multiplying the estimated consumption volumes by the benchmark price.

- Persistence Market Research (2017)⁷⁶
- Mintel Global New Products Database (2018)⁷⁷
- FAO (2011)⁷⁸

Lab-grown meat. Amen (2017) states that lab-grown meat will only be launched between 2020 and 2025. This is also supported by analysis of the company websites of lab-grown meat providers – all are currently in the research and development stage, with plans to launch only in 2021 or later. The 2018 estimate for global consumption of lab-grown meat is thus zero. Markets and Markets (2018) estimates that the global market for lab-grown meat will be worth US\$15.5 million in 2021, and that this is projected to

- Amen (2017)⁷⁹
- Mosa Meat (2018)⁸⁰
- Supermeat (2018)⁸¹
- Future Meat Technologies (2018)⁸²
- Markets and Markets (2018)⁸³

74. Research Nester (2018). Edible insect food market. Available at: <https://www.researchnester.com/reports/edible-insect-food-market-global-demand-analysis-opportunity-outlook-2023/49>
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 78. Food and Agricultural Organization (2011). Spirulina – a livelihood and a business venture. Available at: <http://www.fao.org/3/a-az386e.pdf>
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 80. Mosa Meat (2018). Available at: <https://www.mosameat.com/>
 81. Supermeat (2018). Available at: <https://www.supermeat.com/>
 82. Future Meat Technologies (2018). Available at: <https://www.future-meat.com/>
 83. Markets and Markets (2018). Cultured meat market worth 20 million USD by 2027. Available at: <https://www.marketsandmarkets.com/PressReleases/cultured-meat.asp>
 84. Big Think (2015). "Price of lab-grown burger falls from \$325k to \$11.36". Available at: <https://bigthink.com/ideafeed/answering-how-a-sausage-gets-made-will-be-more-complicated-in-2020>

DESCRIPTION SIZING ASSUMPTIONS SOURCES

NON-TRADITIONAL PROTEINS

PROTEIN CONSUMPTION DEMAND VOLUME AND VALUE: 2018 AND 2025 ESTIMATES

This relates to the sizing of non-traditional protein consumption demand in volume terms for 2018 and 2025, for all 11 defined regions. grow at a CAGR of 4 percent to reach US\$20 million by 2027. Protein consumption in volume terms was computed by dividing the estimated market values by the benchmark price for lab-grown meat. Big Think (2015) estimates that a regularly-sized burger patty made from lab-grown meat will be priced at US\$11.36. Taking the average weight of a pre-cooked burger patty as 45.4 grammes as reflected by MacDonald's (2012), the price per gramme of lab-grown meat is US\$0.25.

- Big Think (2015)⁸⁴
- MacDonalds (2012)⁸⁵
- Scientific American (2018)⁸⁶

A literature review reflects that lab-grown meat will only be available in Europe, North America, Australia and MENA due to the presence of companies involved in this production, greater social acceptance and the likely high prices of the product due to current high production costs – which may only be accepted in high-income regions. 2025 regional-level estimates of lab-grown meat consumption volume are based on regional share of meat-based protein consumption. 2025 consumption values were derived by multiplying the estimated consumption volumes by the benchmark price.

Supply Sizing

In the supply analysis, the sources of protein consumption in the 11 markets, broken down by 50 protein types, were sized for 2018 and 2025.^{87 88} The estimate of protein supply in 2018 for each protein type in each region was taken from the demand sizing analysis for 2018. For 2025, three scenarios were assumed: 'business-as-usual', 'shift to plant-based diets' and 'technological breakthroughs'. The methods for sizing 2025 protein supply for these scenarios are explained as follows:

DESCRIPTION SIZING ASSUMPTIONS SOURCES

PROTEIN SUPPLY VOLUME: 2025 ESTIMATES

2025 SCENARIO 1: 'BUSINESS-AS-USUAL'

This relates to the sizing of protein supply in volume terms for the 2025 business-as-usual or baseline scenario. The 2025 'consuming class (high)' demand scenario was taken to be the 2025 'business-as-usual' scenario. Figures from the demand sizing analysis for protein consumption volume for each protein type and in each of the 11 regions are used for this 2025 'business-as-usual' supply scenario.

85. MacDonald's (2012). "What is the precooked weight of each of your burger patties, and what is the average of each of the patties after cooking?" Available at: <https://yourquestions.mcdonalds.ca/answer/what-is-the-precooked-weight-of-each-of-your-burger-patties-and-what-is-the-average-weight-of-each-of-the-patties-after-cooking/>
 86. Scientific American (2018). "Lab-grown meat: meat produced without killing animals is heading to your dinner table". Available at: <https://www.scientificamerican.com/article/lab-grown-meat/>
 87. This study does not size the protein supplements market in isolation. Data on protein supply derived from protein supplements is captured within the data on protein supply from the various sources of protein supplements. These include dairy (e.g. whey and casein) and plant-based protein (e.g. soy and pea). For example, data on protein supply from soy-based protein supplements is captured within protein supply from soya beans. It should be noted, though, that the protein powder market is large and growing. This was estimated to be worth over US\$12.4 billion in 2016 and projected to grow at a CAGR of 6.3 percent from 2017 to 2025. Source: Grand View Research (2017). Protein supplements market analysis by raw material (whey, casein, pea), by source, by product (protein powder, protein bar, RTD), by distribution channel, by application, and segment forecasts, 2018-2025. Available at: <https://www.grandviewresearch.com/industry-analysis/protein-supplements-market>
 88. Note that data on protein supply from non-dairy alternatives such as almond, soy and coconut are captured within the data on protein supply from plant-based proteins. For example, protein supply from almond milk is captured in the data on protein supply from almond.

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
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PROTEIN SUPPLY VOLUME: 2025 ESTIMATES		
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2025 SCENARIO 2: 'SHIFT TO PLANTS-BASED DIETS'		
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This relates to the sizing of protein supply in volume terms for the 2025 scenario in which a segment of the population in each region shifts from animal-based diets to plants-based diets.

Estimates of the number of consumers in each region projected to switch from animal to plant-based diets in the 11 markets were derived from a literature review of regional or national-level surveys and relevant government regulations (where they apply). Based on this estimated number of consumers who would make this switch between 2018 and 2025 in each region, their per capita consumption of meat, wild catch fisheries and aquaculture proteins was reduced to zero, and offset by an equivalent increase in plant-based protein. Changes to the volumes for individual protein types (e.g. beef, wheat) were computed on a weighted basis (e.g. meat, plant-based). These weights were determined based on the share of each protein type out of the protein category in volume terms, under the 2025 'business-as-usual' scenario.

- Australian Bureau of Statistics (2016)⁸⁹
- The Guardian (2016)⁹⁰
- ING Bank (2017)⁹¹
- Live Mint (2018)⁹²
- Mintel (2017)⁹³
- Public Health Nutrition (2018)⁹⁴
- YouGov Survey (2013)⁹⁵

2025 SCENARIO 3: 'TECHNOLOGICAL BREAKTHROUGHS'		
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This relates to the sizing of protein supply in volume terms for the 2025 scenario in which technological breakthrough are experienced for aquaculture production.

A literature review suggests that technological breakthroughs in aquaculture such as genetic breeding, disease management and fish farming automation technologies will result in increased productivity of aquaculture. FAO (2013) reflects that technological breakthroughs will lead to a 50 percent increase in the CAGR of aquaculture production above historical growth. This increase was offset by an equivalent volume decline in meat-based proteins. Changes to the volumes for individual protein types (e.g. beef, freshwater fish) were computed on a weighted basis under their respective protein categories (e.g. meat, aquaculture). These weights were determined based on the share of each protein type out of the protein category in volume terms, under the 2025 'business-as-usual' scenario.

- FAO Fish to 2030 (2013)⁹⁶

PROTEIN SUPPLY VALUE: 2025 ESTIMATES		
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ALL 2025 SCENARIOS		
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This relates to the sizing of the monetary value of protein supply across all three 2025 scenarios.

The value of the market in each scenario was derived by multiplying consumption volumes with the respective protein prices. The same prices for each protein type in each market that were used for the demand analysis were used again to size the values of each of the 2025 scenarios.

89. Australian Bureau of Statistics (2016). "Australian health survey: consumption of food groups from the Australian Dietary Guidelines, 2011-12".

Available at: <http://www.abs.gov.au/ausstats/abs@nsf/Lookup/by%20Subject/4364.0.55.012--2011-12--Main%20Features--Lean%20meats%20and%20alternatives--13>

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Available at: <https://www.theguardian.com/world/2016/jun/20/chinas-meat-consumption-climate-change>

91. ING Bank (2017). The protein shift: will Europeans change their diet? Available at: <https://www.theguardian.com/world/2016/jun/20/chinas-meat-consumption-climate-change>

92. Live Mint (2018). "No vegetarianism is not growing in India".

Available at: <https://www.livemint.com/Politics/dWUqT4epdPTHNAYuKYVThK/No-vegetarianism-is-not-growing-in-India.html>

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Available at: <http://www.mintel.com/press-centre/food-and-drink/the-move-away-from-meat-infiltrates-asia-pacific>

94. Public Health Nutrition (2018). Reducing meat consumption in the USA: a nationally representative survey of attitudes and behaviours.

Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6088533/>

95. YouGov (2013). "YouGov survey commissioned by Eating Better Alliance - November 2013". Available at: <https://www.vegsoc.org/page.aspx?pid=755>

96. FAO (2013). Fish to 2030: prospects for fisheries and aquaculture. Available at: <https://globalnews.ca/news/4608410/canada-reduce-meat-consumption/>

Implications Sizing

DESCRIPTION	SIZING ASSUMPTIONS	SOURCES
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CURRENT VALUE OF AUSTRALIAN PRODUCTION OF PROTEIN-CONTAINING FOODS		
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This relates to the sizing of Australia's current annual food production value, across all 50 protein types under the 6 protein categories.

The value of Australia's food production market in 2016 (year with latest available data) for all 50 protein types was compiled using data from FAO's agricultural production value database (for plant-based, meat and eggs & dairy), the Australian Government's Department of Agriculture and Water Resources (for wild catch fisheries and aquaculture), and the latest market research (for non-traditional proteins).

- FAO Value of Agricultural Production database (2018)⁹⁷
- Australian Government Department of Agriculture and Water Resources (2018)⁹⁸

PROJECTED VALUE OF AUSTRALIAN PRODUCTION OF PROTEIN-CONTAINING FOODS IN 2025		
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This relates to the sizing of Australia's projected food production value in 2025, across all 50 protein types under the 6 protein categories.

This value was modelled for two scenarios:

1. **'Ride the market' scenario:** The projected growth rates in global protein consumption demand for each protein category were applied to current Australian production of foods containing protein. These growth rates were based on the 'business-as-usual' scenario under the supply analysis. The total value of Australian production of protein-containing foods in 2025 was then assessed.
2. **'Match the global demand' scenario:** Keeping the total production volume of Australian protein-containing foods pegged to the total volume under the 'ride the market' scenario, the breakdown of this total volume by protein category was adjusted to mirror the projected breakdown of global protein consumption demand in 2025 under the 'business as usual' scenario in the supply scenario. The total value of Australian production of protein-containing foods in 2025 was then assessed.

- FAO Value of Agricultural Production database (2018)⁹⁹
- Australian Government Department of Agriculture and Water Resources (2018)¹⁰⁰

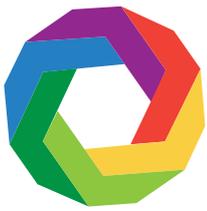
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CATALYST FOR GROWTH

