

THE GLOBAL PROTEIN TRANSITION: AN OPPORTUNITY FOR ARGENTINA

AZA PHASE II

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KEY FINDINGS

To limit the average global temperature increase to 1.5°C above pre-industrial levels, economy-wide decarbonisation is imperative. While the focus is most often on reducing our collective dependence on fossil fuels and advancing the energy transition, **food production systems will also come under pressure to decarbonize**, specifically in countries with large agricultural output such as Argentina. For the Argentinian agriculture sector, however, conventional mitigation options will not be sufficient to reach neither the country's climate targets for 2030, nor their climate neutrality pledge for 2050.

Argentina's agriculture sector may need to undergo a deeper transformation. Globally, food systems are expected to increasingly shift away from a predominant reliance on animal-based protein towards more healthy and sustainable alternatives. Countries, and especially those with sizable livestock production sectors such as Argentina, will inevitably need to adapt to this protein transition.

The global protein transition bears both risks and opportunities, specifically for the Argentinian livestock sector. Already today, there is evidence of ongoing changes in consumer preferences in Argentina's key export markets. Globally, per capita consumption of key meat commodities is projected to decline until 2030. This trend is expected to become more pronounced over time as motivational barriers fall. While the dynamics of changing consumer preferences may not pose a direct threat to producers and exporters of animal-based protein in the short-term, the emergence of near indistinguishable alternatives with clear advantages in terms of costs, health effects, and environmental footprints will inevitably cannibalize demand for animal-based protein.

At the same time, the protein transition presents significant investment opportunities for Argentina. Plant-based products and lab-grown proteins are gaining traction and may make up between 11% and 22% of global protein consumption in 2035.

The global alternative protein industry is booming. The plant-based segment has raised USD 2.2 billion of investments in 2020; the cultivated segment attracted USD 366 million. Additional investment of at least between USD 40 billion and USD 130 billion will be necessary to scale up production capacity and develop the full market potential of alternative protein production systems.

The Argentinian alternative protein industry is slowly waking up to this opportunity. **Argentinian producers could put themselves at the forefront of the protein transition, by targeting technological challenges along the plant-based and cultivated protein value chains, as well as by utilizing existing industrial capacity and capital to reach scale in commercial production.** Several priority investment opportunities exist for the Argentinian private sector, but public investments and support are imperative to overcome structural barriers.

Argentina's macroeconomic and regulatory instability renders it more difficult for the country to raise funding at the required scale. There is an urgent need for public support and facilitation, which the private sector may try to leverage by highlighting the climate change mitigation potential and the wider socioeconomic benefits associated with the sector.

Conventional protein production systems are not aligned with the Paris temperature goal and are, in many cases, not environmentally sustainable nor resource efficient. Plant-based and cultivated protein production systems are characterized by less intensive environmental footprints.

By promoting the development of a strong domestic alternative protein industry and a shift away from animal-based protein production, the public sector can promote export diversification and reduce transition risks, reduce negative externalities of conventional protein production systems, drive domestic value creation and employment, and unlock social welfare gains.

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ABBREVIATIONS

ARG	Argentina
BIFE	Bio Ingeniería en la Fabricación de Elaborados
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BRA	Brazil
AAGR	Average annual growth rate
CHL	Chile
CO₂	Carbon dioxide
EU	European Union
GFI	Good Food Institute
GHG	Greenhouse gases
GMO	Genetically modified organism
IKI	International Climate Initiative
ISR	Israel
LTS	Long term strategy
NDC	Nationally determined contribution
OECD	Organisation for Economic Co-operation and Development
USD	United States Dollar
WP	Work package
UK	United Kingdom
US	United States

1 INTRODUCTION

1.1 ARGENTINA'S AGRICULTURE SECTOR INCREASINGLY SUBJECT TO PRESSURE

It is not possible to limit the average global temperature increase to 1.5°C above pre-industrial levels without addressing greenhouse gas (GHG) emissions from both energy and agricultural production simultaneously. A full decarbonisation of the global energy system would alone not be sufficient to meet the Paris temperature goals, if agriculture or food system emissions were to be neglected (Ritchie, 2021). To stay within the remaining carbon budget, countries need to target an economy-wide decarbonisation that extends even to hard-to-abate sectors such as agriculture and food systems.

Global emissions from agriculture, excluding emissions from land, land use change and forestry (LULUCF) are estimated to increase by 40% between 2000 and 2050, reaching a total of 12 GtCO₂eq. At the global level, substantial increases in productivity, technological advancements, and appropriate policy support may help to keep total agricultural emissions to 8.3 GtCO₂eq (Hedenus et al., 2014). This would still represent a disproportionately large share of the global carbon budget by 2050, meaning an even heavier reliance on other sectors to decarbonise faster and on availability of widespread (highly) uncertain negative emission technologies (Bryngelsson et al., 2016).

Some livestock exporting countries' NDCs feature explicit commitments to reduce livestock sector emissions. However, where concrete measures are proposed, these mostly refer to improving the productive efficiency of production systems, the sustainable combination of livestock and forest systems, and capturing carbon in the soil through improving pastures/grasslands. The reduction of absolute livestock production is commonly not mentioned in NDC.

In Argentina, agriculture and food system emissions make up a large share of the country's GHG footprint. Argentina's agriculture, forestry, and other land use (AFOLU) sectors, including livestock farming and cropping systems, represent 37% of the country's total greenhouse gas (GHG) emissions (Moreira Muzio, 2019). Our analysis has shown that mitigation potential exists in the agriculture sector, particularly with respect to land-use change and livestock systems. However, it also shows that in Argentina conventional mitigation options such as technological and efficiency improvements alone will not be sufficient to reach neither the country's climate targets for 2030, nor their climate neutrality pledge for 2050 (Gonzales-Zuñiga et al., 2022).

Argentinian producers of GHG emissions-intensive agriculture commodities may come under pressure as more stringent environmental requirements are introduced in domestic and international markets, i.e. internal and external transition risks (see Figure 1). Our analysis shows that the GHG emissions intensity of production systems will possibly become a decisive factor in determining the competitive advantage of export-oriented sectors (Marquardt et al., 2022). It also indicates that climate-related exogenous demand shocks, e.g. as a result of changes in consumer preferences, are perceived to affect Argentinian producers, specifically in the livestock sector. Failure to appropriately hedge against these transition risks may have serious economic impacts, given the role of the Argentinian agriculture sector as the backbone of the country's economy.

Argentinian stakeholders should identify and pursue options to future-proof the country's food production systems, not only to align with the country's stated climate action, but also to avoid facing significant transition risks. In a carbon-constrained world, the futureproofing of food and agriculture systems may require far-reaching changes to the rulebook of how these systems work. Deep decarbonisation of the agriculture sector is not feasible without a shift away from GHG-intensive and unsustainable means of production and may likely involve a more structural "protein transition" from animal-based toward alternative protein sources. This will undoubtedly have a substantial impact on existing industries, and is likely to create, as with every transition, both winners and losers.

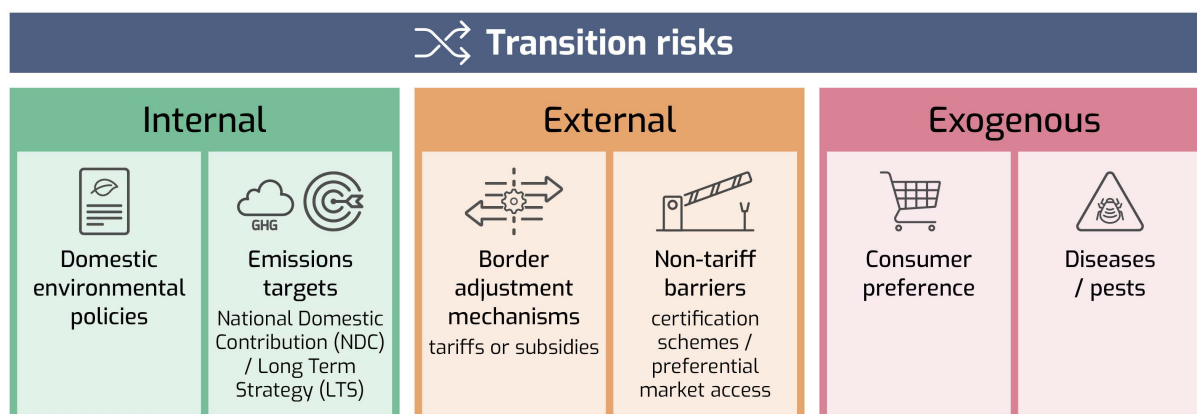


Figure 1: Transition risk typology.

In this report, we explore the risks and opportunities associated with a global protein transition for the Argentinian livestock sector, as well as the role of consumer preferences as an exogenous driver of change. Chapter 2 discusses the outlook for meat demand in the next decade, and questions how much longer animal-based protein can remain competitive as consumer preferences change and alternatives emerge. Chapter 3 introduces the business case for alternative protein products, showcasing different options and trends in global and regional markets, as well as where the opportunities for Argentina are. Chapter 4 concludes that the global protein transition is inevitable and already underway, but Argentina still has time to ride the wave of transformation.

2 APPETITE FOR PROTEIN IS CHANGING

2.1 PER CAPITA DEMAND FOR ANIMAL-BASED PROTEIN TO PLATEAU AND DECREASE AS PREFERENCES CHANGE

Population growth in developing economies, but also rising incomes, are key factors of aggregate demand for all animal-based protein commodities. By 2030, global meat and (fresh) dairy consumption are expected to increase by 14% and 13%, respectively, mostly driven by strong demand growth in Africa and the Asia and Pacific region (OECD/FAO, 2021). In the meat segment, a clear and near universal trend towards higher demand for poultry meat has emerged, because of both its price advantage and perceived health benefits compared to red meat. Demand growth in beef, pigmeat, and sheep is less pronounced. In the dairy segment, consumption of fresh, pasteurised, and fermented products prevails, but regional changes in the composition of demand (e.g. towards more processed dairy products in higher income countries) are expected (OECD/FAO, 2021).

On a per-capita level, demand projections for animal-based protein demonstrate more differentiated trends. Per capita consumption of beef and pig meat has been on a declining trend since the start of this century (see Figure 2), with beef consumption projected to decline by up to 2.2% until 2030 (OECD/FAO, 2021). For the period 2021-2030, the OECD estimates negative annual average growth rates for per-capita beef consumption for all regions except Asia (see Table 1) (OECD/FAO, 2021).

Decreases in per-capita beef consumption may be partly off-set by projected increases (although at a declining growth rate) in per-capita demand for poultry. For dairy, per capita consumption growth is expected to increase over the modelled period. A common trend, however, is the stagnation or decline of per capita demand for most meat and dairy products in high-income countries until 2030 (OECD/FAO, 2021).

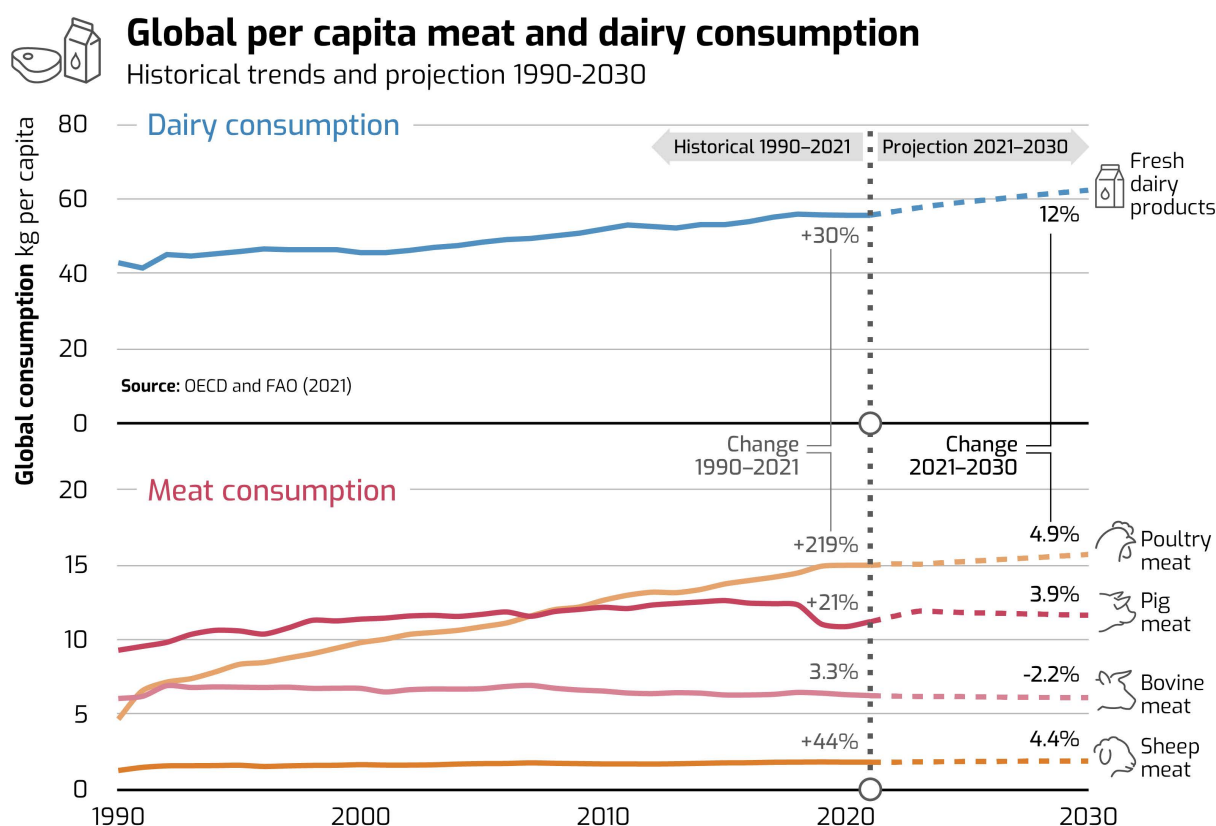


Figure 2: Per capita meat and dairy consumption.

Table 1: Per capita beef consumption (AAGR for ten-year periods), based on OECD/FAO (2021)

Region	1991-2000	2001-2010	2011-2020	2021-2030
Africa	-0.89%	-1.58%	-0.67%	-0.24%
Argentina	-1.87%	-1.11%	-0.26%	-0.43%
Asia	4.90%	3.74%	2.15%	1.60%
China	16.33%	1.46%	3.05%	0.01%
European Union	-1.37%	-0.69%	-0.66%	-0.51%
Latin America	0.84%	-0.20%	-0.78%	-0.62%
Argentina	-1.87%	-1.11%	-0.26%	-0.43%
United States	0.14%	-1.28%	-0.29%	-0.19%
World	1.12%	-0.24%	-0.37%	-0.33%

Presented outlooks on animal-based protein demand assume consumer preferences to evolve according to historical patterns (OECD/FAO, 2021), which are mostly based on non-motivational factors (i.e. population and income level growth). Consumer preference for animal-based protein products, however, is also a function of motivational drivers (e.g. sustainability concerns) and barriers (e.g. cultural values) (see Table 3 in Annex for a complete overview of factors). Animal-based protein consumption projections may as such prove too conservative where significant, exogenous consumer preference change dynamics set it.

In Europe, for example, on average 50% of the population are willing to greatly reduce their meat consumption (Hielkema & Lund, 2021). In Germany and the US, vegetarians already represent 6% and 5% of the population, respectively (OECD/FAO, 2021). With sufficient regulatory support, aggregate animal protein demand may already peak in Europe and North America by 2025, i.e. per capita decreases in demand outsize protein demand driven by population growth (Witte et al., 2021).

In South America, an estimated 90% of the population wants to eat more plant-based foods (Ho, 2020). Another study found this number to be only 70% (Spencer, 2019), but all show a clear trend towards “flexitarianism” (that is, those who greatly reduce meat consumption and only occasionally consume animal protein). In Argentina, according to some estimates already up to 12% of the population is already either vegan or vegetarian and another 12% consider themselves flexitarian (Union Vegana Argentina, 2020)¹. It is likely that observed shifts in diets in Argentina are the result of not just motivational factors but also of non-motivational constraints, i.e. up to 60% of Argentinians are supposedly considering giving up beef because of the economic crisis (Salomon, 2020).

Asian consumers are expected to incrementally spend USD 4.4 trillion on food between 2019-2030 (Skinner et al., 2021). Consumption behaviour, however, is increasingly becoming more value-driven in the region, which may influence several key consumer trends, such as growing interest in sustainable consumption and alternative protein products. More than half of incremental food spending until 2030 in Asia is expected to come from consumer-conscious preference for sustainable food options (Skinner et al., 2021).

¹ The representativeness of the study is questionable due to issues such as potential sampling bias.

The way in which consumer preference change may impact demand for animal-based protein is clearly context specific and driven by an interaction of underlying motivational factors. Health and environmental concerns may be the strongest drivers and especially play a role in decreasing demand for meat (e.g. red beef). Certain (cultural) barriers, however, may initially slow down preference change among some consumer groups. Some motivational drivers, such as animal welfare concerns, may not lead to a complete shift away from animal-based protein consumption, but to a diversion of demand towards products of higher quality, e.g. organic produce (see Box 1). Other socio-economic confounding factors, exogenous drivers (e.g. pests or diseases), as well as – importantly - the availability and price of alternative protein products in a given market may further influence consumer sentiment and set-off dynamic snowball effects (see below).

Box 1: Organic livestock farming in Argentina

ORGANIC LIVESTOCK FARMING IN ARGENTINA

Organic livestock farming is often portrayed as a viable, climate compatible future for current producers facing the low-carbon transition, i.e. part of the solution to the sustainability challenge of the agriculture sector.

However, there are significant obstacles to the development of organic farming. According to the FAO, in 2015, only 2% of Argentina's land (or about 2.9 million ha) was used for organic farming, of which 97% was used for livestock and 3% for crops (Fuchshofen et al., 2017). In 2020 the number scaled to 4.4 million ha, and the number of producers from 1,074 to 1,343 (Cabrini & Elustondo, 2021). Organic products are not yet very prevalent in the export market (where 99% of organic produces are destined) and are rather sold as conventional products in the domestic market (Cabrini and Elustondo 2021).

Additionally, organic livestock farming is currently not more profitable than conventional alternatives and is rather seen as a risk reduction strategy because it is believed to be more resilient in some contexts, e.g. where crop production systems are combined with organic livestock production (see Cabrini and Elustondo (2021)). As such, it can be considered as an investment in the future, in line with expectations that organic food markets will grow faster than conventional markets.

Despite its benefits in terms of animal welfare, pesticide use and biodiversity, the climate impacts of organic livestock farming in terms of its emissions, land use and water use are not necessarily an improvement on those of conventional production methods, nor will they ensure food access due to the higher costs associated (Mondelaers et al., 2009). While there is merit in the idea of organic farming, it should not be seen as a holy grail of sustainability for the livestock sector, or as a solution for producers in a carbon-constrained world.

2.2 CLOSE SUBSTITUTES WILL CHALLENGE THE MARKET POSITION OF ANIMAL-BASED PROTEIN

Argentina's agriculture sector, in particular its export-oriented meatpackers, should pay close attention to consumer preference change in key export markets. As opposed to regulatory or market-based mechanisms imposed domestically or by trading partners, consumer preference change represents a gradually onsetting transition risk for Argentinian producers of animal-based protein.

While motivational factors such as concerns for health, the environment, or animal welfare are likely to drive down per capita demand for animal-based proteins specifically in progressive countries, population growth in developing countries may continue to increase demand for animal-based protein in absolute terms. This may induce producers of animal-based protein to feel confident about future market opportunities and optimistic about demand-driven price increases and greater profits.





Rapidly improving protein alternatives could upend livestock industry Parity in terms of price, texture, taste, and nutritional value is likely to trigger a shift towards both stronger demand and supply of alternative proteins in a mutually reinforcing way		
 Factors influencing protein production	 Prices of raw inputs	Prices for primary agriculture commodities for feed and raw inputs such as grains are expected to remain high or even rise further <ul style="list-style-type: none"> ○ COVID-19 impact: Commodity price levels remain high as a result of COVID-19 induced supply cuts and disruptions. ○ Changing landscape: Structural disruptions, such diversion of feed commodities to biofuel production, or the increasing frequency and intensity of adverse weather events (La Niña), are likely to have lasting impact on input prices.
	 Profitability of livestock production	Higher input prices may reduce profit margins for producers of animal-based protein <ul style="list-style-type: none"> ○ Cost reductions unlikely: Significant cost reductions in the production of animal-based protein are unlikely in Argentina or would compromise animal welfare and drive antibiotic resistance and eco-toxicity. ○ Price ceilings: Producers may face difficulties passing on higher input costs to consumers. Animal-based protein products are subject to price ceilings in the Argentinian market and face export restrictions.
	 Alternative protein improvement potential	Alternative proteins emerge as increasingly indistinguishable substitutes <ul style="list-style-type: none"> ○ Higher efficiency: Alternative protein production benefits from superior input conversion ratios. ○ Decades of cost reductions possible: Further cost reductions in the production of alternative protein are highly likely over coming decades. ○ Increasingly indistinguishable from meat: Significant improvements towards parity in taste, texture, and superior nutritional value are likely. ○ Much lower environmental footprint: Alternative protein production has lower environmental footprints and faces lower environmental cost (e.g. carbon price).

Figure 3: Alternative protein as a close substitute.

However, producers and exporters of animal-based protein continue to face COVID-19 induced supply chain disruptions in upstream and downstream segments, as well as higher input prices (OECD/FAO, 2021). Supply chain disruptions will eventually be resolved as countries progressively lift restrictions and return to pre-crisis mode. Input costs may also stabilize, but only to the extent that costs of critical inputs such as energy and feed commodities have risen as the result of COVID-19 induced supply shortfalls. More structural changes, such as the diversion of feed commodities to biofuel production and the increasing frequency and spread of the La Niña weather patterns (drought) in Argentina are likely to have lasting impact on input prices (Baffes & Temaj, 2021). Technological advances in the production of inputs may help reduce costs, but the scope for efficiency gains is limited, as Argentina already features a highly intensified agriculture system.

Argentinian producers and exporters of animal-based protein will want to pass down higher costs to buyers, in order to maintain profit margins, but their ability to do so may be limited for at least two reasons:

- Firstly, governments may seek to limit inflation in food prices domestically in the interest of food security. This could be achieved, for example, by introducing regulatory measures to mitigate the impact of the transmission of price signals from international to domestic markets (e.g. ceiling prices), as well as by restricting access to international markets (e.g. export bans, as was the case in Argentina in 2021).
- Secondly, producers will be less likely to pass on higher production costs to buyers as cost-competitive, alternative protein products emerge as close substitutes. While plant-based (and eventually cultivated protein) alternatives are also affected by increases in input costs, much lower input conversion ratios in the production of protein alternatives² (Gerhardt et al., 2021) render these substitutes economically superior. Motivational barriers are likely to be overcome, and adoption of alternative proteins will gain pace and scale, which in turn incentivises producers to pivot their product offering accordingly. Parity in terms of price, texture, taste, and nutritional value is likely to trigger a shift towards both stronger demand and supply of alternative proteins in a mutually reinforcing way (see Figure 3).

While the dynamics of changing consumer preferences may not pose a direct threat to producers and exporters of animal-based protein in the short-term, the emergence of near indistinguishable alternatives with clear advantages in terms of costs, health effects, and environmental footprints will inevitably cannibalize demand for animal-based protein (Ellis, 2021). Argentinian producers and exporters of animal-based protein would benefit from developing concrete hedging/risk diversification strategies on how to manage the pending protein transition, which would allow them to identify risks and potentially attractive opportunities.

² Superior input conversion ratios of alternative protein products will create a cost-advantage for alternative protein products, even where input costs are not rising, as the scope for efficiency gains in livestock-sectors is limited (Gerhardt et al., 2021).

3 MORE AN OPPORTUNITY THAN A THREAT?

3.1 THE GLOBAL ALTERNATIVE PROTEIN MARKET IS GROWING FAST

The alternative protein market includes plant-based protein substitutes (including mycoprotein sourced from fungal biomass), protein products cultivated from stem cells, as well as hybrid substitutes combining plant-based and cultivated proteins³. Concerns about the environmental and social costs of animal-based protein are major motivational drivers behind the ongoing protein transformation; products based on alternative proteins are gaining traction and may make up between 11% and 22% of global protein consumption in 2035, if governments provide appropriate regulatory support (Witte et al., 2021).

Plant-based substitutes have already reached significant recognition, initially in the dairy segment, but increasingly also in the meat segment. Motivational- and cost-related barriers to the adoption (see Table 3 in Annex) of plant-based meat alternatives remain, but meat substitutes are increasingly becoming difficult to differentiate from animal meat in terms of appearance, taste, and texture (Lamas, 2021) and are on the brink of reaching price parity (Tubb & Seba, 2019).



Growing market for alternative proteins

Projections of market value and market penetration for plant-based dairy and meat products 2020–2030

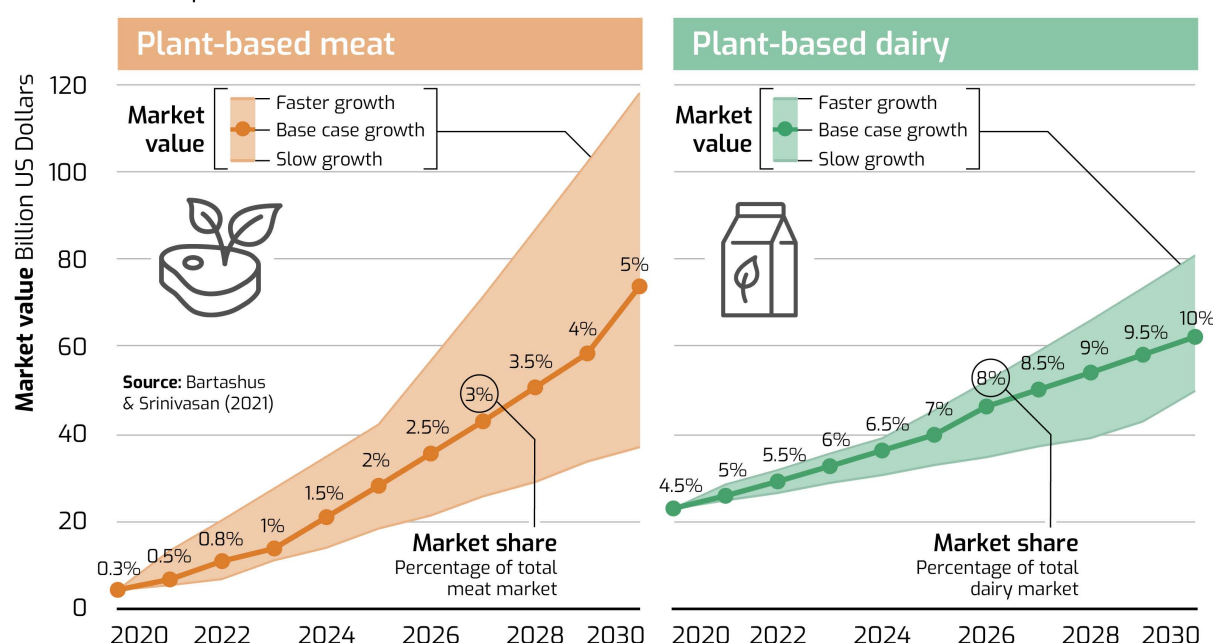


Figure 4: Market value growth.

The plant-based meat (and fish) segment is expected to grow its market share from 0.3% to 5% by 2030, assuming growth dynamics similar to those observed in the plant-based dairy segment (Bartashus & Srinivasan, 2021). This would represent a USD 73.9 billion market opportunity⁴. However, while consumers perceive plant-based protein to be healthier and more sustainable, motivational barriers such as cultural values are likely to be more rigid in certain regions. Most plant-based meat products

³ Insect based protein is sometimes also referred to as an alternative protein source, but is not discussed further in this report.

⁴ Much higher market potentials between USD 77 billion and USD 153 billion are reported by other sources, when referring to protein alternatives more generally (i.e. including cultivated protein) (Dongoski, 2021b).

are primarily based on soy, pea, or wheat isolates, but formulations including chickpea, rapeseed or lupin protein isolates are common as well (Bashi et al., 2019).

The cultivated meat industry has also gained tremendous momentum, specifically since researchers in the Netherlands produced the first lab-grown meat patty in 2013 (Jha, 2013). In 2020, a Singapore restaurant started offering the first commercially available cultivated chicken bite, after gaining regulatory approval by the Singapore Food Agency (Swartz & Bomkamp, 2021). While the sensory and nutritional similarities of cultivated meat vis-à-vis its role model mean that appearance, texture, and taste are unlikely to be a major obstacle to adoption (Smith et al., 2021), regulatory restrictions, food neophobia⁵ and especially the significant price premium currently still associated with cultivated meat continue to be a barrier to widespread commercial viability.

While still in its infancy, recent developments in the cultivated meat segment still hint towards its likely future commercial relevance in the alternative protein market. Several companies around the globe have completed successful pilot programmes testing the feasibility of producing cultivated protein products for commercial markets, thereby setting the foundation for future industry-scale commercial operations (Byrne & Murray, 2021). Commercial viability primarily still depends on the economics of cultivated meat products, but analysis shows that costs can be cut by up to 99.5% via scale, best-in-class manufacturing processes, as well as process optimization (Brennan et al., 2021). It is estimated that cultivated protein products could achieve price parity with conventional meat products as early as 2030 (Sinke & Odegard, 2021).

3.2 THE SECTOR ATTRACTS SIGNIFICANT INVESTMENT, BUT REGIONAL COMPETITION IS STRONG

The investments the alternative protein sector attracts reflect expectations on growth trends. The plant-based segment raised USD 2.2 billion in 2020 (Gaan, 2021), while the cultivated segment attracted USD 366 million (Byrne & Murray, 2021). The investment opportunity continues to be substantial: Processing capacity in the plant-based protein segment will need to attract between USD 11 billion and USD 28 billion. Between USD 30 billion and USD 100 billion may be required for commercial scale bioreactor capacity in the cultivated protein segment (BNP Paribas, 2021). Actual investment needs may be significantly higher, as these estimates do not account for research and development spending.

US firms have attracted most investments over recent years, with the US alternative protein sector featuring some of the vanguards in the industry, e.g. Impossible Foods. Fresh capital for established players such as Impossible Foods enables continued growth, the development of larger product portfolios, and expansion into international markets. The alternative protein industry in Latin America, in comparison, is still in its infancy, but has nonetheless started to attract notable venture capital in anticipation of important market opportunities. The South American domestic alternative protein market is expected to generally follow the global growth trends, forecasted to value at more than 300 million USD in 2025 (CAGR 12.4%) (Mordor Intelligence, 2021). Argentina is the second largest market by revenue share in the region, following Brazil. Brazil features the region's most established alternative protein industry, representing a competitive threat to Argentinian producers.

⁵ The characteristic aversion or fear of unfamiliar foods (Cinar et al., 2021).

Table 2: Alternative protein investment summary, based on Good Food Institute (2021), Dongoski (2021), and Crunchbase (2021)

Invested capital, 2010-2020	Invested capital 2020	Number of unique investors	Major international funding rounds	Major regional funding rounds
PLANT-BASED PROTEIN				
USD 5.4 billion	USD 2.7 billion	>350	Impossible Foods (US): USD 500 million (Series H) in 2021 Allplants (UK): USD 52 million (Series B) in 2021	NotCo (CHL): USD 235 million in 2021 (Series D) Tomorrow Foods (ARG): USD 3 million in 2021 (Seed) Fazenda Futuro (BRA): USD 22.5 million in 2020 (Series B)
CULTIVATED PROTEIN				
USD 490 million	USD 360 million	>120	Eat Just (US): USD 97 million for in 2021 (Series unknown) Aleph Farms (ISR): USD 105 million (Series B) in 2021 Memphis Meats (US): USD 161 million (Series B) in 2020	Cell Farm Food Tech (ARG): USD 200k in 2019 (Seed) Biomimetic Solutions (BRA): USD 100k in 2018 (Seed)
TOTAL				
USD 5.9 billion	USD 3.1 billion			

3.3 THE LATIN AMERICAN ALTERNATIVE PROTEIN SECTOR IS STILL CONCENTRATED

The Latin American protein market is relatively concentrated, with a few firms dominating the industry (see Table 5 in Annex for an overview on key actors). In the plant-based segment, besides the presence of prominent US retailers such as Beyond Meat, several local stakeholders have recently emerged or are already trying to solidify their market position. The landscape of producers and retailers spans innovative start-ups (e.g. Tomorrow Foods in Argentina, Fazenda Futuro from Brazil, or Chile's NotCo), as well as well-established meat producers keen on branching out and diversifying their product offer in response to market opportunities (e.g. JBS or Mafrig Foods from Brazil). In the cultivated meat segment, commercial value chains do not yet exist in the region. Brazilian meat producers have started to invest in cultivated protein start-ups and heavily invest in research labs (e.g. Brazil's JBS (Ho, 2021) and BRF (Michail, 2021)), but Argentinian (e.g. Craveri laboratories' BIFE), Chilean (e.g. Lyef Biotechnologies), as well as Mexican (e.g. Micro Meat) start-ups have emerged in the field as well.

A high level of integration is a common trait of emerging industries (Yaman, 2019), and this is generally also the case for the alternative protein industry in the Latin American market. Companies and new products tend to emerge alongside the development of proprietary technologies, new formulations, or specific input needs. However, few producers in the plant-based protein segment in Latin America feature fully integrated business models, and most are dependent on imported ingredients, such as protein isolates. Although the region's countries feature modern and highly developed agriculture industries, most domestic producers continue to source the majority of their inputs from abroad, specifically from US firms (e.g., Mafrig Foods deal with ADM (ADM, 2021)).

Over time, the market segments of plant-based and cultivated meat are likely to become disrupted by specialized companies focusing on specific parts of the value chain (Yaman, 2019). Highly specialized companies will solve key technological challenges along the value chain, while highly capitalized, large firms (e.g. already established large-scale meatpackers) will focus on industrial production processes required for reaching scale in output (BNP Paribas, 2021). Brazil and Argentina feature the most dynamic start-up sectors in the region, and are likely to lead the innovation wave thanks to large local retail opportunities (domestic demand), modern agriculture value chains (Viton et al., 2019), as well as potentially relevant export opportunities.

3.4 ATTRACTIVE OPPORTUNITIES: SOLVING VALUE CHAIN CHALLENGES

Argentinian producers could put themselves at the forefront of the protein transformation by targeting the technological challenges along the plant-based and cultivated protein value chains, as well as by utilizing existing industrial capacity and capital to reach scale in commercial production (see Figure 5). Several priority investment opportunities exist for the Argentinian private sector, but public investments and support are imperative as well.

Besides necessary investment in plant-based protein production capacity fit for commercial purpose, Argentinian producers could utilize existing and highly modern agriculture production capacity to specialize in the production of protein crops. Pea isolates, for example, represent a versatile, non-GMO, non-allergic, and safe protein source with a comparatively low environmental impact. Pea protein has an economic advantage (price per kilo) over wheat isolates and has one of the lowest levels of environmental impact (Bashi et al., 2019) (see Table 4 in Annex for an overview on protein alternatives). Pea crops may be integrated in existing cropping systems as cover crops or in crop rotations, where they can contribute to nitrogen fixation/reducing synthetic fertilizer use. Argentina features ideal growing conditions (Hommel, 2020) and is in the position to significantly increase its existing production capacity from currently low levels.

Demand for pea protein exceeds current supply, with the global pea protein market expected to value at USD 1.4 billion in 2025 (Markets and Markets, 2020). Pea protein is expected to become the leading plant-based protein source in the medium- to long term (Bashi et al., 2019). Production of pea crops for the plant-based protein market, however, requires crop optimization for improved protein content. Standard pea varieties have protein contents of usually less than 25%, as well as feature undesired taste and colour profiles (Bashi et al., 2019). Crop optimization should also seek to render the production of pea protein more profitable by reducing by-products (such as pea starch) that are difficult to market. Public support for research and development of optimized, high-protein crop varieties is necessary.

Opportunities for alternative protein investment

Argentinian private sector has a golden opportunity to invest in alternative protein development technology and production capacity, helping maintain its role as a leading exporter of protein

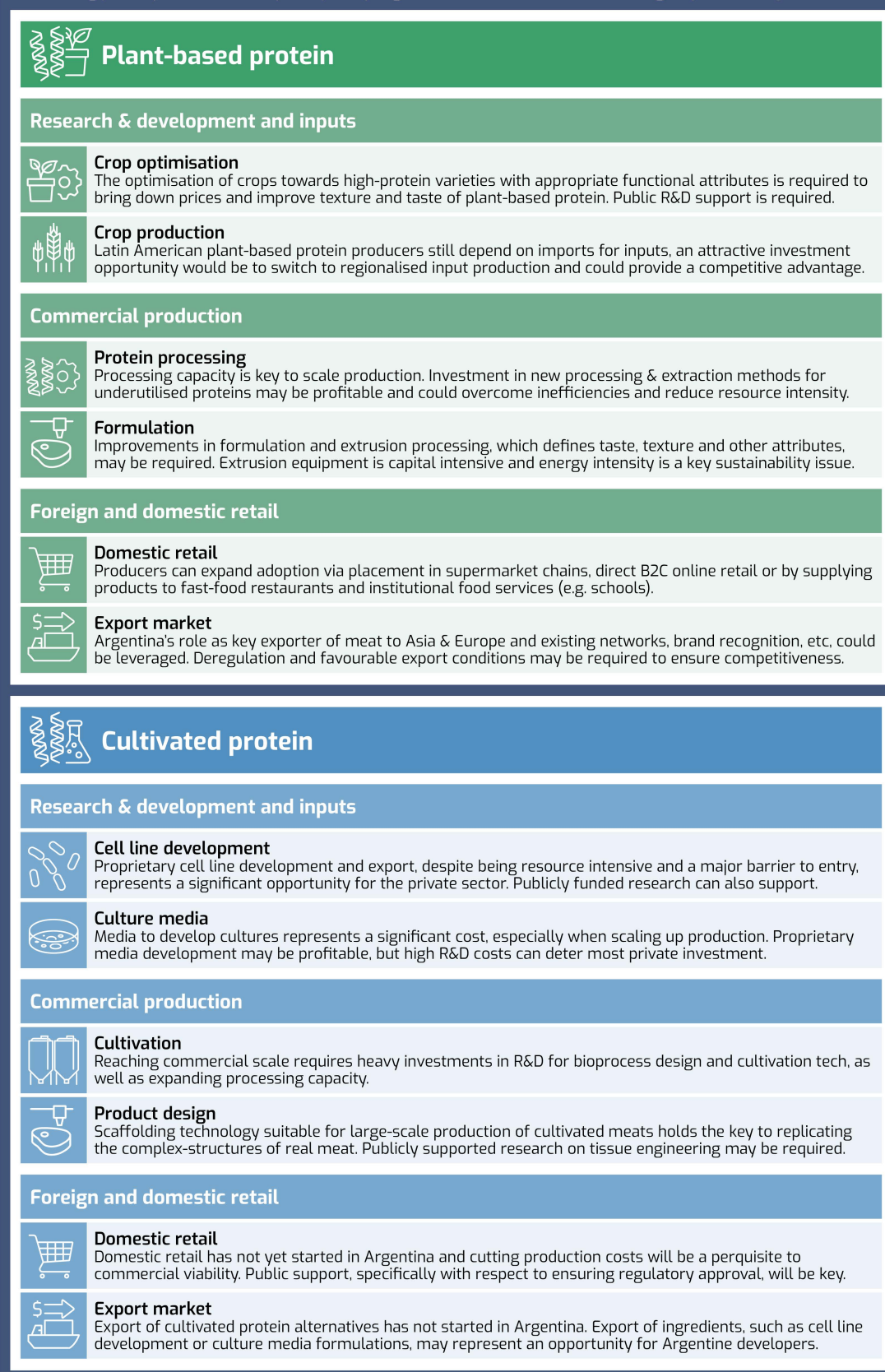


Figure 5: Plant-based and cultivated protein value chains and investment needs, based on Swartz & Bomkamp (2021), Clayton & Specht (2021), Seah et al. (2021), and Humbird (2021)

In the cultivated protein segment, more research and development is required to achieve commercial viability. The Argentinian pharmaceutical company Craveri Laboratories invested in a bioengineering division (Bio Ingeniería en la Fabricación de Elaborados, BIFE) already back in 2016. The start-up produces cultivated meat via fully-integrated cellular agriculture. BIFE is currently the only bioprocessing plant authorized (by the Instituto Nacional Central Único Coordinador de Ablación e Implante) to produce cultivated meat involving cell manipulation in Argentina. In 2021, the start-up conducted the first tasting of bovine meat cell-based cultivated meat samples in Latin America. The artificial nuggets, however, do not yet represent a commercially viable product, with production costs at around USD 1000 per nugget (Salvucci, 2021). Another start-up, Cell Farm Food, shows that already today there may be a business case for the highly specialized production and export of raw material required to produce cultivated meat. The company develops mesenchymal stem cells, which are particularly suitable for scaling up and speeding up cultivated meat production. Cell Farm Foods markets its cell lines through a royalty model, while leveraging Argentina's reputation for high quality meat production (Michail, 2020).

3.5 THE RATIONALE FOR INVESTMENT GOES BEYOND PRIVATE PROFITS

The Argentinian alternative protein industry, both in the plant-based and cultivated protein segment, should seek to regionalize research and development, draw on its agricultural capabilities to develop specialized solutions to remaining value chain challenges, and draw on its industrial capacity to scale-up output. Argentina's macroeconomic and regulatory instability, however, renders it more difficult for the country to raise funding at the scale required. There is an urgent need for public support and facilitation, which the private sector may try to leverage by highlighting the climate change mitigation potential and the wider co-benefits associated with the sector.

Plant-based and cultivated protein production systems are characterized by less intensive environmental footprints (Santo et al., 2020). Plant-based meat substitutes are estimated to have an average emissions intensity of around 2.2 kg CO₂e per 100g of protein. Cultivated meat substitutes have an average emission intensity of about 5.7 kg CO₂e per 100g of protein, albeit with the carbon footprint heavily dependent on the production process and whether required energy is sourced from renewable sources. In comparison, the average emissions intensity of beef is above 40 kg CO₂e per 100g of protein, almost 20-fold the emissions intensity of plant-based protein. Poultry meat production and farmed/wild fishing systems, however, tend to still have lower emissions footprints than cultivated protein production, which may change once bioprocessing technology becomes more mature. Alternative protein production systems generally also require less land (see Figure 6).

Besides the environmental superiority of plant-based and cultivated protein alternatives, advancing the protein transition is likely to produce significant socioeconomic co-benefits. Adapting production systems to changing consumer preferences and the economics of protein production is likely to result in significant employment creation. The International Labour Organisation expects the global plant-based agriculture industry to employ 19 million additional full-time equivalent employees in Latin America by 2030 if the region steps up decarbonisation efforts in its agriculture sectors, while employment in conventional protein industries will decline. In some regions, the protein transformation may turn out to be a stronger job creator than the countries' energy transition (Saget et al., 2020). The emerging cultivated protein industry is expected to further add to this dynamic, estimated to employ at least as many workers per tonne of meat produced as in the conventional protein industry (about 5,000 to 5,500 full time equivalent jobs per 500,000 tonnes of cultivated meat), even if indirect employment in upstream segments and research and development is not included (Brennan et al., 2021). Importantly, however, the protein transformation is also a structural transformation, requiring workforce development and public support for job transitioning.



Environmental footprint of different protein sources

Emissions intensity and land-use ranges for different meat and alternative protein types

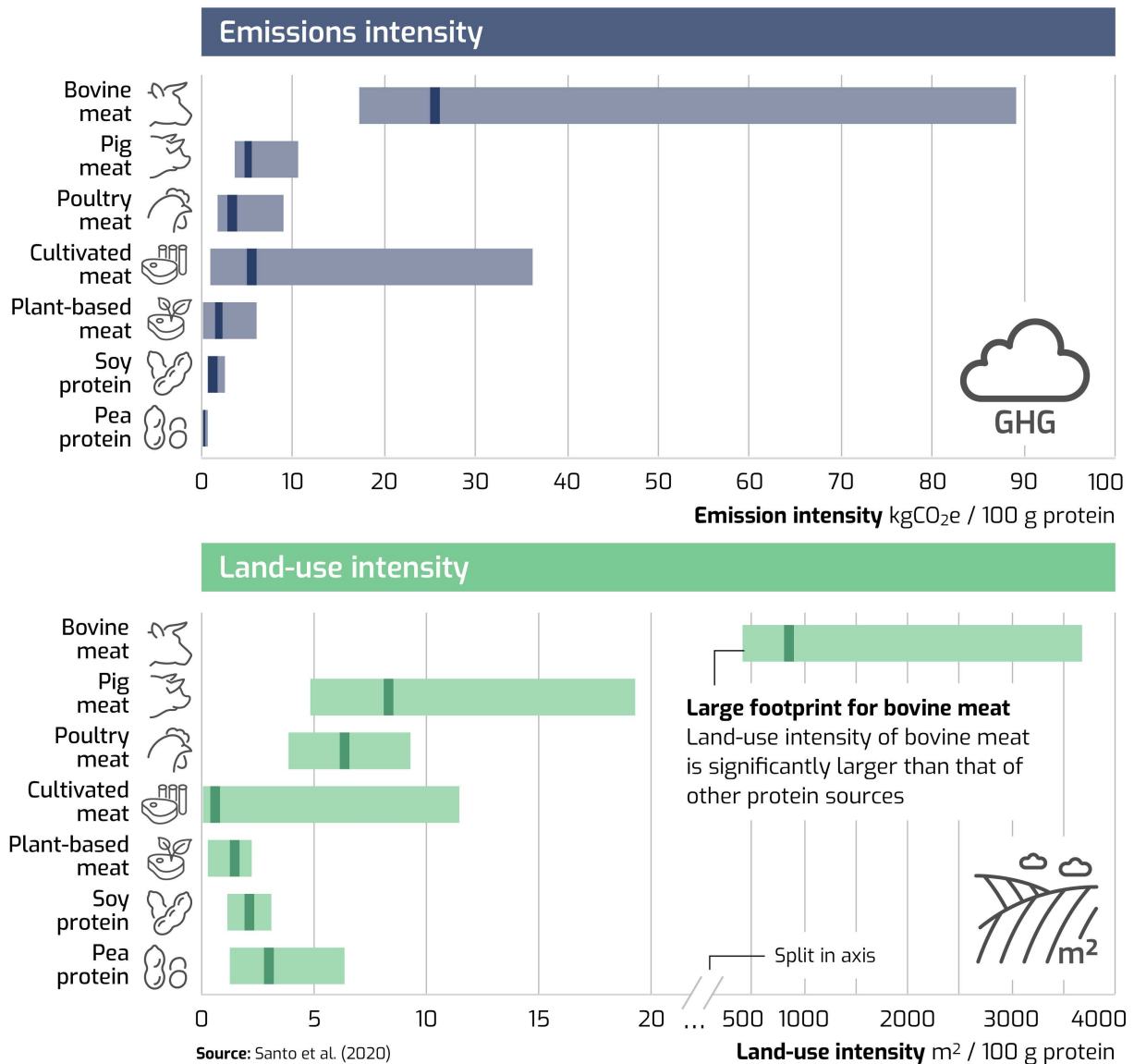


Figure 6: Environmental footprint of different protein sources.

In the medium to long term, Argentina's agriculture sector is also likely to benefit from significant efficiency gains by promoting a large-scale protein transformation. Innovation and economies of scale in plant-based or cultivated protein production systems are expected to drastically reduce the cost of proteins over the next decades. Alternative proteins are expected to be as much as 5 times less expensive by 2030 and 10 times less expensive by 2035, while at the same time featuring superior nutritional and other health-related attributes (Tubb & Seba, 2019). If Argentina can align its agriculture and livestock production systems with the new protein paradigm, significant direct consumer welfare benefits in the form of increased disposable income and health benefits are likely to manifest.

The full extent and impact of a large-scale protein transformation is impossible to predict. While plant-based protein production maintains key elements of conventional agriculture value chains (i.e. the need for cropping systems for input production), the commercialization and wide-spread adoption of cultivated protein production systems may result in disruptive changes to the way countries produce proteins. It is expected that a democratization of cell line information (i.e. the reduction of access barriers) and technology sharing may allow for a greater decentralization of protein production. Eventually, such changes could drastically alter the role geography, climate, or soil quality play in defining countries' comparative advantage in the production and trade of protein commodities (Tubb & Seba, 2019).

4 THE INEVITABLE PROTEIN TRANSITION

Argentina's livestock production system and the growth aspirations of the industry are difficult to align with the country's climate neutrality pledge. In 2016, emissions related to meat production in Argentina represented just over 30% of the entire sector's emissions. The share goes over 50% when including other indirect emissions like those from manure left on pasture and the induced deforestation to make room for cattle. Mitigation options for beef cattle in Argentina would only realistically result in a 20% reduction of emissions, which still leaves the sector's emissions pathway misaligned with where it should be in 2030 to reach climate neutrality by 2050 (Gonzales-Zuñiga et al., 2022). It follows that a transformation of the sector is a climate imperative.

But transition risks for Argentina's animal protein industry do not only stem from the country's climate action ambition; consumers growing more conscious of the environmental impact of Argentina's livestock value chain is a real, albeit slowly onsetting, transition risk for stakeholders in emissions intensive industries. Changing consumer preferences, both locally and in Argentina's export markets, may represent a serious threat to the country's animal-based protein industry, specifically once alternative protein products achieve parity in price, texture, taste, and nutritional value.

The inevitable protein transition, however, also brings significant investment opportunities. The economic rationale for investments in meat substitutes is strong, given the large potential market opportunities domestically and in key export markets. Both plant-based and cultivated protein alternatives are expected to gain price parity in the short and medium term, which is likely to set off snowball effects for adoption. Significant cost reductions are possible in the plant-based and cultivated protein value chain, but barriers to commercial viability and large-scale production need to be overcome. Investors and companies that can find solutions to remaining value chain challenges today are likely to emerge as key players with significant competitive advantage.

Argentina's macroeconomic instability is not helpful to catalyse investments. Public support is required to facilitate private capital influx, reduce regulatory hurdles, and overcome the market failure of suboptimal R&D investment. By promoting the development of a strong domestic alternative protein industry, the public sector can reduce negative externalities of conventional protein production systems, drive domestic value creation and employment, and unlock social welfare gains.

Investment needs are significant and large structural transitions can involve short-term costs. The public sector, however, can seek bilateral or multilateral support to provide de-risking or guarantee facilities, research grants, or leverage other forms of international public and private sector support under the umbrella of climate finance. The public sector should further formalize its climate action ambition by recognizing and planning for the protein transition in its Nationally Determined Contributions (NDCs) and Long-Term Strategy (LTS). This would send a strong signal to the private sector and reiterate the inevitability of a deep transformation in the agriculture sector.

ANNEX

Table 3: Drivers and barriers to consumer preference change for meat products

Category	Description
Motivational drivers of consumer preference change	
Environment	Awareness of the environmental impact of meat has been identified as a major driver of consumer willingness to reduce or eliminate its consumption. Here some studies have shown a direct correlation between both factors, but also noted that even among aware consumers, there are still misconceptions about the climate impact of meat, evidenced by the notion that shopping for regional meat would make its consumption sustainable.
Health	Concerns about the health impacts of high levels of red meat consumption as well as the association of plant-based products with healthier diets are also identified as a major driver. The health costs associated with high animal protein diets have been estimated at 0.3% of global GDP in 2020. However, there is also evidence of a perceived correlation between vegetarian and especially vegan diets and nutritional deficiencies.
Animal welfare	Concerns about what industrial meat production systems mean in terms of animal suffering are a powerful driver among those that have already cut out meat from their diets.
Price	Price changes in meat products can have a powerful effect on demand. However, price elasticity of demand varies in different markets and can be related to the perceived cultural value of meat, as well as to changing income levels.
Snowball effect	Some studies have found that the incentive to reduce or eliminate meat or animal products is higher the more people in a social group are already doing it, creating a snowball effect when it reaches critical mass.
Non-motivational factors associated with increased demand for meat	
Population growth	Growing populations are naturally associated with higher demand for food, including beef and other meat products. However, this is not a specific driver of consumer preference for meat, and therefore not a specific barrier to preference change. It is an underlying factor that can amplify the effect of other barriers.
Income	As with population growth, real income increases are associated with a transition to more protein-rich diets, which entails a higher consumption of meat. This, however, is also not a specific driver for meat consumption, and rather a factor amplifying the impact of existing preferences.

Motivational barriers for consumer preference change

Cultural value	The role of meat in socially constructed identities and traditions is one of the major factors explaining the entrenchment of the preference for meat. Its emotional connection to cultural values can seriously hinder the effect of environmental awareness in preference change.
Language	Associated with the cultural role of meat, the language used to talk about meat substitutes, which often highlights the role of technology in their manufacturing, can have detrimental effects in the perceptions and acceptability of such products.
Neophobia	The familiarity of food products is also a relevant factor. New products, especially those that come to compete with existing highly emotional ones, face the problem of neophobia, or fear of new things. Establishing a product, dissipating fear and uncertainty, and building trust requires time and information.
Lack of knowledge and skills	<p>A relevant barrier is that people don't know how to adapt their diets to reduce meat consumption. Making it as easy as possible to replace meat with substitutes with minimal changes to recipes is expected to have a big impact.</p> <p>Another related barrier is the lack of information available to consumers to make sustainable consumption choices, such as the carbon content of different products.</p>
Taste	Some studies have found taste to be a major advantage of meat against substitutes. The jury is still out on whether substitutes should try to imitate meat or not. But given the importance that consumers place on the taste, texture and smell of meat products, overcoming this barrier will likely be linked to the success of substitute products in replicating the experience of eating meat.
Price of alternatives	Price is also a major determining factor for meat substitutes, which probably can't rely on low demand price elasticities. Reducing their price while keeping quality high is seen as key for their success, and evidence of price trends show they are well underway.

Based on (Bryant & Barnett, 2019; Collier et al., 2021; Curtain & Grafenauer, 2019; Fiorentini et al., 2020; Globescan, 2021; Hielkema & Lund, 2021; Hoek et al., 2011; Komarek et al., 2021; Kopplin & Rausch, 2021; Lemken et al., 2019; Mancini & Antonioli, 2020; Miguel et al., 2020; Milfont et al., 2021; Milford et al., 2019; Onwezen et al., 2021; Pina, 2021; Ritchie et al., 2018; Siegrist & Hartmann, 2020; Springmann et al., 2018; Stoll-Kleemann & Schmidt, 2017)

Table 4. Protein alternatives and their features, based on Bashi et al. (2019)

Product type	Price	Environmental impact	Competitiveness	Challenges
Soy protein	2 USD/kg	Low	Well-developed product with major investments along value chain.	Consumer concerns about safety of GMOs and allergenic and estrogenic effects.
Pea protein	5 USD/kg	Low	It shares soy's advantages in terms of environmental impact and low price, but it also has an advantage because of its non-GMO and non-allergenic nature.	The protein content of pea is around 24%, which means that there is a substantial by-product that needs to be allocated.
Insect protein	41 USD/kg	Low	It has the highest shares of feed to weight ratio and can be raised on low-value agricultural by-products.	It is currently more costly than meat, and the taste is a barrier for adoption.
Myco-protein	13 USD/kg	Medium	It has a high protein and fiber content, as well as low fat. Its taste is neutral, and its texture is close to meat when mixed with eggs.	The feedstock is currently expensive, and there is low acceptance of the product since it's legally required to be labelled as "mold".
Cultured meat	300 USD/kg	High	This product has not yet entered the market, but it is expected to be cost competitive in the next ten years.	The process is still very energy intensive and substantial improvements are still required in the production technology for it to reach cost competitiveness.
Whey protein	7.5 USD/kg	Medium	This is a well-established and accepted product, and can be very versatile due to its neutral taste.	There is increased competition from the dairy-free industry, which has lower environmental impact and no animal welfare concerns.

Table 5: Latin American key actors

Company	Type	Value Chain Segment	Country
Cell Farm Food Tech	Cultivated	Cell line development	Argentina
Neoproteins	Plant-based	Protein isolates	Argentina
Tomorrow Foods	Plant-based	Protein isolates, Formulation	Argentina
Bio Ingeniería en la Fabricación de Elaborados	Cultivated	Culture media, Bioprocess design, Cultivation, Texturization	Argentina
Grupo Insud	Plant-based	Crop optimization, Protein isolates	Argentina
Vegan Nature	Plant-based	Formulation, Retail	Argentina
Ergo Bioscience Inc	Plant-based	Crop optimization	Argentina
Aleph Farms (BRF)	Cultivated	Culture media, Cultivation, Texturization	Brazil
Annora Alimentos	Plant-based	Retail	Brazil
Biomimetic Solutions	Cultivated	Texturization	Brazil
BioTech Foods (JBS)	Cultivated	Culture media, Cultivation, Texturization	Brazil
Ecobras	Plant-based	Formulation, Retail	Brazil
Fazenda Futuro	Plant-based	Formulation, Retail	Brazil
Frizata	Plant-based	Formulation, Retail	Brazil
Geronimo Foods	Plant-based	Formulation, Retail	Brazil
Goshen Alimentos	Plant-based	Formulation, Retail	Brazil
PlantPlus Foods (Marfrig)	Plant-based	Formulation, Retail	Brazil
Mr. Veggy	Plant-based	Formulation, Retail	Brazil
Naturinni	Plant-based	Formulation	Brazil
Olivebra Industrial	Plant-based	Crop optimization	Brazil
Tofutura Industria de Alimentos (Samurai Organic Foods)	Plant-based	Formulation, Retail	Brazil
Soja Mania	Plant-based	Formulation, Retail	Brazil
Sora Alimentos	Plant-based	Formulation	Brazil
SuperBom	Plant-based	Formulation	Brazil
Tensei	Plant-based	Formulation	Brazil
The New Butcher	Plant-based	Protein isolates, Formulation, Retail	Brazil
Vegabom	Plant-based	Formulation	Brazil
Vida Veg	Plant-based	Formulation	Brazil
Vivera (JBS)	Plant-based	Formulation	Brazil
Seara Alimentos (JBS)	Plant-based	Protein isolates	Brazil
Milhao	Plant-based	Crop optimization	Brazil
Luyef Biotechnologies	Cultivated	Culture media, Cultivation, Texturization	Chile
POW! Foods	Plant-based	Formulation, Retail	Chile
The Live Green Co	Plant-based	Formulation, Retail	Chile
Asante	Plant-based	Retail	Mexico
Micro Meat	Cultivated	Cultivation, Texturization	Mexico
Plant Squad	Plant-based	Formulation, Retail	Mexico

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