National Science Challenges

OUR LAND AND WATER

Toitū te Whenua, Toiora te Wai

Emerging Proteins: Threat or Opportunity for Māori?

Summer Studentship Research

by Brent Paehua and Brooke McIvor

PROGRAMME ADVISOR

Dr John Reid

Ngāi Tahu Research Centre

University of Canterbury

RESEARCH SUPERVISION

Dr Simon Barber

Sociology

Ōtakou Whakaihu Waka | University of Otago

Lincoln University – Te Whare Wānaka o Aoraki | UC University of Canterbury | University of Otago | Ruralis | The AgriBusiness Group

Introduction

Emerging proteins is a project that is being conducted and lead by The Agribusiness Group, in conjunction with key stakeholders, to investigate the potential impacts of a global shift toward alternative proteins. Aotearoa is an agriculture-based society the disruption could be significant however, this also brings with it new opportunities for our country.

The two key questions of the research are:

1. What are the opportunities from a shift to any of the viable options for plant-based protein, to address social, environmental, cultural, and economic issues associated with ruminant-based agriculture systems for New Zealand?

2. What is the implication of such a shift in food production for Māori (producers and consumers) and does this fit within Te Ao Māori?

Reasearch Process

- Led by Jon Manhire (AgriBusiness Group), Dr Chris Rosin (Lincoln University) and John Reid (University of Canterbury)
- Part of the ongoing research of land-use decisions
- Hypothesis: *That the potential impacts to New Zealand agriculture and farming systems from the increased demand from new proteins can be effectively defined*
- First workshop, October 2022: Engaging expert support — Prof Rob Burton
- Interviewed interested parties: people within agriculture, researchers, producers etc.
- Collating first round of interview responses
- Second workshop, January 2023
- Research ongoing — production of engagement material

Key Points

The technology is rapidly developing to grow animal and dairy proteins in factories.

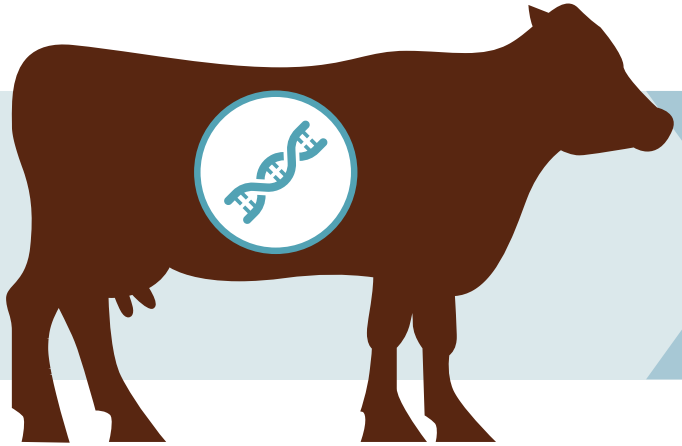
Pilot factories are already up and running.

In the next years, it will likely be cheaper to grow protein in factories than on farms with a lower environmental footprint.

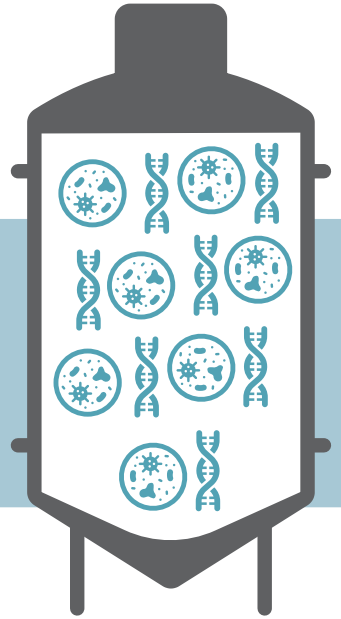
- What are the risks Māori farming enterprises?
- What are the commercial opportunities?
- What are the environmental opportunities?

What are the emerging technologies?

Precision Fermentation (Dairy)



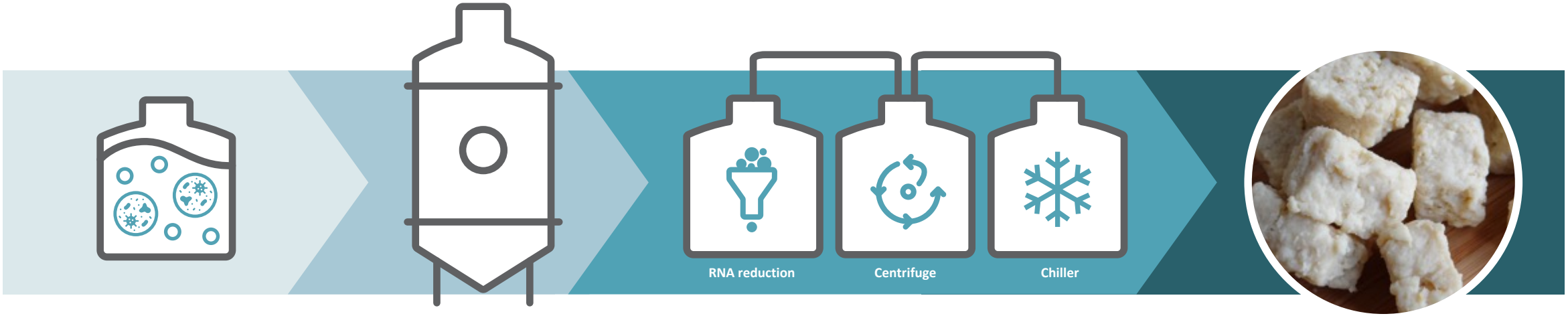
Genes from dairy cattle are placed into yeast that secretes milk proteins.



A glucose serum is then used to feed the yeast.

The milk proteins can then be used to make a range of dairy products.

Precision Fermentation (Plant-based)



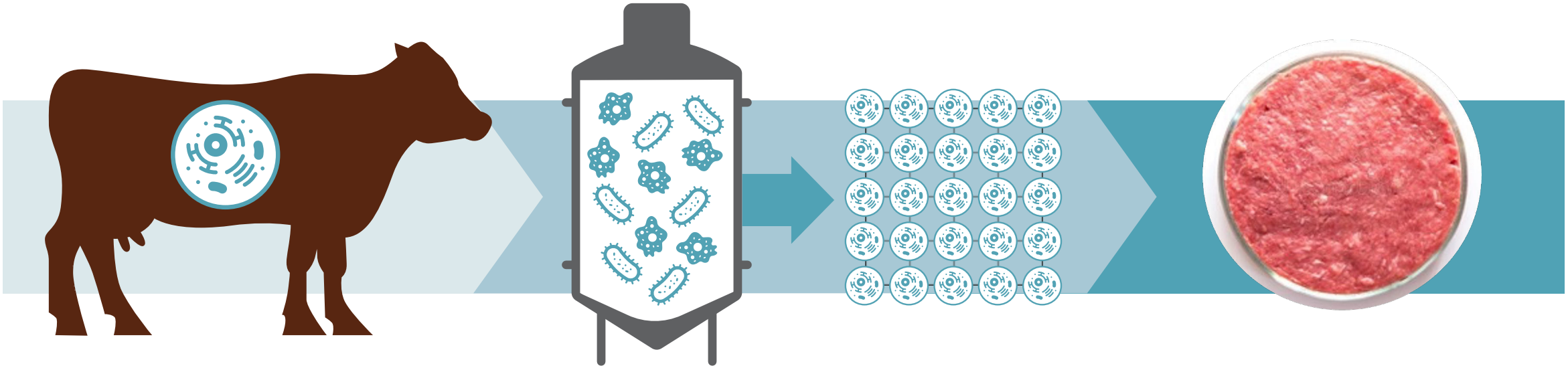
Raw materials consisting of glucose, water and nutrients are mixed and added to a bioreactor with ammonia, oxygen, and a microfungus *(fusarium venenatum)* that has a high protein content.

This is added to a bioreactor which grows the fungus.

- Once fermentation is complete, RNA reduction is required.
- The liquid and solids are then separated in a centrifuge.
- The remaining solids are chilled and harvested as a paste.

The paste is used to create fungal protein — mycoprotein — which is found in many meat alternatives such as Quorn.

Cellular method



Animal cells are grown on scaffolds fed by serum in a bioreactor.

These proteins can then be used to make different meat products.

Plant Proteins

Plants offer a much more traditional alternative source of protein — many of the plants pictured here have been diversified into food alternatives.

What do you think are most common plants used for creating meat alternatives?

Plant Proteins

Many plant-based products are available in our supermarkets today.

Plant Protein Summary

The Good Food Institute has benchmarked plant proteins and provides a great overview of differing strengths (and weaknesses) of plant proteins.

Protein	Protein Concentration	PDCAAS*	Allergen Risk	Commercial Stage	Flavour	Functionality	Cost (/kg protein)	Global Crop Volume (MMT)
Excellent ▲	>30%	>0.8	Usually mild, low pop.	Commodity	Flavourless	Low conc. effect	<$2	>100
Good ■	20–30%	0.6–0.79	↕	Large	↕	↕	$2–4	10–99
OK ✳	10–20%	0.4–0.59	↕	Small		↕	$5–9	1–9
Low ✣	5–10%	0.2–0.39	↕	Start-up	↕	↕	$10–19	0.1–0.9
Poor ▼	<5%	<0.2	Severe in sig. pop.	R&D	Objectionable	Water insoluble	>$20	<0.1

Protein	Protein Concentration	PDCAAS*	Allergen Risk	Commercial Stage	Flavour	Functionality	Cost (/kg protein)	Global Crop Volume (MMT)
Soy	▲	▲	▼	▲	✣	▲	■	▲
Pea	■	■	✳	■	✳	■	■	✳
Wheat	✳	✳	▼	▲	✳	▲	▲	▲
Canola	■	▲	▼	✳	✳	■		■
Chickpea	■	✳	✳	■	✳	■	✣	■
Fava Bean	■	✳	■	✳	✳	✳	✣	✳
Lentil	■	✳	✳	✳	✳		✣	■
Lupin	▲	✳	▼	✳	✣	✳		✳
Mung Bean	■	✳	✳	■	■	■	✣	✳
Navy Bean	■	■	✳	▼	■	✳		✣
Peanut	■	✳	▼	✳	■			■
Sunflower	■	■	▲	✳	✳		✣	■
Almond	■	✣	✣	✳	■	✳	✣	✳
Corn	✳	✣	▲	✳	■	✣	✣	▲
Oat	✳	■	■	✳	■	✣		✳
Potato	✣	▲	▲	■	✳	■	✣	▲
Quinoa	✳	■	■	▼	✳	■	✣	✣
Rice	✣	✳	▲	■	■	✳	✳	▲
Sorghum	✣	✣	▲	▼	■	▼		■

*Protein Digestibility-corrected Amino Acid Score. Source: The Good Food Institute. *The Plant Protein Landscape* (2021)

What is the financial situation?

Current state of investment

The Good Food Institute presents the current state of investment as follows:

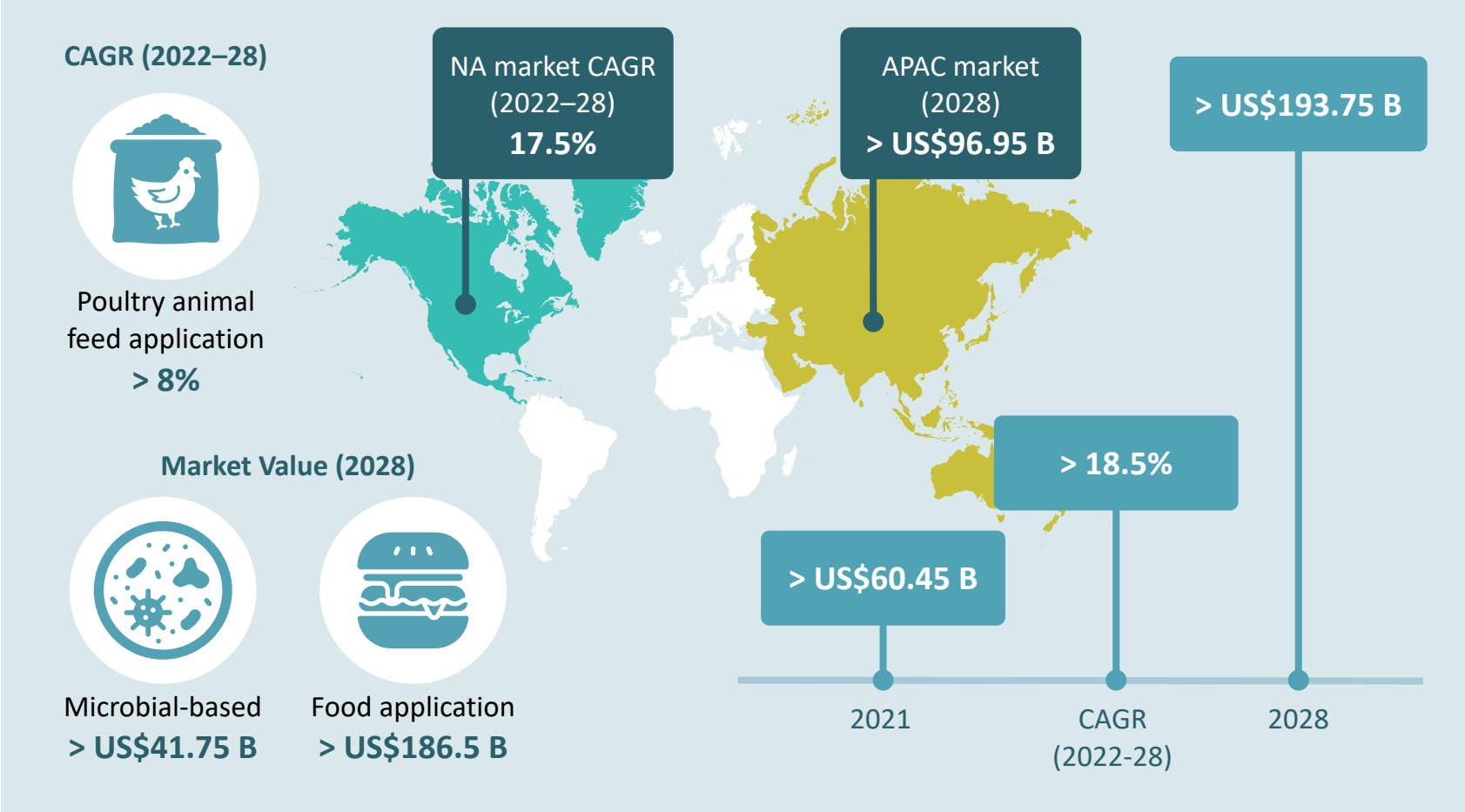
Category	Invested capital 2022	Total invested capital 2013–2022	10-year avg growth 2013–2022
Total alternative protein	$2.9 B	$2.9 B	107%
 Plant-based	$1.2B	$7.7 B	99%
 Fermentation	$842 M	$3.7 B	190%
 Cultivated	$896 M	$2.8 B	196%

Source: The Good Food Institute. *Investing in Alternative Protein.* https://gfi.org/investment/

Global market trends for alternative proteins

According to Global Market Insights, the global alternative protein market is worth US$60.45 billion.

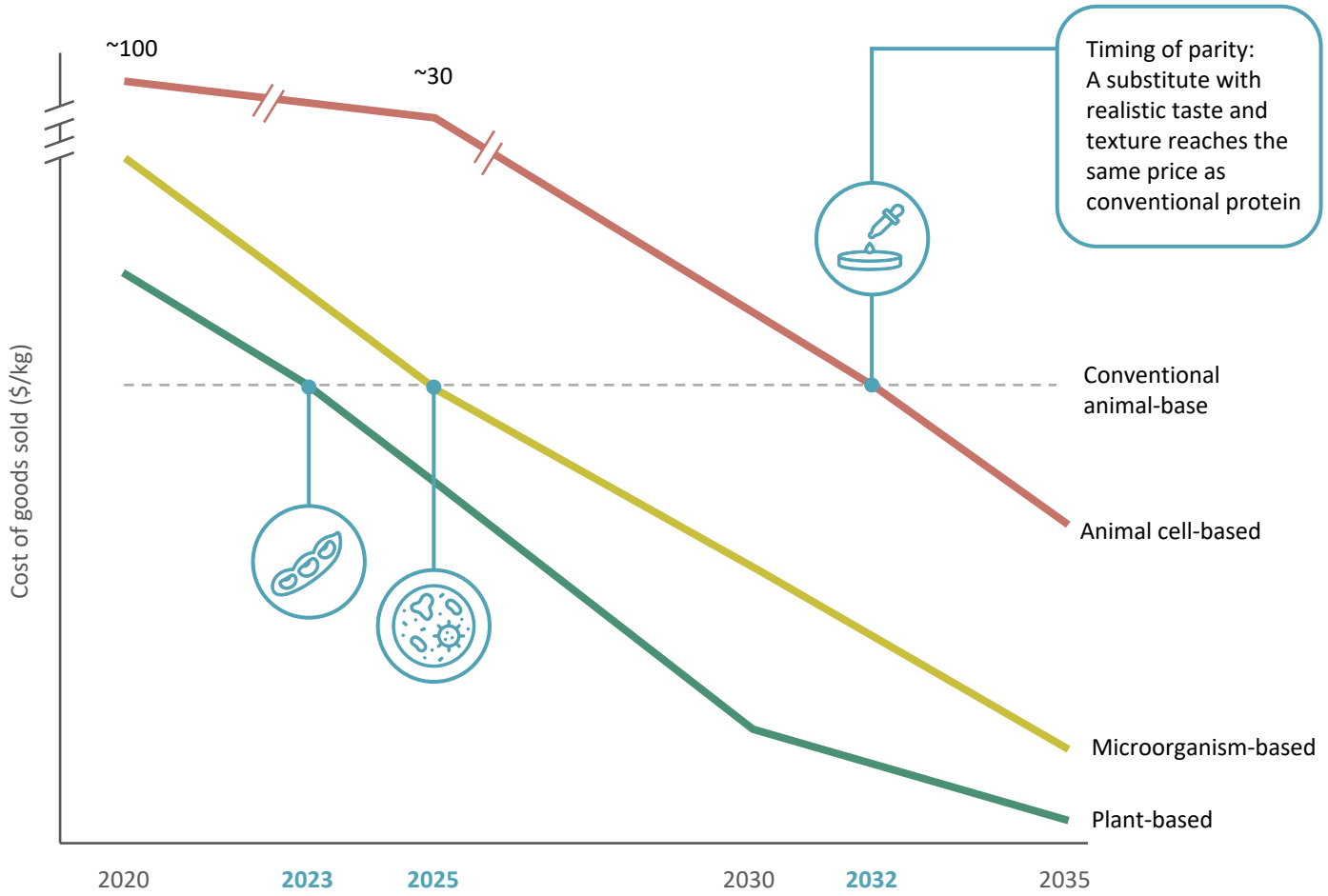
The market is predicted to experience an 18.5% growth (CAGR) between the years 2021–2028 with an increase to US$193.75 billion.



Source: Global Market Insights. *Alternative Protein Market by Source – 2022–2028 (2022).* https://www.gminsights.com/industry-analysis/alternative-protein-market

Product parity

Alternative proteins will reach parity with animal-based protein between the early 2020s–2030s depending on the protein source.



Source: The Good Food Institute. *Reducing the price of alternative proteins (2020)*

What is driving these trends?

1. Animal rights enthusiasts wanting to decrease animal suffering.

2. Environmentalists seeking to lower the environmental footprint of protein production.

3. Entrepreneurs seeking to own the industry and make profits.

Key facts

- 28% of the earth's surface covered by livestock farming.
- Emissions from livestock farming account for at least 16.5% of the planet's greenhouse gases. Over half of the fertile land on Earth is now farmland.
- Meat production is projected to double by 2050.
- NZ's gross greenhouse emissions increased by 21% (1990 –2020).
- Dairy cattle numbers grew by 82% — from 3.4 million to 6.3 million over same period.

If all the world's protein was created via precision fermentation it is feasible that the amount of land required would be the size of greater London.

Challenging our dairy industry

According to the Ministry of Primary Industry, Aotearoa's dairy industry contributes about $19 billion. It is responsible for around 5% of our national GDP and around 23% of total export value.

If trends in investment, scale of production, and price of alternative proteins continue, our current dairy industry and farming enterprises are under threat by low-cost and low-environmental footprint dairy products.

There are drawbacks for young companies in the alternative protein field – developing products and having them commercially available is extremely important.

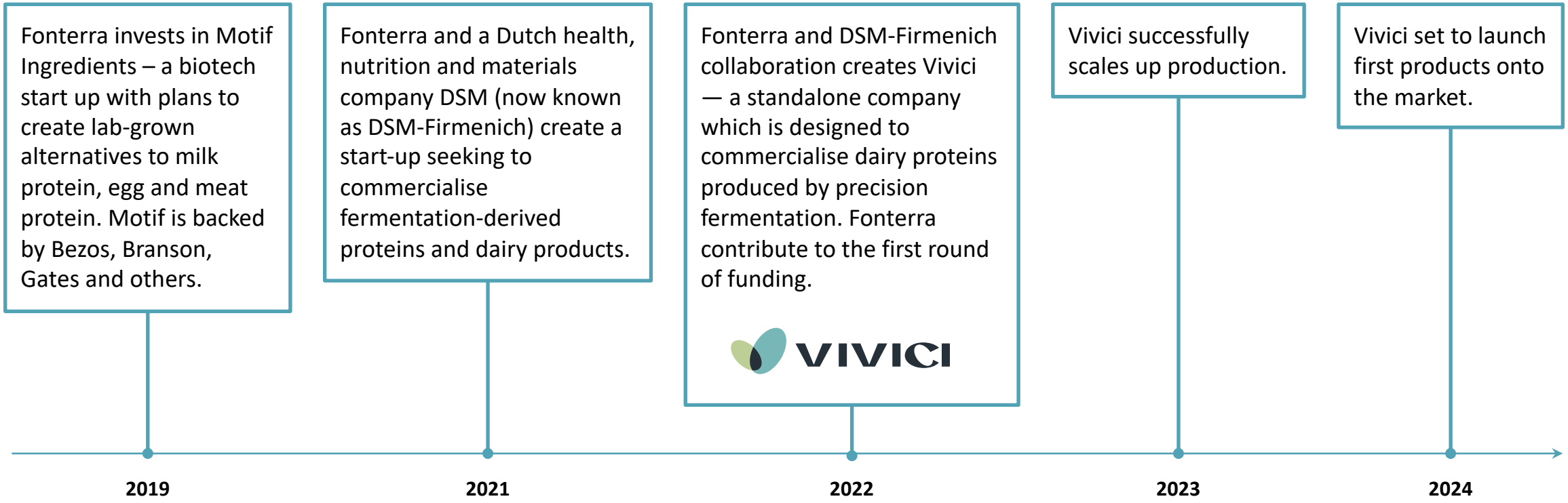
New Zealand companies working in the field

Daisy Lab (Digital Agro-environment and Intelligent Systems) based in Aotearoa, s copying and replace casein and whey-based products.

Leaft Foods Ltd, based in Canterbury, have developed the extract if rubisco from alfalfa plants. Rubisco is the protein found in the plant and upon extraction, becomes a flavour-neutral protein powder that has a similar amino acid profile to beef.

Fonterra and alternative proteins

Given Fonterra is responsible for 30% of global dairy exports, we can be forgiven for assuming they might be against alternative proteins but this is not the case.



Draft 2050 alternative protein scenarios

Scenarios were created to outline the potential outcomes around the future for alternative protein in New Zealand based on expert interview, a literature review, and quantitative data from BCG “Food for Thought” research

Scenario 1

- Reflects the current situation of increased demand in alternative proteins.
- Assumes that new alternative proteins contribute towards increased demand but do not significantly affect traditional protein supply chains.
- Slow growth caused by technical barriers.

Scenario 2

- Precision fermentation takes off.
- Demand tor plant protein continues but technical issues stall the development of cultivated products.
- Sustainability is a key factor driving consumer acceptance.

Scenario 3

- Plant-based protein products take off, whilst some barriers facing precision fermentation and cultivated products are removed.
- Sustainability is a key driver of consumer acceptance.
- Other emerging proteins shift to support the development of enhanced plant-based products.

Scenario 4

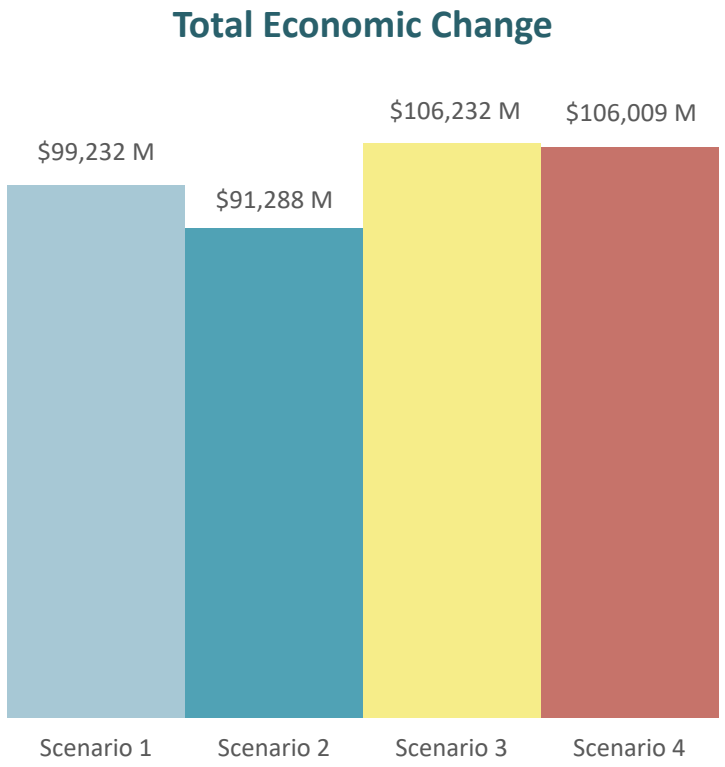
- All current barriers to the success of alternative markets have been removed or are in the process of being overcome.
- Sustainability is a significant factor — price parity is achieved for all alternative proteins.
- Taste and texture has improved.
- Scale of production has increased whilst regulation and market access barriers/tariffs for food are based on GHG emissions and other environmental outcomes.

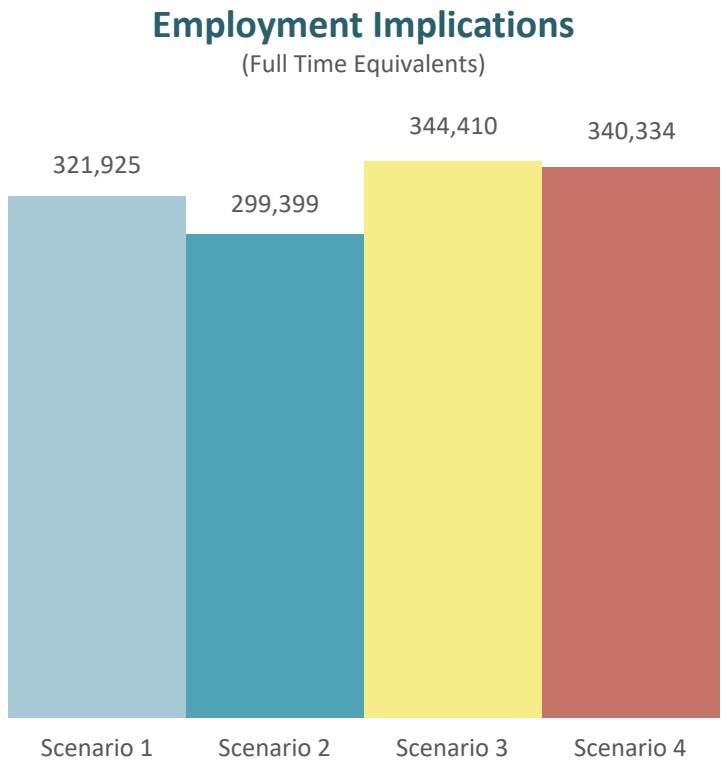
Proposed land use changes

Scenario 1	Scenario 2	Scenario 3	Scenario 4
Base case — business as usual	• 35% reduction in the dairy area • Arable area increases 50% in Canterbury, Southland, Wairarapa and Horizons	• 15% reduction in the dairy area • Arable area doubles across all flat land (25% from dairy, 75% from sheep and beef) — mainly South Island • 15% reduction in sheep and beef sector goes to forestry	• 35% reduction in the dairy area • Arable area doubles across all flat land (25% from dairy, 75% from sheep and beef) — mainly South Island • 25% reduction in sheep and beef sector goes to forestry

Draft 2050 alternative protein scenarios outcomes

Using the scenarios and the proposed land use changes economic and environmental outcomes were modelled for each scenario.



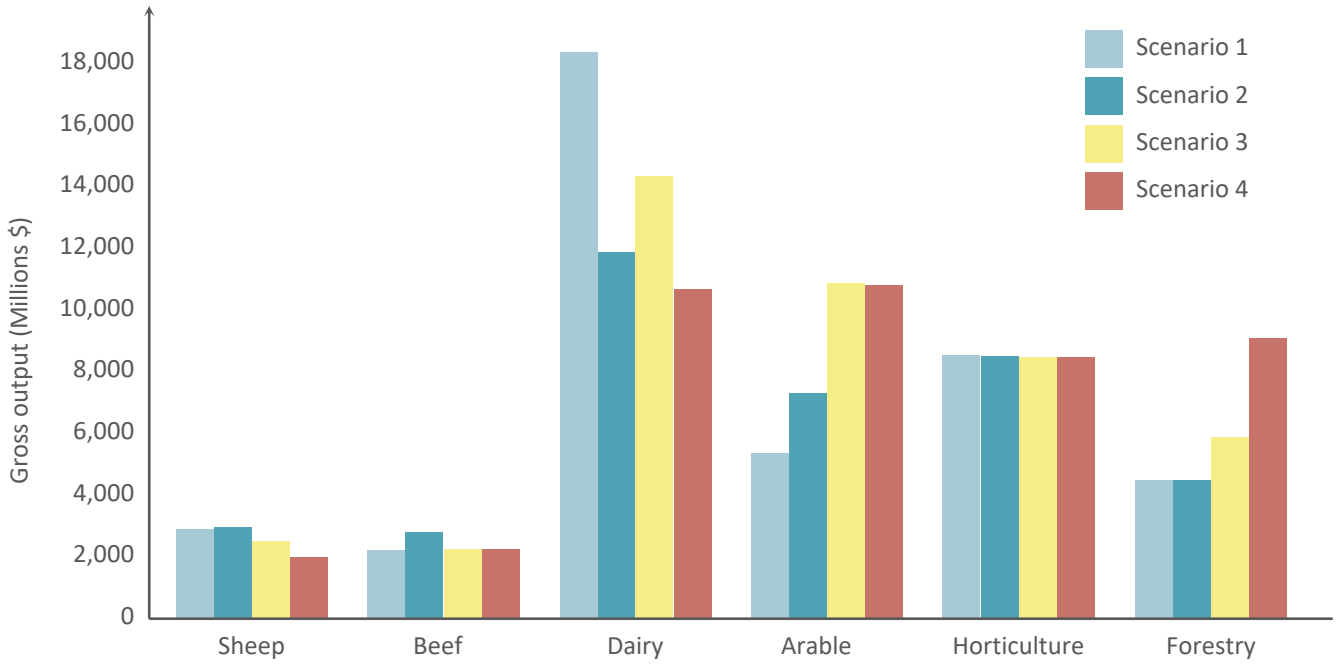


Economic outcomes

The economic modelling indicates that scenarios 3 and 4 would significantly boost employment and total economic output.

It however shows a less favourable picture for agriculture with sheep & beef and dairy output declining from the baseline (scenario 1).

Arable and forestry sectors exhibit growth in total output due to a rise in alternative protein demand and a focus on sustainability.



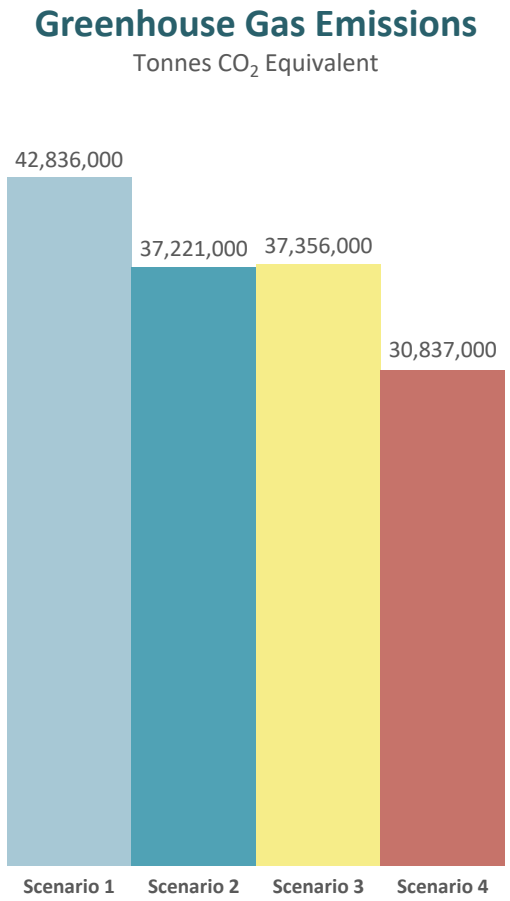
Economic Impact on Agriculture

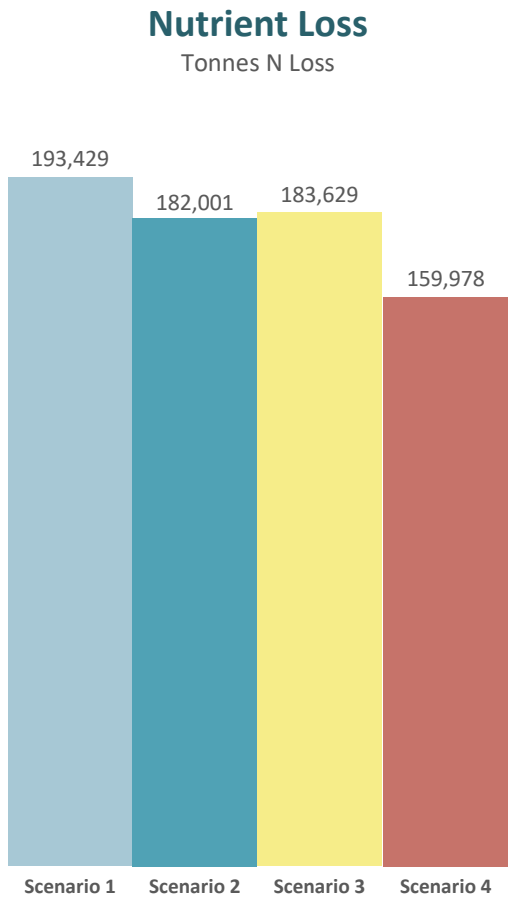
Environmental outcomes

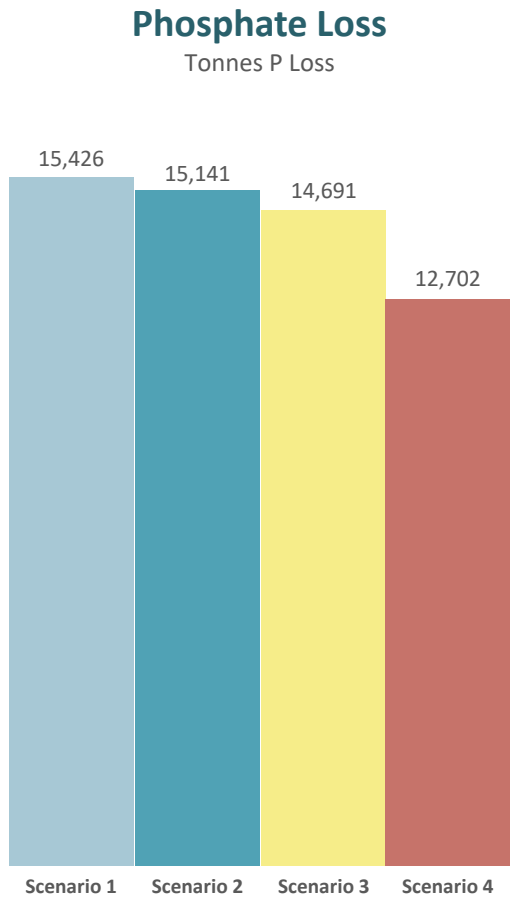
Environmental outcomes were derived from the economic modelling to assess the impact on the environment of various changes in output from the agricultural sectors.

As depicted in the graph to the right, the decline in dairy and sheep and beef production coupled with increased forestry and arable production, yields several positive environmental outcomes.

These include notable reductions emissions, nutrient loss and phosphate.







Examples of production plants & products

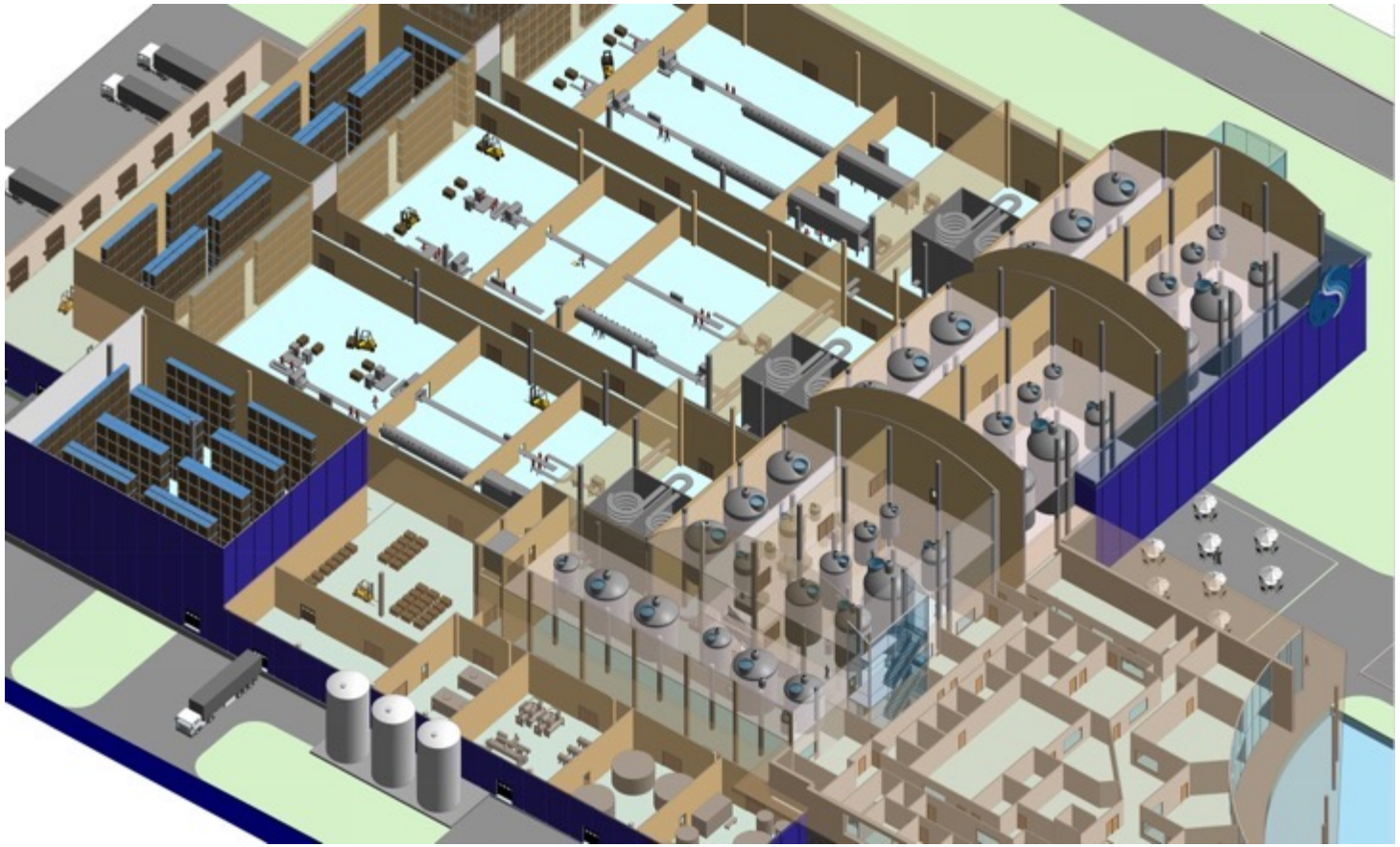
Calysseo

Calysseo has opened the world's first industrial-scale, alternative protein facility in Chongqing, China. This facility can produce 20,000 tons of protein per year.

The facility is designed to quickly expand to increase production up to 80,000 tons of protein per year.

Blue Nalu

Blue Nalu is building a facility that will be capable of producing up to six million pounds of seafood products.



Remilk

Remilk is an Israeli startup that is committed to producing dairy products via precision fermentation.

They are currently producing whey protein dairy products such cheese and yoghurt products. Remilk's planned production should be able to replace about 50,000 dairy cows.

Aleph

Based in Israel, Aleph farms is at the forefront of cultivated protein. In 2022, a 65,000 square foot facility for research and development and trialling upscaled productions was built.

They created the first cultivated, 3D-printed, ribeye steak. Leonardo DiCaprio sits on their board.

Risk to Māori Agribusiness Collectives (MACs)

Risks

- If bio-fermented dairy products can be scaled up and costs reduced, then this could result in falling process and economic pressure on traditional farming.
- Alternative proteins may result in falling prices for red meat and put pressure on the economics of sheep and beef farming.
- Advances in seafood production place our seafood industry at risk — particularly kōura and paua.

Opportunities

- There are opportunities for MACs to become engaged in alternative protein production especially those involving the production of plant proteins.
- There may be other specialist opportunities such as the production of feedstock (precision serum) for cellular meat production.
- Indigenous knowledge of traditional fermentation is currently untapped.

Ngā Hua Pūtea — economic opportunities

- Tino Rangatiratanga — Māori agribusiness and investment in emerging proteins allows for the planning, creation, production and distribution of alternative proteins. This provides an opportunity for Māori to champion change for not just Māori but all of Aotearoa.
- The economic opportunity and potential for the future is vast. Investment in the emerging protein sector is growing at a rapid rate.
- The alternative protein sector rose from $5M to $5B between 2010–2021 despite restrictions in laws and licenses.
- Passive income from retired land in carbon and biodiversity credits.
- Māori can capitalise on potential investments in emerging proteins.

Ngā Hua Taiao – environmental benefits

Although there are significant risks to MACs there are potential broader environmental benefits that align with Māori values and approaches (e.g. kaitiakitanga):

- Reduction on land use = opportunity for rewilding through reconstruction of native ecosystems.
- Māori have long been innovative in areas of new opportunity.
- Using land to produce alternative high-value crops and specialised products (e.g. rongoā) with low environmental impact.
- Researched modelling for future scenarios embracing alternative proteins shows significant decreases in greenhouse gases, phosphate loss and nutrient losses from farms.

Photo: Judi Lapsley Miller

Ngā Hua Tikanga – cultural benefits

- Increasing food security through lowering of food prices for whānau:
  - As of 2015, one in five Māori children will experience food insecurity.
  - As of 2015, roughly 68,000 Māori live in food insecurity.

- Rebirth of traditional practices such as fermentation, preserving and discovering modern application.

- Becoming leaders in alternative protein production.