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The New Zealand Food and Fibre Sector: A Situational Analysis

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Executive Summary

Introduction

1. The Primary Sector Council commissioned the Agribusiness and Economics Research Unit (AERU) at Lincoln University to prepare this situational analysis that provides a global perspective and a national context for developing a vision for New Zealand's Food and Fibre sector at a time when the sector is facing unprecedented levels of change.

2. The Food and Fibre sector includes the primary sector production industries (other than mining) and the related processing industries. It also includes service industries along the value chain from producer to final consumer, including providers of transport, storage, distribution, marketing and sales.

3. The Food and Fibre sector is essential to New Zealand's economy, accounting for more than three-quarters of the country's merchandise exports.

4. The sector is affected by a series of diverse global challenges, including: its contribution to climate change; the impacts of climate change on production and global patterns of food consumption; consumer movements focused on environmental impacts; uncertainties in international trade; Brexit; higher food standards in global markets and maintaining the social licence to farm domestically; increasing awareness of the impacts of animal-based production systems on the environment; the commercialisation of plant-based substitutes; emerging disruptive biotechnologies; debt burdens carried by producers; and the amplified threat of biosecurity incursions.

5. Significant change in the Food and Fibre sector is taking place. Te Hono involves 217 primary sector leaders across the primary sector, pursuing a mission to transform from volume to value. Māori enterprises are developing distinctive commercial brands in world markets. The wine industry, Zespri, Beef+Lamb New Zealand, Pāmu Farms and Organics Aotearoa New Zealand are examples of large enterprises pursuing strategies that link environmental performance with consumer expectations. Fonterra has published a sustainability report to GRI standards, although its Sustainable Co-operative commitment aims to support farmers "without impacting production". Smaller companies are also creating profiles to promote the quality of food and fibre sourced from New Zealand.

6. Public sector support for change in the Food and Fibre sector is reflected in a number of programmes. The Ministry for Primary Industries has adopted an ambition that "New Zealand is the most trusted source of high value natural products in the world. The New Zealand Story is an initiative to support high value exports. The Sustainable Food & Fibre Futures investment programme will fund projects that increase value in sustainable ways. The National Science Challenge on *Our Land and Water* has a key theme that focuses on how global agri-food value chains can create and capture value for New Zealand producers and processors.

7. These changes suggest solid foundations for the transformational change needed to meet the scale and range of international challenges facing the Food and Fibre sector, but there is no room for complacency.

The Food and Fibre Sector and New Zealand's National Wellbeing

8. Like many countries, New Zealand is moving towards a wellbeing framework for guiding policy and monitoring trends in personal and community wellbeing. The Treasury's Living Standards Framework considers 12 statistical indicators of wellbeing. It recognises that the country's total wealth is comprised of different types of capital stocks that provide flows of services used by people to create wellbeing. Figure 2-1 of this report presents a wellbeing framework in this tradition. It emphasises the importance of reinvestment in the capital stocks of total wealth to sustain and expand wellbeing into future generations.

9. The framework can be used to highlight the importance of the Food and Fibre sector to national wellbeing in New Zealand. It not only provides nutrition, but can also generate decent incomes and employment. The report shows that in New Zealand, for every $5 of income created in the market economy, just under $1 is created in the Food and Fibre sector. For every 10 jobs in New Zealand, just over one is in the Food and Fibre production and processing industries.

10. Drawing on Census data, people employed in the production and processing industries tend to have low-level qualifications compared to the rest of the New Zealand economy. Implementing production and processing systems that have smaller environmental impacts may require a more highly qualified workforce than is currently available.

11. The Treasury has projected that real gross domestic product in New Zealand might grow around 2 per cent per annum looking out to 2060. If that occurs, and if the Food and Fibre sector maintains its current position in the structure of the national economy, and if there are no other changes within the Food and Fibre sector, then this implies that primary sector production and Food and Fibre exports would have to double by 2051.

12. That observation supports the central theme of this situational analysis: that the Food and Fibre sector needs to transform itself, *from volume to value*. A doubling in the volume of primary sector production is not feasible, given the impact that this production is having on the environment.

The Food and Fibre Sector and the Environment

13. Environmental quality is one of the key statistical indicators of wellbeing listed in the wellbeing framework of this report. This recognises that environmental standards are important to citizens, including farmers, orchardists and other people involved in primary sector production. Consumers in international markets are increasingly expecting that sustainable environmental standards are maintained in the production, processing and distribution of food and fibre products.

14. The report draws on material in reports produced under New Zealand's Environmental Reporting Act 2015 to present evidence on the impact of primary sector production on five domains: air; atmosphere and climate; freshwater; land; and marine.

15. Intensification of farming through greater use of fertiliser and conversions to dairy farms is known to increase the amount of ammonia emitted to the air, which can acidify soil and cause changes in biodiversity by creating nutrient imbalances. Agricultural biomass burn-offs are associated with black carbon pollution (soot), which can cause health problems.

16. Primary sector production contributes to climate change. A high proportion of New Zealand's gross greenhouse gas emissions come from agricultural production, the highest among OECD countries. New Zealand is also among the most efficient producers in the world in terms of emissions intensity. The release of methane gas from sheep and cattle amounts to almost one-third of New Zealand's greenhouse gas emissions, and there is a clear scientific connection between methane emissions and global warming. New Zealand faces unique challenges, since agriculture has fewer options to make large emissions reductions quickly and cost-effectively compared to the power and transport sectors.

17. Water is a crucial input into primary production systems, and is also one of the most high profile environmental issues in New Zealand. Primary production can have negative impacts on the quality of local water bodies. The leaching of nitrogen and phosphorous are important examples, which mean that land use change can have large consequences for water quality, illustrated by the extensive conversions to dairy farms in Canterbury.

18. Urban expansion has caused the loss of some of New Zealand's most versatile land. The proportion of farmland used for dairying has increased at the expense of sheep and beef farming, while the intensification of farming has led to higher stocking rates, especially for dairy farms. The state of New Zealand's biodiversity and ecosystems, as well as its soil resources, is continuing to decline.

19. New Zealand's marine environment faces significant risks, including: ocean acidification and warming from greenhouse gas emissions; extinction threats for some native marine birds and mammals; and degraded costal marine habitats and ecosystems. New Zealand's most destructive commercial fishing methods have decreased, commercial fish stocks are managed with the aim of ensuring future harvests, and the percentage of New Zealand fish stocks assessed as being overfished has declined.

Value-Added Transformation

20. If the goals are to increase the economic value of the Food and Fibre sector and to reduce the sector's negative impacts on the natural environment, there are a small number of possibilities that can achieve both goals simultaneously. The report discusses four:

    - Adopting new technologies and sustainable practices that will allow increased production with a lower negative impact on the natural environment.
    - Shifting land and water use to products that have a higher economic value and a lower negative impact on the natural environment.
    - Using the outputs of the primary sector to manufacture food and fibre products that are more highly valued by consumers.
    - Using knowledge-intensive business services to target high value market segments in global agri-food value chains.

21. Transformation requires skilled leadership, at enterprise level, industry level and policy level. Professor David Teece, for example, has emphasised the competitive advantage to firms that comes from the *dynamic capabilities* of sensing, seizing and transforming. A key consideration is the leadership skills required to create and sustain global agri-food value chains that return premiums to New Zealand producers and processors. Leadership is also important in designing effective public policy that is supportive of the Food and Fibre sector's development to meet wellbeing goals. This is a challenge to the capability building strategies of organisations in New Zealand and to programmes offered in the country's universities.

Conclusion

22. The Food and Fibre sector is facing major international challenges. Changes are taking place in the sector, providing solid foundations for transformation to meet those challenges. This report has documented the environmental constraints on expanding production in line with projected economic growth. It quotes the observation made by the Treasury in 2016 that "the key issue is how to best support the transition to a world of 'growth within limits'".

23. The potential rewards from achieving transformation are considerable. Professor David Teece has proposed that New Zealand brands should be sufficiently valuable to support a 20 to 30 per cent premium. Trade modelling by the Agribusiness and Economics Research Unit at Lincoln University indicates that a 20 per cent premium for dairy and meat exports to ten trading partners would add $2.1 billion to our annual export receipts. Analysis commissioned by the Our Land and Water National Science Challenge showed that capturing that level of willingness-to-pay in five markets for improved credence attributes of four food and fibre exports would add in the order of 2 percent to New Zealand producer returns.

24. The range and complexity of the international challenges facing the Food and Fibre sector mean that transformational change is necessary. The initiatives taking place in the private and public sector mean that transformational change is possible. The environmental and commercial potentials from success mean that transformational change is rewarding.

Chapter 1
Introduction

The Primary Sector Council was established in April 2018 by Hon Damien O'Connor, the Minister of Agriculture, to provide independent strategic advice to the Government on issues confronting New Zealand's primary industries. The immediate focus of the Council is to develop a vision for the country's Food and Fibre sector. In preparation for that work, the Council commissioned the Agribusiness and Economics Research Unit (AERU) at Lincoln University to prepare this situational analysis that offers a global perspective and a national context for developing that vision.

As the Minister stated when announcing the Primary Sector Council, "New Zealand's primary sector is facing unprecedented levels of change" (O'Connor, 2018a). This Introduction gives an overview of some of those changes. While these provide a strong foundation for meeting international and national challenges, they do not yet amount to the transformation needed to achieve the widely held vision of the Food and Fibre sector shifting from volume to value.

The chapter begins in section 1.1 with the movement away from the traditional focus on 'the primary sector' to the current focus on 'the Food and Fibre sector'. This is followed in section 1.2 by some examples of the major international challenges that motivate the need for a refreshed sector-wide vision for the country's Food and Fibre sector. Section 1.3 documents some of the change currently taking place in the Food and Fibre industries, led by private sector enterprise and supported by public sector programmes. The chapter finishes with an outline of the remainder of the report (section 1.4).

1.1 From Primary Sector to Food and Fibre

When the United Nations System of National Accounts was created in 1953, it divided the economy into three major sectors:

- Primary Sector
- Manufacturing Sector
- Services Sector

That categorisation has underpinned most traditional analyses of national economies. The primary sector is comprised of Agriculture, Forestry and Fishing, plus Mining. Mining is not included in this report. In accord with that traditional approach, Table 1-1 lists the seven Agriculture, Forestry and Fishing industries and presents their value-added contribution to Gross Domestic Product (GDP) for the year ended March 2016 (the latest data available at the time of writing this report). The value-added by primary sector production industries accounted for 5 per cent of GDP that financial year.

Table 1-1: Value-Added by Primary Sector Production excluding Mining, by Industry, New Zealand, Year Ending March 2016

Agriculture, Forestry and Fishing Industries	Value-Added ($ millions)	Percentage Share of GDP
Horticulture and Fruit Growing	1,875	0.8
Sheep, Beef Cattle and Grain Farming	2,878	1.2
Dairy Cattle Farming	2,499	1.1
Poultry, Deer and Other Livestock Farming	573	0.2
Forestry and Logging	1,535	0.7
Fishing and Aquaculture	459	0.2
Agriculture, Forestry and Fishing Support Services and Hunting	1,728	0.7
TOTAL PRIMARY SECTOR (excluding Mining)	11,547	5.0
TOTAL GROSS DOMESTIC PRODUCT (GDP) AT FACTOR PRICES	233,138	100.0

Source: StatsNZ Infoshare, Series GDP(P), Nominal, Actual, ANZSIC06 Detailed Industry Group (Annual-March).

The raw products from primary sector production must be processed before they can be sold to consumers. The processing industries are classified as part of the manufacturing sector, but are clearly strongly connected with the primary sector industries. Table 1-2 therefore lists the eight Food and Fibre processing industries, and their contribution to GDP. Dairy product manufacturing is the largest of these processing industries. Taken together, the industries comprise 6.1 per cent of GDP at factor prices.

Combining the production and processing industries brings the value of the Food and Fibre sector to 11.1 per cent, but this is not the end of the analysis. The value created in the primary sector depends ultimately on what final consumers are willing to pay for the food and fibre they purchase. This depends on services in every step of the value chain from the producer to the consumer, including transport, storage, distribution, marketing and sales. Thus, the service sector in the National Accounts is also connected to the Food and Fibre sector.

To give an indication of the importance of the total sector to the economy, consider revenue generated by New Zealand's merchandise exports. Table 1-3 draws on a regular publication of the Ministry for Primary Industries to present primary industries export revenue for the year ending June 2018. The table also shows the total value of merchandise exports from New Zealand for that twelve months, as recorded by Statistics New Zealand. These data show that the Food and Fibre sector accounts for more than three-quarters of New Zealand's merchandise export revenue. The largest contribution comes from dairy products, which accounts for 30 per cent of all revenue from merchandise exports.

The Food and Fibre sector is therefore essential to New Zealand's economy.

Table 1-2: Value-Added by Selected Processing Industries, New Zealand, Year Ending March 2016

Agriculture, Forestry and Fishing Industries	Value-Added ($ millions)	Percentage Share of GDP
Meat and Meat Product Manufacturing	2,000	0.9
Seafood Processing	512	0.2
Dairy Product Manufacturing	4,240	1.8
Fruit, Oil, Cereal and Other Food Product Manufacturing	2,247	1.0
Beverage and Tobacco Product Manufacturing	2,549	1.1
Textile, Leather, Clothing and Footwear Manufacturing	668	0.3
Wood Product Manufacturing	1,330	0.6
Pulp, Paper and Converted Paper Product Manufacturing	686	0.3
TOTAL FOOD AND FIBRE PROCESSING INDUSTRIES	11,547	6.1
TOTAL GROSS DOMESTIC PRODUCT (GDP) AT FACTOR PRICES	233,138	100.0

Source: StatsNZ Infoshare, Series GDP(P), Nominal, Actual, ANZSIC06 Detailed Industry Group (Annual-March).

Table 1-3: Export Revenue, New Zealand, by Primary Sector Industry excluding Mining, Year Ending June 2018

Primary Sector Industries	Export Revenue ($ millions)	Percentage Share of Exports
Dairy	16,667	30.0
Meat and Wool	9,544	17.2
Forestry	6,400	11.5
Horticulture	5,376	9.7
Seafood	1,778	3.2
Arable	244	0.4
Other Primary Sector Industries	2,707	4.9
TOTAL FOOD AND FIBRE EXPORTS	**42,714**	**77.0**
TOTAL MERCHANDISE EXPORTS	55,490	100.0

Source: MPI (2018, Table 1, p. 2). Total Merchandise Exports comes from StatsNZ Infoshare, Exports – Summary Data - EXP (Annual-June).

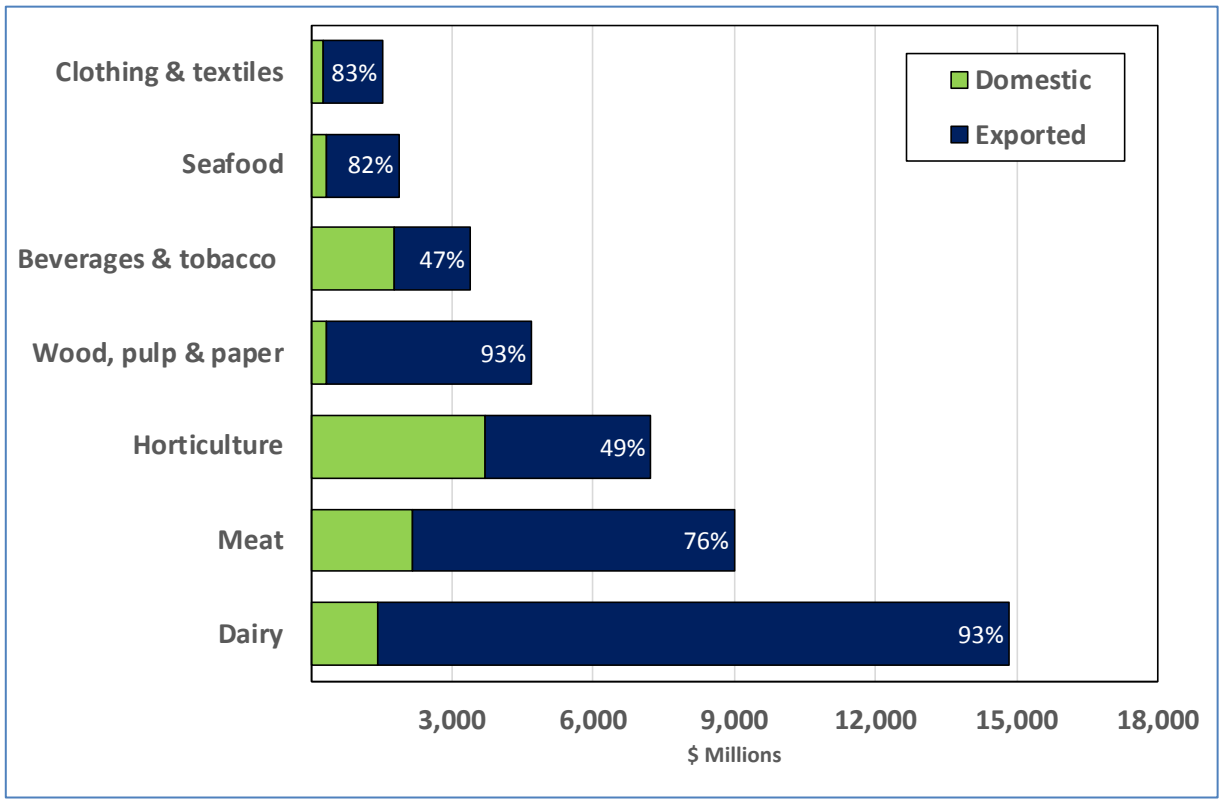
1.2 International challenges impacting on the Food and Fibre sector

A feature of New Zealand's food and fibre sector is that a large share of domestic production is exported. This is shown in Figure 1-1, using input-output data for 2013, which is the latest data currently available. The figure shows the value of sales for final consumption. The proportion exported to overseas consumers is high.

Dairy products are the highest value category (just under $15 billion worth of sales to domestic consumers or for export in 2012/13); the share of exports in final consumption sales was 93 per cent. The next highest category is meat products, where 76 per cent of final consumption sales was exported. The figures for the other categories range from 47 per cent to 93 per cent.

Considering the sector as a whole, the share of Food and Fibre final consumption going to exports in 2012/13 was 76.4 per cent.

Figure 1-1: Value of Final Consumption Sales, New Zealand Food and Fibre Sector, by Product and Location, for the Year Ending March 2013



Source: Authors' analysis based on data reported in Statistics New Zealand (2016).

The strong export orientation of New Zealand's Food and Fibre sector means it is exposed to major changes in world markets. The following bullet points list key examples of current global challenges that are impacting on New Zealand producers and processors.

- Land-based production is contributing to, and will be impacted by, global climate change (OECD-FAO, 2018a, p. 4). In New Zealand, agriculture is the largest sector contributing to gross greenhouse gas emissions (49.2 per cent in 2016, see MfE, 2018a, p. 6). Agricultural productivity is expected to increase in some areas of New Zealand as a result of climate change, but with increased risks of drought, pests and diseases and costs associated with changing land-use activities (MfE, 2018b). The latest report of the Intergovernmental Panel on Climate Change emphasises the requirement for *rapid and far-reaching transitions*, concluding "the next few years are probably the most important in our history" (IPCC, 2018, p. 2).

- The Paris Agreement on climate change aims to keep the global average temperature well below 2° C above pre-industrial levels, while pursuing efforts to limit the increase to 1.5° C. Achieving this will change global patterns of food consumption and production, perhaps dramatically: "Most analysis of stabilising global temperature increases at 2°C or lower includes reducing losses and wastes in the supply chain; changing diets from animal products to plant-based food with equivalent protein content; and a reduction in overconsumption" (Kazaglis *et al*, 2017, p. 18).
- Consumer movements have focused on the environmental impacts of transporting food and fibre over long distances, which can result in New Zealand products being perceived in Northern Hemisphere markets as damaging to the environment (Saunders and Barber, 2008). More generally, "world-class food companies are setting internal standards that are far more stringent than those required by law" (PwC, 2016, p. 13). Important gatekeepers (such as supermarket chains) are adopting high private standards expected by their customers.
- International demand growth is expected to be weak over the next decade, and prices of agricultural commodities are expected to remain low (OECD-FAO, 2018a, p. 15). This challenge is amplified by uncertainties with respect to international trade policies, including policies affecting trade in food and fibre products, and concerns about the possibility of rising protectionism (OECD-FAO, 2018a, p. 16).
- The United Kingdom will exit from the European Union on 29 March 2019, creating opportunities and threats for agriculture in the UK and the EU (Helm, 2017). There will be implications for New Zealand food and fibre exports into the UK, and changed patterns of international trade may affect exports into other markets.
- Consumers globally are demanding higher standards for building trust that food is safe, healthy and good to eat, including requirements for stronger systems of food fraud detection and food traceability, and that production systems meet ethical expectations for responsible innovation, including high animal welfare (PwC, 2016, Dalziel *et al*, 2018b). Federated Farmers and others have recognised "the challenge of maintaining the social licence to farm in New Zealand in the 21st Century" (Rolleston, 2015; see also Farming Leaders Group, 2018).
- Consumers, organisations setting private standards, and regulators controlling market access are increasingly aware around the world that animal-based production systems have adverse environmental impacts (MPI and Plant & Food Research, 2018, p. 3), including on increasing scarce resources such as clean water.

- Companies internationally and in New Zealand are commercialising plant-based substitutes for meat and dairy products that will reduce animal-sourced protein in global diets (MPI and Plant & Food Research, 2018, p. 3; Beef+Lamb New Zealand, 2018a). These disruptive technologies could have a large impact on the demand for New Zealand meat and dairy exports.
- Emerging biotechnologies have the potential to disrupt food and fibre production globally, but New Zealand does not participate in research on some biotechnologies because the country's regulations group all genetic technologies under a single generic heading (Proudfoot, 2018, p. 21).
- Debt burdens carried by producers based on fully-capitalised land values may not be sustainable if production returns become increasingly dependent on how a product is grown, processed and marketed, potentially requiring less rather than more output (Proudfoot, 2018, p. 51).
- Biosecurity incursions of pests and diseases are a persistent threat, amplified by an increased volume of cross-border movements of people and products (MPI, 2016a).

Each of the above bullet points could be the subject of a full chapter in its own right. Nevertheless, it is clear from this list that producers, processors and exporters in the New Zealand Food and Fibre sector are facing many diverse and complex challenges, which will require ongoing transformational change within the sector.

1.3 Changes in the Food and Fibre sector

Significant change in the Food and Fibre sector is already taking place, led by industry initiatives and supported by public sector programmes (Dalziel *et al*, 2018a). This is not a cause for complacency, given the range and scale of challenges facing the sector, but it does mean that a vision for ongoing transformation can build on initiatives already taking place.

An outstanding example of a trans-sector movement promoting a vision for transformation is Te Hono (see https://www.tehono.co.nz/). The Te Hono vision is that New Zealand's primary sector should be "the global primary industry exemplar – economically, environmentally and socially" (Te Hono, 2018a). Its mission is to enable New Zealand primary industry companies to transform from volume to value; that is, "from commodity sales and traditional agribusiness practices to global producers of high value, consumer-centric products and services" (Te Hono, 2018a; see also Brakenridge, 2016, MPI, 2017, p. 16, and Proudfoot, 2018).

Te Hono began when John Brakenridge (CEO, New Zealand Merino), with the support of the Minister of Agriculture and New Zealand Trade & Enterprise, invited a small group of CEOs to participate in the first Te Hono Bootcamp at Stanford University in 2012. It now involves 217 primary sector leaders representing 80 per cent of the primary sector, listed on the Te Hono website (https://www.tehono.co.nz/alumni-profiles). Since 2012, Te Hono has hosted six Stanford Bootcamps and three National Summits.

Te Hono describes itself in the following terms (Te Hono, 2018b):

> ***From our land to the world.***
>
> *A partnership helping to drive the success of the New Zealand primary industry and make Aotearoa, New Zealand, a place where our children and their children want to live, work and thrive.*
>
> *Collaboration, alignment and transformation have been the goals of Te Hono. The movement has brought together a diverse alumni of 220 Chief Executives and leaders who have a deep-seated passion and desire to develop and innovate for transformational change in the New Zealand Primary Sector.*

Another feature of the Food and Fibre sector in New Zealand with transformative potential is the creativity of Māori enterprises in developing distinctive commercial brands in world markets. The Māori economy, defined as privately-owned and collectively-owned businesses acknowledging their genealogical links to Māori ancestors, is estimated to hold $50 billion dollars in assets, including $13 billion in primary sector assets (NZTE, 2017, pp. 42-43). This includes control of 30 per cent of New Zealand's plantation forests, 30 per cent of lamb production, 30 per cent of sheep and beef production, 10 per cent of milk production and 50 per cent of fishing quota (idem, p. 47).

Te Hono and Māori enterprises have the potential to support future transformation across the whole primary sector. There are also important industry initiatives that aim to promote sustainability credentials, both to enhance the value of New Zealand exports and to maintain the Food and Fibre producers' social licence to operate (Rolleston, 2015).

The wine industry, for example, first introduced a sustainability strategy in 1994 (Dalziel *et al*, 2017, chapter 2); by 2016, 98 per cent of New Zealand's vineyard producing area had been certified by Sustainable Winegrowing New Zealand (New Zealand Winegrowers, 2017).

Zespri is another exemplar, "acknowledged as the global leader in the supply and marketing of branded premium kiwifruit" (New Zealand Government, 2012, p. 19; see also Dalziel *et al*, 2017, chapter 3). An important part of the Zespri brand is its commitment to sustainability (Zespri, 2016).

Beef+Lamb New Zealand (2018b) has recently launched the Taste Pure Nature brand platform, which connects its environment strategy – the New Zealand Farm Assurance Programme recently produced under the Red Meat Partnership Programme (see www.nzfap.com) – with its consumer and market insights programme.

Pāmu Farms (the trading name of state-owned enterprise Landcorp Farming Ltd) makes the following promise to its customers and stakeholders (Pāmu, 2018):

> **AT PĀMU, WE'VE SPENT 130 YEARS GETTING TO KNOW NATURE.**
>
> We are Kaitiakitanga – guardians – of nature. The care and respect of nature's lands, animals and people comes first in everything we do.
>
> As creators of the finest natural food since 1886, we are transforming the way food is produced, naturally, with passion, curiosity and innovative fresh thinking.

Organics Aotearoa New Zealand estimates that the total size of the New Zealand organic sector is $600 million, which is an increase of 30 per cent on its estimated size in 2015 (OANZ, 2018, p. 4). Organic exports are up by 42 per cent to $355 million, helping to meet the global demand for organic food that is growing at 10.5 per cent per annum (idem, p. 5).

Table 1-3 records that the dairy industry makes up 30 per cent of New Zealand's merchandise exports by revenue. Fonterra is the world's largest processor and exporter of dairy products, so that its leadership in New Zealand's Food and Fibre sector is paramount. In 2017, Fonterra published its first *Sustainability Report* in accordance with the Global Reporting Initiative (GRI) Standards: Core Option (Fonterra, 2017, pp. 100-103). The report was introduced with a Letter from the Chairman and Chief Executive, which made the following commitment (Idem, p. 2):

> Our Sustainable Co-operative commitment is to support our farmers by investing significantly in the development of new technology and solutions for water quality and on-farm emissions – without impacting production.

The caveat at the end of the commitment illustrates the gap between potential and actual transformation. The commitment to environmental goals in this example is constrained by the commitment to maintain volume targets. The Minister of Agriculture launched a programme in August 2018 that calls for greater transformation (O'Connor 2018b):

> We are moving from volume to value. New Zealand's commodity growth drive has come at the expense of the vital natural resources we need for our primary sector – our soil, water and social license to operate.

Smaller companies are also creating profiles to promote the quality of food and fibre sourced from New Zealand. These are far too many to list, but one example can be offered to illustrate the collaborations between private enterprise and public support.

On 15 October 2018, the HUI Māori Collective was signed in the presence of Hon David Parker and Hon Nanaia Mahuta (NZTE, 2018). It involves 11 Māori businesses exporting premium products, hosted on NZ Post's flagship store on the e-commerce platform Tmall Global (part of the Alibaba Group). This innovative system is underpinned by a world-first verification process (the Food Trust Framework) developed in collaboration between AsureQuality, New Zealand Post and New Zealand Trade and Enterprise for the HUI Māori Collective. It is supported by the FernMark brand, managed by the New Zealand Story Group, which is itself an initiative of the New Zealand Government to support high value exports (https://www.nzstory.govt.nz/).

Public sector support for change in the Food and Fibre sector is reflected in other government programmes. The Ministry for Primary Industries, for example, has adopted an ambition that "New Zealand is the most trusted source of high value natural products in the world" (MPI, 2017b). In keeping with that ambition, MPI developed the *Primary Sector Science Roadmap (Te Ao Tūroa)*, outlining future science needs and opportunities for New Zealand's primary sector. It identified four inter-related areas where the demands of science are critical and rapidly changing (MPI, 2017a, p. 11):

- Sustaining, protecting and adapting our natural resources;
- Growing productivity and profitability with environmental, social and cultural acceptability;
- High-value products for consumers; and
- Integrating primary, production systems, people, communities and values.

The Roadmap explains the opportunity from focusing on high-value products for consumers (idem, p. 16; see also MPI, 2018, p. 3):

> Shifting the balance of our primary production from commodity to high-value products with high marginal return will increase the diversity and complexity of New Zealand's exports. This shift is important for productivity growth and our ability to adapt to the changes and opportunities in global markets. While not a new direction, significant change and innovation will be required if we are to achieve business growth objectives for the sector.

On 21 August 2018, the Minister of Agriculture announced that the Coalition Government was launching the Sustainable Food & Fibre Futures investment programme to fund projects that will help the food and fibre industries "extract more value from what they already do, in a sustainable way that means our natural resources will be there for future generations" (O'Connor, 2018b).

The New Zealand science system is also engaged in this challenge. *Our Land and Water* is a National Science Challenge funded by the government to undertake research that aims "to enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations" (OLW Directorate, 2018, p. 4). A key theme focuses on how global agri-food value chains can create and capture value for New Zealand producers and processors (Saunders *et al*, 2016b).

The examples in this section suggest there are solid foundations for transformational change in New Zealand's Food and Fibre sector. Private sector and public sector leaders have recognised the need for a new vision, to transform from volume to value (Te Hono, 2018a; Brakenridge, 2016; Proudfoot, 2018; Pāmu, 2018; O'Connor 2018b; MPI, 2017a, p. 11; and Saunders *et al*, 2016a). But transformation will require that vision to drive changes across the whole sector, to meet the scale and range of international challenges listed in section 1.2.

These challenges include the urgency of mitigating and adapting to the risks arising from global climate change, as well as responding to new opportunities arising from technological developments and changing consumer expectations. There is no room for complacency.

1.4 Structure of the report

As discussed in the previous two sections, this Situational Analysis is written at a time of considerable challenges in the food and fibre sector, but also great dynamism and innovation. The purpose of the report is to provide a synthesis of existing knowledge that can underpin further work by the Primary Sector Council to develop its long-term vision for the sector. The analysis is presented in three main chapters.

Chapter 2 provides an overview of the importance of the Food and Fibre sector to the national wellbeing of New Zealand, including to the country's ambitions for economic prosperity. This begins with a wellbeing framework for guiding national policy, and then analyses implications for the sector of Treasury forecasts for growth in real gross domestic product to 2060.

Chapter 3 explains some of the key impacts of food and fibre production on the natural environment, outlining some of the risks associated with those impacts. This draws heavily on the five domains listed in New Zealand's Environmental Reporting Act 2015: air, atmosphere and climate; freshwater; land and marine.

Chapter 4 focuses on pathways for value-added transformation, analysed under four inter-related headings:

- Adopting new technologies and sustainable practices;
- Shifting land and water use to higher value outputs;
- Creating high-value consumer goods; and
- Targeting high-value market segments.

The report finishes with a brief conclusion in chapter 5. The range and complexity of the international challenges facing the Food and Fibre sector mean that transformational change is necessary. The initiatives taking place in the private and public sector mean that transformational change is possible. The environmental and commercial potentials from success mean that transformational change is rewarding.

Chapter 2
The Food and Fibre Sector and New Zealand's National Wellbeing

Chapter 1 noted the importance of New Zealand's Food and Fibre sector to the country's economy. This chapter expands on that observation using a framework that reflects the current focus on wellbeing in New Zealand public policy (Robertson, 2018, p. 8). Section 2.1 introduces the framework, concentrating on how national wellbeing is created, measured and sustained. These three components are explained in section 2.2, using examples of the actions, indicators, and capitals most relevant to the Food and Fibre sector.

The wellbeing framework is based on people utilising and sustaining the country's total wealth, categorised into seven types of capital. Four of these (human capital, social capital, economic capital and natural capital) are standard in national wellbeing frameworks. This chapter introduces three further types (cultural capital, knowledge capital and diplomatic capital), drawing on the analysis in Dalziel, Saunders and Saunders (2018).

Section 2.3 discusses reasoned targets for the future contribution of the sector to wellbeing in New Zealand, focusing on its contribution to the national economy. Achieving these targets within environmental constraints will require further transformation of the Food and Fibre sector. Thus this chapter sets the scene for the following two chapters. Chapter 3 will explore environmental sustainability and chapter 4 will analyse value-added approaches for growth.

2.1 A framework for wellbeing analysis

Many countries are constructing wellbeing frameworks for guiding policy and for monitoring trends in personal and community wellbeing. In 2010, for example, the United Kingdom launched *Measuring National Wellbeing* and Italy initiated its *benessere equo e sostenibile* programme. In 2011, Germany created a Commission on Growth, Prosperity and Quality of Life. That developed into a National Dialogue in 2015, which resulted in a wellbeing framework comprised of 12 wellbeing dimensions (Federal Government of Germany, 2017).

New Zealand efforts go back to August 2002, when Statistics New Zealand published a report on *Monitoring Progress Towards a Sustainable New Zealand*. Further work led to a framework for measuring sustainable development constructed around three target dimensions – environmental responsibility, economic efficiency and social cohesion (Statistics New Zealand, 2009a). That framework adopted a capitals-based approach to sustainability that focused on four types of capital: produced and financial capital (or 'economic capital'); natural capital; human capital; and social capital. A companion report presented data on 85 sustainable development indicators, organised under 15 topics (Statistics New Zealand, 2009b).

In 2011, the Treasury introduced its Living Standards Framework (LSF) in a paper entitled *Working towards Higher Living Standards for New Zealanders* (Gleisner *et al*, 2011; see also Gleisner et al, 2012). The designers of the LSF drew heavily on the influential wellbeing framework developed by the Organisation for Economic Co-operation and Development (see OECD, 2017a). Both the OECD framework and the Treasury's Living Standards Framework focus the same four capitals used by Statistics New Zealand (2009). Sustaining or increasing these four capital stocks are recognised as crucial for future wellbeing (Ng, 2018, slides 8-15).

The Treasury's Living Standards Framework is currently undergoing further development, driven at least in part by the Government's focus on wellbeing (Burton *et al*, 2017; King *et al*, 2018). This work has included a report, *Treasury Living Standards Dashboard: Monitoring Intergenerational Wellbeing*, which was commissioned to make recommendations on suitable statistical indicators for monitoring national wellbeing in New Zealand (Smith, 2018).

Figure 2-1 on the following page is based on the above initiatives. It presents a framework for analysing personal and community wellbeing, with three major elements.

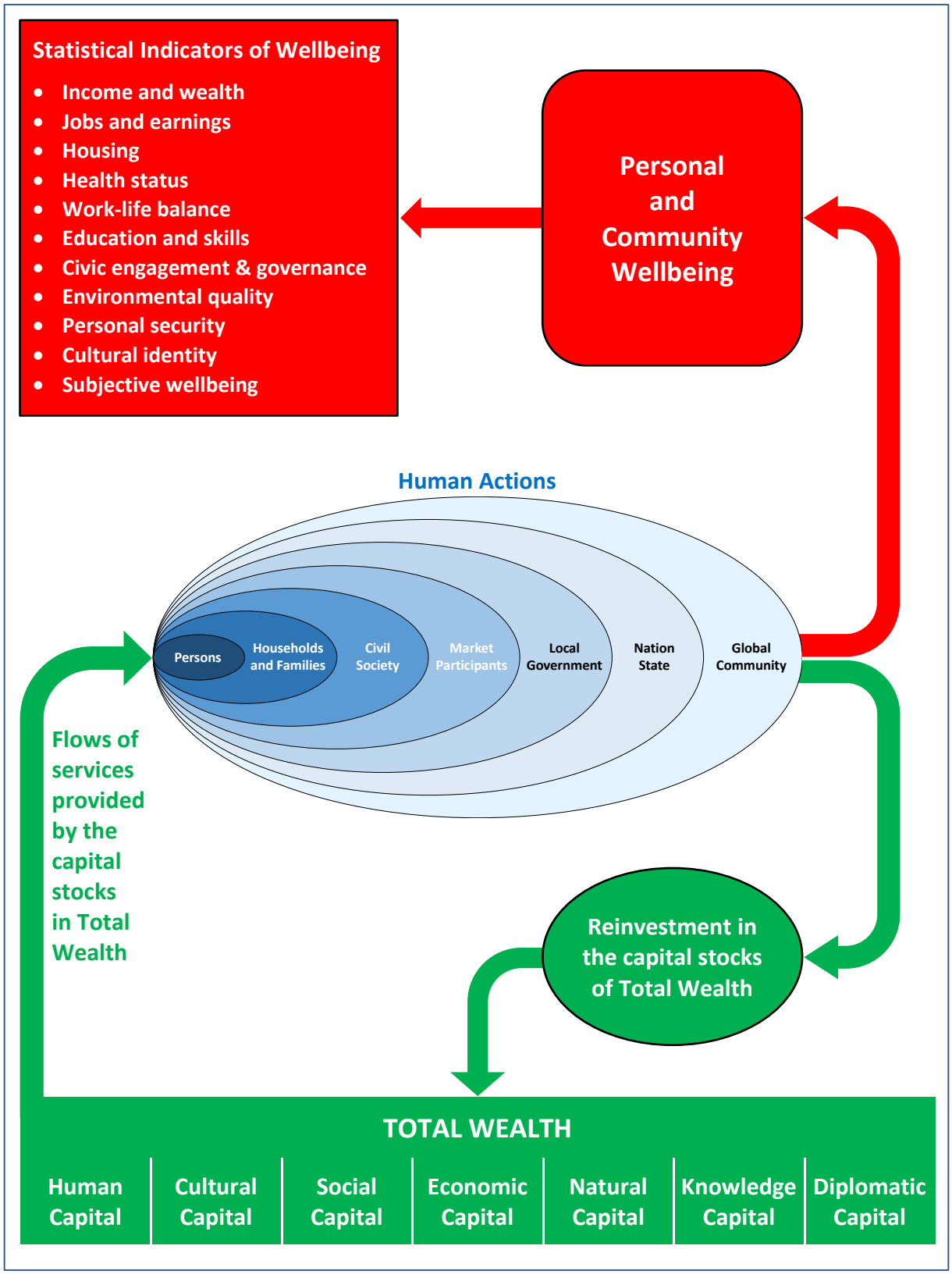
The first element is the country's stock of total wealth, comprised of long-lasting assets providing services that used by individuals and communities to create wellbeing. Figure 2-1 shows seven different types of capital assets: human capital; cultural capital; social capital; economic capital; natural capital; knowledge capital; and diplomatic capital. These are explained in an Appendix to this report, but two points can be noted here. First, the capital stocks provide flows of *services* to people, and it is these services that are important for creating wellbeing. Second, the country must reinvest resources in the capital stocks of its total wealth to sustain and expand wellbeing into future generations.

The second element represents human actions to create wellbeing. The figure recognises that these actions take place at different levels of collaboration, involving larger and larger numbers of people (Dalziel, Saunders and Saunders, 2018, Figure 1.1, p. 12). Some actions are undertaken by individual persons, to reflect their own values and preferences. People form households and families that co-create wellbeing. People engage in institutions of civil society to expand wellbeing through collective actions. Participation in the market economy, both as sellers and buyers of goods and services, can expand capabilities for wellbeing enormously.

In the public sector, local government and the nation state have distinctive capabilities for promoting wellbeing, such as addressing the well-known issues that arise when goods and services have the property of an economic public good or give rise to externalities. Finally, some serious risks to human wellbeing such as global climate change or international terrorism require coordinated responses from the global community.

The third element in Figure 2-1 is the personal and community wellbeing created by human actions. Wellbeing can't be observed directly, but it is possible to create a list of *statistical indicators of wellbeing* that can be monitored for trends over time. Figure 2-1 presents a list of twelve indicators, of which 11 come from the OECD (2017a) wellbeing framework. The item not in the OECD list is *cultural identity*, which is widely adopted in New Zealand frameworks (Statistics New Zealand, 2009b, p. 127; MSD, 2016, p. 175; Ng, 2017, slide 7; and Smith, 2018, p. 25).

Figure 2-1: A Wellbeing Framework



Source: Authors' figure, based on Dalziel, Saunders and Saunders (2018), OECD (2017a) and Ng (2017).

2.2 Creating, measuring and sustaining wellbeing

The framework presented in the previous section can be used to highlight the importance of the Food and Fibre sector to national wellbeing in New Zealand.

The first point to observe is that a large amount of human activity is devoted to the production, processing, transportation, storage, marketing, selling and quality assurance of food and fibre. This activity takes place at every level of human action in Figure 2-1, from each individual person who chooses to develop a career in parts of the Food and Fibre sector to the global institutions that regulate international trade.

The scale reflects the importance of food and fibre for human wellbeing. The United Nations Sustainable Development Goals, for example, has Zero Hunger as its second goal, which it introduces as follows (https://www.un.org/sustainabledevelopment/hunger/):

> It is time to rethink how we grow, share and consume our food. If done right, agriculture, forestry and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centered rural development and protecting the environment.

As that quotation observes, the Food and Fibre sector not only provides nutrition, it can also generate decent incomes. Income and wealth is the first statistical indicator of wellbeing in Figure 2-1. To assess the contribution of the New Zealand Food and Fibre sector to income generation, consider its contribution to gross domestic product (GDP). This can be done using National Accounts input-output tables published occasionally by Statistics New Zealand.

In 2015, for example, AGMARDT, ANZCO, Beef+Lamb New Zealand, Fonterra and Zespri commissioned the AERU at Lincoln University to prepare a research report "assessing the contributions that the agri-food sector has made to the wellbeing of New Zealanders over the decades and in the present day" (Saunders *et al*, 2016a, p. 2). The report used the latest Input-output tables then available (which were for the year ending March 2007) to estimate the importance of the sector to income generation in New Zealand for the latest industry-level data then available (which were for the year ending March 2012).[1]

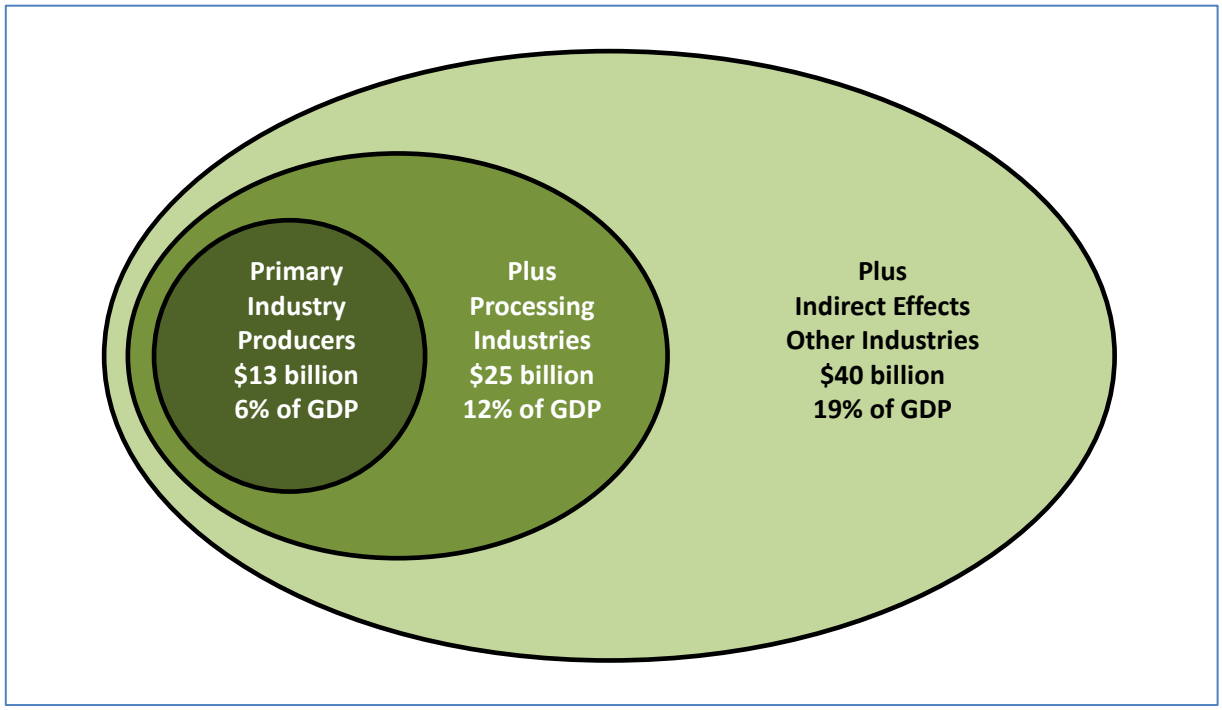
The results are depicted in Figure 2-2. The total value of GDP at factor prices in 2011/12 was $210 billion. This can be thought of as the total market income (excluding indirect taxes) generated in New Zealand that financial year.

The contribution made by the agri-food primary industries (that is, the producers) was $13 billion, or 6 per cent of GDP. The value added by the agri-food processing industries was $12 billion, increasing the contribution to $25 billion, or 12 per cent of GDP. The indirect effects of that activity on the value added of other industries are estimated by the AERU to have been $15 billion, which brings the total contribution to $40 billion, or 19 per cent of GDP.

Thus, for every $5 of income created in the market economy, just under $1 is created in the Food and Fibre sector.

[1] More recent input-output tables are available for the financial year 2012/13, published as Statistics New Zealand (2016), but have not yet been used to update the analysis in Saunders *et al*. (2016a).

Figure 2-2: Contributions of the Agri-Food Sector to Gross Domestic Product, New Zealand, for the Year Ending March 2012



Source: Saunders *et al*. (2016a, Figure 2-7, p. 16).

The second statistical indicator for wellbeing is Jobs and Earnings. Table 2-1 presents data on employment in Food and Fibre production and processing industries as recorded in the 2013 Census. There were just over 2 million employed residents in the Census. This included 129,420 people in the production industries (6.5 per cent of all employment) and 87,945 in the processing industries (4.4 per cent).

Thus, for every 10 jobs in New Zealand, just over one is in the Food and Fibre production and processing industries.

Table 2-2 presents qualifications data from the 2013 Census. People tend to have low-level qualifications in the production industries and in the processing industries. More than one-quarter of both workforces reported having no qualifications, whereas the equivalent ratio for all New Zealand industries was 14.2 per cent. Less than one-third reported qualifications beyond the equivalent of secondary school (Level 3) in the production and processing industries, compared to nearly half for all industries.

It is important to note that the figures in Tables 2.1 and 2.2 do not include employment in the industries providing inputs for the production and processing industries. Some of these may have high levels of qualifications (for example, in the industries providing knowledge-intensive business services to the Food and Fibre sector); nevertheless, implementing production and processing systems that have smaller environmental impacts may require a more highly qualified workforce than is currently available.

Table 2-1: Employment in Food and Fibre Production and Processing Industries, New Zealand, March 2013

Food and Fibre Production and Processing Industries	Number of People Employed	Percentage Share of Employment
Agriculture	105,576	5.3
Aquaculture	822	0.0
Forestry and logging	5,469	0.3
Fishing, hunting and trapping	2,166	0.1
Support services	15,387	0.8
Total Production Industries	*129,420*	*6.5*
Food products	54,024	2.7
Beverage and tobacco products	5,454	0.3
Textile, leather, clothing and footwear	10,506	0.5
Wood products	13,830	0.7
Pulp and paper products	4,131	0.2
Total Processing Industries	*87,945*	4.4
TOTAL PRODUCTION AND PROCESSING INDUSTRIES	217,365	10.9
TOTAL EMPLOYMENT ALL INDUSTRIES	2,001,009	100.0

Source: Statistics New Zealand Census 2013 data, accessed from NZ.Stat, 5 November 2018.

Table 2-2: Distribution of Qualifications in Food and Fibre Production and Processing Industries, and All Industries, New Zealand, 2013

	Production Industries		Processing Industries		All Industries	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
No qualification	31,692	25.6%	23,631	28.2%	273,615	14.2%
Level 1-3	55,083	44.5%	35,676	42.6%	746,598	38.8%
Level 4-6	23,883	19.3%	15,462	18.4%	420,123	21.9%
Bachelor Degree	10,077	8.1%	6,696	8.0%	325,497	16.9%
Postgraduate	3,069	2.5%	2,340	2.8%	156,114	8.1%
Not classified	5,619		4,149		79,059	

Note: The percentage calculations omit the "Not classified' data.

Source: Saunders *et al*. (2016a, Table 2-7, p. 27), using Census 2013 data.

Returning to Figure 2-1, the Food and Fibre sector draws on services provided by the capital stocks making up New Zealand's Total Wealth. To sustain wellbeing, or to expand capabilities for wellbeing in the future, New Zealand must reinvest resources into those capital stocks. This is an important consideration for any sector strategy. This is not part of the brief for this report, but the Appendix gives an overview of the seven capitals and some context of their relevance for the Food and Fibre sector.

2.3 Economic targets for the Food and Fibre sector

The major theme of this chapter is that the Food and Fibre sector is important for wellbeing in New Zealand, including through its contributions to the national economy. Section 2.2 recorded that for every $5 of income created in the market economy, just under $1 is created in the Food and Fibre sector. Further, Table 1-3 in chapter 1 recorded that the Food and Fibre sector accounts for just over three-quarters of New Zealand's merchandise exports.

Given that context, what might be a reasonable benchmark for economic targets for the sector over the next four decades?

A starting point for an answer is the 2016 statement on New Zealand's long-term fiscal position, *He Tirohanga Mokopuna*, produced by the Treasury. This document is a statutory requirement under the Public Finance Act 1989. It includes projections on productivity and economic growth over the following 40 years, as well as "what if" projections of government expenses on items such as healthcare, New Zealand Superannuation, education, law and order and welfare. The projections are connected, of course; if New Zealand is to maintain and improve standards of health, education, retirement income and welfare, then the economy must grow to provide the tax base for quality public services.

The projections for economic growth to 2060 are based on assumptions for three key parameters (Treasury, 2016, p. 16):

- Increases in New Zealand's working age population (population growth);
- Increases in the proportion of the working age population who are employed (changes in the participation rate); and
- Increases in the amount of output produced per employed person (labour productivity growth).

This is a standard neoclassical growth model. It does not explicitly recognise limits that might be imposed by environmental constraints (although these limits can be implicit in the labour productivity growth assumption). The Treasury is aware of these environmental constraints, and chapter 5 of *He Tirohanga Mokopuna* analyses issues concerning natural resources. It recognises that some aspects of New Zealand's natural capital are in decline, with particular pressures on fresh water, soil and biodiversity (Treasury, 2016, p. 48). It acknowledges in the context of freshwater management that "the key issue is how to best support the transition to a world of 'growth within limits'" (idem, p. 50). This report will return to these issues in the following chapter.

The Treasury (2016, p. 18) summarises its projection for economic growth as follows:

> *Looking out to 2060, this Statement projects real GDP growth to average around 2 percent per year*. Taking into account the effects of an ageing population on labour force growth, labour productivity growth is projected to be the main contributor to increases in GDP per capita. For modelling purposes, the Treasury assumes that labour productivity growth will average 1.5 percent per year from the early 2020s, which is broadly in-line with historical averages.

Based on that projection, it is possible to construct scenarios for the future growth path of the Food and Fibre sector, if it maintained its current position in the structure of the national economy. This report focuses on two key points in New Zealand's Food and Fibre value chains: the value added in the primary production sector at the beginning of the value chains, and the revenue earned by Food and Fibre exports as they leave the country. Thus the scenarios are based on the following question:

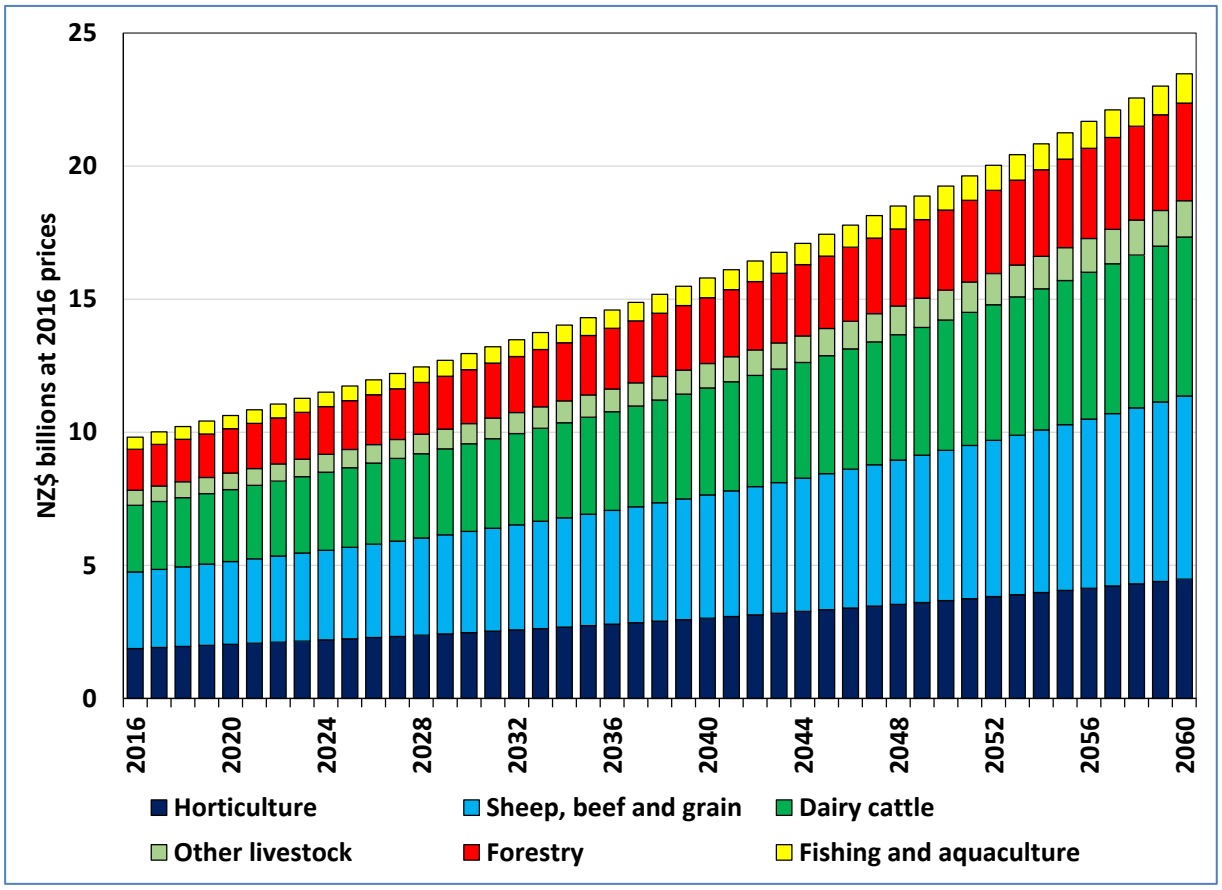
- If the national economy grows at 2 per cent per annum on average, and
- if the Food and Fibre sector maintains its current position in the structure of the national economy, and
- if there are no other changes within the Food and Fibre sector, then
- what is the expected increase in primary sector production in 2060, and
- what is the expected increase in Food and Fibre exports in 2060?

The answers are presented in Figures 2-3 and 2-4. In both cases, the base year is taken to be 2016, which is the latest year for which detailed production data by industry are available.

Figure 2-3 shows projected selected primary sector production from 2016 to 2060. The series does not include Mining or Agriculture, forestry and fishing support services and hunting. The graph shows the selected industries: Horticulture; Sheep, beef and grain; Dairy cattle; Other livestock; Forestry; and Fishing and aquaculture.

In the year ending March 2016, the total value of production in these primary sector industries was $9.8 billion, with $5.4 billion coming from Sheep, beef and grain and from Dairy cattle. If the national economy grows by 2 per cent per annum, then to maintain its share of gross domestic product, the total value of production in these primary sector industries will need to reach $23.5 billion by the year ending March 2060. This is an increase of 139 per cent.

Figure 2-3: Projected Selected Primary Sector Production, New Zealand, 2016-60



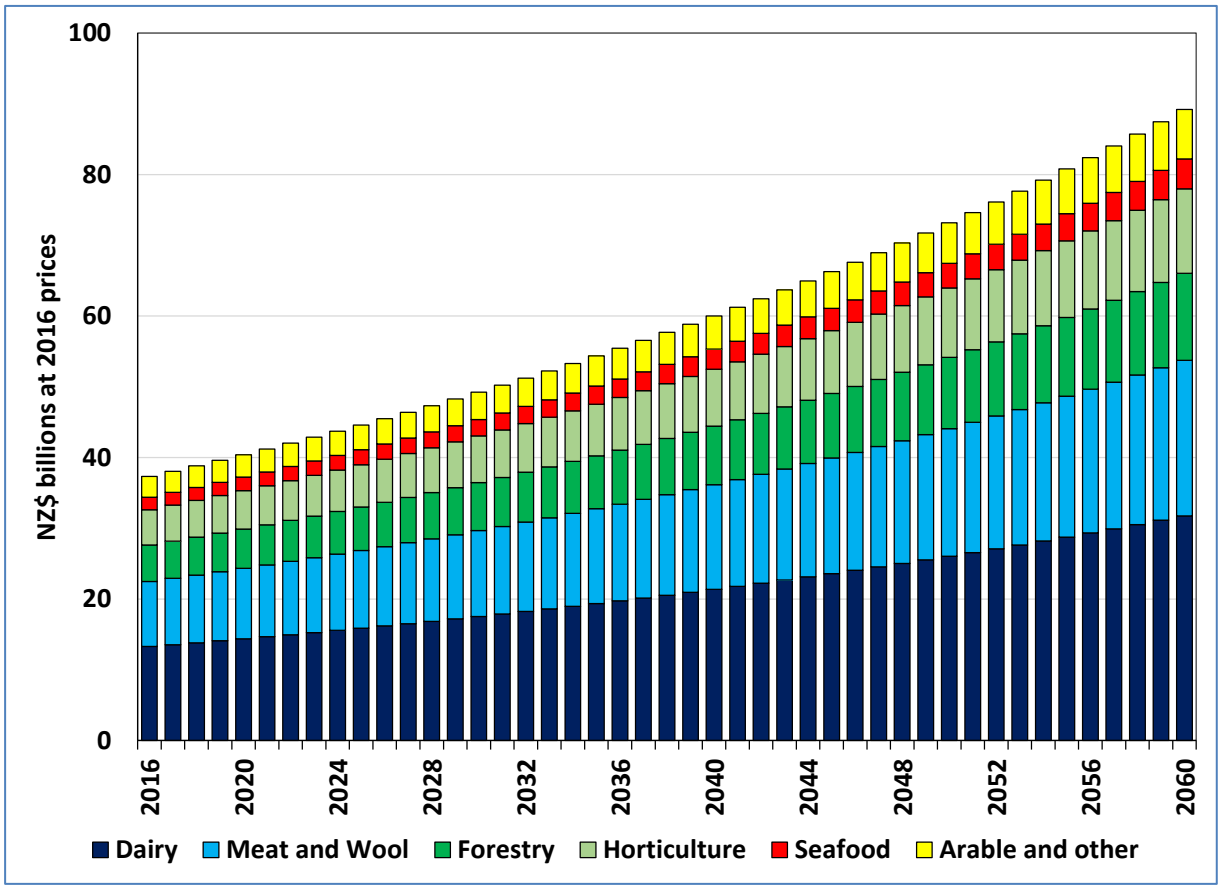
Source: Authors' calculations based on Statistics New Zealand (2017) data for 2016.

Figure 2-4 repeats the analysis for export revenue. In the year ending March 2016, the total revenue from Food and Fibre exports was $37.3 billion, with just over one-third ($13.3 billion) coming from Dairy products. If the national economy grows by 2 per cent per annum, then to maintain its share of gross domestic product, the total revenue from these primary sector industries will need to reach $89.2 billion by the year ending March 2060. By construction, this is again an increase of 139 per cent.

The reasoning behind these conclusions is straightforward. Any statistical series that increases by 2 per cent per annum will double its value after 35 years. In the example of this section, this implies that primary sector production, and Food and Fibre exports, would have to double by 2051, if nothing else changed.

Of course, the central theme of this situational analysis is that the Food and Fibre sector needs to transform itself, *from volume to value*. This is an implicit recognition that a doubling in the volume of primary sector production is not feasible, given the impact that this production is currently having on the environment. This is documented in the following chapter.

Figure 2-4: Projected Selected Food and Fibre Export Revenue, New Zealand, 2016-60



Source: Authors' calculations based on MPI (2018) data for 2016.

Chapter 3
The Food and Fibre Sector and the Environment

This chapter provides evidence on the impact of the food and fibre sector on the natural environment. This is important for its own sake, since environmental quality is one of the key statistical indicators of wellbeing listed in the wellbeing framework of Figure 2-1 in the previous chapter. This recognises that environmental standards are important to citizens, including farmers, orchardists and other people involved in primary sector production. As listed in chapter 1, it is also apparent that consumers of food and fibre in international markets are increasingly expecting that sustainable environmental standards are maintained in the production, processing and distribution of food and fibre products.

The chapter follows New Zealand's Environmental Reporting Act 2015, which requires the Secretary for the Environment and the Government Statistician jointly to produce and publish reports on New Zealand's environment covering five domains:

- Air
- Atmosphere and climate
- Freshwater
- Land
- Marine

To date there has been at least one domain report published for each of these headings (MfE and Stats NZ, 2014, 2016, 2017a, 2017b, 2018a and 2018b), plus a synthesis report (MfE and Stats NZ, 2015). The following sections of this chapter draw on these reports, supplemented by other material (for example, OECD, 2017b, and NZPC, 2018), to discuss in turn how each of the five domains is affected by the Food and Fibre sector. The final section then gives a brief summary to set the scene for chapter 4.

Some preliminary caveats should be noted.

First, the focus of the chapter is on the Food and Fibre sector, but this does not imply that this sector is the only, or even primary, cause of environmental issues in New Zealand. A wide range of human activities impact on the natural environment. This includes urbanisation, for example. Between 1996 and 2012, urban land area in New Zealand increased by 10 percent, driven in part by population growth and involving the loss of some high-class agricultural land (MfE and Stats NZ, 2018a, p. 58). Urban run-off and modification of water bodies are degrading water quality (MfE and Stats NZ, 2017a, p. 31). Most exposure to particulate matter in the air occurs in urban areas (MfE and Stats NZ, 2018b, p. 29).

Second, following the example of the data sources used, most of the discussion in this chapter concentrates on primary sector production. The processing industries also have an impact on the environment, however, and there are also environment issues associated with the storage and transport of Food and Fibre products. The "Food Miles" controversy illustrates how some consumers can be sensitive to concerns about emissions associated with long-distance agri-food value chains (Saunders and Barber, 2008).

Third, this chapter examines environmental constraints on production of food and fibre. Consequently, the focus is on trends that indicate deteriorating environmental impacts, but there have also been some positive trends. For 277 monitoring sites of water bodies in the pastoral class, trends in dissolved reactive phosphorus between 2004 and 2013 were improving at 57 per cent of sites, compared to 15 per cent of sites where the trend was worsening (the remainder were indeterminate; MfE and Stats NZ, 2017a, p. 46).

3.1 Air

The MfE and Stats NZ (2018b) report on *Our Air 2018* notes three potential issues of air quality and agriculture.

- An increase in particulate matter pollution can damage vegetation, decrease biodiversity and reduce yields (idem, p. 26).
- Intensification of farming through greater use of fertiliser and conversions to dairy farms is known to increase the amount of ammonia emitted to the air, which can acidify soil and cause changes in biodiversity by creating nutrient imbalances (idem, p. 54).
- Agricultural biomass burn-offs are associated with black carbon pollution (soot), which can cause health problems (idem, p. 55).

In all three examples, the report notes gaps in the scientific knowledge of the extent of the problem, so that more research would be needed to identify whether these potential issues require policy attention.

3.2 Atmosphere and climate

The domain report on *Our Atmosphere and Climate 2017* begins by observing that the dominant issue in this domain is human-induced climate change (MfE and Stats NZ, 2017b, p. 4). New Zealand's share of global greenhouse gas emissions is small (0.17 per cent) but among OECD countries New Zealand has the second highest level of emissions relative to GDP and the fifth highest level per person (idem, p. 17). The country's annual average temperature has increased by 1 degree Celsius since 1909, which is in line with global patterns (idem, p. 7). The report warns (ibid):

> Climate change is already potentially irreversibly affecting New Zealand's natural systems. We can expect more severe effects on the environment and our human systems as the climate continues to change.

Consequently, this section discusses two issues: the contribution that the Food and Fibre sector is making to the country's greenhouse gas emissions; and the potential impact that climate change may have on primary sector production in New Zealand.

With respect to the former, MfE and Stats NZ (2017b, p. 17) report provides a summary of New Zealand's emissions.

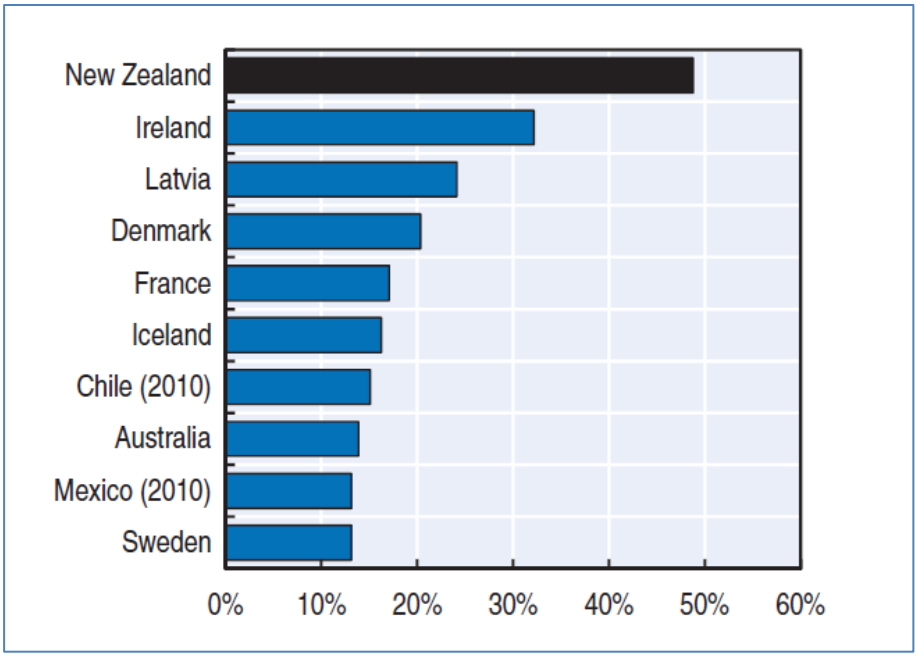
> Over the period 1990 to 2015, New Zealand's gross and net greenhouse gas emissions increased 24 and 64 percent respectively, although most of the increase in gross emissions occurred by 2005.
>
> Net emissions take into account the carbon dioxide absorbed by forests and then released when the trees are felled. The large increase in net emissions is the result of increases in gross emissions combined with higher logging rates in production forests (Ministry for the Environment, 2017a).
>
> Population growth and increased domestic production have driven the increase in gross emissions since 1990 (Ministry for the Environment, 2017a). Most of these increases came from agricultural production and road transport. Agricultural emissions from livestock digestion (mostly methane) rose 5 percent, while emissions from agricultural soils (mostly nitrous oxide from nitrogen fertiliser use and excrement from grazing livestock) rose 51 percent. Road transport emissions (mostly carbon dioxide) rose 78 percent (see table 1 [not reproduced here]).
>
> The increased agricultural emissions were mainly due to increased dairy production and were partly offset by a drop in emissions from sheep as a result of reduced sheep numbers. Increasing emissions from energy generation have been moderated by an increase in the share of energy from renewable sources (Ministry for the Environment, 2017a).

New Zealand is unusual internationally because a high proportion of its gross greenhouse gas emissions come from agricultural production. This is in part because a very high proportion of New Zealand's energy requirements come from renewable resources. Figure 3-1 on the following page shows the top ten OECD countries for contribution from agriculture to the country's greenhouse gas emissions. New Zealand is easily the highest in that list, with just under 50 per cent. The OECD (2017b, p. 67) comments:

> New Zealand has an unusual emissions profile, with nearly half of its emissions coming from agriculture (Figure 1.8). This is the highest share in the OECD, reflecting the importance of agriculture, including food and livestock production, in the economy. Most of the agriculture-related emissions are biological emissions, mainly methane (CH_4) from ruminant cattle (enteric fermentation) and nitrous oxides (N_2O) from animal waste and fertilisers.

Another feature of the New Zealand Food and Fibre sector, however, is that "New Zealand is among the most efficient producers in the world" in terms of emissions intensity (Kerr, 2016, p. 15). Consequently, efforts by New Zealand to help improve the efficiency of food producers in countries with similar farming systems (parts of Brazil, Chile and Columbia, for example) "could lead to larger global emission reductions than could ever be achieved within New Zealand" (idem, p. 30).

Figure 3-1: Contribution of Agriculture to Greenhouse Gas Emissions, Top Ten OECD Countries, 2014



Source: OECD (2017b, Figure 1.8, p. 69).

Manaaki Whenua (2018) notes that "the release of methane gas from ruminant livestock (sheep and cattle) amounts to almost 1/3 of New Zealand's greenhouse gas emissions, and it is the largest contributor". There is a clear scientific connection between methane emissions and global warming. A recent report to the Parliamentary Commissioner for the Environment from the New Zealand Agricultural Greenhouse Gas Research Centre, for example, reported three main findings on this connection (Reisinger, 2018, pp. 4-5):

> The main finding from this study is that if New Zealand were to hold its livestock methane emissions constant at 2016 levels, the amount of methane in the atmosphere due to those emissions would level out within a decade, but warming from this methane would still increase for well over a century, albeit at a gradually declining rate. …
>
> If New Zealand's methane emissions were held constant from today onwards, the additional warming in 2050 would be about 10-20% above the warming that has been caused by New Zealand's methane emissions to date. By 2100, the additional warming would increase to about 25-40%, and to about 40-55% by 2200. …
>
> If New Zealand wished to ensure that its livestock methane emissions cause no additional future warming relative to the warming caused by those emissions to date, it would have to reduce those methane emissions by about 10-22% below current levels by the year 2050, and 20-27% by 2100.

That report concluded that "New Zealand might wish to reduce its methane emissions by more than the 10-22% range indicated in this report to reduce the overall contribution from this gas to global warming below where it is today", while recognising that such a decision would "depend on complex judgments about the economic, social and environmental consequences of such reductions" (idem, p. 35).

The Prime Minister's Chief Science Advisor has noted that New Zealand faces some unique challenges, since agriculture has fewer options to make large emissions reductions quickly and cost-effectively compared to the power and transport sectors (Gluckman, 2018, p. 5). He describes five main strategies (idem, p. 6):

- On-farm land-use decisions that reduce GHG emissions per unit of land area or increase carbon sinks – including forestry and other tree plantings, and horticulture blocks.
- Feeding practices, grazing and pasture management – including forage selection and the balance between stocking rates per hectare and individual performance per animal.
- Animal husbandry including breeding for high genetic merit in terms of breeding, productivity and emissions profiles.
- Animal housing and effluent management
- Precision-farming techniques – including irrigation and fertiliser management.

Afforestation, which is part of the Food and Fibre sector, offsets greenhouse gas emissions from other sources. In recent years, however, afforestation in New Zealand has been outweighed by deforestation (OECD, 2017b, p. 21):

> By removing carbon dioxide from the atmosphere, forests help us meet our net emissions reduction commitments. However, this is only effective if the forest area increases to match our increasing emissions. Almost every year since 1990, additional land around New Zealand has been planted in new forests, but this has not been enough to balance the amount of deforestation that has taken place over the same timeframe. From 2006 to 2015, there was about twice as much deforestation (120,115 hectares) as afforestation (64,207 hectares).

The potential impacts of global climate change on Food and Fibre production is difficult to predict, especially since it is not yet clear what the scale of climate change will be after international mitigation efforts. One likely impact is that producers are likely to face greater climate variability and climate events such as droughts and floods (Kenny, 2001; NIWA, 2013; Ernst & Young, 2018). Impacts might be positive and negative in different parts of the country (OECD, 2017b, p. 41):

> Soil moisture and drought is one indicator of a range of potential future impacts for agriculture and other primary industries. Impacts are regionally and locally specific and may be both positive and negative. Alongside drought, for example, impacts may include: change in yield and quality of pasture, trees, broad-acre crops (such as wheat, barley, oats), and pasture species; changes in pressures from weeds, pests, and diseases; stress on animals and plants from increased warm days (above 25 degrees Celsius); and water shortages and increased irrigation demand (Clark *et al*, 2012).

3.3 Freshwater

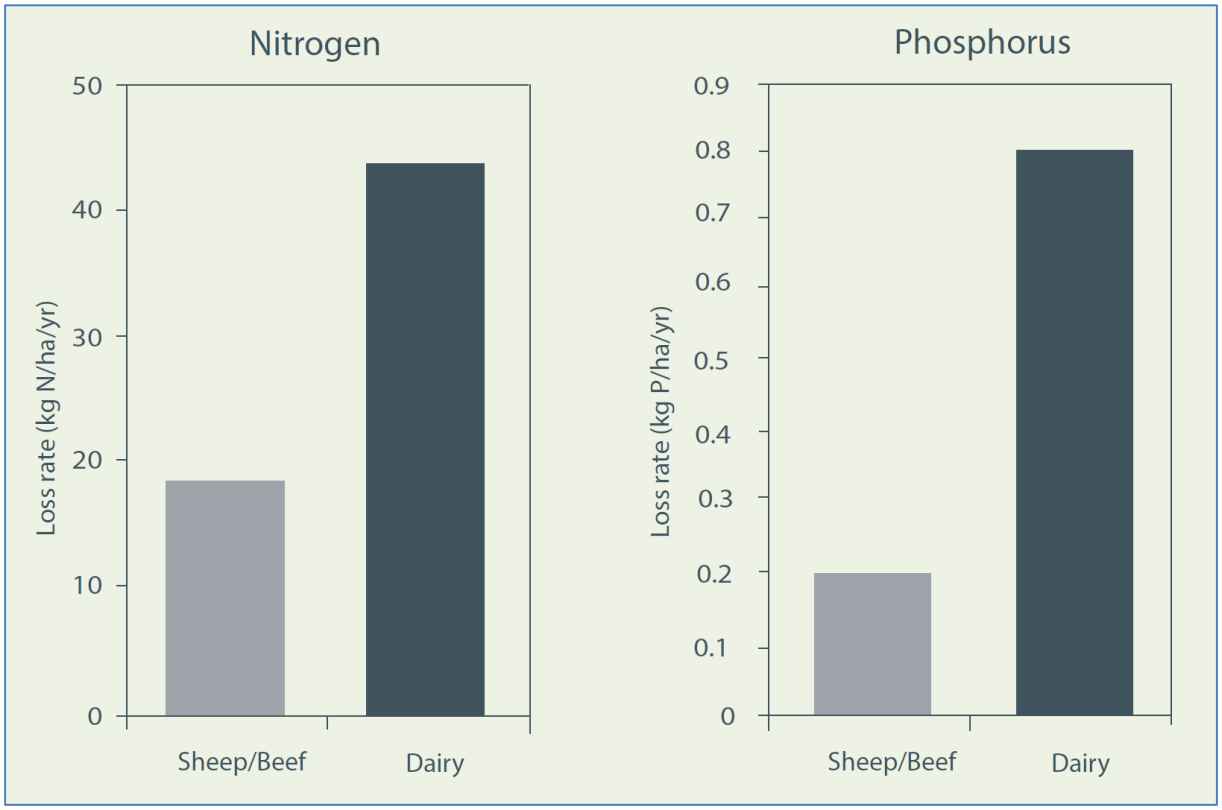
Water is a crucial input into primary production systems. In 2013-14, for example, 51 per cent of New Zealand's total consented water value (excluding hydroelectric use) was allocated for irrigation (MfE and Stats NZ, 2017a, p. 13), which has provided greater reliability of production, increased yields and improved quality of production (idem, p. 62, citing Corong *et al*, 2014).

Freshwater is also one of the most high profile environmental issues in New Zealand. This is reflected, for example, in the government's report *Essential Freshwater: Healthy Water, Fairly Allocated*, published in October 2018. It has three objectives: stopping further degradation and loss; reversing past damage; and addressing water allocation issues (New Zealand Government, 2018, p. 7).

Primary production can have negative impacts on the quality of local water bodies. Altered flows as a result of taking water from rivers for irrigation, for example, can impact on downstream ecological processes with harmful consequences (MfE and Stats NZ, 2017a, p. 61). It has been estimated, to give another example, that 137 million kilograms of nitrogen was leached from agricultural soils in 2012, which is an increase of 29 per cent above the level in 1990 (idem, p. 29).

The science of how excessive levels of nutrients – especially nitrogen and phosphorus – can diminish water quality is well understood (Wright, 2012, chapter 5). An implication, however, is that land use changes can have a profound impact on the quality of freshwater. This was demonstrated in 2013 when the Parliamentary Commissioner for the Environment brought together two models, Land Use in Rural New Zealand and Catchment Land Use for Environmental Sustainability, to analyse how a shift towards dairying was affecting nitrogen and phosphorous leaching into waterways (Wright, 2013).

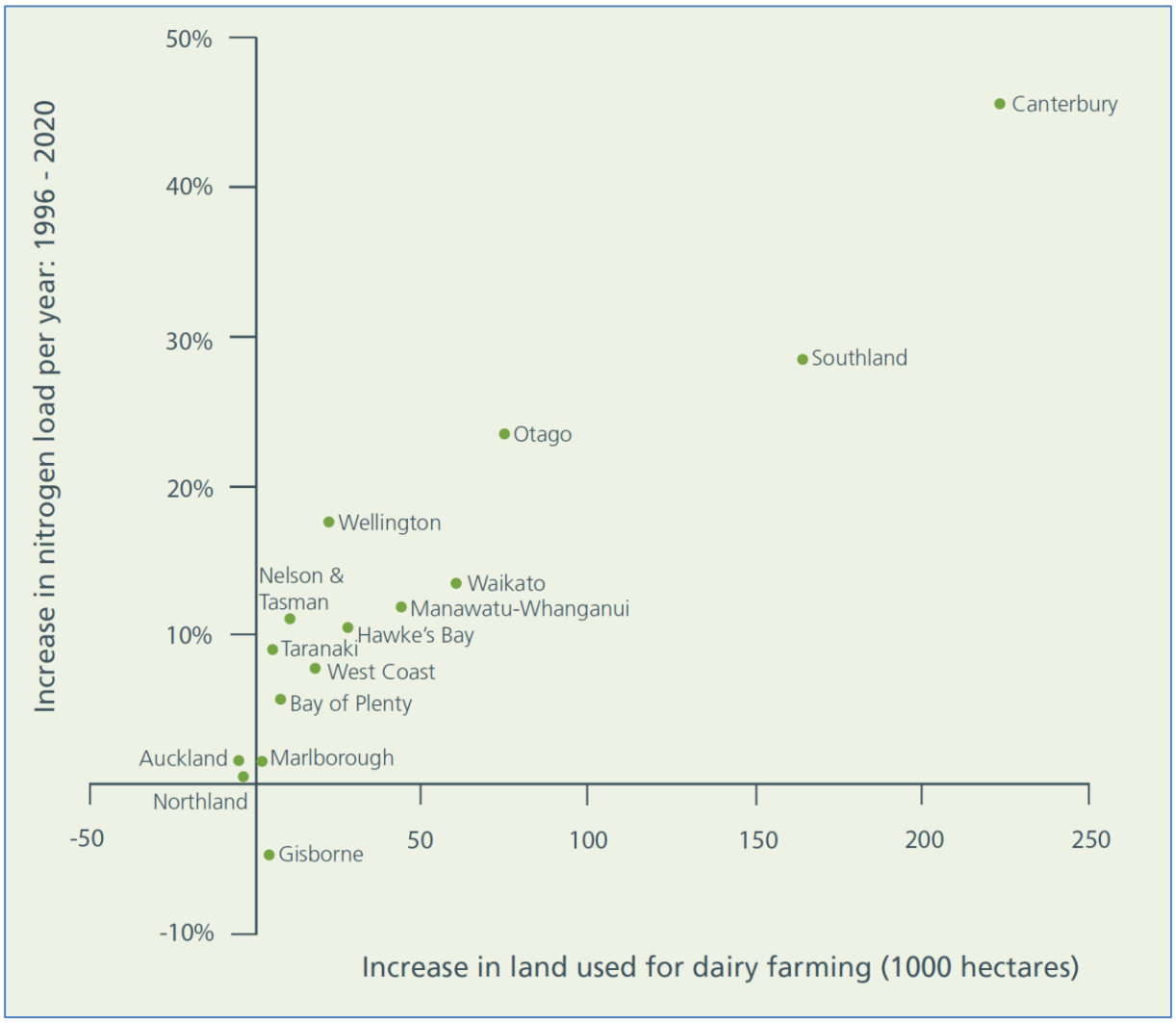
Figure 3-2: Nitrogen and Phosphorus Loss Rates on Alluvial Soil in Canterbury, Intensive Sheep/Beef Farm versus Intensive Dairy Farm



Source: Wright (2013, Figure 4.4, p. 37).

The result of the analysis is presented in Figure 3-2 on the previous page and Figure 3-3 below. Figure 3-2 shows that nitrogen and phosphorus loss rates increased by an order of magnitude in a conversion of an intensive sheep/beef farm on alluvial soil in Canterbury to an intensive dairy farm. Figure 3-3 translates that observation into the implications for nitrogen loads, which are positively correlated with dairy farming expansion, particularly in Canterbury and Southland.

Figure 3-3: Modelled Increases in Land Used for Dairy Farming and Nitrogen Load, Regional Averages, New Zealand, 1996 to 2020



Source: Wright (2013, Figure 7.1, p. 76).

This example illustrates how land use changes can have large consequences for water quality. It is not only farm conversions that have this feature. The above report noted that increasing physical output per hectare can be achieved in two ways (Wright, 2013, p. 42):

- Increasing inputs, such as fertiliser, supplementary feed, and water; or
- Using inputs more efficiently, perhaps by improving genetics or adopting precision agriculture techniques for water and fertiliser.

The former is generally associated with greater nutrient losses, and had been the major driver of a 60 per cent productivity gain in dairy farming over two decades (ibid).

Returning to the wellbeing framework in Figure 2-1, the increase in outputs might be expected to increase wellbeing, but the greater adverse environmental impacts call for a higher level of reinvestment in natural capital. This can take the form of mitigation practices that may be costly. Wright (2013, pp. 44-47) gave examples of mitigation practices adopted by dairy farmers. In 2013, industry stakeholders launched Sustainable Dairying: Water Accord, which is a set of national good management practice benchmarks to lift environmental performance on dairy farms (DairyNZ and DCANZ, 2016).

The Parliamentary Commissioner for the Environment updated her report two years later (Wright, 2015). This recognised the range of mitigation techniques increasingly used on dairy farms to reduce nutrient losses, but found that these were not sufficient to keep nitrogen losses constant, let alone reduce them (idem, pp. 11-12). She concluded that the dairy industry continued to face some big challenges (idem, p. 22).

3.4 Land

Following on a major theme in the previous section, the recent report in New Zealand's environmental reporting series that focused on land noted four significant land use changes in the last two decades (MfE and Stats NZ, 2018a, p. 6):

- expansion in urban areas (a 10 percent increase between 1996 and 2012), and accompanying loss of some of our most versatile land
- reduction in the area of land in agricultural production (7 percent decrease between 2002 and 2012)
- increase in the proportion of farmland used for dairy (42 percent increase in area between 2002 and 2016), and a decrease in the area in sheep and beef (20 percent reduction between 2002 and 2016)
- continued intensification of farming, including a shift in the past 15 years to higher stocking rates, especially for dairy.

The report found "that the state of our biodiversity and ecosystems and our soil resources is continuing to decline" (idem, p. 7). An important example is that soils are affected by erosion and intensifying agriculture, summarised in the following six bullet points (idem, pp. 8-9):

- New Zealand has naturally high rates of erosion, due to a combination of steep terrain, rock and soil types, and climate. Erosion can be accelerated when tree cover is removed. Erosion models comparing soil loss to water with land cover types show 44 percent of the soil that enters our rivers each year comes from pasture (exotic grassland). This is equivalent to 84 million tonnes of soil out of the 192 million tonnes estimated lost each year.

- Soil monitoring programmes in 11 regions across the country between 2014 and 2017 show that results for 83 percent or more of tested sites were within target range for five of the seven indicators (pH, total carbon, total nitrogen, mineralisable nitrogen, bulk density). However, the remaining two indicators give reason for concern.
- More than 48 percent of tested sites were outside the target range for two indicators of soil quality: phosphorus content (an indicator of soil fertility) and macroporosity (a measure of how many pore spaces there are in the soil, which is an indicator of the soil's physical status).
- Of tested sites, 33 percent had soil phosphorus levels that were too high. Excess phosphorus can travel into waterways through erosion and run-off, where it can trigger growth of unwanted plants and reduce water quality.
- Of tested sites, 44 percent were below the target range for the macroporosity soil indicator (indicating soil compaction). Soil compaction makes soil less productive, and can reduce soil biodiversity and restrict plant growth. As compaction impedes drainage, it can also result in increased greenhouse gas emissions from urine on soils, and an increased amount of phosphorus and eroded soil reaching waterways.
- Sites under more intensive land uses, such as dairy, cropping and horticulture, and dry stock, were more frequently outside the target range for these two soil quality indicators. In particular, 51 percent of tested dairy sites had excess soil phosphorus and 65 percent of tested dairy sites were below the target range for macroporosity. Some horticultural and cropping sites also had high phosphorus levels (37 percent) and low macroporosity levels (39 percent). Drystock sites also had low macroporosity levels (41 percent).

The Ministry for Primary Industries has recognised the importance of better land and soil management, not just by officials but also by businesses, landowners and the general public (MPI, 2015). It has identified four overarching pressures (idem, p. 7):

- Agricultural intensification, identified as a production increase per unit of land area;
- Land use changes, including urban expansion, farm conversions and poor matching of land use to inherent capability;
- Climate change, resulting in hotter, drier conditions, intense rainfall events, sea level rise and high concentrations of carbon dioxide; and
- Legacy effects from significant land modification through forest clearance, land development, fertiliser application and cultivation.

The analysis in the report concludes (idem, p. 14):

> In the coming years it will be crucial to avoid making decisions on land use that can have long-lasting or irreversible impacts on the ability of soils to provide services. Such a shift in approach could result in a reduction in key pressures and better realise the full potential of New Zealand's soils.

3.5 Marine

New Zealand's environmental reporting series published a report on the country's marine environment in 2016 (MfE and Stats NZ, 2016). It emphasises three top issues (idem, p. 7):

- Global greenhouse gas emissions are causing ocean acidification and warming.
- Native marine birds and mammals are threatened with extinction.
- Coastal marine habitats and ecosystems are degraded.

There is uncertainty about the full implications of ocean acidification, but it could cause widespread changes to marine ecosystems and affect harvested species such as pāua, mussels, and oysters (idem, p. 23 and p. 24). Ocean warming may change the distribution of wild fisheries and aquaculture species, with the possibility of challenges and opportunities for New Zealand's fishing and aquaculture industries (idem, p. 25).

At sea, the main source of human-related pressures on seabirds are bycatch from commercial and recreational fishing and marine pollution. Bycatch of seabirds is decreasing but a major cause of death for some species (idem, p. 29).

Land-based practices can damage coastal marine habitats and ecosystems. Examples include: excess transfer of sediment from land into waterways; excess nutrients (especially nitrogen and phosphorous) washing down waterways into estuaries and coastal waters; run-off from roads and other sources containing heavy metals; and sewage pollution (idem, pp. 39-41).

The report did not have sufficient data to draw firm conclusions about the full ecological impacts of commercial, recreational, and customary fishing on coastal and open ocean ecosystems. Nevertheless, it did make some observations (idem, pp. 51-53):

- New Zealand's most destructive commercial fishing methods have decreased.
- New Zealand's commercial fish stocks are managed with the aim of ensuring future harvests (the Quota Management System).
- In 2015, 17 per cent of New Zealand's fish stocks were assessed as being overfished, requiring active management intervention to rebuild stock; this can be compared to 29 per cent of fish stocks overfished worldwide.
- In 2015, 78 per cent of the total landings of fish by weight and value came from stock of known status.

3.6 Summary

In recent years, producers have increased agricultural productivity through greater input use and significant land-use changes to higher value products. This enterprise has contributed to regional and national economic growth, but this chapter has demonstrated systemic impacts that damage freshwater quality and soil quality, as well as contributing to greenhouse gas emissions causing climate change.

Chapter 2 observed that, *if nothing else changed*, for the Food and Fibre sector to retain its share in the growth New Zealand economy, the volume of its production would have to double by 2051. This chapter has demonstrated this is not possible, given the environmental limits impacting on primary sector production. Hence change is required, on a large scale.

The income, wealth, jobs and earnings created in the Food and Fibre sector are important for the wellbeing of New Zealanders, but so is the quality of the country's natural environment. The following chapter therefore provides a survey of four approaches that are being used to address the challenge of moving from volume to value within environmental boundaries.

Chapter 4
Value-Added Transformation

The previous two chapters has set out the challenge facing New Zealand's Food and Fibre sector. To maintain its share in meeting economic growth targets, the sector must double its export revenue by 2051 (chapter 2), but primary sector production is already creating environmental issues that could not sustain such an expansion without a transformation of current practices in the sector (chapter 3). As the Treasury observes in its recent statement on New Zealand's long-term fiscal position, "the key issue is how to best support the transition to a world of 'growth within limits'" (Treasury, 2016, p. 50).

The importance of this issue has been explicitly recognised by the creation of a National Science Challenge, *Our Land and Water – Toitū te Whenua, Toiora te Wai*, devoted to the following mission: "To enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations" (see its website at www.ourlandandwater.nz/the-challenge/).

If the goals are to increase the economic value of the Food and Fibre sector and to reduce the sector's negative impacts on the natural environment, there are a small number of possibilities that can achieve both goals simultaneously. This chapter focuses on four.

- Adopting new technologies and sustainable practices that will allow increased production with a lower negative impact on the natural environment.
- Shifting land and water use to products that have a higher economic value and a lower negative impact on the natural environment.
- Using the outputs of the primary sector to manufacture food and fibre products that are more highly valued by consumers.
- Using knowledge-intensive business services to target high value market segments in global agri-food value chains.

The first four sections of this chapter considers current initiatives in New Zealand under each of these headings. The chapter finishes with a brief section on fostering leadership in the Food and Fibre sector, both in the current generation and in future generations.

4.1 Adopting new technologies and sustainable practices

The importance of discovering and adopting new technologies that can increase yields and reduce environmental impacts has been long recognised. An often-cited review in *Nature* published in 2002, for example, presented the issue using language similar to that used in this report (Tilman *et al*, 2002, p. 671):

> A doubling in global food demand projected for the next 50 years poses huge challenges for the sustainability both of food production and of terrestrial and aquatic ecosystems and the services they provide to society. Agriculturalists are the principal managers of global useable lands and will shape, perhaps irreversibly, the surface of the Earth in the coming decades. New incentives and policies for ensuring the sustainability of agriculture and ecosystem services will be crucial if we are to meet the demands of improving yields without compromising environmental integrity or public health.

The review described this as "one of the greatest scientific challenges facing humankind because the trade-offs among competing economic and environmental goals, and inadequate knowledge of the key biological, biogeochemical and ecological processes" (idem, p. 672). It concluded that achieving the goal of sustainable agriculture "will require increased crop yields, increased efficiency of nitrogen, phosphorous and water use, ecologically based management practices, judicious use of pesticides and antibiotics, and major changes in some livestock production practices" (idem, p. 676).

Internationally, the direction that technological progress takes – which is influenced by strategies, policies, programmes and other actions, is recognised as one of the key drivers of progress towards sustainability of food and agricultural systems. A recent analysis by the Food and Agriculture Organisation of the United Nations described the required innovation in the following terms (FAO, 2018, p. 52).

> Boosted investment ensures the transition towards a more sustainable use of natural resources and climate change mitigation compared to BAU [business as usual]. Low-input precision agriculture, agroforestry, intercropping, and organic agriculture and/or other resource and climate-friendly production methods contribute to moving towards "circular" economies, that is economies based on reusing goods and recycling waste, with limited impacts on ecosystems. Chemical use overall is restrained: for example, regulations on nitrate usage or fertilizer quantity and type are in place, which favours precision and/or organic agriculture. Food systems generating low GHG emissions are favoured, and fresh food consumption is promoted. Consumers receive information on the origin, content, quality, and sustainability levels of processed food. Adopting conservation agriculture, agro-ecological approaches, agroforestry, and other environmentally-friendly techniques allows yields to increase against current levels – albeit more moderately than under BAU – and to converge across countries, while food systems drastically reduce GHG emissions compared with current levels. Greater crop diversification and integrated pest management approaches strengthen resilience to shocks. Agricultural prices rise worldwide, reflecting both pressure on demand and the adoption of sustainable production practices.

In New Zealand, there are a number of science programmes that are aiming to create new knowledge that will reduce negative environmental impacts from the production of food and fibre.

As noted at the beginning of this chapter, the Our Land and Water National Science Challenge mission is "to enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations". It has organised its science programmes around three themes, one of which is called "Innovative, resilient land and water use www.ourlandandwater.nz/the-challenge/innovative-resilient-land-and-water-use/):

> This theme will evaluate, model and assess land and water resources and the environmental, social, cultural and financial suitability of land use practices. Our research will look at new technologies, concepts and enterprises that enable individual and collective land and water users and regulators to best adapt to market signals, to derive optimal value chains and achieve their primary production targets within community and regulatory limits.

Another theme on the Our Land and Water National Science Challenge is called "collaborative capacity" (http://www.ourlandandwater.nz/the-challenge/collaborative-capacity/):

> Individuals, communities, and Iwi have the social processes, data, tools and capacity to agree and implement co-developed solutions to adopt new technologies, concepts and enterprises that fit optimal value chains and achieve primary production targets within community and regulatory limits. This theme will look at the best processes and methods to enact change via an increase in collaborative capacity.

Both themes in the Challenge are funding research programmes and smaller projects to deliver on the above objectives. A summary can be found in OLW Directorate (2018).

The New Zealand Government is funding major research programmes to develop technologies for mitigating greenhouse gas emissions from primary sector production. The Pastoral Greenhouse Gas Research Consortium (PGgRc), for example, is a partnership between New Zealand's pastoral industries and the New Zealand Government that has operated since 2002 (see https://www.pggrc.co.nz/). The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) was launched in March 2010 (https://www.nzagrc.org.nz/). Its vision is "to provide knowledge, technologies and practices which grow agriculture's ability to create wealth for New Zealand in a carbon-constrained world" (NZAGRC, 2017, p. 4). The NZAGRC and the PGgRc work together to fund research that will reduce agricultural greenhouse gas emissions from New Zealand (NZAGRC and PGgRc, 2016).

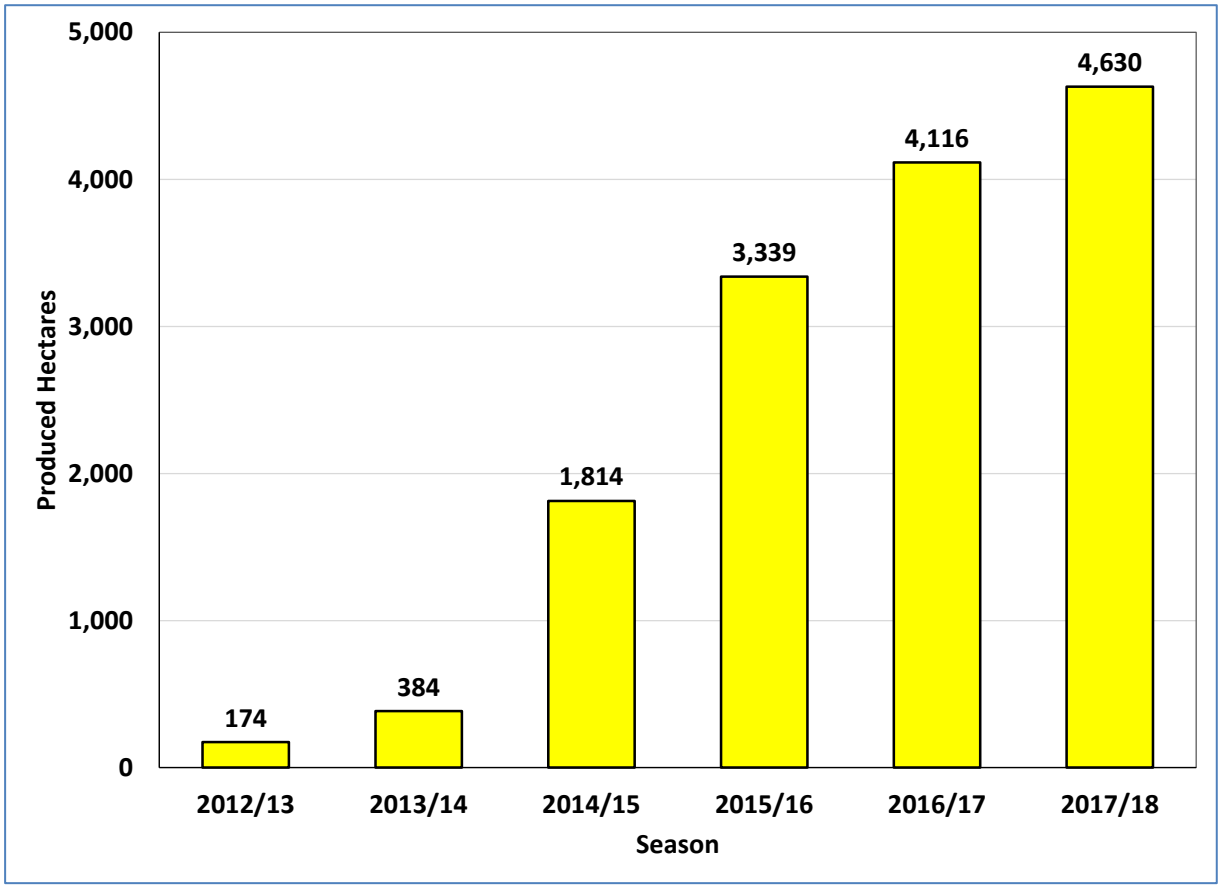
The above examples illustrate that a considerable amount of research is taking place within New Zealand research institutions (including the Universities and the Crown Research Institutes) to develop new technologies that can increase yields and reduce environmental impacts from primary sector production.

There is also a shift towards the adoption of 'precision agriculture' tools adapted for New Zealand conditions by organisations such as the New Zealand Centre for Precision Agriculture at Massey University and Lincoln Agritech Ltd at Lincoln University. In late 2012, Precision Agriculture Association New Zealand was formed, holding its first AGM on 13 November 2013. Its mission is "to increase the awareness and use of PA technologies in land-based primary production systems, access funding for research and the development of PA technologies, build capability within the sector and promote adoption of PA through industry events, symposiums and field days" (https://precisionagriculture.org.nz/).

4.2 Shifting land and water use to higher value outputs

New Zealand producers can shift land and water use very quickly in response to market opportunities. This is illustrated in Figures 4-1 and 4-2. The former shows the introduction of a new kiwifruit cultivar, SunGold, after its development in the joint Plant & Food Research and Zespri kiwifruit breeding programme. In its first year of commercialisation, 174 hectares were in production with the new cultivar. Just six years later, total production came from 4,630 hectares in 2017/18. It has been estimated that the new cultivar will create 8,328 new jobs and $1,291m in the rural industry by 2030, and $310m for regional Iwi on an annual basis (Scrimgeour *et al*, 2017, p. 34).

Figure 4-1: Produced Hectares of Zespri SunGold and Organic SunGold Kiwifruit (Gold3), New Zealand, 2012/13 to 2017/18



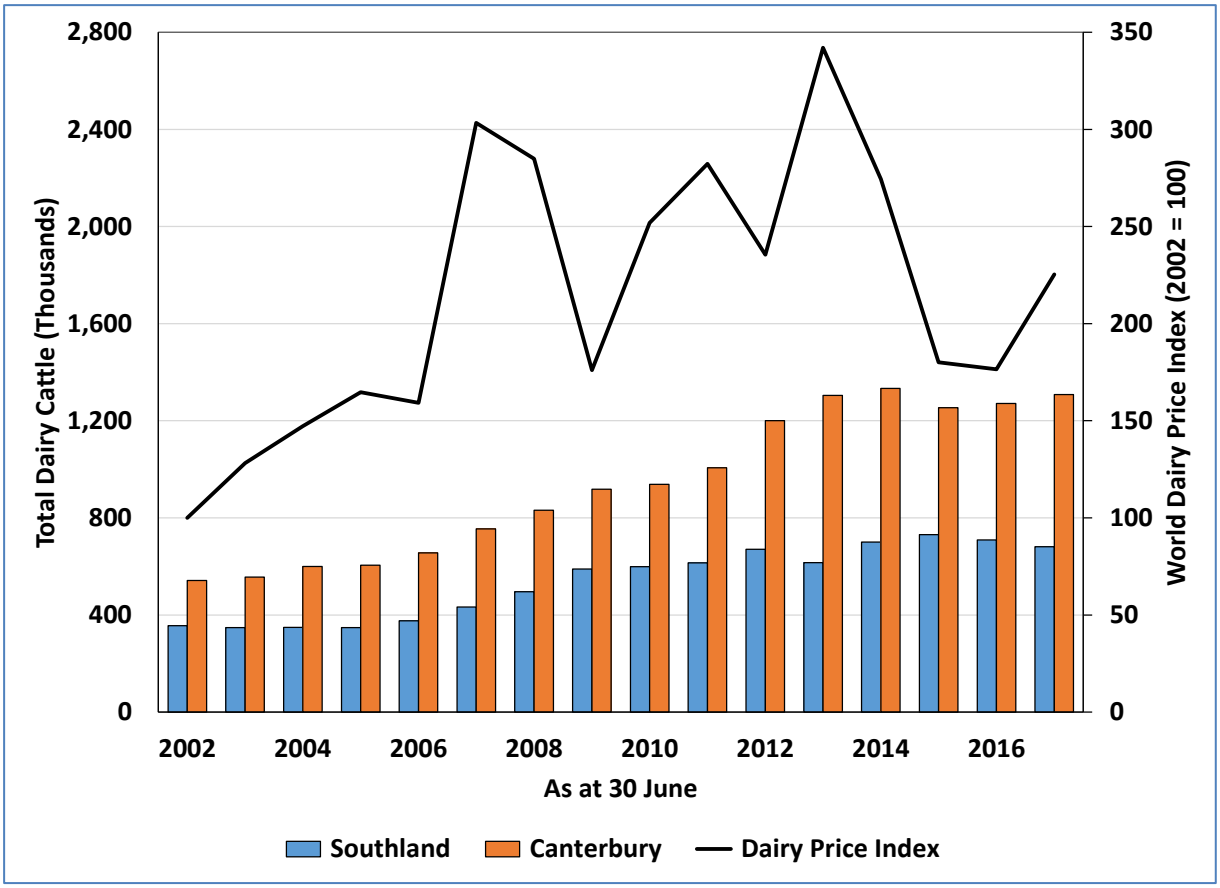
Source: Zespri Annual Reviews, accessed at www.zespri.com/companyinformation/investors.

Figure 4-2 shows an indicator of the world price of dairy products, based on the nominal price of whole milk powder recorded in OECD-FAO (2018b). This price series doubled between 2006 and 2013. The size of the dairy herd in the South Island increased sharply over the same period, as shown in the data for Canterbury and Southland in the Figure. The total number of dairy cattle increased from 655,676 at 30 June 2006 to 1,333,220 at 30 June 2014. In Southland, the total was 375,911 in 2006, and the numbers peaked at 731,209 at 30 June 2015.

One of the research programmes in the Our Land and Water National Science Challenge is exploring how to expand this responsiveness of land and water use to include environmental limits (OLW Directorate, 2018, p. 18):

> Managing within limits refers to managing resource use for sustainable production, without exceeding limits such as water takes and contaminant discharges. Implementing these changes will require a shift from the traditional focus on land-use capability for production, to a broader view that accounts for land-use effects on economic, environmental, social and cultural (EESC) values at whole-catchment scales. We call this broader view 'land-use suitability'.

Figure 4-2: World Dairy Price Index and Total Dairy Cattle, Canterbury and Southland, As At 30 June, 2002 to 2017



Source: Total Dairy Cattle comes from NZ.Stat series Livestock Numbers by Regional Council. World Dairy Price Index comes from the nominal price of whole milk power data in OECD-FAO (2018b).

The research programme is developing new tools for evaluating land-use suitability, taking into account environmental, social and cultural values, as well as economic values. The first tool is a classification system based on national-scale environmental datasets and is being referred to as Productivity within Environmental Constraints (PEC). A prototype GIS-based tool for analysing land-water systems is in development.

There is a range of land use models available in New Zealand – a good summary is provided by Anastasiadis *et al*. (2013). These models can be used to explore how different external events (such as climate change) or policy changes (such as the inclusion of the agriculture into New Zealand's emissions trading scheme) might lead to land use changes.

4.3 Creating high-value consumer goods

The products supplied by primary sector producers are processed into food and fibre that is distributed to consumers. Considerable financial rewards are possible for enterprises that create innovative consumer goods that offer new or better experiences for their purchasers. This was emphasised, for example, in the *Primary Sector Science Roadmap* developed by the Ministry for Primary Industries (MPI (2017a, p. 16):

> Shifting the balance of our primary production from commodity to high-value products with high marginal return will increase the diversity and complexity of New Zealand's exports. This shift is important for productivity growth and our ability to adapt to the changes and opportunities in global markets. While not a new direction, significant change and innovation will be required if we are to achieve business growth objectives for the sector.

The Primary Growth Partnerships programme funded a number of initiatives that aimed to create high-value consumer goods. The following examples are taken from MPI (2016b).

- **FoodPlus**, which aimed to generate more value from the red meat carcase by developing new and innovative uses for different parts of the animal focusing on food, ingredients and health care products.
- **Lighter Wines**, which was designed to position New Zealand as number one in the world for high quality, lower alcohol and lower calorie wines.
- **Marbled grass-fed beef**, which aimed to identifying the best genetics for creating high-value, premium-priced marbled grass-fed beef that is internationally recognised for its superior eating qualities.
- **New Zealand avocados go global**, which aimed to transform New Zealand's avocado industry into supplying premium health food to high-value markets.
- **Sheep – Horizon 3**, which undertook market research to determine which market segments have the greatest potential for New Zealand sheep milk, and aimed to develop high-value products to meet this demand.
- **The Omega Lamb Project**, which aimed to reach existing and emerging markets with a new class of premium lamb products with improved health qualities.
- **Transforming the Dairy Value Chain**, which sought to enable the creation of new dairy products, among other objectives.
- **W^3: Wool unleashed**, which aimed to applying a customer-led approach to wool production and processing to develop products that align with customer preferences.
- **Whai hua**, which developed immune-enhancing dairy milk products targeting health-conscious consumers in Asian and New Zealand markets.

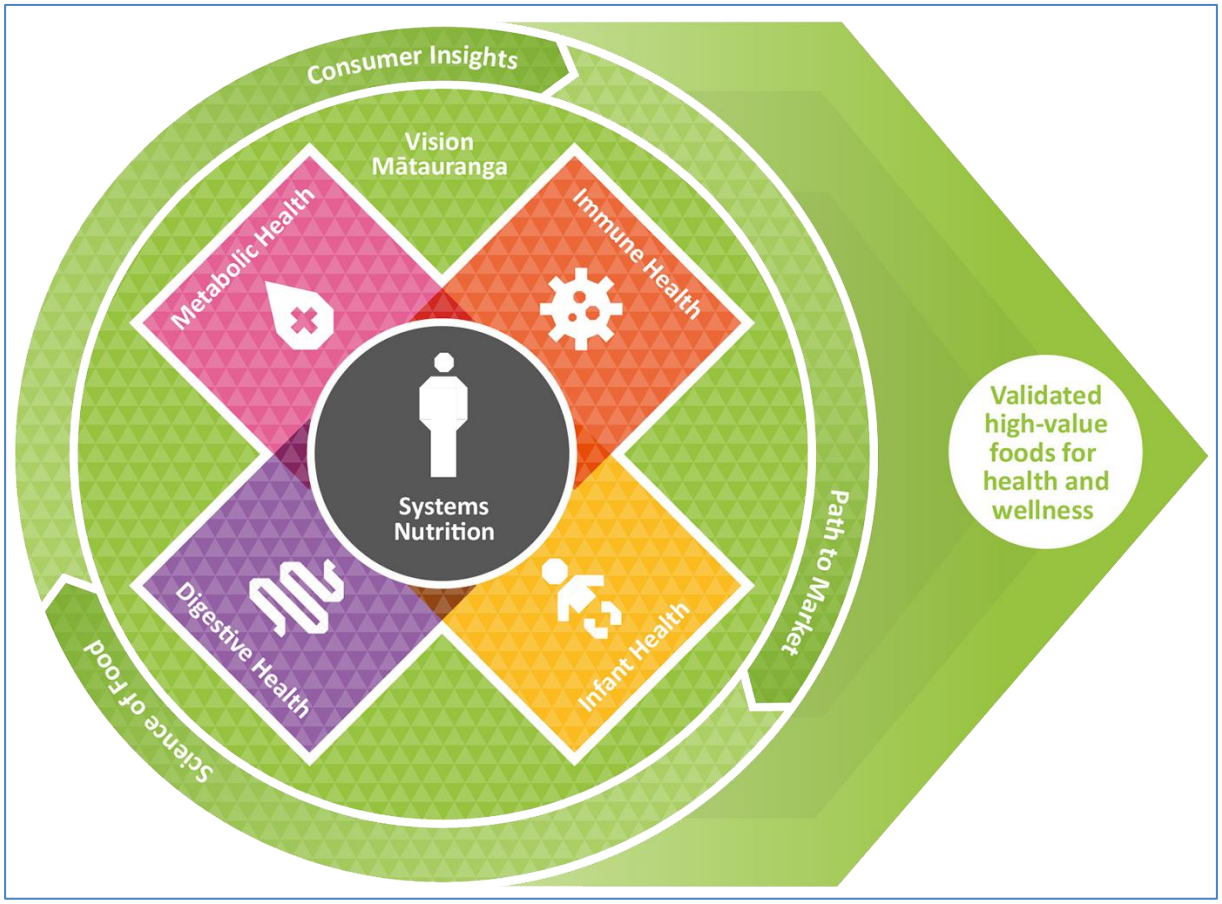
The Primary Growth Partnerships programme has been absorbed into Sustainable Food & Fibre Futures. This will continue to fund innovative projects that will create more value from the food and fibre industries, including projects about developing new products or services.

Another initiative based on the importance of creating high-value consumer goods is the High-Value Nutrition (HVN) National Science Challenge, whose mission is "to grow the science excellence and knowledge New Zealand needs to create and deliver food to the world that people choose to stay healthy and well" (see https://www.highvaluenutrition.co.nz/). Figure 4-3 explains the approach taken by the Challenge, which is strongly focused on consumer insights, the path to market and the science of food. The integration of these three features results in validated high-value foods for health and wellness.

The Challenge explains its commitment to consumer insights in the following terms (https://www.highvaluenutrition.co.nz/the-science/consumer-insights/):

> A deep understanding of consumers can be the difference between a product that disappears without trace and one that achieves hundreds of millions of dollars in sales. By truly understanding the priorities of Asian consumers, we will both help focus our health and nutrition research investments on consumer-relevant biomarkers as well as empower New Zealand food and beverage providers to address real market needs.

Figure 4-3: The HVN Systems Nutrition Approach



Source: https://www.highvaluenutrition.co.nz/.

4.4 Targeting high-value market segments

Section 1.1 at the beginning of this report noted that the value created in New Zealand's primary sector depends ultimately on what final consumers are willing to pay for the food and fibre they purchase. Consequently, the aim of New Zealand exporters should be to target those consumers who place the highest value on the qualities of New Zealand food and fibre. This was well summarised in the KPMG Agribusiness Agenda report for 2017 (Proudfoot, 2017a, p. 5):

> We grow enough food to feed around 40 million people; once we have fed ourselves and our visitors, we can export enough food to feed about 35 million people. The goal with this is not to feed the full diet for 35 million people but to provide a small part of the diet to a much larger group of people for which they will pay a premium price. Achieving this aspirational goal relies not only on evolving the way in which we handle current production but also on responding to the rapid evolution of market conditions as new products and solutions become available.

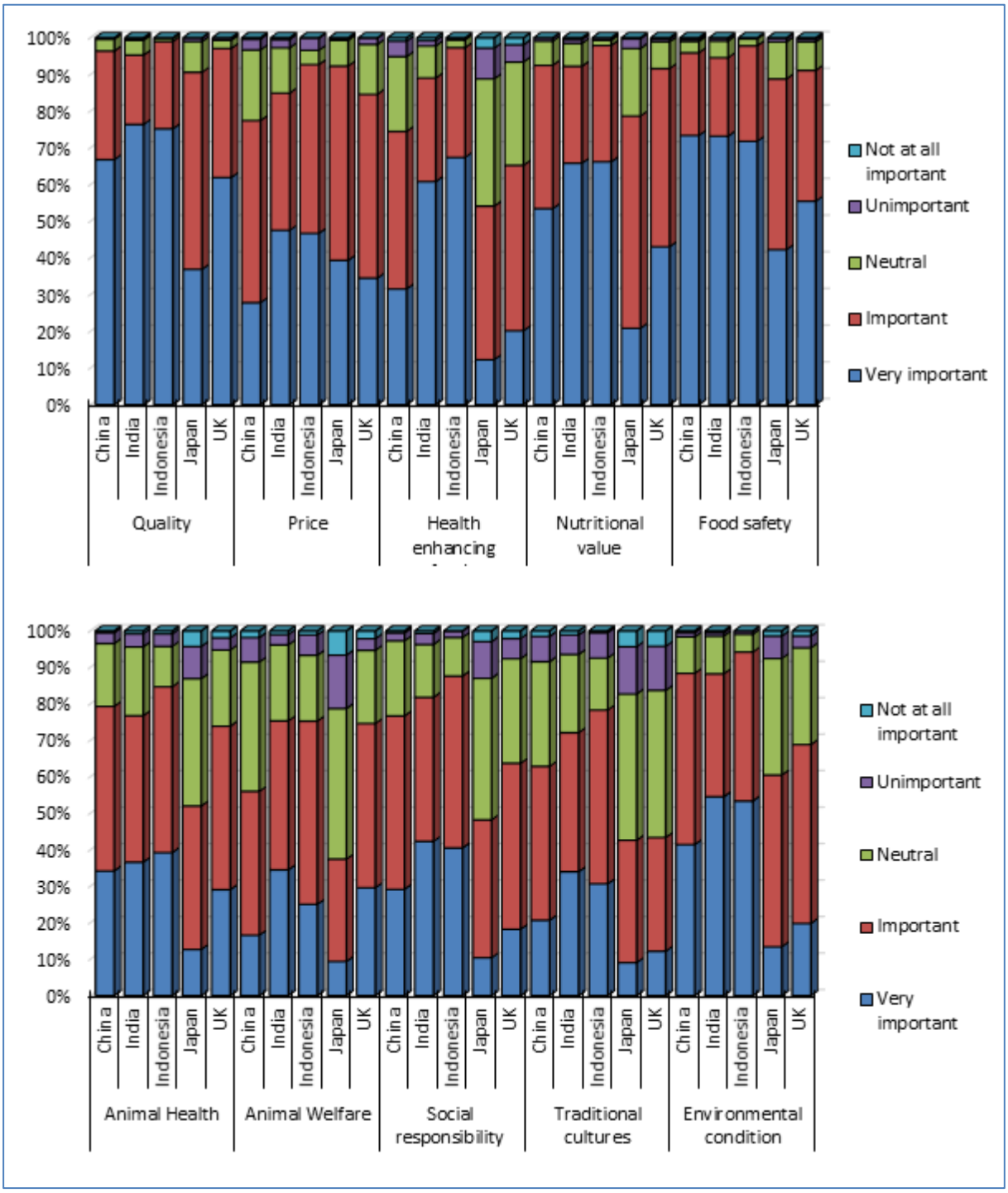
Identifying high-value market segments is a specialist skill, part of what has come to be called knowledge-intensive business services (KIBS; see, for example, Muller and Doloreux, 2009, and European Commission, 2012). It requires in-market analysis of consumer preferences, preferably using sophisticated choice experiment techniques that provide more reliable knowledge than older willingness-to-pay methods (Bennet and Blamey, 2001).

An important source of premium prices is that some consumers are willing to pay for certain attributes of the production of food and fibre goods, such as animal welfare, environmental sustainability, social responsibility and cultural authenticity. The veracity of claims made about these attributes has to be taken on trust by consumer when they are making purchase, and so these attributes are called 'credence attributes'. Many studies have shown how higher prices can be obtained by marketing credence attributes valued by consumers (see, for example, Grunert *et al*, 2014, Tait *et al*, 2016, Miller *et al*, 2017, and Dalziel *et al*, 2018b).

Between 2013 and 2016, the Ministry of Business, Innovation and Employment funded the Agribusiness and Economics Research Unit at Lincoln University to undertake a research programme on Maximising Export Returns. This involved research in five export markets (China, India, Indonesia, Japan and the United Kingdom) to examine how consumers of New Zealand food and fibre products in those markets perceive and value credence attributes such as food safety, animal welfare, environmental protection and cultural authenticity.

Figure 4-4 presents a typical result from that research. Panel surveys of 1,000 consumers in each country were undertaken between March and April 2015. Participants were asked to rate on a five point scale the importance of ten key attributes when shopping for food and beverages. The results are shown in the Figure. As expected, quality and food safety are the most important attributes, but other credence attributes are also important, with some differences in how these are ranked in different markets. Consumers in China, India and Indonesia rated credence attributes more highly than consumers in Japan and the United Kingdom, which confirmed findings in an earlier pilot study by Tait *et al*. (2016).

Figure 4-4: Importance of Attributes When Shopping for Food and Beverages



Source: Guenther *et al*. (2015), Figures 3-1 and 3-2.

A key insight from that programme is that different markets can perceive credence attributes in different ways. In determining whether a product is safe to eat, for example, consumers in China, India and Indonesia pay more attention to environmental conditions than consumers in Japan and the UK. Differences such as these offer opportunities for knowledge-intensive business services to add value to sales programmes in different markets.

Section 4.1 described two themes in the Our Land and Water National Science Challenge. A third theme in that Challenge is devoted to Greater Value from Global Markets. This theme is researching how market oriented value chains can create and capture value for food and fibre producers (Saunders *et al*, 2017b). It has included four research reports involving choice experiments in four key markets: wine and beef in California; and kiwifruit and yoghurt in Shanghai (Tait *et al*, 2018a, 2018b, 2108c and 2018d). This research provides further evidence that consumers are willing to pay a premium for certain credence attributes, and New Zealand does enjoy a high reputation in these four specific markets.

This last observation suggests that New Zealand might aim to increase its international profile as a country of origin for high quality food and fibre. A report by Futurebrand (2014, p. 30) has argued that "brand-driven consumption is increasing exponentially worldwide with the explosion of new middle class consumers in the BRIC markets (Brazil, Russia, India, China) and other developing nations". That report continues (ibid) that "it is arguable that Country of Origin brands will start to contribute significantly to national reputation and overall country brand strength." This is also the vision of Te Hono, discussed in chapter 1 of this report.

The Ministry of Business, Innovation and Employment has funded a five year research programme that aims to provide new knowledge on how local enterprises can achieve higher returns by ensuring global consumers understand the distinctive qualities of the physical, credence and cultural attributes of agri-food products that are 'Made in New Zealand' (Saunders *et al*, 2017). The programme is called Unlocking Export Prosperity, and brings together researchers from the Agribusiness and Economics Research Unit at Lincoln University, from Plant and Food Research, from the Ngāi Tahu Research Centre at the University of Canterbury, and from The Leadership Lab in Christchurch. Its first research reports will be published by the end of 2018.

4.5 Development of capabilities for skilled leadership

A key theme in this report is the urgency of ongoing transformation in the New Zealand Food and Fibre sector. This requires skilled leadership, at enterprise level, industry level and policy level. David Teece, for example, is a New Zealand economist now based in the Haas School of Business at the University of California, Berkeley, who rose to prominence as a result of his seminal research on the capability theory of the firm (see Teece, 1982, 2017, and 2018). That research emphasised the competitive advantage that comes from *dynamic capabilities*, which he has recently defined as follows (Teece, 2017, p. 698):

> For applied purposes, dynamic capabilities can usefully be broken down into three primary clusters of activities: (1) identification, development, co-development and assessment of technological opportunities in relationship to customer needs (*sensing*); (2) mobilization of resources to address needs and opportunities, and to capture value from doing so (*seizing*); and (3) continued renewal (*transforming*).

These are highly sophisticated skills. In New Zealand, a forthcoming report for the Unlocking Export Prosperity research programme by Jordan Mayes, Gabrielle Wall and Peter Cammock on *Value-Based Leadership in New Zealand Agri-foods Exporting Enterprises* concludes with the following observation (Mayes et al, 2018, final paragraph):

> While relationships between leadership and value creation in agri-food products is complicated, the importance of leadership cannot be understated. This review has found a multitude of evidence supporting relationships between leadership and value creation. Leadership should not only be considered an important correlate of value creation, but a critical antecedent without which value-adding would likely be unsuccessful. While practitioners will find difficulties in finding the right styles of leadership and assessing leadership in terms of context, its inclusion in agri-food export enterprises is crucial for the creation of price premiums and encouragement of sustainable exporting success.

A key consideration is the leadership skills required to create and sustain global agri-food value chains that return premiums to New Zealand producers and processors. KPMG Global Head of Agribusiness, Ian Proudfoot, captured headlines when he told the audience at the Zespri Momentum conference in March 2017 that New Zealand's total food-related exports were about $38b, but “by the time those food exports were translated through the value chain to end-users, that value had risen to about $250b” (Proudfoot, 2017b).

Consequently, care must be taken for the development of capabilities for skilled leadership, both in the current generation and in future generations. This is a challenge to the capability building strategies of private organisations in the Food and Fibre sector, but also a challenge to the country’s business schools.

Leadership is also important in designing effective public policy that is supportive of the Food and Fibre sector’s development to meet wellbeing goals. The Government, for example, makes substantial investments each year in research and development that aims to create new knowledge that will contribute to economic, social, cultural and environmental wellbeing. This includes funding for the country’s Universities, Institutes of Technology, Crown Research Institutes, Regional Research Institutes and other specialist organisations.

The Government also invests in primary, secondary and tertiary education that intends, among other goals, to give New Zealanders access to skills that are valued by commercial enterprises.

The design and management of these national innovation and skills ecosystems require skilled policy advisors who understand the specific characteristics of the Food and Fibre sector. This is a challenge to the capability building strategies of the public sector in New Zealand, but also a challenge to the programmes offered by the School of Government at Victoria University of Wellington.

Chapter 5
Conclusion

The purpose of this report has been to provide a situational analysis of New Zealand's Food and Fibre sector that offers a global perspective and a national context for developing a refreshed vision at a time of unprecedented change. Chapter 1 listed major international challenges being faced by the Food and Fibre sector, which are worth repeating here:

- Land-based production is contributing to, and will be impacted by, global climate change (OECD-FAO, 2018a, p. 4). In New Zealand, agriculture is the largest sector contributing to gross greenhouse gas emissions (49.2 per cent in 2016, see MfE, 2018a, p. 6). Agricultural productivity is expected to increase in some areas of New Zealand as a result of climate change, but with increased risks of drought, pests and diseases and costs associated with changing land-use activities (MfE, 2018b). The latest report of the Intergovernmental Panel on Climate Change emphasises the requirement for *rapid and far-reaching transitions*, concluding "the next few years are probably the most important in our history" (IPCC, 2018, p. 2).

- The Paris Agreement on climate change aims to keep the global average temperature well below 2° C above pre-industrial levels, while pursuing efforts to limit the increase to 1.5° C. Achieving this will change global patterns of food consumption and production, perhaps dramatically: "Most analysis of stabilising global temperature increases at 2°C or lower includes reducing losses and wastes in the supply chain; changing diets from animal products to plant-based food with equivalent protein content; and a reduction in overconsumption" (Kazaglis *et al*, 2017, p. 18).
- Consumer movements have focused on the environmental impacts of transporting food and fibre over long distances, which can result in New Zealand products being perceived in Northern Hemisphere markets as damaging to the environment (Saunders and Barber, 2008). More generally, "world-class food companies are setting internal standards that are far more stringent than those required by law" (PwC, 2016, p. 13). Important gatekeepers (such as supermarket chains) are adopting high private standards expected by their customers.
- International demand growth is expected to be weak over the next decade, and prices of agricultural commodities are expected to remain low (OECD-FAO, 2018a, p. 15). This challenge is amplified by uncertainties with respect to international trade policies, including policies affecting trade in food and fibre products, and concerns about the possibility of rising protectionism (OECD-FAO, 2018a, p. 16).
- The United Kingdom will exit from the European Union on 29 March 2019, creating opportunities and threats for agriculture in the UK and the EU (Helm, 2017). There will be implications for New Zealand food and fibre exports into the UK, and changed patterns of international trade may affect exports into other markets.

- Consumers globally are demanding higher standards for building trust that food is safe, healthy and good to eat, including requirements for stronger systems of food fraud detection and food traceability, and that production systems meet ethical expectations for responsible innovation, including high animal welfare (PwC, 2016, Dalziel *et al*, 2018b). Federated Farmers and others have recognised "the challenge of maintaining the social licence to farm in New Zealand in the 21st Century" (Rolleston, 2015; see also Farming Leaders Group, 2018).
- Consumers, organisations setting private standards, and regulators controlling market access are increasingly aware around the world that animal-based production systems have adverse environmental impacts (MPI and Plant & Food Research, 2018, p. 3), including on increasing scarce resources such as clean water.
- Companies internationally and in New Zealand are commercialising plant-based substitutes for meat and dairy products that will reduce animal-sourced protein in global diets (MPI and Plant & Food Research, 2018, p. 3; Beef+Lamb New Zealand, 2018a). These disruptive technologies could have a large impact on the demand for New Zealand meat and dairy exports.
- Emerging biotechnologies have the potential to disrupt food and fibre production globally, but New Zealand does not participate in research on some biotechnologies because the country's regulations group all genetic technologies under a single generic heading (Proudfoot, 2018, p. 21).
- Debt burdens carried by producers based on fully-capitalised land values may not be sustainable if production returns become increasingly dependent on how a product is grown, processed and marketed, potentially requiring less rather than more output (Proudfoot, 2018, p. 51).
- Biosecurity incursions of pests and diseases are a persistent threat, amplified by an increased volume of cross-border movements of people and products (MPI, 2016a).

The New Zealand Food and Fibre sector has faced challenges in the past, and as the authors of this report have previously noted (Saunders et al, 2016, p. xi):

> The history of the country's agri-food production, processing and exporting is replete with examples of New Zealand enterprise creating and capturing value through the interaction of four key elements:
>
> - changes in international trade;
> - developments in domestic industries and policies;
> - innovations in science and technology; and
> - creations of trusted commercial brands.

In line with that history, chapter 1 of this report described some changes currently taking place in the sector, led by industry initiatives and supported by public sector programmes. This includes the mission of Te Hono to enable New Zealand primary industry companies to transform from volume to value, the creativity of Māori enterprises in creating commercial brands in international markets, and the growing number of large and small exporters in New Zealand profiling the sustainability of their production, processing and distribution processes.

It also includes public sector programmes inspired by the ambition of the Ministry for Primary Industries that "New Zealand is the most trusted source of high value natural products in the world" (MPI, 2017b).

The chapter used those examples to suggest there are solid foundations for transformational change, but also recognised that achieving that transformation potential will require changes across the whole sector, to meet the scale and range of international challenges faced by New Zealand food and fibre exporters.

Chapter 2 documented the importance of the Food and Fibre sector to wellbeing in New Zealand. It introduced a framework for this purpose, presented in Figure 2-1. The framework is based on major public sector initiatives in keeping with the government's commitment to promoting wellbeing in New Zealand public policy (Robertson, 2018, p. 8). Thus the first two statistical indicators of wellbeing are Incomes and Wealth followed by Jobs and Earnings. Chapter 2 made the following observations:

For every $5 of income created in the market economy, just under $1 is created in the Food and Fibre sector. For every 10 jobs in New Zealand, just over 1 is in the Food and Fibre production and processing industries.

If the national economy grows at 2 per cent per annum on average (as projected by the Treasury, 2016), and if the Food and Fibre sector maintains its current position in the structure of the national economy, and if there are no other changes within the Food and Fibre sector, then what is the expected increase in primary sector production in 2060, and what is the expected increase in Food and Fibre exports in 2060?

The short answer given in chapter 2 is that primary sector production, and Food and Fibre exports, would have to *double* by 2051, if nothing else changed. This is required not only for the sector to contribute its share to generating decent incomes, but also to contribute to the tax revenue needed to maintain and improve standards of health, education, retirement income, welfare and other quality public services.

It is not possible for the physical outputs of primary sector production to double by 2051, because of the environmental constraints already evident. This was surveyed in chapter 3, which focused on air, atmosphere and climate, freshwater, land and marine. In each case, there is clear scientific evidence of environmental limits to primary sector production. The threats arising from global climate change are a good example of an urgent issue, with New Zealand primary production both causing a large proportion of the country's greenhouse gas emissions and likely to be affected in uncertain ways by the current pathway for climate change.

Thus, "the key issue is how to best support the transition to a world of 'growth within limits'" (Treasury, 2016, p. 50).

Chapter 4 addressed that issue. It observed that if the goals are to increase the economic value of the Food and Fibre sector and to reduce its damage of the natural environment, then only a small number of possibilities can achieve both goals simultaneously:

- Adopting new technologies and sustainable practices that will allow increased production with a lower negative impact on the natural environment.
- Shifting land and water use to products that have a higher economic value and a lower negative impact on the natural environment.
- Using the outputs of the primary sector to manufacture food and fibre products that are more highly valued by consumers.
- Using knowledge-intensive business services to target high value market segments in global agri-food value chains.

The chapter presented examples of major programmes taking place under each heading, confirming the observation in chapter 1 that there are solid foundations for transformational change in New Zealand's Food and Fibre sector. It is not necessary to choose only one of the strategies for increasing value. They can be implemented simultaneously, and would reinforce each other. Chapter 4 finished by recognising that achieving transformation requires skilled leadership, in both the private sector and the public sector. Consequently, organisations and educators must pay attention to developing capabilities for skilled leadership.

The potential rewards from achieving transformation are considerable. In 2015, for example, one of New Zealand's most influential economists, Professor David Teece, presented to the Te Hono Stanford Bootcamp for New Zealand Primary Sector CEOs at Stanford University in California. In that presentation, Teece (2015, slide 8) noted that there doesn't appear to be a single strong New Zealand brand, other than New Zealand itself. He observed that a brand is not simply a label, but "is a story, and a customer relationship/experience built on trust that is sufficiently valuable to support a 20-30% price premium."

Trade modelling by the Agribusiness and Economics Research Unit at Lincoln University indicates that a 20 per cent premium for dairy and meat exports to ten trading partners would add $2.1 billion to our annual export receipts (Saunders *et al*, 2016a, Table 5-7, p. 79). Analysis commissioned by the Our Land and Water National Science Challenge showed that capturing that level of willingness-to-pay in five markets for improved credence attributes of four food and fibre exports would add in the order of 2 percent to New Zealand producer returns (Dalziel *et al*, 2018, Table 2, p. 498).

The range and complexity of the international challenges facing the Food and Fibre sector mean that transformational change is necessary. The initiatives taking place in the private and public sector mean that transformational change is possible. The environmental and commercial potentials from success mean that transformational change is rewarding.

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Appendix: The Seven Capital Stocks

Figure 2-1 in this report presented seven types of capital stock making up the country's Total Wealth. This section considers each type of capital stock in turn. For each capital, there is a definition (drawing on the respective relevant chapter in Dalziel, Saunders and Saunders, 2018), a brief explanation of its relevance to the Food and Fibre sector, and a short discussion of how reinvestment can be supported.

Human capital

Human capital refers to an individual person's expanded capabilities for wellbeing as a result of formal education, relevant experience or improved health. In a market context, higher human capital is associated with greater skills that increase a person's labour productivity; that is, an employee with more education, greater experience or better health typically produces a greater value of output per hour or work. This opens up opportunities for higher earnings than available to a person with lower human capital.

The Food and Fibre sector requires people with general and specialist skills working in the private sector and the public sector. The private sector skills range from expertise in different aspects of production in New Zealand's primary sector industries to experience in sophisticated market analysis of different market segments in New Zealand's export destinations around the world. Public sector skills include expertise in designing and implementing biosecurity systems, experience in creating and supervising effective regulatory regimes, and diplomatic skills in negotiating access of New Zealand products into overseas markets.

Individuals choose to invest resources in their human capital by participating in education. These choices can have profound impacts on personal and national wellbeing, so that access to quality careers education and guidance is valuable. It is important that schools and tertiary education institutions offer education that remains relevant to the evolving skill demands of industry, influenced by new technological and commercial opportunities. The rapid change occurring in some technologies means that life-long education and retraining is required to maintain a skilled workforce for industries competing in international markets.

Cultural capital

The key idea behind the metaphor of cultural capital is that a young person growing up in their extended family context inherits from previous generations diverse cultural values and norms for practising those values. Those values and norms can be called cultural capital, helping people to develop a sense of place in their communities, in the natural environment and in the nation. As the Ministry of Culture and Heritage observes on its website, "cultural expression is central to a vibrant, healthy society [and] also reflects and reinforces what it

means to be a New Zealander, helping to build connection and cohesion". Cultural capital defined in this way is never set in stone; each new generation transforms the cultural heritage it has received as part of the community's cultural vitality.

The New Zealand Food and Fibre sector is imbued with cultural norms and values. Family farms have been a feature of the sector since the nineteenth century. Iwi, hapū and whānau are significant producers of food and fibre, operating with strong cultural values of association with land and water. The Resource Management Act requires all persons under the Act to have particular regard to cultural norms such as kaitiakitanga, stewardship, efficiency, maintenance of amenity values and respect for intrinsic values of ecosystems. Cultural norms of collaboration and being good neighbours can be found everywhere in rural regions and towns throughout New Zealand.

Just under two-thirds of New Zealanders live in urban areas, which is close to the OECD average of 68 per cent.[2] This means that public investment decisions based on population can favour urban-dwellers, to the disadvantage of citizens living in rural areas. The maintenance of facilities needed for cultural vitality in the regions (including for Māori communities) requires specific attention.

Social capital

Cultural capital refers to norms and values passed down the generations. In contrast, social capital refers to the shared networks, norms and values that govern interactions among people of the current generation, including across cultural groups. A key aspect of social capital is the degree of trust that can be expected between people who do not know each other. The greater is the level of trust in a community, the easier it is for people to collaborate with each other to create business opportunities or initiate social projects.

People in the Food and Fibre sector have created a wide range of local and national civil society institutions to facilitate collective action for wellbeing. Producer cooperatives are an example of collaboration in market activities. Trust relationships within Food and Fibre value chains are complex. In some value chains, the level of trust is very high, with enduring commitments among participants in the value chain based on shared values rather than formal contracts. In other value chains, participants enter into transactions based on current opportunities rather than with the intention of building long-term relationships.

The development of social capital begins in schools, where children learn how to work together with others outside their immediate family. It is possible for public policy to foster effective networks to increase social capital, and to help enforce shared community norms. Social capital can be strengthened by developing societal aspirations or common goals, which might be one of the purposes of the vision to be developed by the Primary Sector Council. Policy can also be developed to expand access to social capital for people who may have been traditionally excluded on the basis of characteristics such as gender or race.

[2] An urban areas is defined here as having "a minimum threshold of 150 people in each square kilometre, a maximum travel of 60 minutes to the centre, and a minimum population of 50 000" (New Zealand Productivity Commission, 2017, p. 70).

Economic capital

Economic capital covers three broad categories of long lasting assets: (1) physical assets, including infrastructure, buildings, plant, machinery, vehicles and equipment; (2) financial assets, including equities, shares, debentures, bank deposits and cash; and (3) intellectual property, including patents, trademarks, copyright and registered brands. In each of these categories, investment in economic capital can greatly increase the productivity of an enterprise, and so expand capabilities for wellbeing.

The requirements for economic capital in Food and Fibre enterprises can be very high. Producers typically require specialised structures and machinery that have little alternative uses. A processing plant may require a large financial investment to incorporate the latest technologies that meet strict safety and other standards. The creation of a new plant variety right or a trusted global brand takes years to achieve, requiring access to sufficient financial capital during the development phase.

There is a substantial literature on policies that can support investment in economic capital, since this has been long recognised as a key for higher living standards (expressed, for example, in the influential neoclassical growth model of Robert Solow, 1956). These beneficial policies include a fundamental respect for property rights and a stable policy environment.

Natural capital

Natural capital refers to the way in which the environment provides services that contribute to the wellbeing of people, sometimes called ecosystem services (Dymond, 2013, provides a New Zealand overview). The Millennium Ecosystem Assessment (2005, p. v) recognised four major categories: "*provisioning services* such as food, water, timber, and fiber; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling".

Food and fibre are explicitly included in the above examples for provisioning services, recognising the essential role of the environment in primary sector production. Production also has potential impacts on the other categories of ecosystems services. It can affect water quality for example (regulating services), recreational opportunities (cultural services) and soil formation (supporting services). Processing, storage and transport of food and fibre also have environmental impacts. These impacts are one of the reasons that the sector recognises the importance of maintaining a social licence to farm (Rolleston, 2015).

Humans have long known the importance of reinvestment for maintaining soil fertility; for example, through the application of fertilisers. In the same way, it is possible to take specific actions to diminish or mitigate the negative impacts of the Food and Fibre sector on all the ecosystem services provided by natural capital. These actions typically involve economic costs, and so there are policy questions around what costs are justified by the benefits created and who should bear those costs.

Knowledge capital

Knowledge capital refers to the way in which scientific research is continuously expanding the stock of human knowledge, leading to technological progress. Knowledge capital has a unique role in economic models of living standards growth. This was recognised in 2018 by the shared award of the Nobel Prize in Economics to Paul Romer in recognition of his "endogenous growth theory", which demonstrates how growth in knowledge capital is the single most important factor for growth in living standards (see, for example, Romer, 1986, 1994).

No one should doubt that the Food and Fibre sector is highly knowledge-intensive. In New Zealand and globally, technological advances have contributed to high productivity growth in primary sector production and processing. Precision agriculture and food process engineering advances are contributing to further growth. Knowledge intensive business services are enabling enterprises to obtain higher returns from their food and fibre products.

New Zealand has invested in several public institutions that receive funds to increase the stock of knowledge capital for the Food and Fibre sector. This includes the country's Universities (all of which are undertaking research in business services), Crown Research Institutes and Institutes of Technology and Polytechnics. There are also private sector organisations, including the Cawthron Institute based in the Nelson region. A challenge for any national innovation system is to align research effort with genuine commercial opportunities.

Diplomatic capital

Diplomatic capital refers to the institutions and norms that that have been created to foster cross-cultural collaborations on a global scale. This includes practices of state diplomacy that have been developed over centuries, but also includes norms and protocols required by multinational firms and international non-governmental organisations. Strong, effective diplomatic capital is required to address some of the world's most pressing problems that are beyond the scope of any single country (such as global climate change).

In August 2017, New Zealand was party to around 1,900 international treaties (MFAT 2017, p. 4). Many international agreements that are entered into by New Zealand are important for the Food and Fibre sector, because of the sector's high reliance on exports (see Figure 1-2 in the previous chapter). This includes free trade agreements; New Zealand was the first OECD country, for example, to enter into a free trade agreement with China (MFAT, 2008).

The Ministry of Foreign Affairs and Trade is responsible for leading New Zealand negotiations on free trade agreements. The Ministry for Primary Industries works on expanding international market access for New Zealand food and fibre by influencing international trade frameworks and international standards. It is also responsible for maintaining New Zealand's government-to-government 'competent authority' relationships and functions.