Chapter 10:

Requests under s5K relating to the Nationally Determined Contribution and biogenic methane – supporting evidence

We have been asked two additional questions – about the compatibility of the Nationally Determined Contribution (NDC) with the 1.5°C goal, and about what long-term reductions of biogenic methane emissions the country might be required to make. In this chapter we show our work on how we have used the IPCC modelling in our assessment of the NDC. We also discuss the long-term global and local trends that will influence what contribution reductions of biogenic methane might need to make to limiting warming in the future.

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10.1 Introduction

In addition to providing advice on first emissions budgets of Aotearoa, the Minister for Climate Change has asked the Commission to provide advice on two other matters.

The **first** is related to biogenic methane. Specifically, the Minister has asked the Commission to provide:

> *"advice on the potential reductions in biogenic methane emissions which might eventually be required by New Zealand as part of a global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above preindustrial levels.*
>
> *In providing this advice the Commission must:*
> - *a. leave aside considerations on the current target range for biogenic methane specified in section 5(Q)(1)(b) of the CCRA;*
> - *b. consider the available scientific evidence on the global biogenic methane emissions reductions likely to be required to limit global average temperature increase to 1.5° Celsius above pre-industrial levels;*
> - *c. consider New Zealand's potential contribution to global efforts to limit biogenic methane emissions, reflecting its national circumstances; and*
> - *d. consider a range of potential scenarios for economic, social and demographic changes which might occur in New Zealand and globally until 2100."*

The **second** is related to Nationally Determined Contribution of Aotearoa under the Paris Agreement. Specifically, the Minister has asked the Commission to provide:

> "*a report on New Zealand's first Nationally Determined Contribution (NDC), including:*
> - *a. advice on whether the NDC is compatible with contributing to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels; and*
> - *b. recommendations on any changes to the NDC required to ensure it is compatible with global efforts under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels."*

The methodology we have used to analyse the two questions and our findings are included in *Chapter 8: The global 1.5°C goal and Nationally Determined Contribution for Aotearoa* and *Chapter 9: Eventual reductions in biogenic methane* of the Advice report. This chapter outlines additional evidence relevant to the two requests under s5K of the Act. It describes:

- The methodology for converting from emission targets to NDC emission budgets and how the results of the IPCC's 1.5°C modelling has been applied to Aotearoa.
- Reference material on the future economic, social and demographic trends that might occur to 2100.

Further evidence relevant to these requests is included in *Chapter 1: The science of climate change* and *Chapter 2: What other countries are doing*.

10.2 Methodology to convert NDC targets to NDC emission budgets

In this section we describe the conceptual approach to converting targets to NDC emission budgets, how this was done under the Kyoto Protocol, and the approach we have taken to doing so and how that differs slightly from the methodology used under the Kyoto Protocol.

The country's first NDC is a 30% cut in net emissions by 2030 compared to 2005 gross levels. The NDC uses an emissions budget approach which means we are taking responsibility for emissions over the whole period 2021-2030.

There is an approach to converting targets for a single year to allowed emissions over a whole period. This is described in a technical document developed for the Kyoto Protocol[1] and the initial report on the country's 2020 emissions target provides an example of its application in practice[2]. In assessing possible alternative NDCs associated with 1.5°C pathways we have used a version of this approach. Some features of that methodology are particular to the Kyoto Protocol and are no longer necessary and so have not been applied. This section describes how the calculation is done and the parameters and assumptions the Commission has chosen in doing so.

10.2.1 General approach

The key concept is that the total amount of emissions the country is allowed to emit each year during the NDC period is calculated by taking a straight line from the previous target to the future target. The actual emissions pathway does not have to follow this exact trajectory so long as the country's total emissions over the period is less than the allowed level.

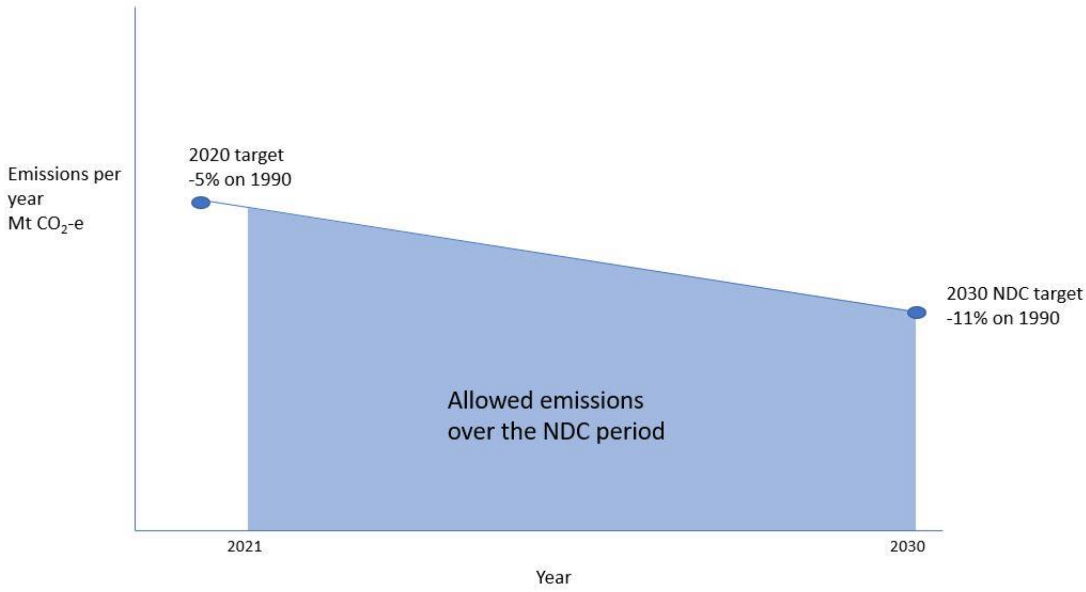


Figure 10.1: Illustration of conversion of the existing 2030 target to an NDC amount[3]

[1] (UNFCCC Secretariat, 2010)
[2] (Ministry for the Environment, 2016)
[3] The 2030 target is to reduce emissions to 30% below 2005 levels. Here it is presented as a reduction against 1990 levels for easier comparison to the 2020 target that preceded it.

10.2.2 Kyoto Protocol approach

The Kyoto Protocol methodologies that were used to determine the allowed emissions under the first NDC use a slightly more complex calculation. Under the Kyoto Protocol approach, the starting point for the emissions trajectory is the midpoint of the previous period, not the final year of the previous target. This was chosen because under the Kyoto Protocol, allowed emissions levels were averaged over the period and it was this average that was the stated target. Using that average target level in the final year as the start point for the next target would overstate the allowed emissions as the emissions in the final year of the previous period should be below the average by the final year as illustrated in Figure 10.2 below.

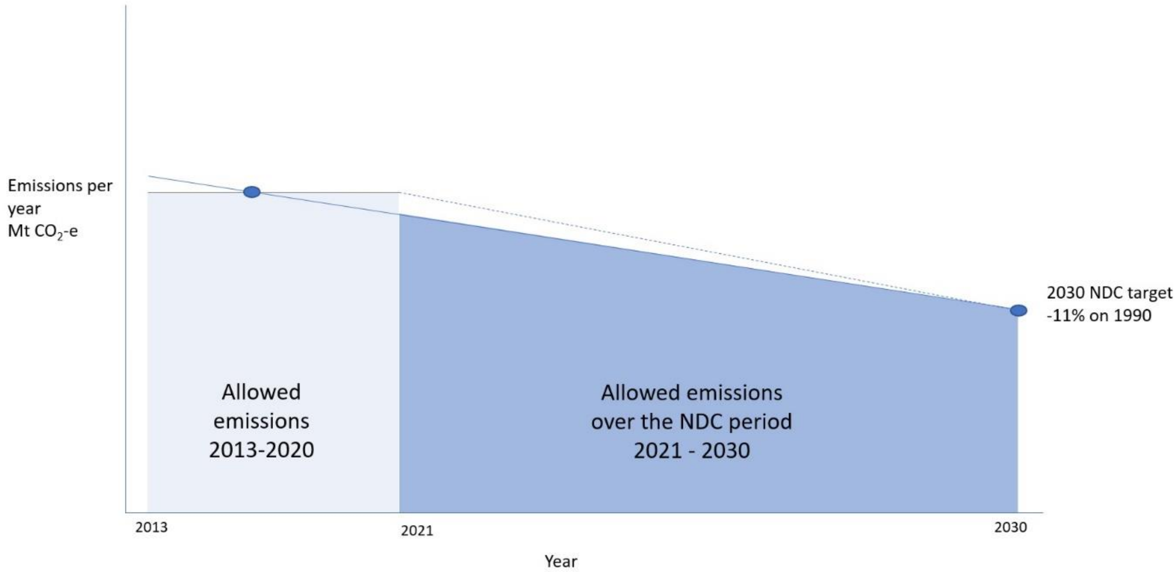


Figure 10.2: Illustration of Kyoto approach to converting targets to NDC amounts

These approaches do not distinguish between gases and apply the overall emissions reduction to the total sum of greenhouse gases expressed in CO_2e.

Using this approach, the Ministry for the Environment previously calculated the allowed emissions budget for the NDC period 2021-2030 was 601 Mt CO_2e.[4] This was based on estimates of past emissions from the greenhouse gas inventory published in 2017. The 601 Mt CO_2e figure will be adjusted and finalised in 2023/24 after the greenhouse gas inventory covering the 2020 year has been finalised and reviewed. We have applied this approach using the latest inventory figures and calculated that the current NDC allows net emissions of 585 Mt CO_2e over 2021-2030. This is our current estimate of the NDC emissions budget.

In assessing possible NDCs that would be compatible with the IPCC's modelling of pathways compatible with 1.5°C, we have applied the general version starting from the previous 2020 target. This is because the country's 2013-2020 commitment was expressed as a target level in 2020 and calculated as an emission budget from that stated target. As the target expresses a trajectory to a level in 2020 and not only an average over the period, it is unnecessary to start from the middle of the previous period.

[4] (Ministry for the Environment, 2019b)

10.2.3 Applying the IPCC modelled reductions to Aotearoa

In our advice on the compatibility of the NDC, we compare the current NDC to hypothetical NDCs as if we had taken a target based on the reductions in greenhouse gases modelled by the IPCC in its Special Report on 1.5°C. Here we explain how that was done, the judgements that have to be made in applying the methodology above and what judgements and parameters we have used in doing so.

Gases

We have applied separate trajectories for each of the three main greenhouse gases, carbon dioxide, methane, and nitrous oxide, to distinguish between the different levels of emissions reductions modelled for different gases. These were then reaggregated together using the GWP_{100} metric from the IPCC Fourth Assessment Report to create a total NDC emissions budget. Aggregate emissions of fluorinated gases were assumed to decrease by 85% below 2018 levels by 2036 in line with the phase out of these gases agreed under the Montreal Protocol. The cuts to agricultural methane and nitrous oxide modelled by the IPCC were applied to total emissions of methane and nitrous oxide respectively, as the vast majority of the country's emissions of those gases are from the agriculture sector.

Start year

We have applied the general approach beginning from the 2020 target level of 5% below 1990 levels. As the 2020 target was expressed as a reduction level to be achieved in 2020, it is unnecessary to start from the mid-point of the previous period. Further, to do so would be to inconsistently apply the emissions trajectory for the 2021-2030 period to the latter half of the 2013-2020 period. So long as the NDC emissions trajectory starts from the level of the 2020 target in 2020, this will correctly represent the transition from one target to another.

In applying the IPCC modelled reductions by gas, we have applied the 2020 emissions reduction target of 5% on 1990 levels to each of the three main gases as the start point for each gas.

Base year

The current NDC is expressed as a 30% reduction in emissions on 2005 levels. The emission reductions modelled by the IPCC for 1.5°C compatible pathways are expressed as percentage cuts by gas against 2010 levels.

In describing the NDCs that would be associated with the IPCC 1.5°C range we have therefore used a 2010 base year to be consistent with how the IPCC developed them, and converted these targets to absolute levels of emissions in 2030 of each of the three main gases.

Forest accounting

Consistent with the Kyoto Protocol based target accounting approach, forestry is excluded from the base year.

The reductions in carbon dioxide modelled by the IPCC are to net emissions. Under the agreed accounting rules for the Kyoto protocol, emissions and removals of carbon from land use change and by forestry are excluded from the base year in calculating targets if the sector was a net sink of emissions in the base year – which it was in Aotearoa.

This is because carbon removals from new plantation forestry deliver a one-off removal from the atmosphere over the first decades of the life of the forest. After that time, the forest is neither a sink nor a source of emissions as removals from growth are balanced by emissions at harvest. After that time, the forest is neither a sink nor a source of emissions as carbon removals from growth are balanced by emissions at harvest. Including these emissions removals in the base year would mean an ongoing level of new forest planting would be required to maintain net emissions at a constant level. This does not accurately represent the level of effort in the base year and would not be sustainable indefinitely.

At a global level however emissions from land use change represent additional emissions every year through deforestation and need to be reduced in the same way gross emissions do.

Chapter 3: How to measure progress, provides further detail on this issue.

Fluorinated gases

The three main gases comprise 98% of total greenhouse gas emissions. The remaining 2% are from fluorinated gases – hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

In the NDC trajectories, fluorinated gases have been held constant at 2018 levels in 2020, and then reduced in a linear trajectory to the target of an 85% reduction by 2036 consistent with the agreement made under the Kigali amendment to the Montreal Protocol to reduce emissions from HFCs.[5] HFCs comprise 95% of emissions of fluorinated gases so one trajectory has been applied for fluorinated gases in the aggregate.

10.2.4 Application to Aotearoa

Trajectories for each of the three main gases are calculated from the 2020 starting point, to the 2030 target level, converted to carbon dioxide equivalent using GWP_{100} values from the Fourth Assessment Report (25 for methane, 298 for nitrous oxide), and aggregated together with the trajectory for fluorinated gases. The upper and lower quartiles of emissions reductions modelled by the IPCC for 1.5°C pathways by gas were used for the target level in 2030. The quartiles were used to exclude the least feasible of the modelled scenarios while still providing a range. The sum of emissions over the 2021-2030 period provides the indicative allowed emissions over the NDC period associated with the IPCC 1.5°C ranges.

The range of emissions reductions modelled for the world for the three main greenhouse gases are given in Table 10.1 below.

Table 10.1: Percentage emissions reductions by gas by 2030 modelled by the IPCC

	Percentage change relative to 2010 by 2030	
	Lower quartile	Upper quartile
Net carbon dioxide emissions	-40%	-58%
Agricultural methane emissions	-11%	-30%
Agricultural nitrous oxide emissions	+3%	-21%

Table 10.2 steps through the figures for each of the three main gases. It includes what emissions of each gas was in 1990, and therefore what the 2020 target level is pro-rated to each gas (a 5% reduction on 1990 levels). It includes 2010 emissions of each gas. The upper quartile and lower quartile emissions reductions from Table 10.1 are applied to 2010 emissions to get two sets of 2030 end points for the NDC trajectory for each gas.

[5] (Ministry for the Environment, 2019a)

Table 10.2: Aotearoa NDC emissions trajectory start and end point calculations by gas

	Start point		**End point**		
	1990 emissions (kt gas)	**2020 target 5% reduction on 1990 (kt gas)**	**2010 emissions (kt gas)**	**IPCC 2030 Lower Quartile reductions (kt gas)**	**IPCC 2030 Upper Quartile reductions (kt gas)**
Net carbon dioxide	25,446	24,174	34,958	20,975	14,682
Methane	1,292	1,227	1,373	1,222	961
Nitrous oxide	16.5	15.7	23.1	23.8	18.2

Table 10.3 describes the start and end point for emissions of fluorinated gases used in the NDC calculations. As fluorinated gases comprise around 2% of total emissions, only one emissions trajectory has been used.

Table 10.3: Aotearoa start and end points used for fluorinated gas emissions

	2018 emissions (kt CO_2e)	**2036 target level, -85% (kt CO_2e)**
Fluorinated gas emissions	1,903	285

Table 10.4 and Table 10.5 then step through the emissions trajectories of each gas by drawing a straight path from the given start point in 2020 to the target level in 2030 for the lower quartile and upper quartile of IPCC 1.5°C pathways respectively. For the fluorinated gases, the trajectory is drawn to the target level in 2036 and the emissions over 2021-2030 are presented. Aggregating the volume of emissions allowed by these trajectories over 2021-2030 is how the NDC range of 524-604 Mt CO_2e were calculated.

Table 10.4: NDC emissions trajectories by gas and in total for the IPCC lower quartile 1.5°C pathway

	Emissions trajectory associated with IPCC lower quartile cuts for 1.5°C pathways						
Year	**Carbon dioxide ($kt\ CO_2$)**	**Methane ($kt\ CH_4$)**	**Methane ($kt\ CO_2e$)**	**Nitrous oxide ($kt\ N_2O$)**	**Nitrous oxide ($kt\ CO_2e$)**	**Fluorinated gases ($kt\ CO_2e$)**	**Total ($kt\ CO_2e$)**
2020 start point	24,174	1,227	30,673	15.7	4,681	1,903	61,431
2021	23,854	1,226	30,660	16.5	4,921	1,802	61,237
2022	23,534	1,226	30,648	17.3	5,161	1,701	61,043
2023	23,214	1,225	30,637	18.1	5,400	1,600	60,849
2024	22,894	1,225	30,622	18.9	5,640	1,499	60,655
2025	22,574	1,224	30,609	19.7	5,880	1,398	60,461
2026	22,254	1,224	30,596	20.5	6,120	1,297	60,267
2027	21,934	1,223	30,583	21.3	6,360	1,195	60,073
2028	21,615	1,223	30,570	22.1	6,600	1,094	59,879
2029	21,295	1,222	30,558	22.9	6,840	993	59,685
2030	20,975	1,222	30,545	23.8	7,080	892	59,491
Total 2021-2030	224,144	12,241	306,026	201.3	60,003	13,472	**603,643**

Table 10.5: NDC emissions trajectories by gas and in total for the IPCC upper quartile 1.5°C pathway

	Emissions trajectory associated with IPCC upper quartile cuts for 1.5°C pathways						
Year	**Carbon dioxide ($kt\ CO_2$)**	**Methane ($kt\ CH_4$)**	**Methane ($kt\ CO_2e$)**	**Nitrous oxide ($kt\ N_2O$)**	**Nitrous oxide ($kt\ CO_2e$)**	**Fluorinated gases ($kt\ CO_2e$)**	**Total ($kt\ CO_2e$)**
2020 start point	24,174	1,227	30,673	15.7	4,681	1,903	61,431
2021	23,225	1,200	30,008	15.9	4,756	1,802	59,791
2022	22,276	1,174	29,343	16.2	4,831	1,701	58,151
2023	21,326	1,147	28,678	16.5	4,906	1,600	56,510
2024	20,377	1,121	28,013	16.7	4,981	1,499	54,870
2025	19,428	1,094	27,349	17.0	5,055	1,398	53,230
2026	18,479	1,067	26,684	17.2	5,130	1,297	51,590
2027	17,530	1,041	26,019	17.5	5,205	1,195	49,949
2028	16,581	1,014	25,354	17.7	5,280	1,094	48,309
2029	15,631	988	24,689	18.0	5,355	993	46,669
2030	14,682	961	24,024	18.2	5,430	892	45,029
Total 2021 - 2030	189,535	10,806	270,161	170.9	50,929	13,472	**524,098**

10.3 What social, economic and demographic changes may occur that could affect methane emissions from Aotearoa?

This section summarises information on key social, economic and demographic factors and changes that may occur until 2100 that could affect the level of methane reductions Aotearoa makes. The material considers both global 'megatrends' and factors within Aotearoa.

The section draws on a number of domestic and international sources. Key amongst these is a summary report of national and international factors that can affect the primary sector and land use, produced by the Our Land and Water National Science Challenge.[6]

10.3.1 Population growth and food demand

The world population is expected to continue to increase over the century, reaching more than 9 billion people by 2050. Figure 10.3 shows this with the medium, high and low projections from the United Nations Population Prospectus 2019. Global population growth rates are expected to slow over the century, although by how much is uncertain. Estimates used in the IPCC 1.5°C pathways put the likely global human population at between 9-11 billion by the end of the century.[7]

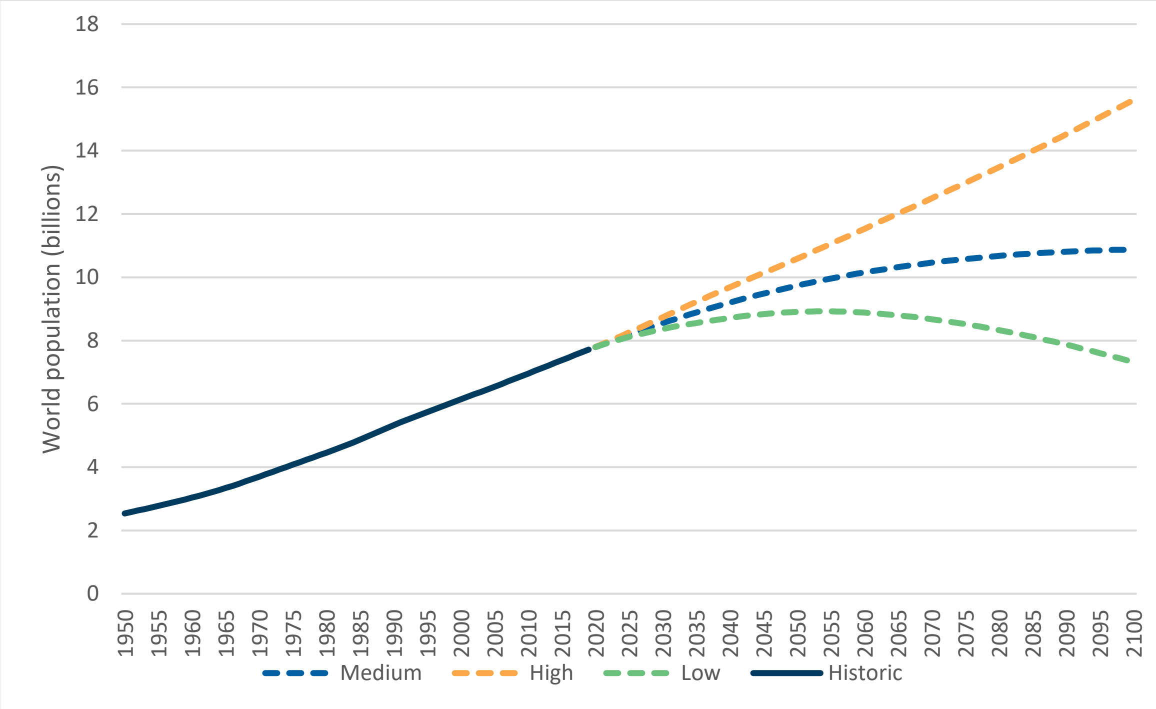


Figure 10.3: Historic and projected global population growth[8]

Population growth rates vary in different parts of the world. It is expected that Africa (predominantly sub-Saharan Africa) will account for most of this growth, with the population increasing from around

[6] (Driver et al., 2019)
[7] (IPCC, 2018)
[8] (United Nations, 2019)

1.3 billion to 4.3 billion people by 2100. In comparison, European and Latin American populations are expected to decline by 2100.[9]

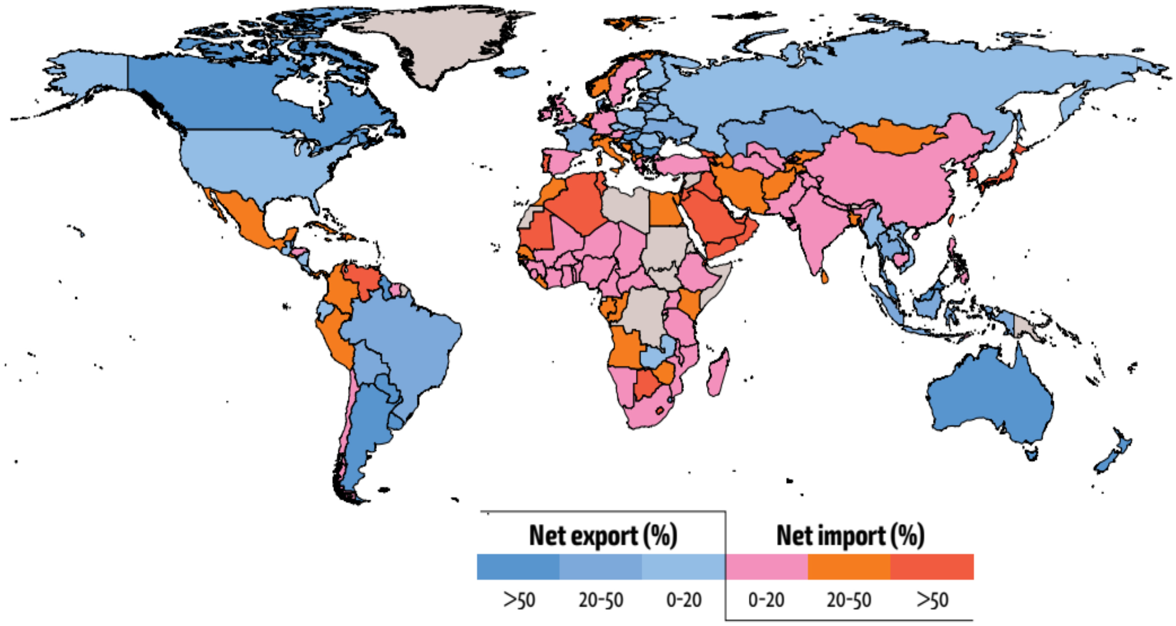
This growing population will require food and nutrition. A number of estimates exist for changes in food demand, which include both an increase in total amount and changes in the type food required.

The Food and Agriculture Organisation (FAO) has estimated the need to double global food production by 2050 to meet the expected demand of around 9.7 billion people, although this need is not evenly distributed around the world. Food demand in sub-Saharan African and South Asia is expected to double, and increase by around a third in the rest of the world. The FAO also predicts increasing demand for animal products, fruit and vegetables and more processed foods, due to a combination of increasing wealth and greater urbanisation.[10]

The IPCC 1.5°C pathways also model food demand, and largely expect individual demand for food (calories/person/day) to stay the same or to increase over the rest of the century. Combined with the expected increases in total population, this will lead to an overall increase in food demand.

Food exporting countries such as Aotearoa will have an important role to play in meeting this projected increased demand. As Figure 10.4 shows, many of the regions that will experience the greatest population growth are also already net food importers.

[9] (United Nations, 2019)
[10] (FAO, 2017)



Source: FAO Global Perspectives Studies, using 2011 food balance sheets from FAO, 2016a.

Figure 10.4: Percentage of net food imports in domestic food supply in total calories[11]

Aotearoa exports food and fibre to over 140 countries. The top ten countries by revenue are shown in Figure 10.5. China is the country's largest export destination, with dairy, meat and wool and forest products making up the majority of products sold.

[11] (FAO, 2017, p. 29)

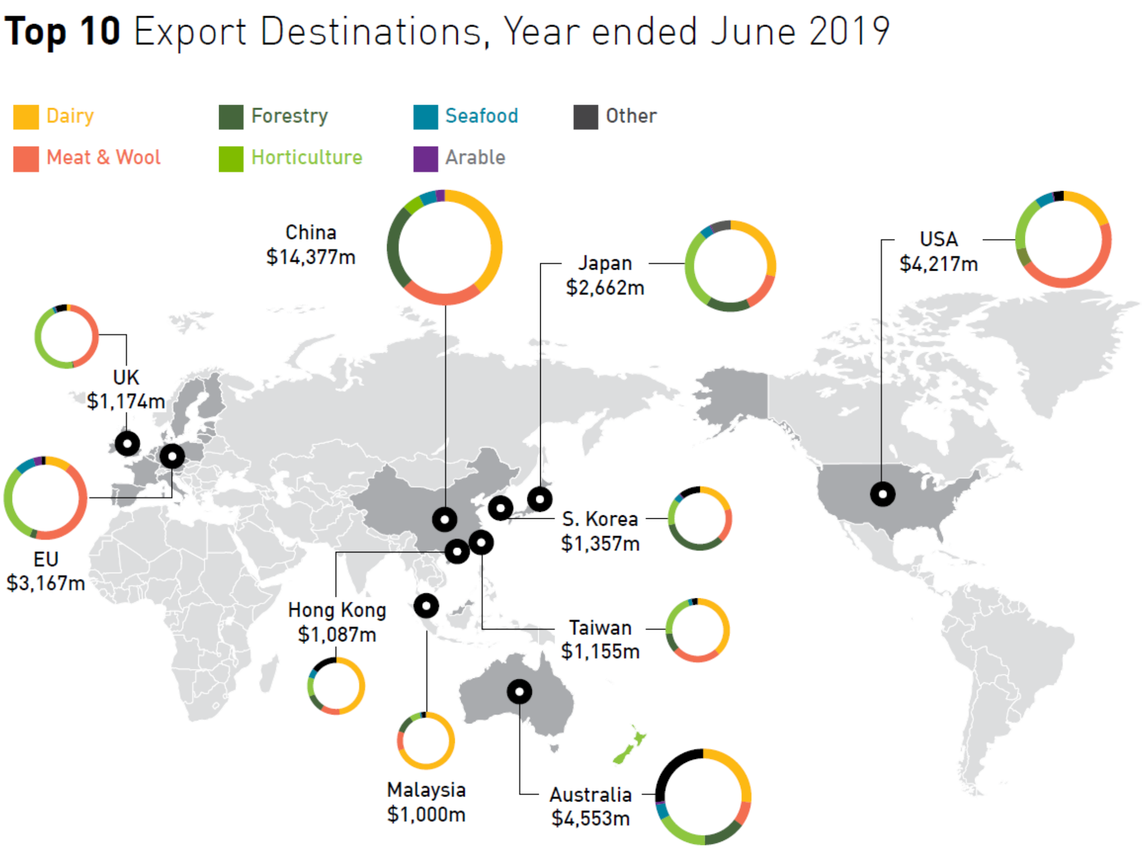


Figure 10.5: the top ten countries that Aotearoa exports food and fibre to[12]

The bulk of global population growth is expected to occur in regions that are not currently major export destinations for Aotearoa, such as sub-Saharan Africa and South Asia. Most Aotearoa dairy and meat exports are targeted at middle-class and premium consumers in China, Europe and North America. However, in addition to global population growth, incomes in many developing countries are expected to rise and bring with it an expanded global middle-class. Historic trends and population surveys show a clear relationship between increasing incomes and consumption of meat and dairy products, which may favour producers in Aotearoa.[13]

10.3.2 Demand for low emissions agricultural production

Both globally and domestically, there are growing concerns about quality and environmental footprint of food. Food safety and quality is a fundamental expectation, and Aotearoa does well in this regard. We have well developed systems and processes to ensure the quality of the food that we consume domestically and export.

Rising consumer expectations regarding the climate impact of products could affect the context of the country's biogenic methane emissions reductions in several ways.

Firstly, it could lead to changes in demand for meat and dairy exports. On one hand, this could favour Aotearoa producers if consumers place a premium on lower emissions varieties of the products they already consume. The country's meat and dairy products are already some of the least

[12] (Ministry for Primary Industries, 2020, p. 5)
[13] (Godfray et al., 2018)

emissions intensive (emissions per unit of product) in the world,[14] and this efficiency has been increasing over time. There has been an efficiency gain of approximately 33% for sheep meat, a 30% for beef and a 20% for dairy between 1990 and 2017 (Figure 10.6).

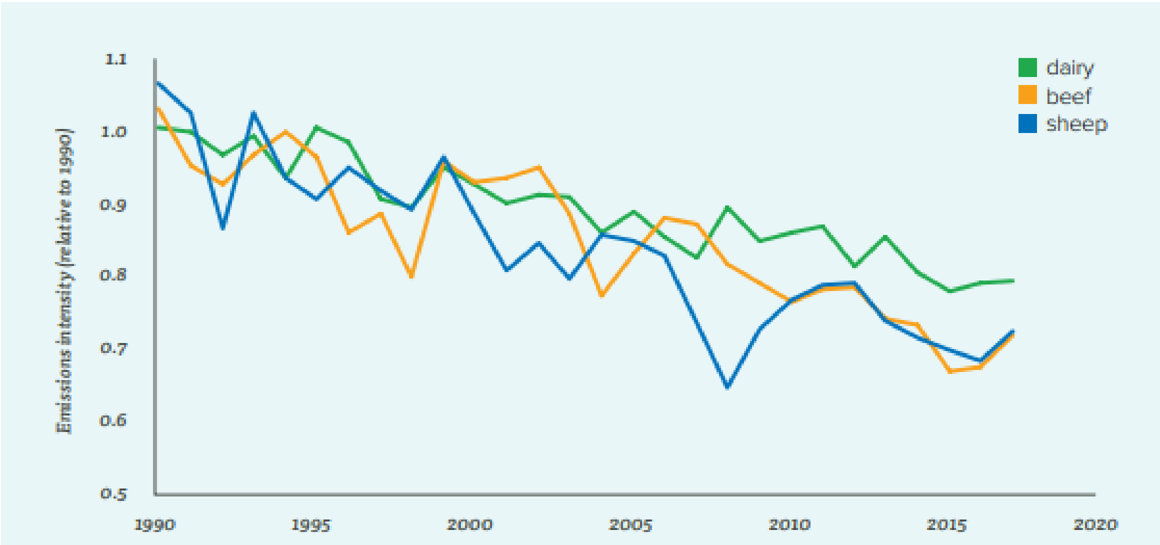


Figure 10.6: Emissions intensity (emissions per unit of product) 1990 to 2017.[15]

Secondly, a shift in preferences towards low emissions products could negatively impact Aotearoa exports if preferences move not to lower emissions versions of meat and dairy products but away from these products entirely.

The production of some alternative protein products has been shown to have lower environmental impacts, including producing significantly less greenhouse gas emissions, than traditional ruminant-based dairy production.[16]

Alternative dairy products, based on plant ingredients such as soy, nuts and other plant products are a growing global market. The global market for dairy alternatives was valued at US$15.5 billion in 2017 and expected to grow to US$38.9 billion by 2025.[17] Global dairy company Danone has recently invested around US$60 million in plant-based production to allow it to complete in the alternative dairy category.[18]

Similar, demand for other alternative protein sources is also growing. These sources include foods such as edible insects, plant and non-ruminant proteins, and cultured or synthetic proteins.

There has been significant growth the availability of plant-based proteins over the last decade, including within Aotearoa – one domestic supermarket chain recorded a 36% increase in demand for plant-based protein between 2018 and 2019.[19] Globally, it has been estimated that plant-based

[14] (Parliamentary Commissioner for the Environment, 2019)
[15] (Interim Climate Change Committee, 2019, p. 27)
[16] For example, see (Poore & Nemecek, 2018)
[17] (Driver et al., 2019)
[18] (Driver et al., 2019)
[19] (Stuff, 2019)

meat replacements could make up 25% of global demand by 2040, compared to less than 10% in 2015.[20]

There is also growing interest in the production of cultured or synthetic proteins that are produced using biotechnical methods. They include culturing of animal tissue cells within laboratory conditions to create alternatives to animal grown 'meat', and recombinant genetic technologies to produce milk or milk constituents, in place of milk from a cow or other ruminant. Fonterra has recently invested in a US-based food developer involved in alternative milk production to diversify its product portfolio.[21]

To date, no company has successfully brought a cultured meat or milk alternative to market, although there are more than 30 companies globally that are seeking to do so.[22] There are a range of reasons for this, including costs or production, uncertainties around acceptance by consumers, and a lack of regulatory systems to support commercialisation. Current estimates put the arrival of cultured meats on supermarket shelves at anywhere between 1-20 years.[23]

However, there is unlikely to be a global abandonment of animal-based proteins due to cultural and nutritional reasons. Animal-based food contain essential nutrients that are not always easily produced in certain environments. Vitamin B12, for example, is almost only found in animal products.

It is not possible to definitively say what the overall impact of these developments – both increasing demand for relatively low emissions animal-based products that Aotearoa already produces, and for alternative sources of protein that do not come from ruminants – will be on production systems in Aotearoa. It is also not possible to say exactly what impact they may have on emissions of biogenic methane.

In light of this, both producers and government agencies have largely taken a 'watching brief' approach,[24] although as noted above, Fonterra has taken the more proactive step of investing in a US-based alternative milk company.

10.3.3 Other environmental challenges

Other environmental challenges are also related to the sources of biogenic methane emissions in Aoatearoa (waste and agriculture). These include freshwater quality, soil health, biodiversity loss and soil erosion. The growing pressure of these challenges combined with efforts to address them may have important consequences for efforts to reduce methane emissions.

Freshwater quality has been a particular focus of attention over the last few decades as large areas of sheep and beef farming and plantation forestry were converted to dairy. Although rates of nitrogen and phosphorus and pathogen loss into waterways varies with land management, rates of nutrient loss into waterways are generally higher from dairy operations than from sheep and beef farming and forestry.[25] In some parts of the country where there have been large-scale land

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[20] (A. T. Kearney, 2019)
[21] (Fonterra, 2019)
[22] (Burton, 2019)
[23] (Driver et al., 2019)
[24] For example, The Treasury states *"While, artificial meats may not be in a position to significantly disrupt the market at present, they do pose a risk. This risk is not sufficiently certain in timing or magnitude to meaningfully incorporate into the Treasury's economic forecasts at this stage. However, it is a risk that the Treasury will continue to monitor."* (The Treasury, 2018)
[25] (Parliamentary Commissioner for the Environment, 2013)

conversions, such as Canterbury, Southland and the central North Island, indicators of water quality and ecological health have significantly declined.[26]

Declining freshwater quality is a threat to many native species, this is also exacerbated by the clearance and conversion of native habitats – such as forests, wetlands and natural grasslands – often into pasture.[27]

Farmers and farmer groups have traditionally self-managed many of the environmental impacts of farming – either as a by-product of production-based activities, or through voluntary actions.

Over recent decades, farming industry bodies have also offered support to farmers in managing environmental impacts and have developed a range of voluntary schemes aimed at addressing environmental impacts. Most notably over the last few years, industry groups and agriculture companies have worked with the Government to manage impacts on freshwater through the voluntary accord *Sustainable Dairying: Water Accord.*[28] The *He Waka Eke Noa – Primary Sector Climate Action Partnership* was established between the government and the primary sector in late 2019. The partnership aims *"to equip farmers and growers to reduce emissions, maintain or increase sequestration, and adapt to a changing climate."*[29]

Local and central government have also introduced a range of legislation and actions aimed at manging the environmental impacts of farming. Key among these has been the Resource Management Act 1991, and more recently, the National Policy Statement for Freshwater Management and supporting National Environmental Standards.[30] The Resource Management Act has driven in some key improvements in water quality – for example the removal or improvement of point-source discharges from dairy operations, has resulted in significant reductions in phosphorus levels and improvements in water clarity in many areas.

The Government has also recently amended the National Policy Statement for Freshwater Management with the aim of strengthening environmental protection. The impact that the changes to the National Policy Statement for Freshwater Management are expected to have on greenhouse gas emissions are outlined in *Chapter 7: Where are we currently heading?*.

Waste management is also associated with other environmental challenges. While modern, engineered landfills mitigate some of the environmental impacts associated with their construction and management, they have wider ecological effects which may lead to landscape changes, loss of habitats and displacement of fauna. Waste leaching, particularly from older landfills, can also contaminate nearby soils and aquifers.[31] New landfills must be designed to prevent leaching and are subject to close compliance and environmental monitoring.

Overall, efforts to manage the environmental impacts of agriculture and waste can be expected to have largely positive impacts on biogenic methane emissions. Changes to agricultural management practices that help improve water quality impacts – such as modifying livestock feed or adjusting

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[26] (Ministry for the Environment & Stats NZ, 2020)
[27] (Ministry for the Environment & Stats NZ, 2020)
[28] (Dairy Environment Leadership Group (DELG), 2015)
[29] (He Waka Eke Noa, 2020)
[30] (New Zealand Government, 2020) and (Ministry for the Environment, 2020)
[31] For example, a greater frequency of extreme weather events like storms and flooding as a result of climate change may also increase the risk that landfills are disturbed, resulting in the release of waste into the environment. Many old landfills are close to rivers or the coast. (Parliamentary Commissioner for the Environment, 2008)

stocking rates – should also result in fewer methane emissions. Similarly, efforts to reduce the production of waste in the first place, or to divert waste away from landfills to composting or recycling, should also lead to reductions in biogenic methane emissions.

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