The path to 2050?

The research into the capacity of the New Zealand pastoral sector to achieve agricultural emissions reduction through system change.

The Future Farm Systems Research Programme White Paper

Report prepared by
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Executive Summary

The necessity for the New Zealand agricultural sector to contribute to global emissions reduction is increasingly apparent. Outside of New Zealand's international commitments, domestic legislation, or our customers' requirements, it is in our farmers' own interest that everyone can do what they can to slow, stop, and, ideally, reverse human impacts on the climate.

With methane emissions tightly linked to feed intakes and nitrous oxide emissions largely derived from the nitrogen cycle, most currently applicable emissions mitigations relate to farm management practices. The implementation of most mitigations also has a cost, normally by way of lowered profitability, to the farm system. Much of the recent research effort has focused on better understanding the drivers of the associated biological processes, finding ways to disrupt them to identify more cost-effective ways to mitigate them. There was therefore an opportunity to investigate the more disruptive impacts and transformational solutions associated with the New Zealand pastoral sector reducing its agricultural greenhouse gas (aGHG) emissions. As a result, the Ag Emissions Centre initiated and funded a Future Farm Systems Research Programme in 2022

This body of research, completed over the past three years, supports the premise that change is indeed possible at farm level, but there are limitations and wider implications.

While farm systems and land use change mitigations have the potential to allow individual farms to significantly lower emissions, actions-to-date unsurprisingly comprise "low-hanging fruit" and have tended to be limited in scale. The expectation of potential regulatory intervention and emerging customer requirements have undoubtedly been a factor in decisions by early adopters to proceed with mitigation, but only to the extent that makes commercial sense (or perhaps just beyond it). The current Zero Carbon Act targets set a strategic direction, but in themselves appear inadequate to drive change on-farm to any significant level.

Further to this, reducing emissions is complex and "messy", not linear. It would appear it is easier for farmers to undertake this journey with others than doing so individually. Doing so collectively provides (a) mutual support/reassurance about the difficulty of this issue (which is critical for ongoing engagement) and (b) an exposure to different risk appetites, solutions, and approaches that can empower farmers to step outside of their own paradigms and risk parameters. The work also identified some important findings about farmer engagement with emissions reduction.

- Farmer willingness to engage in a farmer-led project varies significantly. They seem to be more willing to engage when there is an external pressure-point to do so (such as the proposed emissions pricing that still existed at the start of this research) and commitment wanes if this drops off.
- There appears to be limited farmer confidence in mitigation technologies, apart from genetics, being able to contribute significantly to reductions. This is mostly around market acceptance and cost/practicality to utilise. Most participants see farm system change, land use change, and alternative revenue sources as critical factors in how they respond.
- The research has also identified that there are still significant gaps in farmer understanding about the drivers of emissions and, subsequently, what that means in terms of the extent of and impact from system changes needed to achieve variable levels of emissions reduction.
- Participants referenced a lot of information that seems to contradict New Zealand's international position and our markets' growing expectations. This clearly highlights the lack of supporting information out there from [trusted] agricultural sources around what the sector needs to do and why, and where the evidence sits for this. Rural media, both analogue and digital channels, appear to be dominated by "anti-mitigation" narratives, with limited to no alternatives presented.
- There was an underlying perspective by participating farmers that they need to be rewarded [now], somehow, for environmental performance and/or being early adopters.

While technological solutions are increasingly likely to play a collective [and possibly dominant] role in deliberate emissions reduction, land use change seems to be a widely expected outcome for the sector in the medium-term, whether directly driven by mitigation, adaptation, or both. In saying this, the research by no means suggests this will be a fait accompli.

- It appears extremely difficult to pick any so called "winners" amongst alternative land uses to replace ruminant agriculture at the necessary scale to replace the economic engine and export earnings currently provided by dairy, sheep, beef and deer farming.
- Challenges with scaling up post-gate supply chains, a current lack of financial competitiveness, and limits to capital availability are some of the key reasons for this. This does not preclude their development or potential growth, but it does speak to the risks and costs associated with doing so.

While a lot of emissions mitigation strategy necessarily focuses on individual farmer outcomes, communities are also cognisant of the impacts that moving to a lower emissions primary sector might entail. This will look different across regional New Zealand, not just due to the geo-physical limitations that determine appropriate land uses, but due to pre-existing socio-cultural drivers and the state of and access to infrastructure. Despite the inherent uncertainty of how a low emissions future for New Zealand's primary sector might ultimately be experienced, this research indicates such pathways do exist, albeit with a range of community preferences for them and likely differing regional expressions.

- It does seem, however, that even given the size of the recently scaled back methane reduction target of 14-24%, the primary sector's transition to lower emissions will involve fewer ruminants, new or expanded supply chains, and a need for significant capital investment, both within specific sectors and in public infrastructure.

Understanding the main drivers of success in reducing greenhouse gas emissions will therefore be crucial for decision-making by central and regional authorities. These drivers include community aspirations, infrastructure costs, and social/economic impacts. Any community is most likely to succeed in our uncertain future when the targeted outcome aligns with community support and adequate resources.

The research ultimately highlights the importance of collaboration, the need for integrated policy across all environmental challenges, and the role of government and community support in achieving the emissions reduction goals for the pastoral sector.

While there are specific take-home messages for industry, government and for the science sector, given the complex challenges that the research identifies face the pastoral sector in reducing agricultural emissions, it is also critically important that we continue to research the options for methane and nitrous oxide reduction that would enable the continuation of a pastoral sector of similar economic value to today.

In making this recommendation we are fully cognisant of the fact that, due to a broader range of environmental and social impacts, not least the need to reduce emissions, farming as we know it today must continue to evolve and improve - quickly. Given, however, the reality that Aotearoa New Zealand's standard of living continues to rely on the production of food and fibre from our natural resources, it is not tenable in our view to advance narratives that such activity needs to substantively cease.

We need to find ways, if we can, working together, to have both our environmental cake and to eat the economic one.

Lee Matheson Erica van Reenen

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Chapter One:
Introduction

The Future Farm Systems Research Programme

As a result of a review of existing literature by the Ag Emissions Centre (formerly known as the New Zealand Agricultural Greenhouse Gas Research Centre) in 2021[1] it was identified that there was an apparent gap in the body of research associated with lowering farm emissions. Existing research has tended to focus on incremental changes – what might be considered "business as usual" (BAU). It was determined that there was an opportunity to investigate the more disruptive impacts and transformational solutions associated with the New Zealand pastoral sector reducing its agricultural greenhouse gas (aGHG) emissions[2].

Consequently, the Ag Emissions Centre initiated and funded a Future Farm Systems Research Programme in 2022. This programme has two parts.

Behind the farm gate

The first part, led by Erica van Reenen from AgFirst Whanganui-Manawatū, focused on the farm-level transition to a low emissions future.

This essentially comprised work that concentrated on the farm level mitigation (both incremental and disruptive) needed to lower biogenic methane and nitrous oxide emissions and the drivers/barriers behind existing and further adoption.

The research interrogated a range of farming operations that had already independently taken steps to reduce emissions (Chapter 3), to better understand the decision-making processes and associated drivers underpinning existing strategies being adopted to lower emissions and help build resilience to future warming. The larger component of the research (Chapter 4), which is still ongoing, comprised exploring the mechanisms and dynamics of five voluntary groups of landowners and farmers, from across the motu, who were engaged in identifying and designing a collaborative solution to achieving a meaningful aggregate reduction in biological greenhouse emissions. Researcher interactions with the groups were specifically designed to ensure the initiatives, whilst supported by the Ag Emissions Centre, were truly "farmer-led", with professional input only provided as and when the groups initiated it.

Beyond the farm gate

The second part of the programme, led by Lee Matheson from Perrin Ag, applied a wider, more disruptive, and longer time-frame lens to emissions reduction.

This research attempted to envision what a low emissions future for the primary sector might deliver in the absence of sufficient technological solutions that its customers might accept, or that have sufficient efficacy to allow our current land use systems to endure.

The research investigated what the implications might be for the primary sector in how its adoption of mitigations to reduce emissions interacts with the need to adapt to embedded climate change and the flow-on effects to our economy and communities at large. As well as detailed investigation into the supply chains of representative land uses that might be required to deliver the scale of agricultural emission reduction proposed (Chapter 5), a range of plausible low emission future scenarios were developed in both Te Tai Tokerau Northland and Murihiku Southland. These were explored and subsequently analysed with community and sector stakeholders, providing insight into the diverse range of wider impacts that lowering emissions might deliver for regional New Zealand (Chapter 6).

Bringing it all together

While components were visibly discrete, the programme should be considered as an integrated body of work. Each tranche of research had synergies with the other and the delivery teams collaborated and were able to leverage off each other's respective milestones and lessons as the programme proceeded.

This white paper is, therefore, intended to bring together the combined insights from all parts of this research programme and make its key messages and conclusions accessible to the diverse audience for the research - other farmers and growers, Māori agribusinesses and landowning entities, industry bodies, regional councils, research organisations, and central government.

At the time of publication, research with the farmer groups collaborating to reduce emissions continues, restricting the insights herein to those identified to date.

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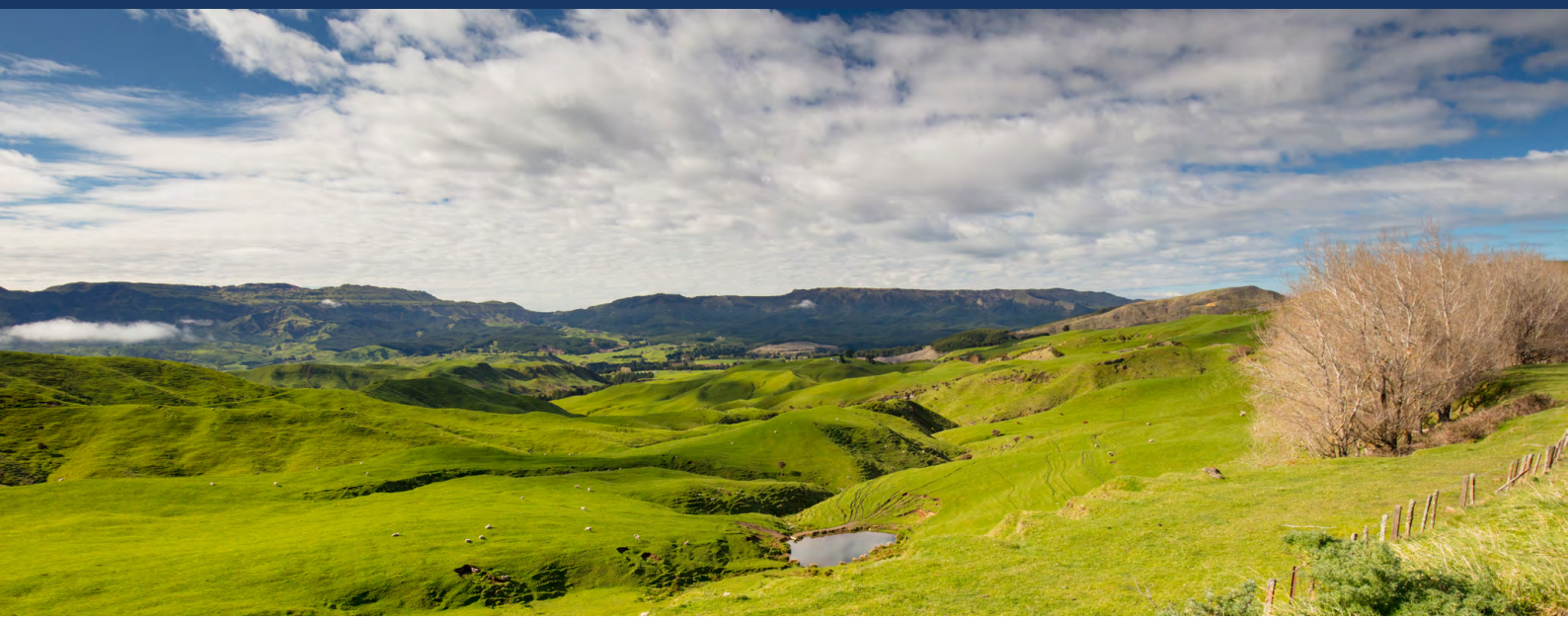
[1] https://www.ag-emissions.nz/publications/future-farm-systems-stocktake/

[2] Agricultural greenhouse gas emissions (aGHG) comprise the biogenic methane and carbon dioxide emissions (bGHG) and nitrous oxide emissions that are derived from agricultural activity

Chapter Two:

The changing landscape



Why reduce emissions?

The necessity for the New Zealand agricultural sector to contribute to global emissions reduction is increasingly apparent. Outside of New Zealand's international commitments, domestic legislation, or our customers' requirements, it is in our farmers' own interest that everyone can do what they can to slow, stop and, ideally, reverse human impacts on the climate.

Some level of anthropogenic climate change is considered to be essentially locked in for current and near-term generations, with some of these impacts already being felt across the motu. While adaptation to climate change has not been a focus of the future farm systems programme, expected impacts provide important context, motivation and rationale for on-farm mitigation and its associated wider implications.

A review of the expected impacts of climate change on the environment for New Zealand farming was completed by Batley et. al. (2022)[3] as part of this research.

[3] Batley, L., Stantiall, J. & L Matheson. 2022. A literature review on expected climate change impacts and farm system and land use changes and their associated economic outcomes for New Zealand farmers, with a focus on the Te Tai Tokerau Northland and Murihiku Southland regions. A report prepared for the New Zealand Agricultural Greenhouse Gas Research Centre. 76 pages.

Expected impacts of climate change on our primary sector

Climate change will predominantly increase temperatures across New Zealand, which is expected to increase droughts and fire risk throughout most of the country but will also result in warmer winters.

Warmer winters, however, result in more snow and ice melt which changes the hydrology of rivers, especially those which are fed by glacial and snowmelt. Some parts of New Zealand will receive more rainfall, such as the west coast of Southland, while other parts are expected to receive less, such as Northland. Wind is likely to increase in central and southern parts of New Zealand, while extreme weather events are likely to become more common across New Zealand. Ocean levels, temperature and acidity are all expected to increase, which has implications for coastal infrastructure as well as saltwater intrusion into aquifers.

One major aspect of increasing carbon dioxide levels is carbon fertilisation, which results in more efficient plant growth, especially in temperate species, and is likely to increase plant growth across New Zealand. However, there is also expected to be a considerable increase in weeds, pests and diseases, due to warmer temperatures, which are likely to establish initially in the north and migrate south. In warmer climates, such as Northland, animal health and production are likely to be compromised, while pasture quality is expected to decrease due to lower quality tropical pastoral species becoming dominant in the sward. Additionally, temperate grasses and legumes will struggle to survive warmer summers, leaving the overall impact of climate change on pasture production unclear.

Pastoral production in other parts of New Zealand is likely to become more winter and spring dominant, which will have wider implications on pastoral based systems. The most likely adaptation for the pastoral sector will be to diversify into more temperate or heat and drought tolerant animal and plant species, or to increase irrigation capacity which will require more water storage infrastructure.

The increase in temperatures is predicted to allow crops currently grown in the north to move further south and to be sown earlier, while crops in northern regions may need to change to more subtropical and tropical species. Conversely, the increase in winter temperatures may negatively impact vernalisation requirements of plants, which may affect the arable industry but will predominantly affect the horticultural industry.

Increasing wind may lead to more exotic forestry damage, although exotic forestry species are likely to be more resilient than indigenous forest species at adapting to climate change.

Aquaculture will be impacted by increasing water temperature, changes in wave activity, sea level, river flow, acidification and the connectivity of existing coastal ecosystems, as changes occur to water structure and oceanographic currents. Inshore fish species will be more affected than offshore species, and species will tend to migrate south to buffer the effects.

Finally, extreme weather events will impact all industries, as well as infrastructure which will have flow on effects. There is very little literature that identifies the cumulative effects of climate change, which is noted in several studies.

Chapter Three:

What's already possible behind the farm gate?

Reducing on-farm emissions

While a requirement for the New Zealand agricultural sector to reduce emissions was ultimately only mandated in the 2019 Zero Carbon Act, the sizeable contribution of the sector to the national emissions footprint has been well understood for some time, as has the likely need for the sector to reduce. New Zealand's relatively unique emissions profile (at least among developed nations) means that any meaningful contribution to reducing either gross emissions or additional warming requires the agricultural sector to reduce its annual methane and nitrous oxide emissions.

There has been no lack of vocal discussion on arguments for and against emissions reduction from farmers. There has also been detailed research and analysis on the potential intersections between policy options, commercial implications and emissions reporting, culminating in the now defunct He Waka Eke Noa initiative. While much of the outwardly visible activity on emissions reductions appears to have focused on the politics of this issue, there is a significant body of research on the mechanisms and efficacy of agricultural emissions reduction within New Zealand farming systems, even if is primarily focused on incremental change.

What the research already tells us

With methane emissions tightly linked to feed intakes and nitrous oxide emissions largely derived from the nitrogen cycle, often amplified by nitrogenous fertiliser use, most currently applicable emissions mitigations relate to farm management practices. Emissions are not easily measured, so there is a heavy reliance on modelling. Modelling of the same mitigations by different groups of researchers has helped to provide confidence where the results have been similar. Technical mitigations (e.g. feed additives) rely very heavily on science and in some cases the science has not been completed yet.

The implementation of most mitigations has a cost (by way of lowered profitability) to the farm system. Farm practice change tends to result in the loss of production and accompanying net revenue, particularly for meat and fibre systems, while technological and infrastructural mitigations increase operating costs. The extent of this will vary depending on the capacity of farmers to capture potential productivity gains through implementation, the cost of novel technology, the relative values of saleable product and input costs (particularly for dairy), and the relative profitability of alternate low emissions land uses. Incentives to reduce from either governments or markets will also be an important consideration.

While existing research suggests the cost of some mitigation might be low, or in some instances enhance profitability, these studies have often relied on modelling that, while being theoretically correct, is often very difficult to achieve in practice. Some mitigations have co-benefits for other environmental and farm issues such as reductions in nitrogen and phosphorus loss, reduction in sediment loss, lower water use, sometimes increased production and/or net revenue, and sometimes reduced labour requirements.

Based on the literature reviewed by Batley et. al. (2022), the mitigations likely to have the biggest impact for dairying are either not yet commercially available (methane inhibitors and methane vaccines at an expected 30% reduction in aGHG) or involve reduced stocking rates, either alone or as part of a mitigation bundle (10-20% reduction). Feeding extra lipids could provide a 20% reduction in aGHG. Removing all nitrogen fertiliser either alone or as part of a bundle have a range of reductions between 6% and 14%. Restrictive grazing, which involves the removal of animals from pasture for extended periods of time (with subsequent impacts on nitrous oxide emissions) was in the order of 10% reduction (range of 3% to 14%). Removing all cropping on Waikato dairy farms provided about a 7% reduction. Reducing stocking rate and improving cow performance at the same time has a range of 3% to 9% reduction in aGHG. Genetic selection for lower emission animals has an expected range of reduction between 3% to 15% for dairy cows but takes time to be reflected in an entire herd. A change to once-a-day milking has the potential to reduce aGHG between 5% and 10% if the reduced feed demand is not diverted to other uses. Using a methanogen inhibitor additive to effluent storage ponds might provide a 4-5% reduction in methane emissions. Most other mitigations investigated result in less than 3% reduction in aGHG (e.g. alternative feeds, inhibitor-coated N fertilisers, methane capture in effluent ponds, planting riparian areas and creating wetlands).

The mitigations likely to have the biggest impact for sheep and beef cattle are either future-based (methane vaccines at a potential efficacy of a 30% reduction in aGHG) or involve reduced stocking rates, either alone or as part of a mitigation bundle (10-20% reduction). Planting pines on marginal country (10% of the farm area and associated stock reductions) results in a net emissions footprint improvement of about 25% after accounting for sequestration. Trees for erosion control and shelter could similarly reduce net emissions by 7.5% to 13% and riparian areas, 7%. Of course, for maximum effect (and ease of administration) these mitigations fundamentally rely on carbon sequestration in such forests being able to directly offset biogenic methane, something not currently provided for under New Zealand legislation, but advocated for by some commentators, including the Parliamentary Commissioner for the Environment[4]. Genetic selection for lower emission animals has a range of reduction between 5% to 10% for sheep but takes time to be reflected in the whole flock. As with dairying, most other mitigations investigated result in less than 3% reduction in aGHG (e.g., improved animal performance, adjusting stock classes or ratios, removing nitrogen).

[4] Parliamentary Commissioner for the Environment. Alt-F Reset: Examining the drivers of forestry in New Zealand. April 2025. 236 pages.

Deer enterprises have been more difficult to research due to smaller numbers and often being included as part of sheep and cattle farms, but where modelling has occurred similar outcomes as those for sheep and beef cattle have been identified.

Emissions from arable enterprises are much lower than from livestock systems and there are almost no methane emissions (as arable farmers with livestock tend to have them for a short period of time as part of their rotations). Based on the literature reviewed, the mitigations likely to have the biggest impact for arable enterprises are irrigation management (up to 30% reduction in aGHG) and nitrogen management (10-20 % reduction). Most other mitigations resulted in less than 5% reduction.

Similarly to arable, emissions from horticultural enterprises are much less than from livestock and there are almost no methane emissions. Consequently, much of the literature has been focussed on non-agricultural CO_2 emissions, which was outside of the direct scope of this work. Mitigations likely to have the biggest impact for horticultural enterprises are the planting of riparian areas (5% net improvement) and a bundle of mitigations for kiwifruit - increasing productivity, using biochar from the prunings, and reducing nitrous oxide emissions from N fertiliser (3% to 4% reduction in aGHG).

What we are seeing in practice

Five case studies were chosen to provide a cross section of land uses, location, focus (resilience or reducing biological greenhouse gases), whenua Māori, and mechanism (management change or land use change) from pastoral farming enterprises across New Zealand. For these farm businesses, the gross biological emissions reductions achieved ranged from 2.2% to 16% over three to five years. In most of the case studies, emissions fluctuated between the base year and current year due to seasonal variation and the vagaries of implementing system change. Drivers of emissions reductions were rarely singularly focused with most having a combination of stocking rate reductions and management changes as well as land use changes within systems, to a greater or lesser extent, across the case studies.

Most (but not all) knew their emissions number before the case study analysis was completed, but most did not have a specific written plan to address emissions or a clear understanding of their emissions profile.

In all the case studies, there is a strong focus on improving efficiency and management practices to improve overall farm performance, which then also reduced greenhouse gas emissions. This probably explains the relatively small emissions reductions achieved from farm system changes alone. Overall farm performance included better pasture management, genetics, feed utilization, and overall farm system optimization. This contrasts slightly with existing research, in which mitigations have been the primary focus, and gains in efficiency and productivity typically identified as a mechanism to reduce the otherwise negative financial impacts of farm system mitigation. Where more costly mitigation strategies were employed, such as indigenous tree planting and land retirement, external funding was often sourced, which helped promote these actions.

Decision-making processes involved careful evaluation of the environmental, economic, and social implications of their actions. The case study farmers come from a wide range of locations and farming systems. There was also a cross-section of age and experience in the farmers interviewed. Decision making was not undertaken individually in any of the case studies. This was driven in part due to the ownership structure (e.g. trustees, investment managers, multiple generations, directors, or broader farm team). Case study farmers drew on their own experiences or those who have farmed the land before them to support their decision-making processes, as well as accessing information and external advice more broadly.

While all case study farmers were environmentally conscious, the core driver for change was not emissions reduction (apart from in one case study); rather, it was improving overall business performance, resilience, and environmental outcomes. This emphasises the need to promote good business practice to support emission reductions. However, not all improvements for farm businesses will lead to gross emission reductions, so supporting farmers and the wider industry to understand where these boundaries lie will be worthwhile.

Collaboration and engagement with stakeholders, including equity partners, dairy companies, and local communities, play a significant role in supporting positive change. The case studies highlight the importance of building strong teams, seeking external advice, and working together to achieve sustainability goals.

For all the case study farmers where there were stakeholders outside of the immediate decision-makers, their approach and decisions were generally trusted and supported, supporting and/or enabling them to implement the change. This highlights the importance of having good people who are equipped to communicate their aspirations to effect change.

Given the global (and national) urgency to reduce emissions, it is important to recognise that across all case studies the observed changes were made over a protracted period, each time-step improving outcomes or adjusting to changing conditions. This was particularly important where there were multiple interests wanting confidence that it was the right approach, with each step proving the validity of the approach.

Barriers to emissions mitigation

Several barriers to implementing emissions reductions on farm were identified through these case studies. Some were faced by the case study farmers, and some identified for their farming peers.

- Confused messaging and misinformation made getting the team on-board difficult.
- Appropriate land use works in theory but can have practical challenges to overcome (e.g. ended up retiring a good piece of land as keeping it in the production system would make stock management very hard).
- Need to get the fundamentals right (i.e. good level of base production/profit alongside capacity and capability) before big changes can be made – highlights the incremental nature of change and influence of people.
- Falling financial returns will lessen appetite for change – although it may encourage it if changes can improve financial performance.
- Finding good people who can ensure farm system changes will be implemented well can be difficult.
- Climate volatility is increasing, making system changes difficult in some instances.
- General volatility and flow-on impacts (Covid, Ukraine, etc.) can limit/reduce appetite for change.
- Lack of policy certainty came through strongly, including in relation to agricultural emissions pricing as well as changes being discussed with the ETS.
- Lack of integrated (environmental) policy was also strongly expressed.
- The lack of direction leads to some farmers not doing anything for fear they will have gone the wrong direction when there is policy certainty or that they will be penalised (or not recognised) for what they have already done.
- Disconnection from market drivers – farmers are farming the land, not the market.

An opportunity for collective solutions?

While the actions taken to reduce emissions by the case study farmers had been voluntary, even if under a spectre of likely regulation and market signals, these had also been largely undertaken in isolation from other farming businesses.

The emergence of catchment groups in the wider sector and formal collectives within Māori agribusiness suggest there is an appetite and capacity for farmers to work collectively to achieve emissions reduction. Collective or collaborative action provides several potential benefits, such as increased confidence to act, the sharing of knowledge, mutual accountability and perhaps the benefits of scale for more costly mitigations and an opportunity for less regulation.

The potential of collective farmer response and action to contribute to the agricultural sector's emissions reduction was a next logical focus for the research.

Chapter Four:

Solutions for farmers, by farmers

An alternative to rules?

New Zealand's approach to reducing the environmental impact from farming activity has primarily been a regulatory one, with farmers and growers, where relevant, required to comply with limits or restrictions on activities that are considered as being contributory to environmental degradation, such as loss of contaminants to water.

The farming sector has often pushed back on regulatory mechanisms, citing the capacity and preference of farmers to initiate voluntary change in lieu of rules. While some initiatives, such as the 2003 Dairying and Clean Streams Accord, could be considered to have been effective in achieving improved environmental outcomes, there is a vocal perspective that unregulated actions are too slow, too few or have too little impact to be meaningful.

Regulated solutions are not, however, necessarily the panacea that might be expected. They can be resource intensive for the agencies required to administer them, even with a degree of cost-recovery from farmers. Nor are they necessarily timely – the Waikato Regional Council's Plan Change 1 was first notified in 2016 and, after an interim decision from the Environment Court in May 2025, is still not fully operative after nine years.

While this research does not enable a valid comparison between the efficacy of regulatory solutions and those voluntarily initiated by farmers and growers, it does provide an opportunity to explore the potential for farmer-led initiatives to play a role in emissions reduction, and to better understand the mechanisms and drivers that could improve the capacity of true farmer-led change frameworks to deliver meaningful outcomes at scale for the environment, in this case the reduction of agricultural emissions.

The farmer-led approach

The so-called "farmer-led" approach to extension and behaviour change is not a new concept but has had only emergent practice here in New Zealand.

At its core, this approach is based on participants collectively engaging to achieve a beneficial outcome, through a facilitated process that provides participants with the maximum agency around the development and implementation of possible solutions. It also allows for the ideation of farmer-led research, depending on the opportunities that arise.

This differs from the more traditional extension or behaviour change approach ("top-down"), where an external expert will tend to identify appropriate solutions for a fully defined problem and participants' involvement in the process is largely limited to relatively passive knowledge acquisition, data provision, and ultimately a decision around adoption.

The Red Meat Profit Partnership (RMPP) primary growth partnership (PGP) was a scaled attempt to support active farmer-led knowledge acquisition and farm system change to increase the profitability of the sector (the Action Network). Funding was made available to farmer groups, with which they could engage facilitators and relevant subject matter experts (SMEs) as they saw fit to investigate ways to improve their farm gate profitability.

A 2022 evaluation of the RMPP initiative by Sapere[5] did not, however, provide substantive detail on the efficacy of farmer-led extension approach and it is unclear the extent to which the process being farmer-driven was responsible for any of the suggested $247.3 million value uplift expected by 2040, as discrete from the opportunity provided by simply funding farmer extension. Our experience of the initiative was that in many instances existing farmer discussion groups joined the Action Network and accessed RMPP funding with little practical change in how the knowledge transfer process was initiated or delivered from a traditional top-down approach.

The Sapere review did report that "the future use of the Action Network extension tool/approach will be critical to achieving desired practice changes that are required to meet regulation of freshwater and greenhouse gas emissions."

In this vein, a farmer-led framework was chosen to investigate the potential for farmers to collectively identify solutions to give effect to the Zero Carbon Act and the agricultural sector's contribution to gross emissions reductions.

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[5] www.mpi.govt.nz/funding-rural-support/primary-growth-partnerships-pgps/completed-pgp-programmes/red-meat-profit-partnership/independent-evaluation-of-the-red-meat-profit-partnership

The farmer groups

During the research, five farmer groups from across the motu were identified and subsequently initiated a process to voluntarily explore mitigating greenhouse gas emissions. They are, in order of establishment:

Ten owner-operated and corporate farms from the mid-Taieri, in Maniototo (34 months).

A group of nine sheep and cattle farms from Upper Moawhango/Upper Rangitikei (19 months).

A rōpū of five Māori-owned dairy farms at Ruatoki, in the Eastern Bay of Plenty (16 months).

Nine farms in the Waimakariri catchment, in North Canterbury (4 months).

Eight primarily Māori-owned farms located across Te Tairāwhiti, the Gisborne region (just established).

All the established groups have been meeting every four to six weeks (except during busy periods on farm such as calving and lambing), a frequency far greater than anticipated.

The challenge

All the farmer groups were provided with the same opportunity statement as the basis of their collective engagement. It is as follows:

"Identify how the collective can give meaningful effect to the aspirations of the Zero Carbon Act while retaining their financial viability and directly contributing to the reduction of gross methane emissions from the primary sector."

Each group have budget at their disposal, albeit within the control of the programme, to contract appropriate subject matter experts to assist them in this process, but with a defined timeframe to work and support to work through roadblocks as and when they occurred. The groups' progress was observed by an expert researcher, who also conducted interviews with participants outside of formal engagements, to capture and document the process and develop understanding about participants' attitude to make change to reduce agricultural emissions.

What we have learned

As flagged in Chapter One, all the five groups are still working towards emissions reduction and the research into how they might do so is ongoing. Despite this, there are already several insights that warrant sharing and have relevance to the sector's ambitions and requirements in its response to climate change.

Farmer willingness to engage in a farmer-led project varies significantly. They seem to be more willing to engage when there is an external pressure-point to do so (such as the proposed emissions pricing that still existed at the start of this research) and commitment wanes if this drops off. Across most groups, participation has reduced by approximately 25% within the first few months to form a core group (apart from the established Māori initiated rōpū, which has held and actually expanded participation since inception). There are a range of reasons for this.

Even though most of these groups have worked together previously, there is still a reasonably significant "forming process" that they need to go through – climate change is complex, there is a lot of conflicting information in the readily available public domain, and farmer-led as an extension framework is still relatively new. Group confidence took longer than anticipated to build due to this complexity and "newness" of the topic.

While all the groups have at least one member who has naturally taken a leadership role in supporting the direction of the group, there are a range of abilities that contribute to the groups' taking ownership of farmer-led change and group direction. Some farmers "get it" quite quickly, and others take a long time. Allowing space for this is important. The facilitators' ability to identify the stage of the journey that the group and individuals within the group are at and to help manage for any differentiation is a vital contribution to the group progressing. Similarly, facilitators need to be able to recognise when the group has enough base information and can move to the next step, while retaining farmer-led direction. Clear frameworks to guide facilitators, groups and potentially subject matter experts would be useful to support expansion of this approach (e.g. outlining tools to shift thinking from gathering base information to potential solutions).

Despite the programme's strong networks within the Māori agribusiness sector, the two specific Māori rōpū took significantly longer to identify than their non-Māori counterparts, leading to the perhaps unsurprising conclusion that a conventional approach to establishing rohe-level rōpū is inadequate. These rōpū also needed to onboard a wider range of people within their businesses (managers, advisors, governors) in a multi-step process that reflected a respectful following of tikanga.

Despite the delays in getting underway, the rōpū based out of Ruatoki has taken the kaupapa on and run with it. The entities involved were working together already, which potentially helped, and were already investing in understanding/positioning their businesses for reduced environmental impacts. Unlike the three non-Māori groups, they also have not challenged the base premise (i.e., the necessity to reduce emissions) in some way, shape or form. Neither did they start talking about individual farms until at least four months into the programme. This supports a perspective that operating collectively came more naturally to them and was also reflective of the mix of people involved in the kaupapa - those whose role it is to step back from the day-to-day job of farming and be strategic, and those who are working the farm.

Farmer-led is hard for farmers to engage with and for supporters ("experts", industry, etc.) to comprehend but comes with time and a facilitator who fully understands what farmer-led is and protects it. Finding facilitators who will genuinely enable farmer-led is, however, expected to be challenging. It is also a difficult thing to teach/develop. Identifying facilitators who already operate this way and support/develop them further where required would appear to be the best approach in the short-term.

The approach to group outcomes has varied between groups. The three non-Māori groups have cycled through a conventional, linear, property-centric process – (a) interrogating the issue, (b) identifying individual baseline position, (c) setting targets (or identifying the need to set targets), (d) exploring mitigation opportunities and (e) estimating accompanying costs/profit impact. Only once they had exhausted mitigations beyond incremental (and low[er] cost) changes to their systems did they (f) start exploring more transformational or out-of-the-box ideas, such as identifying alternative sources of revenue (or approaches to this) that individual businesses can participate in to recover profitability.

This sits in slight contrast to the Ruatoki rōpū, who started by (a) establishing the community outcomes that reduced emissions might support or deliver on, (b) identifying potential mitigations both behind the farm gate and within their community, (c) investigating the co-benefits and implications of adoption, (d) identifying the opportunity for collective engagement/adoption and only then (e) evaluating how implementation might impact on individual businesses. Conceptually for this group, community was a larger driver than individual focuses, despite the importance of each entity remaining in sound financial positions.

While none of the groups are yet at a stage where final solutions have been identified, the direction of the ideation around collective effect/solutions has been variable.

The three main trends have been:

- Harnessing the power of the collective to optimise capital investment (e.g., shared assets, bargaining power for procurement).
- Leveraging collective scale to generate commercially viable opportunities for revenue replacement (e.g., a "regional" biodiversity credit).
- Collective accountability to an outcome through sharing of ideas for individual adoption.

In the final phase of this research, a framework is currently being developed that is designed to help extension programmes with how to select the learning approach to use to be most effective e.g. collaboration, codesign, researcher led, farmer led etc. This will require a deep dive into the various group approaches to enable proper comparisons, given there is no concurrent control group as such to compare farmer-led change with other solution-focused approaches except that of our own experience with other group extension.

Will voluntary farmer-led responses be enough?

It is still too early to be able to identify if the precise solution(s) that each group might adopt are sufficiently novel, scalable, or feasible to add to the sector's aggregate emissions reduction tool kit. Whilst an important output from the research, the reality is that given the diversity of New Zealand's regions, catchments and rural communities, collective solutions are highly likely to be extremely variable. As such, evaluating the potential for farmer-led initiatives, ideally ahead of or in lieu of regulation, to deliver a step-change in the sector's contribution to emissions reduction, is a more critical outcome.

There was collective agreement across all the groups that farmers need to do "something" to respond to climate change – there are different individual motivations for this, and different levels of individual aspiration. While the groups involved in this programme are not necessarily a representative sample of the farming population, they have come from a cross-section of the community, express a diverse range of views and provide evidence that commitment to action can occur ahead of regulation.

The first two groups realised after approximately six months that stock number reductions would likely be necessary and started focusing on replacing lost revenue. Interestingly, they all see this as short-term though and that over time they will be able to increase numbers back up because of technology, such as genetics and other potential changes in the way they operate.

One of the groups has collectively struggled to reconcile that methane is a problem and the extent to which methane reductions are required by the sector. They have referenced a lot of information that seems to contradict New Zealand's international position and our markets' growing expectations. This clearly highlights the lack of supporting information out there from [trusted] agricultural sources around what the sector needs to do and why, and where the evidence sits for this. Rural media, both analogue and digital channels, appear to be dominated by "anti-mitigation" narratives, with limited to no alternatives presented.

At this stage, only one group has adopted a hard emissions reduction target, although a second group is planning on setting theirs quite quickly after they have base-level information, as having a hard target and a credible baseline is important to them.

However, when adequately resourced and provided with time and a genuine farmer-led approach, farmers can be quite aspirational. Noting that the current near term legislative target is a 10% reduction in agricultural emissions by 2030, the group that has established a target for themselves has set a gross reduction target of 10% by 2026 (from 2022 levels) and 25% by 2030. This is, however, a very aspirational target and the group have only achieved half of the 2026 target they set. It is difficult to directly connect involvement with the project with the level of reduction. The group are exploring whether this is a sustainable level of reduction relative to individual economics. The opportunity to increase income through premiums and/or identify some other income source will play a significant part in this assessment.

Key challenges to voluntary, farmer-led solutions

While the research indicates that farmers have the capacity to make transformative change in the absence of a regulatory requirement, there are several barriers that have hindered progress in the groups that this programme has observed and would be expected to similarly limit broader uptake.

These include:

- **A lack of accessible, credible agricultural science communication.** Despite the wide and pervasive coverage of climate change and emissions reduction, all the groups have required specific and relatively intensive education about the fundamental science of climate change and agricultural emissions, and the related political considerations, usually from the well-respected scientists and officials at the coal face of this issue. Not everyone will ultimately subscribe to the necessity of emissions reduction or find the accepted science compelling, but most participants in this research are comfortable that they will need to reduce emissions in some way, shape or form. If a farmer-led approach to mitigation scales, there is risk of overwhelming a small cohort of experts to ensure farmers can satisfy their individual enquiry about the importance, necessity, and value of emissions reduction. This will also be less of a concern if technological or genomic solutions end up as the primary mechanism to deliver emission reduction, combined with market and/or regulatory requirements, but increasing farmer awareness and acceptance about the need for emissions reductions will still be very important.
- **Difficulties finding and training the right facilitators.** While this isn't a specific issue this programme has faced, we have identified this as a risk for any scaling up of farmer-led change. Programmes like RMPP have had a significant positive impact in increasing the number of facilitators working in the sector, upskilling them and helping support the commercial value proposition of effective facilitation. There still appears, however, to be an inherent sectoral "muscle memory" when it comes to how group facilitation "works" - farmers are unused to driving the direction of behaviour change-focused extension and facilitators are at risk of too easily falling back into a traditional delivery model when the uncomfortable silence after asking "what would you to do?" extends beyond 10 seconds. Facilitators that promote active group learning processes provide significant benefit to the groups collective and individual thinking and decision making.
- **Limited confidence in mitigation technology.** There appears to be limited confidence in mitigation technologies, apart from genetics, being able to contribute significantly to reductions. This is mostly around market acceptance and cost/practicality to utilise. Most participants see farm system change, land use change, and alternative revenue sources as critical factors in how they respond.
- **The potential for early adopters to be penalised or unrecognised.** Grandparented approaches to allocations associated with water contaminants continue to act as a handbrake on early adoption or more ambitious action by farmers to lower emissions. Beyond the adoption of good management practices and parallel productivity gains, emission mitigations invariably come with some level of economic cost. While this reality doesn't necessarily deter adoption by all farmers, concerns that further, more costly mitigation might be required at a later stage with no recognition of prior action appears to be a significant disincentive to farmer action in

this area. Recognising the farmers that are doing something is important to those involved in the programme. There is consistent concern that if they respond too quickly, they will be grand parented, or pseudo-grandparented (i.e. that all of the low-hanging fruit to move has been taken and ability to go further gets harder).

- **Mismatch between climate action ambition and current incentives.** Farmer motivation to engage appears to be strongly linked to market signals (as reflected in product prices). There was an underlying perspective by participating farmers that they need to be rewarded [now], somehow, for environmental performance and/or being early adopters. There was a sentiment expressed that it was felt likely to be relatively cost-effective to recognise incremental change by New Zealand farmers compared to meeting our global commitments via international wealth transfer. Group members also had a strong view that the amount of cost to New Zealand farmers needs to be tempered relative to those being borne by farmers in other jurisdictions i.e., if New Zealand leads in this area, it could make our product more expensive and markets may choose to go with cheaper options that have not had the same level of environmental financial burden.
- **An inconsistent or absent policy focus on systems approaches.** Many of the so-called wicked problems that face New Zealand agriculture have attempted to be addressed in their respective silos. This is despite the interrelationships that exist between most of them and the additional energy and time that is required by farmers and stakeholders when they are tackled separately. Amongst the groups there is collective interest in understanding emissions in the broader context of the environment (water, biodiversity, soils, etc.) but, perhaps having been conditioned to think about issues independently, integrated solutions thinking has been slow to come to the fore. While some of this siloed approach may have historically been unavoidable, current or new policy responses to specific environmental issues need to accommodate or dovetail into existing initiatives that farmers are engaged with. One of the groups started investigating nature-based solutions/biodiversity credit type approaches as a mechanism to finance emissions reduction but identified that no one appeared to understand (and therefore value) the ecology of their environment, so have been left feeling disenfranchised. Furthermore, the time input required for successful farmer-led solutions is significant and farmer fatigue with knowledge acquisition, co-development, and policy engagement was evident amongst farmers involved in this research. As such, it would seem to make sense to leverage farmer engagement across multiple issues, where possible.
- **Isolation.** While the nature of the research prevented collaboration between the groups, there is a strong appetite expressed by all the existing groups to all get together at some point and share experiences – knowing there are other groups like them that they cannot engage with has been a little disappointing for some.

When change is required at scale, resources are constrained, and time is of the essence, standardised approaches and mechanisms often have significant appeal. Managing and facilitating farmer-led groups needs to be flexible and adaptable, which is not something our established monitoring and compliance systems are either used to or can easily accommodate. There does, however, need to be recognition that no group will be the same, run the same, or achieve the same output/outcome (although this final point should be viewed positively). This necessity may pose challenges to broader use of this process.

There also appears to be risks that the industry (or a potential progression partner) might not see the opportunity in the same way or value it in the same way as the farmers involved in its development. This poses the question of how does a grass-roots group manage leading out a novel innovation and how can it best be supported by the sector and wider stakeholders?

Regarding participants, in initial farmer-led groups farmers must learn to adapt to the farmer-led approach and their role within it. After participating in one such group this should, however, be clearer for them.

This farmer-led approach to transformative behaviour change is also likely to only fit a certain type of farmer participation. It requires participant farmers to:

- have time availability;
- possess a learning mindset;
- see the need for an issue to be addressed (even in the absence of a policy stick);
- see the issue as larger than themselves and want to contribute;
- be willing to work with their peers who may be on a very different wavelength; and
- be able to manage the initial lack of structure and direction that seems to pervade the first one to eight meetings.

There is a clear tension between the group solution and/or individual farm solution. This is not necessarily a bad thing but appears to be a dynamic that a group needs to evolve through before ultimately settling on acceptance that both focuses can be accommodated as a feasible outcome.

Opportunities

Despite the challenges facing farmer-led behaviour change programmes, this research suggests there are clear opportunities to support emissions reduction through this process or related-initiatives.

Where farmer-led approaches are desired or considered most appropriate, they will be enhanced by:	• The development of frameworks to support group maturity and decision-making. • Scaling their impact by linking to biodiversity and water quality work already occurring – maintaining a systems lens. • Application in different regions, to help build regional diversity aspects into solutions. • Promoting and supporting collaboration between active farmer-led initiatives.
In general, all emissions reductions initiatives, including farmer-led activities, would be assisted by:	• Enabling/encouraging early adopters through rewards, recognition, and policy protection. • Investing in agricultural science communication, to build trust in policy decisions and counter misinformation. This needs to be more proactive than directing farmers to websites, links or the occasional rural press article. It also needs to cover material that has been covered before, e.g. why we do not account for carbon stored in pasture. • Ensuring policy (government) and policy response (industry) recognise and, ideally, account for the interrelationships between the concurrent environmental challenges the farming sector is being asked to address.

The relatively low cost and potential high return potential of a farmer-led approach also warrants highlighting. While not applicable for all situations, funding appropriate groups of farmers to voluntarily demonstrate change potential ahead of [planned] regulation might be more effective than the aggregate cost of [often combative] farmer and industry engagement on proposed or notified policy direction.

Chapter Five:

If less cows, then what?

An inconvenient truth

While analysis of farm level mitigations confirms small gross reductions in agricultural greenhouse gas emissions are achievable with limited negative financial impact, it is well recognised that more significant gross reductions from pastoral farming systems invariably result in reduced output and ultimately lower profitability. The strong correlation between feed eaten and methane emissions is largely responsible for this inconvenient truth, which means that in the absence of technology that can disrupt or reduce this biological relationship, achieving large reductions in methane is inexorably associated with changes in land use away from ruminant agriculture.

The dairy, red meat, and wool sectors make a significant contribution to the New Zealand economy, estimated to be delivering NZD 39.3 billion (72.2%) of almost NZD 60 billion of export earnings projected from the primary sector in the 12 months to 30 June 2025[6]. It is, therefore, unsurprising that irrespective of the accompanying climate impacts, there is concern and unease from farmers through to government about the domestic socio-economic implications of reducing the size of and/or output from these industries.

[6] www.mpi.govt.nz/resources-and-forms/economic-intelligence/situation-and-outlook-for-primary-industries/

Acknowledging the recently published alternative findings of the Methane Review Panel[7] and subsequent policy change to a 14-24% reduction, the Climate Change Response (Zero Carbon) Amendment Act 2019 had identified the gross methane reductions required from the primary sector of 10 per cent by 2030 and between 24 and 47 per cent by 2050. Whilst considered "on-track" to achieve the 2030 targets, the majority of this reduction will ultimately be attributable to land use change from pastoral agriculture to alternative land uses, like forestry and permanent horticulture. Indeed, some of the case studies discussed in Chapter 3 had already undertaken land use change to some extent and within the farmer collectives, land use change has been a live discussion. Absent a vaccine, bolus, inhibitor or rapid genetic gain, the 2050 trajectory would ultimately need to be achieved in a similar way.

While there are already several agricultural or horticultural land uses with lower emissions profiles and higher financial returns than dairying or red meat production, their geographic suitability, environmental footprint, capital requirements, and/or market access provide limits on their capacity to significantly replace existing land uses.

Though there are rightly concerns expressed about the risk of one monoculture replacing another, the reality is that to be socially and economically viable, alternatives to our cornerstone agricultural industries would need to be adopted at a scale that delivers meaningful emissions reduction and aggregate economic activity to be a viable alternative to our current pastoral industries.

Alternative food and fibre crops

To evaluate the capacity of alternative [lower emissions] land uses to provide a suitable mechanism for emissions reduction, five land uses, considered to be broadly representative of available options in New Zealand, both existing and emergent, were analysed in this project . They were[8]:

Milling wheat	a crop with domestic food security implications.
Chestnuts	a perishable nut crop.
Blueberries	a horticultural crop with emerging supply chain constraints.
Industrial hemp	a novel arable crop with diverse product.
Tōtara	a non-radiata production timber crop.

While all these crops have the potential to be produced at greater scale than they currently are, the analysis identified several key parameters that have not only limited their commercial scale today but would likely prevent their significant expansion tomorrow. That said, most of these issues are not insurmountable but the timeframe in which they would need to be addressed to have a significant contribution to emissions reduction seems extremely challenging at best, near impossible at worst. They may also exist, to a lesser extent, in some of our established agricultural industries (in similar situations to the options selected). These key challenges, many of which are interrelated, are summarised below.

[7] www.environment.govt.nz/publications/methane-science-and-target-review/

[8] Full analyses available at https://www.ag-emissions.nz/publications/disruptive-diverse-land-use-change-options-for-the-ruminant-pastoral-agriculture-analysis-of-wheat-chestnut-blueberries-hemp-and-totara/

Financial competitiveness

While pastoral agriculture does occur on land equally suitable for arable or horticultural purposes, much of New Zealand's grazing activity is on land that is ultimately unsuitable for cropping, either due to its geophysical characteristics, providing a physical limitation to cultivation or harvesting, or because the resultant yields would be deemed uneconomic at the prevailing market prices, which are typically influenced by global supply and demand.

For example, the lower expected average North Island wheat yields (8 t/ha) relative to the South Island (10 t/ha) significantly reduce the expected profitability of this enterprise, even with a premium for their closer location to their customer mills. As a result, growing milling wheat in the North Island struggles to be competitive with the livestock enterprises it might supplant or the alternative arable crops that could be used to diversify exclusively livestock systems (such as growing maize for silage). Even when considering the expected financial impact of pricing methane (and nitrous oxide) emissions at the farm level, milling wheat in the North Island seems unable to outperform the lamb or bull beef finishing enterprises it could replace at grain yields less than 10 t/ha and is not even close to being competitive with pastoral dairying[9].

Hemp's inability to compete with the financial returns achieved by dairy farms in New Zealand would seem to be a significant driver as to why it is not considered to be a commercially viable alternate land use for these farm systems. It was identified that returns from hemp could provide another cash cropping option for sheep and beef farms that had land suitable for arable cropping in their businesses. However, these opportunities are limited given the small number of sheep and beef farms that sit in this category[10].

Even where New Zealand is a net importer of food (which generally supports higher domestic prices), domestic product still needs to be cost-competitive with global substitutes.

From a true food [nutrition] security point of view, New Zealand would seem to have an annual deficit of as much as 30,000 ha of milling wheat. While wheat from Australia remains available to import, the farm gate price for milling wheat in the South Island only needs to be $110/t lower than the landed price of wheat from Australia (based on current domestic freight prices) to be competitive at the mill. Whether this price is sufficiently high enough to deliver the volumes required by the mills is not clear. This relative pricing pre-condition occurred in 2022, but domestic production in that year still only delivered 30% of New Zealand's annual requirements. This suggests a much higher price, potentially accompanied by more favourable contract terms, would be required to encourage more area to be planted. Unless consumers are prepared to pay a significant premium for locally sourced wheat, it seems unlikely this will occur[9].

Perishable crops required for domestic consumption will probably achieve a sustained price advantage [due to a lack of competition], but the size of the domestic market limits industry scale, such that a specific crop might be part of several individuals' emissions reduction strategy, but not available to the whole sector.

[9] McQuillan-Reese, L. 2022. Market forces or market failure? An analysis into the opportunity for expanded milling wheat production in New Zealand.

[10] Inness, M. 2023. Potentially Hemp. An analysis into the opportunity for commercial expansion of hemp production in New Zealand.

[11] Mitchell, R., Dowd, A., Matthews, M. 2023: Playing the long game. An analysis into the opportunity for commercial expansion of tōtara as a plantation forest in New Zealand.

Price competitiveness is also likely to be an issue for alternative forestry species, given the longer timeframes in play and the costs of establishment relative to radiata pine.

The initial cost in establishing a plantation-tōtara forest is the most likely deterrent to landowners converting to this low methane option. Due to the high costs involved in planting plantation-tōtara (estimated between $15,625 and $32,690/ha) and the 80-year delay before initial log harvest, some method of supporting the farmers with the costs of establishment, and reducing initial outlay, will likely be required for the successful establishment of this industry[11].

Capital investment

Almost all of New Zealand's food and fibre exports require post-gate processing of some kind to ensure product can be exported in a form that meets a customer's needs at a value point that is also acceptable to the grower. At smaller scale, such processing infrastructure tends to be more costly per unit of saleable product and often requires a minimum level of throughput to function or be justified. Due to New Zealand's lack of an industrial manufacturing base, it also normally needs to be imported, often from countries with a stronger currency. When combined with the typically low direct financial returns from post-gate processing or manufacturing, expensive infrastructure can be a barrier to industry growth.

It is estimated that a capital investment in the order of $1,050,000 would be required for grower to mechanically harvest and produce chestnut flour (as an alternative to fresh nut sales) from a three ha orchard[12].

Low levels of return on investment in post-harvest and processing infrastructure

Even in New Zealand, one doesn't have to look too far to observe the challenges associated with the agricultural post-harvest sector. Over-investment in manufacturing plant to deal with seasonal peaks and the resulting systemic underutilisation of capacity doesn't accommodate high financial returns. The use of co-operatives to minimise the financial burden for individuals of owning low returning assets can be successful once production hits a critical mass; but when an industry is either in its infancy or decline, persistent (as opposed to merely seasonal) overcapacity exacerbates the costs of processing raw product into a form suitable for customer purchase. Most horticultural and arable crops have an even shorter "harvest" window than pastoral land uses, which both increases production risk and the potential underutilisation of processing capacity for large periods of the year. The latter might be acceptable/tolerable if the underlying value of the crop is high enough to offset the capital "cost" of processing, but such investment seems likely to be a substantial barrier to increased scale unless entrepreneurial individuals and entities are prepared to underwrite/internalise the associated risks. While many industries invariably start this way, they will often have developed over an extended period of time – a luxury that the New Zealand primary sector may not have.

The capital investment required to move into a self-sufficient value-added chestnut production system in harvesting and freeze-drying processing infrastructure is unrealistic for a famer with a typical three ha chestnut orchard over a 15-year time horizon, given the investment has an internal rate of return of -11%. High capital infrastructure costs for small growers could potentially be eased by pooling resources between producers or purchasing second hand equipment. However, the need to process (in this case freeze dry) the chestnuts within three weeks of harvest is a significant impediment to this. The required freeze dryer (FD300GPC) would need to run almost at capacity during this time to process the crop from a single three ha orchard. There would be scope to increase throughput (a further 2.97 t of chestnuts, effectively a further hectare of production) and capital efficiency if the dryer ran seven days per week and at its maximum volume of 300 kg/day. This would "improve" the internal rate of return of the investment for a four ha orchard, albeit marginally, to -10% – still insufficient to entice most growers to make the investment.[10]

[12] Stone, C. 2023: Scale-up or continued stagnation? An analysis into the opportunity for commercial expansion of chestnut production in New Zealand

The lack of coordinated industry knowledge and activity

One of the strengths of the New Zealand primary sector is that as export focused industries selling largely undifferentiated products at the farm gate, a grower's competitor is essentially the grower in the destination or competitor country, not the grower next door. While there is invariably some first mover advantage for the developer/early adopter of a novel production system or management technique, outside of, say, proprietary genetics (and an associated customer relationship), in the medium- to long-term there is usually little to no price disadvantage from sharing knowledge with other farmers or growers. This willingness to share knowledge and information between individuals in the same industry, supported by public good investment through universities and government science agencies, has gone some way to "de-risk" entry into and expansion of established sectors. Shared investment (through product levies) in biosecurity, market access, and knowledge extension has also been positive.

This situation is not the same for some of the novel and emergent land uses that might be required to replace some pastoral farming activity. Smaller, newer industries tend to rely more heavily on the small domestic market (which might potentially extend to Australia) or niche customers, often linked to a specific variety or attributes to ensure commercial success. This makes suppliers inherently more competitive and less willing to share information unless there is a commercial imperative to do so.

Based on the apparent financial returns from blueberry production (internal rates of return between 6 and 11%) and there being no obvious limits to capital availability, the primary reasons limiting blueberry expansion appear not to be financial. The main limitation to the expansion of blueberries would seem to be the fragmented structure of the sector, product shelf life causing higher freight and biosecurity costs, labour availability, access to technical support and expertise and existing post-harvest infrastructure – all things that might limit the long-term potential of the sector and with it, the confidence of farmers to invest given the long (11-16 year) pay-back period of development[13].

While we suggest that alternative land uses that have the potential to meaningfully contribute to emissions reduction will necessarily have to be export driven, the reality is that some entrepreneurs or early adopters might consider the risk of information sharing and industry collaboration too "costly" or risky for their nascent businesses. This could slow sector expansion and limit the availability of capital required to invest in supporting market development or in value-added processing. While understandable, such behaviours potentially increase the risk profile of an otherwise profitable activity.

[13] Schroder, B. 2023: Blossoming Blueberries? An analysis into the opportunity for commercial expansion of blueberry production in New Zealand

The shallow depth of our domestic markets

With a population of only five million people, domestic demand for food and fibre products tends to quickly outstrip the potential for domestic production, exposing novel or emergent industries to the necessity of exporting earlier than might be experienced in other jurisdictions. This tends to restrict the capacity of domestic markets to support industry growth to little beyond proof of concept, early-stage product development and small-scale processing. This reality likely increases market risk, potentially reduces the appeal for early-stage investment, and rapidly exposes industries to global competition (and prices). The small size of this primary market may also extend to the secondary markets that might take byproduct (e.g., hemp seed cake) or out-of-spec product (e.g. the feed grain market) and thereby ensure minimum pricing for production or increase aggregate returns.

Another reason that seems likely to be limiting the expansion of the hemp industry was the absence of a secondary market for hemp seed. Currently growers are at high risk of not receiving any revenue for seed crops that fail or for seed that doesn't meet food processing standards. This risk is too great for pastoral farmers considering hemp as an alternative land use option.[9]

So, is land use change at scale a realistic prospect?

Large scale land use change has shaped New Zealand's recent past. By way of comparison, the area planted in vineyards in Marlborough increased by 18,500 ha between 2003 and 2018[14], the conversion of exotic forestry to pasture in the Central North Island in the early 2000s was approximately 33,600 ha[15] and the conversion of dryland sheep and beef land to dairying in Canterbury has been in the order of 275,000 ha[16].

Despite there being clear examples of significant shifts in land use change within New Zealand's supposedly static farmed landscapes, giving effect to land use change of this magnitude with existing land uses is not easy and poses significant logistical, financial, and societal challenges. Doing this for relatively novel or nascent land uses is likely to be even more challenging.

To explore this issue, the potential implications of integrating a limited combination of alternate land use changes within the geo- and biophysical potential of a Canterbury catchment were explored using a simplified modelling process. For this exercise, the Hororata catchment (c. 33,000 ha) was selected due to various topography and elevation allowing integration of a variation of alternative land uses.

The scenarios included incorporating arable cropping to varying extents within an irrigated dairy farm system (Scenario 1), the partial conversion of sheep and beef cattle farmland to a mix of intensive horticulture and indigenous production forestry (Scenario 2), and a combination of these (Scenario 3).

All three scenarios resulted in reductions in agricultural greenhouse gas emissions and nutrient losses, but all had accompanying losses in farm gate operating profit or required substantial capital investment. The scenario with the best modelled outcome for profitability was Scenario 2, due to the high returns estimated from intensive horticulture essentially offsetting the lack of returns from indigenous production forestry. The largest reduction in biological GHG emissions was achieved in Scenario 3, which had the greatest reduction in pastoral land use and greatest extent of land use change (c. 6,965 ha, or 21% of the total catchment area). This scenario, which modelled the integration of alternative land uses into both types of livestock farms also had the largest reduction for both nitrogen and phosphorus loss. These results, all at the farm gate, were unsurprising given the underlying financial and environment outputs. Considering the implementation of such change at scale was less straightforward.

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[14] New Zealand Winegrowers Inc. 2021. Annual Report 2020. https://www.nzwine.com/media/17492/annual-report_2020_final_web.pdf

[15] Waikato Times 2013. Hart offloads all 30 Carter Holt farms. www.stuff.co.nz/waikatotimes/news/8962691/Hart-offloads-all-30-Carter-Holt-farms#. www.wairakeiestate.co.nz

[16] Livestock Improvement Corporation Ltd & DairyNZ Ltd. 2023. New Zealand Dairy Statistics 2022-23 https://www.dairynz.co.nz/media/tb0bjret/dairy_statistics_2022-23_book_-final.pdf

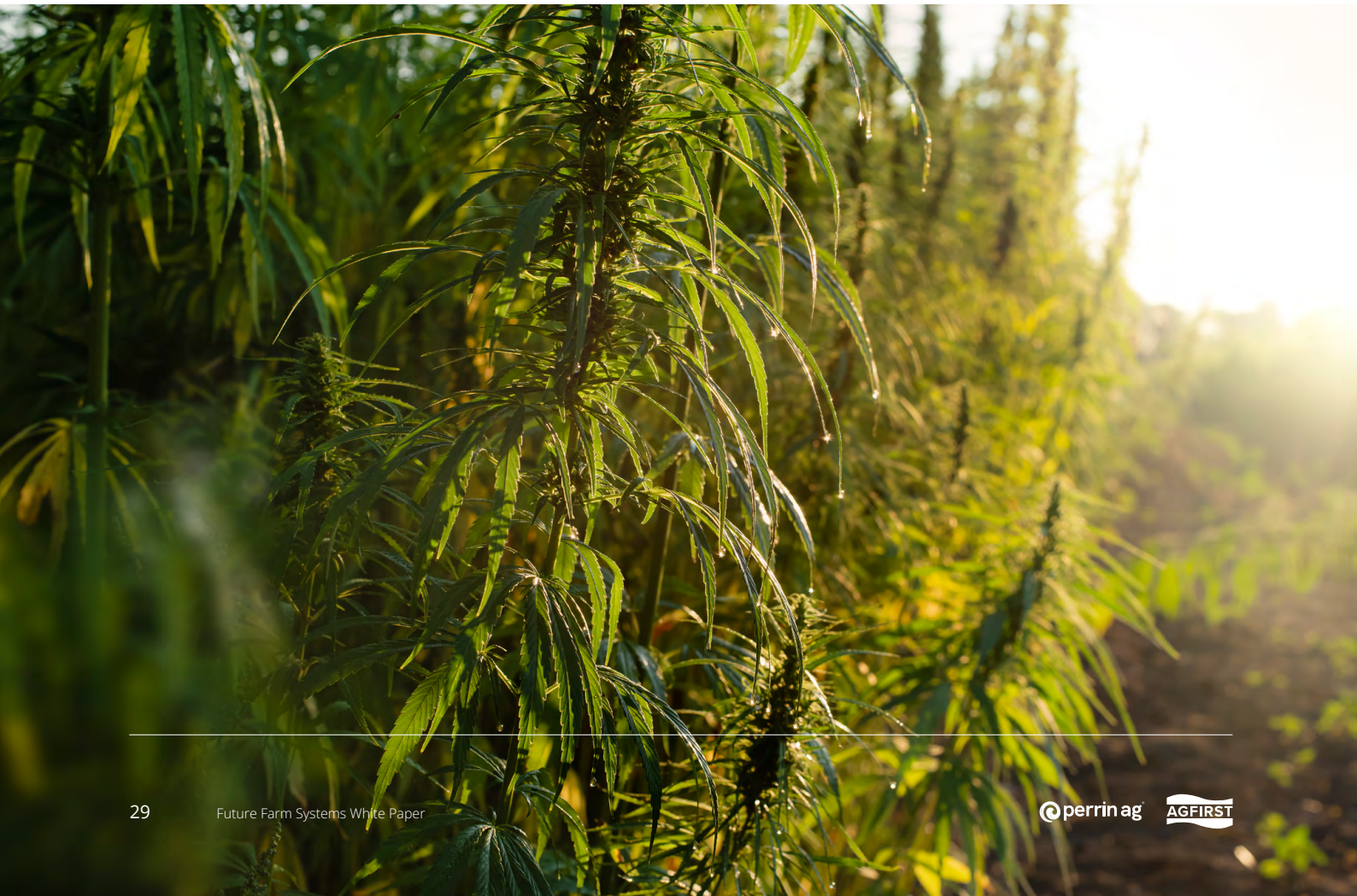
The extent of [positive] environmental impact may not be as high as might be expected. For example, to practically integrate a sustainable harvest system for indigenous productive forestry, it is likely a phased planting regime is required. This then means that forest might be incorporated into a landscape over a period of 80 years. In terms of reaching aGHG targets by 2050, this rate of land use change has severe limitations. The effects on reducing aGHG emissions with this land use are not fully realised until the final year of planting, which is likely to be much later than 2050.

Significant capital investment was also required for all land uses that were identified. This either falls on the landowner or other entities in the supply chain (e.g., contractors). A lack of financial resources is not the only limitation. Lack of knowledge, skills and labour shortages also need to be considered. The scenarios modelled for this research demonstrated that although a change in catchment land use might have minimal effects on current supply chains, if a few catchments, let alone a whole region, were to incorporate some of these changes then the implications are large.

It is acknowledged that the modelling completed here was not sophisticated enough to provide for any degree of individual business or catchment optimisation. Despite this limitation, it seems clear that the integration of alternative land uses investigated in the Future Farm Systems Research Programme do not provide a simple solution to emissions reduction, either behind the farm gate or in the wider supply chain. Optimising land use at farm level may have significant implications for the supply chain and may require significant capital investment behind and beyond the farm gate, or lowered profits.

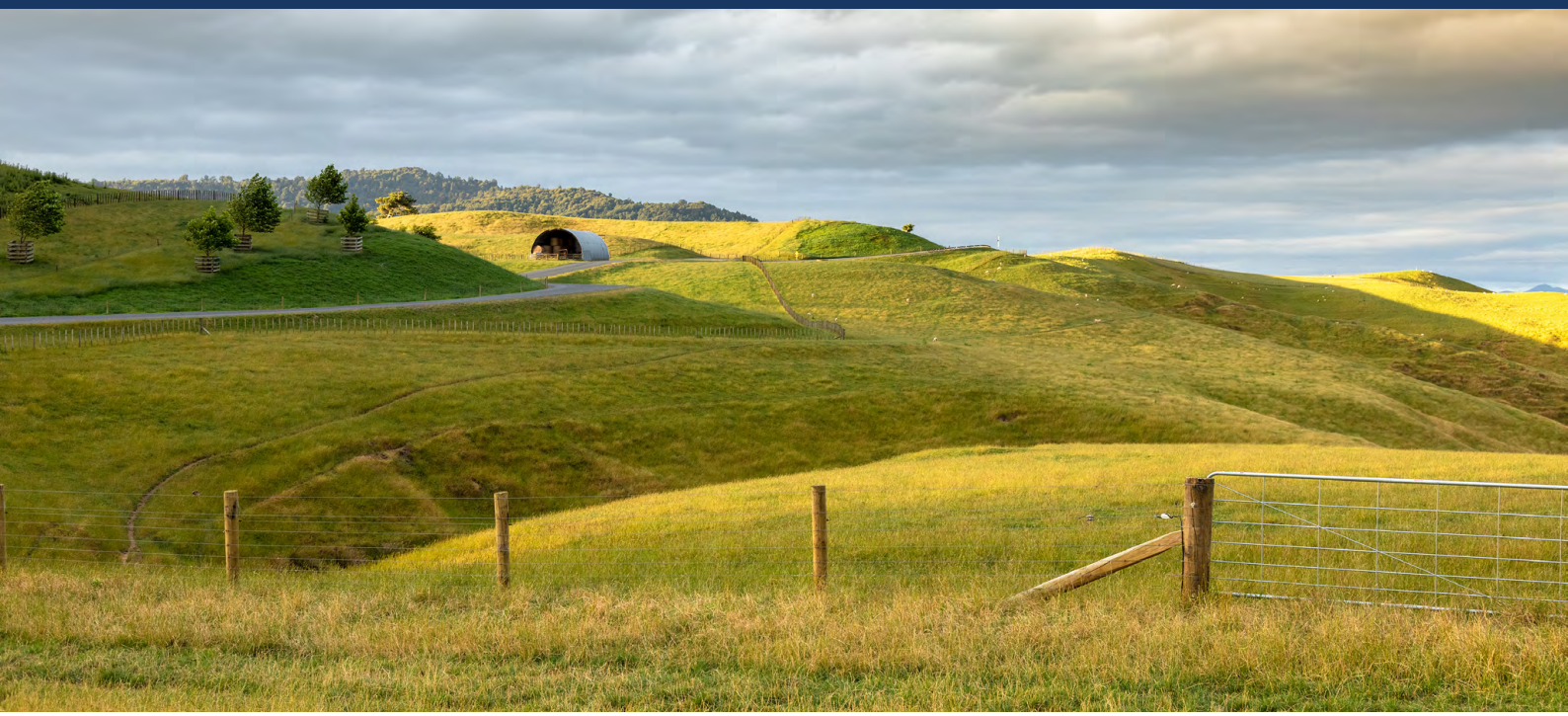
Incorporating alternative land uses to the extent that is practical and financially feasible to landowners at current prices may be insufficient for a meaningful contribution to the achievement of emissions reduction targets. Collective approaches may aid in reducing the financial burden on individual landowners, but the lack of capital and infrastructure throughout the whole supply chain will likely have limiting effects. To enable sufficient adoption of alternate land uses to an extent sufficient to make a significant reduction in agricultural emissions, the requirements for, and role of government support need to be further addressed.

The potential role of government and wider impacts of emissions reduction were subsequently considered in the last phase of this research.



Chapter Six:

Envisioning a low emissions future



The wider implications of emissions reduction

Given the possible combinations of individual preference, collective actions, and land use choices, it stands to reason that emissions reduction from the farming sector will look different across New Zealand. As a result, the impacts on communities and regional economies will also be different. As discussed above, the relatively short period in which the sector might need to deliver changes removes the main natural hedge for adaptation and transition – time.

Given the wide range of strategies that farmers and growers might employ to reduce emissions, it is simply impossible to predict outcomes with any certainty. By examining several plausible scenarios it is, however, possible to develop insights into the likely direction of travel for our regions because of emissions reduction.

As already mentioned, New Zealand is no stranger to land use change at scale. It is also familiar with the unintended consequences of such land use change, such as debris from clear-felled plantation forestry on highly erodible East Coast hill country, or the declining water quality that has occurred alongside dairying's expansion through Canterbury.

In the absence of technology that allows business-as-usual to continue, it seems likely that our primary sector will undergo considerable change as it makes a meaningful reduction in emissions, some of which we are potentially already seeing. Knowing that change is likely, even if not certain, it makes sense to start to consider the impact of land use change on stranded assets (e.g., the closure of meat processing as lambs are replaced by forestry), the need for reallocation of capital, pressure on critical social infrastructure and potential changes in employment.

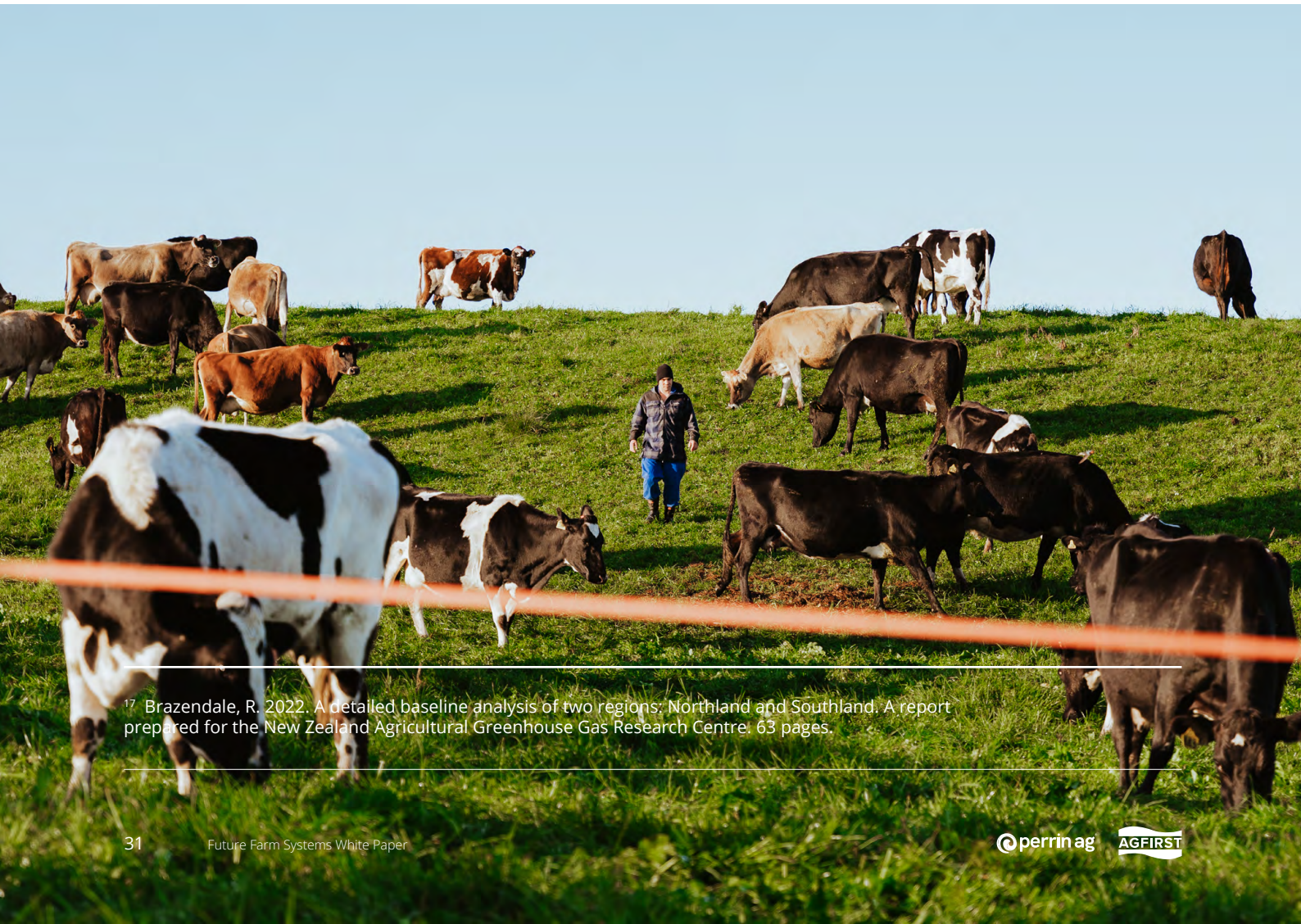
Undertaking this investigation for two regions, Te Tai Tokerau Northland and Murihiku Southland, that, in one sense, represent the extremes of agricultural systems here in New Zealand, also helps establish a likely range in outcomes across the motu.

A deliberate decision was made for this research to be complementary to, rather than include, the econometric analysis of possible changes. This was done to make the potential impacts of emissions reduction from the primary sector more accessible and tangible for as wide a range of stakeholders as possible.

From Cape Reinga to Bluff

Despite being located at either end of the motu, Northland and Southland share numerous similarities. Both have a strong reliance on the primary sector as a foundation for economic activity, with dairying the largest agricultural land use in both regions and both having moderate existing and potential aquaculture operations. Their populations both tend to have a lower skill set (as measured by educational attainment) than other parts of New Zealand, and both regions have significant coastlines and extensive roading networks[17].

However, as they transition to a low emissions future, each region has significantly different opportunities and threats. These are summarised below.



[17] Brazendale, R. 2022. A detailed baseline analysis of two regions: Northland and Southland. A report prepared for the New Zealand Agricultural Greenhouse Gas Research Centre. 63 pages.

Northland example

Strengths

- Substantial external funding has been available to support feasibility studies and start up stages for new enterprises.
- Climate is suited to alternative crops such as tropical fruits.
- Fledging alternate crop enterprises already underway.

Weaknesses

- Lower skills and capability of workforce.
- Under-represented population of working age people.
- Pockets of high-quality soils that limit scaled development of alternate crops.
- Infrastructure, particularly roading, make freight more expensive and with greater environmental impact (dust).

Opportunities

- Water storage schemes will increase the reliability of water supply through periods of droughts.
- Smaller scale, marginally economic dairy farms are well suited to land use change.
- Lower levels of employment compared with the rest of New Zealand suggests some workforce capacity.

Threats

- More extreme climatic events wreaking havoc with high value crops and expensive infrastructure.
- Fragmented development.
- High competition for workers arising from multiple regional development projects.

Southland example

Strengths

- Large areas of high-quality soils.
- Water quality improvement imperatives are likely to add momentum to changes to lower emitting farm systems.
- Great South has a stated aspiration to become a low emissions economy.
- Temperate climate highly suitable for pastoral farming.

Weaknesses

- Economy very reliant on pastoral and ruminant animal farming systems.
- N loss to rivers and sediment losses exceed national standards and this may constrain land use options.
- Lower skills and capability of workforce.
- Near full employment means there is very limited capacity.

Opportunities

- Just Transition may provide funding and start-up capital for alternate land use projects.
- The eventual closure Tiwai Aluminium Smelter may release skilled workforce for re-deployment.
- Climate change may result in more favourable climate conditions for a greater range of crops.

Threats

- Stranded capital associated with pastoral agriculture.
- More extended dry periods or droughts may test water storage and supply.
- Strong westerly winds channelled through Foveaux Strait can result in soil losses and windthrow placing limitations horticulture crop options.

In the context of expected climate change, Northland probably faces the greatest challenges to its existing agricultural systems. As a result, mitigations will need to operate amongst more novel land use alternatives and the impacts of climate change might provide stronger drivers for implementation. This compares to Southland, where the climate is expected to be more favourable to its existing farming landscape, at least until the middle of the century, and as such, mitigations are more likely to focus on application to existing land use systems.

Some possible futures

While the expected trajectory for climate in the medium-term is reasonably settled, the socio-economic environment within which our food systems and rural communities will operate is largely unknown. Most predictions of the future tend to be a so-called neutral extrapolation of current trends, "business-as-usual", which might be useful in validating existing strategies and generating acceptability amongst stakeholders but are limited in their value for exploring unexpected outcomes or testing the resilience of our systems. To this end, four possible alternate future scenarios were developed through a co-design process with stakeholders in Northland and Southland.

The scenarios were deliberately designed as mutually exclusive alternatives that were considered by stakeholders to contain elements that are all plausible but also that are all equally likely, as well as unlikely, possibilities. The actual future is expected to lie somewhere between all the scenarios.

These four alternate future scenarios and their key themes, through which to explore the impacts of aGHG mitigations, were as follows.

(a) Diversity is the new specialty
- Innovative local businesses, mixed landscapes, and flexible employment.

By 2050 there will be a high demand for locally available produce in regional New Zealand and responding to this will be of greater priority than supplying our export markets. Regional and national infrastructure is resilient and flexible, connecting producers, processers, and markets. As a result, there will be a range of viable diverse land uses across regional landscapes. Readily available investment from international and domestic capital markets and high-quality agri-business education provides for highly innovative product development and niche marketing.

A lot of young people continue to move from rural communities to urban areas for jobs and to start their careers. In primary industries there will be a lot of use being made of artificial intelligence and immigration to fill positions for unskilled workers. Māori can protect mātauranga Māori through certifying and branding recognised products, with royalties and licensing providing for an on-going income stream.

(b) The world's food basket of choice - Increased plant-based foods, vibrant rural communities, mātauranga Māori incorporated.

By 2050 there will be a high demand for centrally sourced produce for supermarket chains of exceptional provenance. The use of robot-technology and artificial intelligence means that planting, weeding, and harvesting will become very efficient at scale. Large scale horticulture of complementary varieties and arable cropping rotations dominate flat and rolling landscapes. Livestock farming is restricted by regulations to hill country away from waterways.

Training organisations will be working with industry and iwi groups to provide micro-credentials for agricultural workers. Reliable rewarding work will be available in rural areas and attracting people back from the cities. New genotypes and products are being developed by overseas design agencies and multiplied up in New Zealand. These have included aspects of mātauranga Māori and cultural values to make them distinctively Aotearoa New Zealand, but with the guardianship and responsibility for this mātauranga provided by iwi and hapū.

(c) Feeding the world – Export opportunities, well-resourced training, efficient production, skilled workers.

With global food demand impacted by ongoing conflict and climate change, there will be a high demand for export products to suit a variety of markets, which provides for highly variable land uses across the landscape. However, at the margins price and availability trumps provenance. Readily available investment and agri-business education supports innovative production systems and optimised supply chains. These have included leveraging mātauranga Māori to optimise productivity and the widespread incorporation of cultural values into employment practices to better align with the needs of the workforce of Aotearoa New Zealand.

Training organisations are working with industry and iwi groups to better enable vocational training for agricultural workers. Reliable rewarding work in what is clearly New Zealand's most important industry is attracting people back from the cities.

(d) Green shoots - Overseas investment, alternate food systems and production, urban drift.

By 2050, across New Zealand landscapes it is noticeable that there has been investment from overseas companies into contracts for large scale horticulture and arable cropping to supply international food companies. Production systems are highly mechanised, utilise cutting edge technology, and a lot of young people will move from rural communities to urban areas for jobs in the primary sector to start their careers. New genotypes and products, primarily utilising genetic engineering, are being developed by overseas laboratories and are being field tested and multiplied in New Zealand for farmers throughout the world.

Māori will be able to protect the mātauranga associated with the heritage food and fibre crops that are an intrinsic part of Māori culture through certifying and branding recognised products. In doing so they will create a bastion of as yet unmodified plant and animal species, with a unique and commercially desirable provenance for which Māori retain proprietary commercial rights.

The impact of the primary sector reducing emissions was then explored in all four of these plausible futures by groups of regional stakeholders.

Through the looking glass...

Amongst a plethora of themes (see Figure 1 below) the primary expectation across both regions and all possible futures was that there would be a reduction in the size of the pastoral farming sector, with a commensurate increase in horticultural, arable and forestry activity and movement/drift of primary sector related-activity towards urban areas. While the genesis of the Future Farm Systems Research Programme was, in part, driven by a desire to understand how our primary sectors might achieve emissions reductions targets in the absence of a technological solution, this was not an inherent precondition of the scenarios that were explored.

Participant thinking was not confined to new or novel ideas but also included existing and emerging technologies that we are aware of in both an international and national context. Given the limited mention of these upcoming technologies in the stakeholder discussions, it could be inferred that these technologies may not be widely considered as prominent or viable solutions within the current discourse on addressing agricultural emissions reduction.

This highlights a potential gap in awareness or prioritisation of such solutions in stakeholder thinking. This aligns with insight from our research into farmer-led solutions that there might be low confidence in or difficulty in envisaging technology as a solution to emissions reduction. It may also be that there are other underlying drivers of this expected change (like water quality or market pricing) that might be more influential on land use than the need to reduce emission per se.

Irrespective, this observation would suggest that even in the event of a cost-effective and commercially accepted vaccine or inhibitor for methane, there is an expectation that the future for the New Zealand primary sector has fewer numbers of ruminants than today. This suggests that existing supply chains for the pastoral livestock sector will experience accelerated underutilisation, and that expanded or new supply chains will be required.

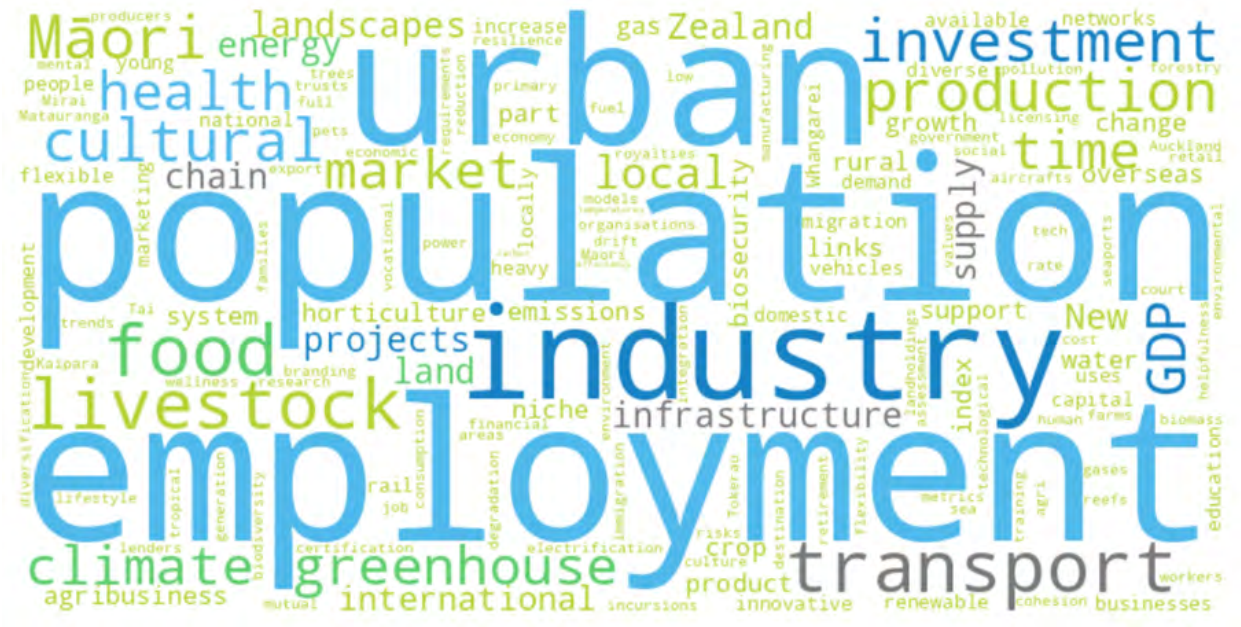


Figure 1: Word cloud of stakeholder ideation about a low emissions primary sector

Related implications of a primary sector with a reduced emissions footprint are listed below.

Labour	• Availability of manual labour for tasks related to growing, harvesting and post-harvest management and technical expertise to support the production of horticultural crops (existing and new crops) and marketing of these crops. • Correct immigration settings to support the availability of migrant labour for manual work due to an insufficient existing domestic labour pool. • Capability building for technical expertise and marketing in the regions, including the establishment of a technical institutes or centres of excellence.
Energy	• Need for the installation of more sustainable energy generation such as solar, geothermal, methane, biofuels, and hydrogen to support a more energy-intensive post-harvest supply chain, making local energy generation more viable and not adding load to existing energy transmission infrastructure or emissions.
Transportation	• Improved roading networks for transportation to domestic markets, especially Auckland, and connection to airports, seaports and possibly land ports for connection to rail networks is required to support the production of greater volumes of perishable products that need to reach the consumers faster than longer-life products, such as milk powder or frozen meat. • More freight trucks on the roads will result in greater emissions unless the freight vehicle fleets are electrified. Technical development is required and charging infrastructure expanded. Electrification of other forms of transportation – trains, ships, and planes – could reduce emissions.
Water availability	• Horticultural crops are sensitive to moisture stress at critical times and hence the availability of irrigation water at these times is likely to be a major enabler for this land use change. The post-harvest management of these crops including packing and processing of these crops also requires water.
Biosecurity	• The introduction of new crops such as tropical fruits may increase biosecurity risks and amplifies the importance of protection against risks of insects and plant borne diseases incursions.
GE	• The opportunity to manage biosecurity risks with genetically modified plants should be explored and debated. Remaining competitive with other international producers of horticultural crops is unlikely without GE.
Research and development into new technology	• More investment into research and development of new technologies was identified during both regions' workshops. These included further research into alternative plant and insect organism is required as an opportunity for new commercial crops and as biosecurity risks. Alternative pesticide sprays and fertilisers were also identified as areas for further research. Continuing research into the reduction of greenhouse emissions from livestock systems was also highlighted.
Urban contribution	• Workshop results indicated that participants believed it was crucial for individual households to be aware of their greenhouse gas emissions. Participants emphasized the importance of introducing comprehensive food waste reduction initiatives to promote environmental sustainability and reduce the overall carbon footprint.

The Māori economy	• Greater recognition of mātauranga and Te Tiriti principles within the primary sector. • Leveraging mātauranga Māori to support/increase productivity, but without compromising the rangatiratanga of mana whenua. • Protection, certification and branding of heritage Māori cultivars. • Development of more urban marae to support rangatahi moving to urban centres.
Role of government	• Government incentives for trialling new technologies, particularly in the bio and mechanical sectors, could incentivise investment and innovation, supporting economic diversification and mitigating risks associated with market fluctuations. • Changes in foreign ownership regulations were mooted to attract capital and expertise, facilitating infrastructure development and economic growth.

It should also be noted that while there were consistent themes, the likely expression of the same future scenarios typically varied between the two regions, reflecting their socio-economic, demographic, and bio-physical differences. This suggests that regional, as opposed to national, solutions and approaches to lowering primary sector emissions are likely to be more effective and have greater engagement with and buy-in from those affected. While this may seem inherently obvious, it is likely that individual regions will have different levels of capacity and capability to implement or manage necessary change.

Devolving to the regions the implementation of the potentially significant changes required in some of the possible futures may require considerable investment and capability building in regional agencies, many of which are already under resourced. It may also require a change in the funding and taxation mechanisms that ultimately fund regional infrastructure.

New Zealand is a largely market-driven, export-based economy and depends on its ability to perform in the global marketplace. While it can be assumed that the primary sector would be able to independently respond to market and government signals to reduce emissions, the need for government to support the sector (and wider community) in doing so is very apparent. Accelerated investment in transportation links, water storage, energy infrastructure and the availability and skillset of labour were common themes across the various futures, albeit with regional variation. While infrastructure, education and immigration settings have long been key areas of the economy in which government has a critical role to play, this research highlighted the importance that provincial communities might place on these three key components of government activity. Current "tweaks" to policy settings, unwinding or reinstating recent policy decisions and incremental increases in funding allocation may not be sufficient to support the rate and extent of change required by 2050.

The role of the Māori economy in a low emissions future was evident. In only one of the eight regional future combinations was there considered a risk that the extent of Māori involvement in the regional economy would reduce. Interestingly this assessment was due to an expectation of Māori in Te Tai Tokerau being disproportionately impacted by ongoing urban drift. Indeed, in all other possible futures the size of the Māori economy (as indicated by population and extent of land ownership) was expected to grow. Engagement and collaboration with mana whenua in shaping regional approaches to successfully lowering emission from the primary sector will therefore be critical. While this work didn't explore what such engagement or decision-making frameworks might look like, the urgency with which communities need to act means proactive and constructive engagement with mana whenua needs to accelerate.

Drivers of success

Managing the transition to a future where there will likely be external forces directing which scenario is realised requires regional organisations and communities to be flexible. Preparing for more than one "expected" future is a key requisite for such future planning.

Government is unlikely to [be able to] undertake action on all opportunities identified by communities in this research, so understanding the key actions that will provide the greatest gains for and least disruption in the transition to a low emissions future is essential. The speed of transition for New Zealand to meet the emissions reduction targets is considerable. Put simply, no region has time to waste before making changes for the future.

Central to decision making for central government and regional authorities is understanding the likely drivers of success in individual regions. As discussed above, the regionally specific responses needed to successfully transition the primary sector to a lower emissions future will invariably require greater devolution of decision making from central to local government. The extent to and mechanisms by which industry partners with government to achieve necessary change remains unclear, but it is apparent that the required transition will require significant capital investment. This will be particularly as regional authorities will also need to be concurrently adapting to climate change.

There are a range of decisions that central and local government will be required to make over the next 25 years in relation to each region and its greenhouse gas position relative to our collective target. Policy makers will be required to appropriately weigh up support for the range of future scenarios with greenhouse gas reductions at some scale but also consider the accompanying infrastructure costs and social and economic disruption.

For example, in Northland, change in legislation to support renewable energy opportunities is considered critical for the region's future energy needs. Investment into improving the road condition and network is essential for the region to be able to succeed. Improvements will enable critical supply chain accessibility for growth. Implementing low-emissions transport options such as EVs and electric shipping to diversify supply chain mobility was identified as an opportunity for the region. To further support future readiness for Northland, central government need to support research and development across the primary sector.

Conversely, Southland presents some different decision-making opportunities for central government and regional authorities. An untapped potential for Southland appears to be the diversification of the energy mix produced in the region. Further investment into research and development technologies for greenhouse gas emissions was also identified by community members as being important to the region.

So, are we ready?

The question of whether we are "ready" in New Zealand for a low emissions future for our primary sector is uncertain. Recognising the need for change and having a view as to what that might look like are not the same as doing it, although the former are useful first steps. As other elements of this research have demonstrated, the knowledge about what is currently possible is available, but how we create the capacity and capital required to do so is more challenging.

The expectations of a New Zealand with a low[er] emissions primary sector should be by no means unrecognisable from the New Zealand we see today. While not necessarily being enamoured with the changes our pastoral sector and its supporting industries seem required to make, the regional communities we investigated seemed fully awake to the reality of that change and could, across a diverse range of possible futures, identify key changes and investment in the wider community that would be required.

Most of those changes reflect the existing trends or emerging needs needed not just for a decarbonised economy, but also for the kind of communities that people would probably recognise as wanting to be a part of – prosperous, cohesive, inclusive, and resilient. In that sense, much of what we identified in this part of the research was not necessarily new.

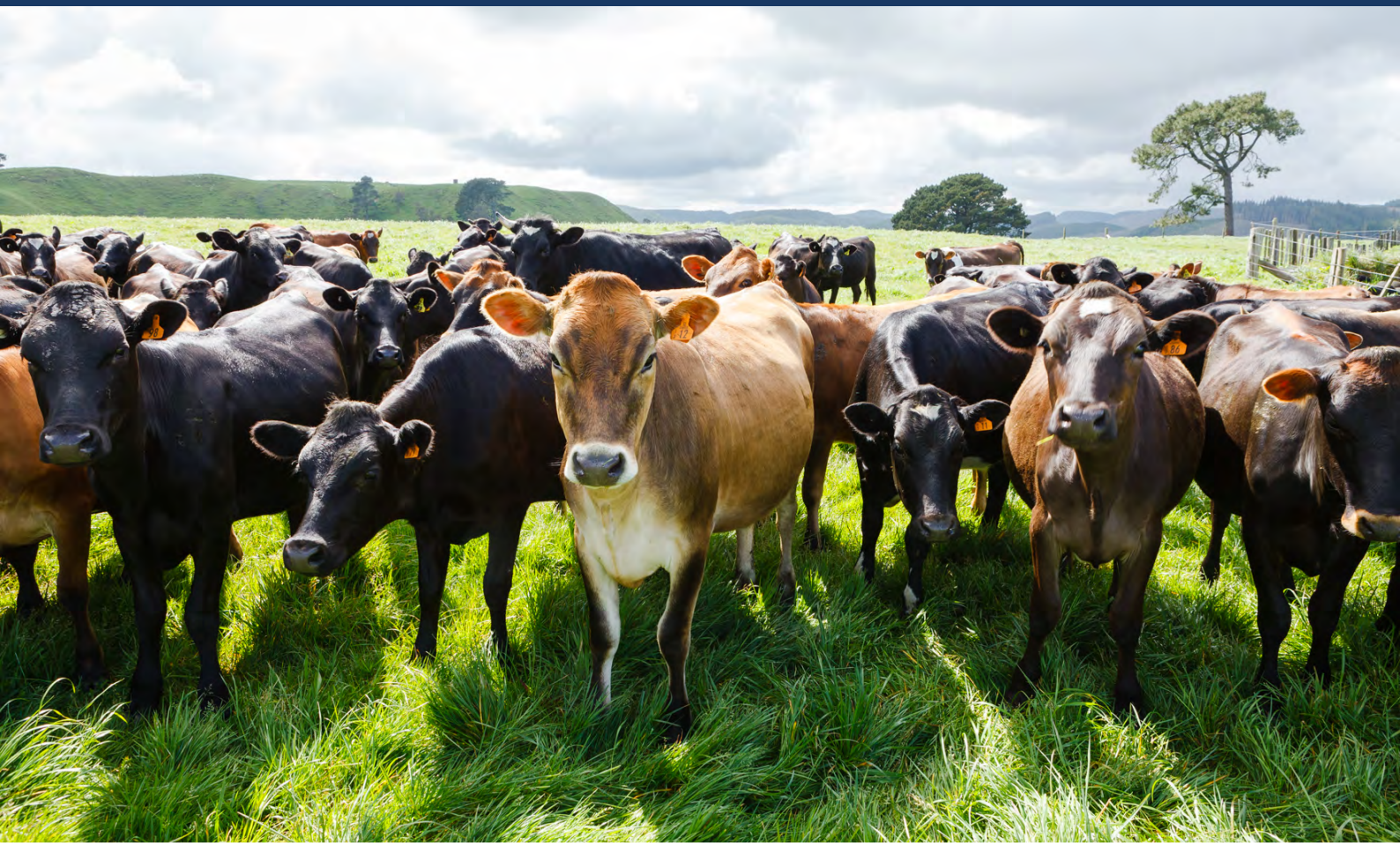
What does stand out in all of this is that given the regional differences in how a lower emissions primary sector will take effect in any given area, it seems that even in a small country like New Zealand we will require "local" ownership, accountability and direction for the implementation of the solutions needed. A centralised, "one size fits all" approach is likely to be inadequate to enable the change the sector and community needs to achieve.

The research also serves as a prescient reminder that reducing agricultural emissions cannot and should not be considered the purview and sole responsibility of farmers themselves. While farmers ultimately control the levers to effect emissions reduction through their private business and investment decisions (and have a responsibility to do so), the wider community, including government, must recognise that for such reductions to have the best outcomes for the country, they cannot simply sit back and ask that it happens.

So, are we ready? Well, if we aren't, New Zealand had better get going. Quickly.

Chapter Seven:

So, what does this all mean?



Our future farm systems...

Ultimately, this research indicates change is possible at farm level, but there are limitations and wider implications.

While farm systems and land use change mitigations have the potential to allow individual farms to significantly lower emissions, it is unsurprising that when we consider the nature and extent of on-farm mitigations that have currently been adopted by farmers they have tended to comprise "low-hanging fruit" and been limited in scale. The spectre of potential regulatory intervention and emerging customer requirements have undoubtedly been a factor in decisions by early adopters to proceed with mitigation, but only to the extent that makes commercial sense (or perhaps just beyond it).

Dialogue with farmers throughout this programme suggests there is opportunity for, and interest by farmers, to engage with the need to lower emissions in the absence of a clear regulatory or commercial impact, but active awareness of the issue needs to be ongoing to drive farmer engagement. Clear communication with farmers about the science and the opportunities is key, as is ensuring farmers have agency in their response to the need to lower emissions and the opportunity to take ownership of, and accountability for the change they might need to implement to meet customer and/or societal expectations and requirements.

Emissions pricing for agriculture has been a political hot potato for over two decades. While there is strong resistance to facing a price, the greater threat is the uncertainty caused by in-decision. While farmers are by and large comfortable with a lack of certainty and deal with this on a near daily basis in relation to climate and market volatility, where uncertainty can be addressed, this supports better decision-making and allows farmers to work on solutions, rather than not knowing the exact problem they need to address.

The current Zero Carbon Act targets set a strategic direction, but are in themselves, inadequate to drive change on-farm to any significant level. There is also a significant range in the methane targets for 2050 – in of itself creating significant uncertainty. Certainty around level of pricing and timing should be a priority to help farmers to integrate emission reduction planning into their business approaches. Bipartisan agreement on the 2050 methane target should also be a priority.

Further to this, reducing emissions is complex and "messy", not linear. It would appear it is easier for farmers to undertake this journey with others than doing so individually. The group experience provides (a) mutual support/reassurance about the difficulty of this issue (which is critical for ongoing engagement) and (b) an exposure to different risk appetites, solutions and approaches that can empower farmers to step outside of their own paradigms and risk parameters.

Whether tackling emissions reduction within a collaborative framework is enhanced through leveraging pre-existing groups is unclear. While progression through early-stage group dynamics can be accelerated when existing groups are "re-purposed" for emissions reduction activity, this is no guarantee of rapid attainment of solutions. Even with a common purpose, farmers have a range of perspectives and preparedness/capacity to embrace change and "success" in addressing an earlier "wicked problem", such as water quality, doesn't automatically transfer into emissions mitigation. The research has also identified that there are still significant gaps in farmer understanding about the drivers of emissions and, subsequently, what that means in terms of the extent of and impact from system changes needed to achieve variable levels of emissions reduction.

While technological solutions seem increasingly likely to play a collective [and possibly dominant] role in deliberate emissions reduction, land use change seems to be a widely expected outcome for the sector in the medium-term, whether directly driven by mitigation, adaptation or both. It appears, however, extremely difficult to pick any so called "winners" to replace ruminant agriculture, given challenges with scaling up post-gate supply chains, a current lack of financial competitiveness, and limits to capital availability.

As such, outside of what is currently being observed on hill country landscapes where forestry is directly challenging the farm-gate profitability of sheep and beef farming, the proximate risks of wholesale monocultural conversion as a solution to agricultural emissions seems unlikely. Of course, any resultant "mosaic" of land uses seems most likely to be a function of this inability to commercially scale alternative food and fibre land uses to a size that can replace the economic engine and export earnings currently provided by dairy, sheep, beef and deer.

The challenges facing the initiation of new food and fibre industries doesn't preclude their development or potential growth, but it does speak to the risks and costs associated with doing so. The role of government in helping de-risk the innovation and investment required to scale viable land uses to assist in emissions reduction should be carefully considered.

...and our future food system

While emissions mitigation strategy necessarily focuses on individual farmer outcomes, communities are awake to the impacts that moving to a lower emissions primary sector might entail. This will look different across regional New Zealand, not just due to the geo-physical limitations that determine appropriate land uses, but due to pre-existing socio-cultural drivers and the state of and access to infrastructure. Despite the inherent uncertainty of how a low emissions future for New Zealand's primary sector might ultimately be experienced, such pathways do exist, albeit with a range of community preferences for them and likely differing regional expressions. It does seem, however, that the primary sector's transition to lower emissions will involve fewer ruminants, new or expanded supply chains and a need for significant capital investment, both within specific sectors and in public infrastructure.

Understanding the primary drivers of success in reducing greenhouse gas emissions will be crucial for decision-making by central and regional authorities. These drivers include community aspirations, infrastructure costs, and social/economic impacts. Any community is most likely to succeed in our uncertain future when the targeted outcome aligns with community support and adequate resources.

There is a prevailing sentiment expressed that people are not inherently resistant to change but instead seek active involvement in decision-making processes guided by a clear rationale that aligns with their region's long-term strategy. It is also imperative that decision-making extends beyond the national level, empowering regional authorities to mandate and implement community-scale responses. Government support, especially in legislative changes that enable renewable energy, water availability and infrastructure improvements, is however considered essential for regional readiness and development.

Given the urgency of meeting emissions reduction targets, government, sector, and community actions must prioritise interventions that offer significant greenhouse gas reductions with minimal disruption. This involves strategic decision-making to support solutions that balance environmental goals with economic and social sustainability.

Recommendations

As the Future Farm Systems Research Programme draws to a close in its current form, there are several recommendations that we make for industry, government and future research.

Recommendations for industry

Irrespective of the industry's range of sub-sector specific views on emissions reduction and the role of the wider sector in that, the delivery of emissions reduction needs to be supported by industry and complement government or market-driven initiatives and requirements.

Regarding specific insights from this body of work, we would recommend industry:

- Promote the use of farmer-led extension to socialise the changes required and develop the solutions for these.
- Continue to invest in the development of the facilitator capability required to support farmer-led change.
- Invest in both funder and project management awareness and upskilling for supporting farmer-led projects.
- Support cross-group sharing and knowledge exchange.
- Promote the benefits of an integrated policy approach, and support farmers with the integration where it does not exist yet.

Recommendations for government

We see the clear opportunities for government in primary sector emissions reduction as two-fold.

With respect of the primary sector itself, we believe there is value for government to:

- Create recognition/reward schemes for early movers.
- Develop policy and funding models that incentivise systems-level outcomes across multiple environmental objectives.
- Expand the funding of scalable, supported farmer-led groups.

Of equal importance are the priorities government might need to have and what actions they might need to take to ensure necessary change behind the farm-gate is supported beyond the farm gate, and to ensure such changes are ultimately positive for our communities' socio-economic prosperity.

- Government needs to be alert to the increased pressure that a lower emissions primary sector is expected to create for energy, water and transportation infrastructure, and proactively respond accordingly.
- Local communities should have a significant role in decisions that will enable them to best adapt to the implications a region's primary sector with reduced emissions will create. This essentially means devolving decision making and resource allocation to appropriate regional agencies.
- Provide policy certainty to the primary sector on targets, pricing, and timing, ideally with bipartisan/cross-party support to enable long-term decisions to be made behind the farm-gate.

For future science and research

The Future Farm Systems Research Programme was a novel programme in that it funded research into elements of the New Zealand pastoral farming system that for a range of reasons had limited institutional focus. Having now completed much of the programme, our insights for future research and analysis similarly have a focus on elements of and adjuncts to farm systems that more traditional, operationally interested farm system research might not prioritize.

These include:

- Addressing communication gaps with evidence-based, rural-focused information proactively and actively delivered.
- Testing the framework being developed out of this farmer-led solutions research.
- Investigating factors that increase or lower farmer risk in adoption of alternate land uses.
- Broader analysis into the scaled impacts of land-use change on existing supply chains, including the potential for redeployment/redesign of existing infrastructure and assets.
- Understanding the scalability and profitability of post-harvest and processing components for novel and emergent low emissions land uses.
- Ensuring that investigation into the wider (i.e., regional) economic effects of reducing environmental impacts provides for the opportunity to develop a greater understanding of the socio-economic parameters that support and ultimately determine the success of fundamental changes to our food-driven economy.

Given the challenges that the research has highlighted face the pastoral sector in reducing agricultural emissions, it is also critically important that we continue to research the options for methane and nitrous oxide reduction that would enable the continuation of a pastoral sector of similar economic value to today.

In making this recommendation we are fully cognisant of the fact that, due to a broader range of environmental and social impacts, that farming as we know it today must continue to evolve, and that necessary changes to address declining water quality, biodiversity, employment conditions, for example, may have benefits for greenhouse gas emissions, and vice versa. Given, however, the reality that Aotearoa New Zealand's standard of living continues to rely on the production of food and fibre from our natural resources, it is not tenable in our view to advance narratives that such activity needs to substantively cease. We need to find ways, if we can, to have both our environmental cake and eat the economic one.

Final thoughts

While emissions reduction from [pastoral] farm systems has been the focus of this research programme, this issue has numerous interrelationships, both with other environmental issues and the economy outside the farm gate. This reinforces suggestions that an alternative to a siloed approach is required to deliver a viable solution to this wicked problem. Wicked problems, need wicked solutions.

There is a need to identify potential solutions that provide for continued primary sector production that generates aggregate economic value from a shrinking environmental footprint. Our view is that combining the elements of the Future Farm Systems Research Programme into an applied regional case study to find such a solution warrants consideration.

This would be a practical mechanism to assess the potential of farmer-led change behind the farm gate to successfully address interrelated environmental challenges in a coordinated approach with wider industry and government stakeholders. Multiple farmer collectives across a region, each bound to a specific catchment area, could first individually and then collectively ideate on solutions to the same, integrated issue, with their solutions shared and analysed alongside regional stakeholders. The outputs could then be tested in respect of the wider regional economy. For example, exploring investment in the supply chain of alternative land uses, potentially repurposing infrastructure, etc.

This approach could subsequently inform and support a ground-up, co-design process for a genuine integrated policy with respect to environmental management in our regional landscapes. Given that any such policy would need to be implemented at a regional level, this could be a novel way of developing a complex policy and "ironing out the kinks", so to speak. The myriads of stakeholders and participants involved in achieving policy outcomes would be part of the process from the start (rather than consulted after the fact).

Funding for such broad projects have always been challenging, with many funds focused on specific aspects (e.g. water quality, but not greenhouse gases; environmental outcomes but not economic or social implications). Perhaps collaborative funding is also required?

While the primary sector has generally always embraced change (or at least adaptation), the pace and magnitude of the challenges ahead are confronting for many. Individual farmers can adapt and change to a point but require support and investment beyond the farm gate with a degree of coordination, or at least a general sense of everyone heading in the same direction. While focused on emissions reduction, the Future Farm Systems Research Programme has provided some food for thought in what this direction could look like with some practical testing of these concepts from the ground up. There remains, of course, more work to be done, and by all of us, to shape the future state of a primary sector with pastoral production continuing to thrive at the heart of it.

Ēhara tāku toa i te toa takitahi, engari he toa takitini.
My strength is not that of a single person, but the strength of many.

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