Exploring realities: Impacts of lowering primary sector [biogenic] emissions for two case studies

Courtney Stone[1], Lee Matheson[1], Terry Parminter[2], Rob Brazendale[1] & Abbey Dowd[1]

[1] Perrin Ag Consultants Ltd, NZ
[2] KapAg Limited, NZ
Email: courtney@perrinag.net.nz

Abstract. The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) initiated the Future Farm Systems Research Programme to explore transformative system changes that could support the agricultural sector to achieve the Government's 2050 climate targets. The study focused on case studies in Te Tai Tokerau Northland and Murihiku Southland, gathering input from experts, stakeholders and local representatives through workshops in 2024. Scenarios were developed from participant input, allowing for the exploration of potential differences both between and within regions. Scenario analysis explored value chain impacts and identified regional pathways to low emissions futures, which include reducing ruminant numbers, developing new supply chains and requiring significant capital investments. Results highlight that successful emissions reduction depends on aligning community aspirations with economic realities and infrastructure costs. Effective transitions necessitate strategic decision making and active community engagement, aiming to balance environmental, social and economic outcomes.

Keywords: regional impacts, extension, land use change, farmers, growers, greenhouse gas emissions.

Introduction

Policy background

The New Zealand government have set a net-zero emission goal (all greenhouse gas emissions other than biogenic methane) by 2050 under the Paris Agreement (Ministry for the Environment 2024). Government and private sector initiatives such as the Resource Management Act (RMA), reform of the RMA itself, the One Billion Trees programme, the Emissions Trading Scheme (ETS) and others, provide substantial opportunities for policy and implementation strategies to assist the national transition (Blaschke 2020). Striking a balance between adapting for the future and sustainable growth will require collaboration to ensure economic, environmental and social outcomes are aligned (Raihan 2023).

Regional background

A detailed analysis of Te Tai Tokerau Northland and Murihiku Southland was undertaken, incorporating likely climate change impacts from the farm gate through the whole value chain. This included effects on production, capital infrastructure, supply chain logistics, social impacts and natural resources (Perrin Ag 2022). Northland was identified as a research region for this project given its large Māori (Indigenous peoples) economy, population and long history of primary industry leadership by *mana whenua* (Māori with recognised customary interest or territorial rights over that area). Southland was identified as a second region to study offering contrasting socio-economic, demographic and bio-physical features. The analysis in this new project was intended to inform a framework that could be developed and applied to other challenges for different regions across New Zealand.

New Zealand has made commitments to international and domestic emissions targets, with the domestic target requiring a minimum of a 24% reduction below 2017 biogenic methane emissions by 2050. Regional perspectives on the central government targets, as opposed to national perspectives, are potentially more likely to create greater engagement and 'buy-in' by regional communities in potential solutions and approaches (UNCHS 1999). Regional organisations play a crucial role in community development by tailoring strategies and responding to local needs to ensure effective implementation of biogenic greenhouse gas (bGHG) policies.

Individual regions have various levels of capacity and capability to implement or manage necessary change. Devolving to the regions the implementation of the potentially significant changes required in any potential future may require considerable investment and capability building in regional agencies, many of which were already under resourced. It may also require a change in the funding and taxation mechanisms that fund regional infrastructure (Badenhorst & Zheng 2024).

This project was designed to build on and make use of the results from computable general equilibrium (CGE)/partial equilibrium modelling that was used in an earlier literature review (Brazendale 2022) of the regions to quantify possible future trends.

Research background

While previous studies have explored elements of land-use change under policy scenarios (PCE 2024), signals for on-farm change (Bewsell et al. 2023), and evaluation of practice change (Herrig et al. 2024), there remains a significant gap in the integration of participatory strategic foresight with scenario planning to empower community and stakeholder-driven decision making on greenhouse gas (GHG) emission reduction. This research addresses this gap by combining these methodologies to define the boundaries of plausible futures for regional policy and industry development, offering a novel, participatory, and inclusive approach to co-developing strategies for GHG mitigation. Similar research was recently undertaken by the Parliamentary Commissioner for the Environment (PCE) exploring land use change under different policy settings in two case study catchments, Wairoa in Northland, and Mataura in Southland (PCE 2024). Other similar studies that have been conducted by Bewsell et al. (2023) on understanding signals influencing on-farm change, and Herrig et al. (2024) on using an evaluation method to demonstrate how users consider practice change.

The dairy industry in New Zealand has explored scenario analysis to determine possible, plausible futures that might support the design of resilient farming systems, while also raising awareness of challenging longer-term issues and innovation opportunities. Shadbolt (2017) conducted this research with a holistic approach, assessing the impact of (and likely responses to) plausible disruption at a regional scale, from the changes existing primary industries might implement to reduce biogenic GHG emissions. It is crucial to understand decision-makers' perceptions of barriers and motivations at a regional level, as past efforts have primarily focused on national-level decisions concerning local mitigation strategies (Archie 2018).

The research will benefit those who hold decision-making power at a national, regional or community level. The results will be important for groups in strategic decision making, balancing environmental goals with economic and social sustainability. Understanding of variations at a regional scale to develop tailored and effective strategies for communities will be critical in successfully achieving emissions reduction targets from the primary sector.

Objectives

The New Zealand primary industries have been working together with regional and central government to address climate change concerns and reduce GHG emissions. This study aims to explore the regional impacts of various plausible scenarios for lowering primary sector emissions for farm systems in Te Tai Tokerau Northland and Murihiku Southland, assessing their long-term implications for both the primary sector and Aotearoa New Zealand.

1. To understand community members expectations of regional changes (social, cultural, structural, and economic) between 2024 and 2050.
2. To explore how community members anticipate these changes will affect people like them by 2050.
3. To analyse community perceptions of how existing New Zealand GHG commitments may influence their region under different scenarios.
4. To identify strategies proposed by community members to mitigate increases or decreases in greenhouse gases.
5. To assess the regional implications of community preferences for various scenarios.

Changes in land use, production systems, and supply and value chains would introduce new functionalities, potentially driving both increases and decreases in regional GHG emissions from associated sectors. In a low [biogenic] emissions future, what interventions could further support the region's success in this reimagined future with reduced bGHG emissions? Additionally, what measures might be necessary to prevent an increase in broader GHG emissions due to these changes?

Research approach

Scenario development

The scenarios in this study were developed using a qualitative scenario analysis methodology derived from Schoemaker (1993) as per Parminter et al. (2003) and Shadbolt et al. (2017). This basic method was used twice – firstly in deriving the scenarios (Phase 1) and then in exploring the scenarios in the context of lowering emissions (Phase 2). This mixed methods approach was chosen to deliver descriptive insights, as opposed to metrics. The method involves undertaking preliminary background research regarding the regions' current physical, socio-economic, and demographic states and the likely impact of embedded climate change on their primary sectors. Regional stakeholder workshops were held to identify the dimensions, or boundaries of the possible futures for their regions (Phase 1). A series of key "ecosystem" parameters were

developed, represented as continuums, with contrasting outcomes identified based on participant perspective and observation. Scenario descriptions were then drafted to sit inside the mix of scenario dimensions framed around their regional context. The preliminary research supported the research team in its understanding of the regions ahead of the Phase 2 workshops and so assisted in workshop facilitation by ensuring the clarification of any assumptions where the research team needed to supplement insufficient or incomplete participant contributions in developing the scenarios. The implications of lowering primary sector biogenic emissions in the two regions were explored in the Phase 2 regional workshops.

The project addresses the challenge of exploring future uncertainties by developing four plausible scenarios for two regions. These scenarios are informed by the input of experts, stakeholders, and local representatives, ensuring diverse perspectives are considered in envisioning potential futures. The scenarios were deliberately designed as mutually exclusive alternatives that were considered by the participants to contain elements that were all plausible but also that were all equally likely as well as unlikely possibilities. The actual future was expected to lie somewhere between all the scenarios (Burrows & Gnad 2018).

Participants

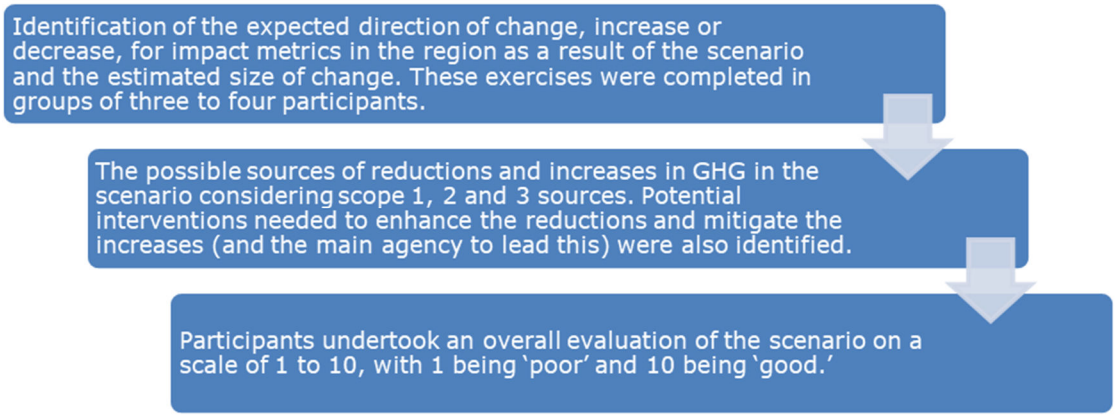
To encourage participation from different communities, a series of either four or five workshops in February and March 2024, were facilitated by the research team in both Te Tai Tokerau Northland and Murihiku Southland. An additional and separate workshop in each region was held specifically for *mana whenua*. Attendees for all workshops were identified through the researchers' professional networks, catchment groups, industry good bodies and sector leaders, Farmers and growers, including Māori professionals were invited to attend workshops in their regions. A list of 40-50 attendees was developed for each of the expert/stakeholder workshops to secure 25-30 participants per workshop. The invitation list was not restricted, and workshops were advertised widely to ensure participation from those that had heard about the events and wanted to be involved.

All participants were offered a *koha* (cash gift) in recognition of their time and input into the workshops and reasonable travel costs were refunded. *Koha* could either be received personally or made as a donation to a charitable organisation or *marae* (meeting house) of their choosing.

Facilitated workshops

At each workshop two facilitators assisted small groups of three - four people to complete group-templates that were consistent across all workshops and regions. The templates had standardised open questions and incorporated collective decision-making processes (Figure 1) to resolve relevant problems about future planning in each region. The templates included numerical scales to compare results from different people within groups, between groups within the same workshop, between workshops within the same region, and even between regions. Participants used Post-it® notes and other non-numerical data to help explain their numerical scores and record responses of themselves and/or the group in their own words. Plenary discussions were included in the workshops and recorded where possible (with permission) to allow themes and ideas not captured through the exercises to contribute to the workshop data.

Figure 5. Method for key workshop outputs to inform findings of insights



Facilitators assisted the groups to understand the templates and ensure that everyone had an opportunity to contribute to the responses. After the workshops, the facilitators organised the

Post-it® notes into themes and analysed the workshop results by looking for relationships between participant responses.

To address the first objective of the research regarding expected regional changes, the workshop exercise was carried out in small groups to identify the expected changes, comparative advantages, opportunities, and comparative disadvantages, threats, that could affect people across their region. To address the second research question on the impacts of the expected changes, each group selected a focus value chain that the members were familiar with was relevant for the region. Using this value chain, they identified the main forces operating on it that provided "enhancers" and "disruptors" to it and all the effects of these pressures on the supply chain. To address the third question on the effects of reducing bGHG emissions, people were provided with the baseline metrics for their region and a description of one of the four plausible scenarios. They used this information to describe and estimate trends in the comparative outputs (population, employment, land use, GHG emissions, regional GDP etc) for each of the four 'possible futures'. For the fourth question people contributed ideas and what potential mitigations might be, to deliver the bGHG decreases or mitigate accompanying GHG increases. For the fifth question evaluating the regional scale impacts of participant perceptions, the researchers estimated the expected regional benefits and costs for each scenario of a potential future and compared this with participant's overall preferences.

Development of scenarios about the future (Phase 1)

After each Phase 1 workshop, the data from the all the templates in that workshop were analysed together. The Post-it® notes and session transcriptions were organised into themes that were reviewed by the research team. They identified all the forces impacting upon the region from the Post-it® note concepts and these were associated with contrasting concepts. For example, "increasing population" could be associated with "decreasing population." The main pairs of concepts were then arranged along a continuum, reflecting the conditions expected to have the greatest impact on each region's future. From the continuum plausible scenarios were prepared. Each of the scenarios had to address the same sets of metrics and be:

- Representative of a set of contrasting poles of the continua
- Equally plausible and/or implausible to participants and the research team
- Internally consistent

Summaries of each workshop were prepared and circulated to both attendees and those individuals who expressed interest in participating but who found that they were unable to attend. Continua were then confirmed or developed from the data. These included continua that were relevant to both regions as well as continuum specific both to the individual regions and to their *mana whenua*.

The four scenarios were described as a coherent 'story' and their main elements visually illustrated. This was intended to provide a succinct way of integrating each scenario as a complete economic, social, and environmental system. A brief description of each scenario is provided in Table 1.

Table 1. Brief description of scenarios, their key themes, and acronyms

Possible scenarios	Acronym
Diversity is the new specialty (DITNS) – Innovative local businesses, mixed landscapes, and flexible employment.	DITNS
The world's food basket of choice (WFB) – Increased plant-based foods, vibrant rural communities, mātauranga Māori (indigenous knowledge) incorporated.	WFB
Feeding the world (FTW) – Export opportunities, well-resourced training, efficient production, skilled workers.	FTW
Green shoots (GS) – Overseas investment, alternate food systems and production, urban drift.	GS

Analysis of scenario impacts upon each region (Phase 2)

A Mixed Methods Research approach (Timan et al. 2019) was applied to the results of the Phase 2 workshops to evaluate the impacts of the different scenarios about the future on the regions. The analysis was two-fold, beginning with a simple descriptive statistical analysis and then a word cloud diagram of the transcripts based on the number of times specific words were used derived from ChatGPT 4 (12 April 2024).

After the numerical analysis, a more flexible, natural approach was used. This approach built on the insights from the numeric results and adapted as new information was considered (Turner

2009). Themes were developed from the numerical results and associations discovered between several themes. Such associations increased the researchers' understanding of the concepts and their significance to the participants. The themes were analysed by the research team through a process of triangulation (Olsen et al. 2004; Webb 2009) to ensure the examination of the same dimension of the research data from a mixed methods approach. Post-it® note concepts were assigned a theme (association could be both positive and negative) that the concept was best described by. The themes were reviewed and narrowed to 5-10 key themes, each represented by the sub-themes that reflected the workshop participants' contributions.

Analyses of GHG effects and possible interventions to mitigate these

The GHG interventions were analysed through a two-step process. The first step involved each intervention being attached to all the relevant reductions and increases. Interventions were then ordered on universal appeal across all scenarios. These interventions were then attached to an estimated extent of change level between 1-5 and anticipated scale of return. The top interventions that were identified across each aspect of the analysis were collated as the recommended interventions for policy makers to explore. These interventions were likely to be flexible in supporting the establishment of the realised future, irrespective of how they might play out.

Comparison of the regional scale impacts of each scenario

Phase 2 workshop participants described the type and significance of the changes that they associated with the scenarios by comparing business as usual (BAU) and each scenario in turn. In this part of the study the research team used these results from the workshops as well as an analysis of historic social, economic, and environmental settings, to estimate the significance of the expected changes at a regional scale. For each scenario, this additional analysis focussed on:

- How much additional capital might be required for additional infrastructure including: new roads, seaports, airports, housing, public transport, and schools?
- How much social disruption could result from each scenario including things like the scale of: international immigration, regional migration and unemployment?
- How much economic disruption might be created in each scenario: including things like changes in: land use, supply chains, processing, transport and exporting?

A Likert five-point scale (Likert 1932) was used to make these estimates, calibrated to the estimates made by the workshop participants. Estimates were calculated by analysing and averaging workshop participants' responses:

- Level 1: Minimal change (0-10%)
- Level 2: Small change (10-25%)
- Level 3: Moderate change (25-50%)
- Level 4: Significant change (50-75%)
- Level 5: Major change (75-100% or more)

Results

The following results explore how Northland and Southland may be affected by four potential scenarios. Key insights from participant workshops highlight anticipated changes in land use, economic drivers, and GHG emissions, with particular attention to the transition from pastoral farming to horticulture, renewable energy opportunities, and workforce shifts. Regional differences in community preferences, perceived risks, and the magnitude of change required to achieve each scenario are examined. These results provide a comprehensive assessment of how different scenarios may disrupt regional economies, labour markets, and infrastructure, as well as the strategies required to mitigate GHG emissions.

Plausible scenarios for Northland

Workshop participants from Northland found the Diversity is the New Specialty (DITNS) scenario more favourable than the other three scenarios (highest scenario evaluation ranking). All scenarios in the regions identified that changes in land use were likely to occur in future. In the DITNS scenario, a significant shift from livestock to other land uses was anticipated. Participants indicated that lower stocking rates and the retirement of livestock farmers was expected to drive much of this change. Additionally, the transition to a lower emissions future and advancements in genetic engineering is likely to reshape farming practices, prompting farmers to explore more resilient crops. Participants highlighted a potential short-term risk of the system becoming more intensive if stocking rates were reduced. Across all scenarios, livestock numbers were expected to reduce to meet New Zealand's GHG emissions targets by 2050. The Feeding the World (FTW) scenario was expected to result in the smallest reduction in livestock land use, with a focus on

maintaining high production levels, including dairy and beef products for various overseas markets. In all scenarios horticulture and forestry land uses were expected to increase in future.

Across all scenarios in Northland, investment in roading to support supply chain movement was considered critical. It is likely that this view was amplified by recent transport issues that have highlighted this vulnerability. With the potential to develop and produce a variety of new products, Northland faces a heightened vulnerability to breaches in biosecurity measures which could introduce harmful pests or diseases. Such threats could impact agricultural production and trade opportunities in the region.

How might each scenario disrupt Northland?

Participants in each of the Phase 2 workshops in Northland were provided with the base impact metrics for the region, outlined in Table 2. If New Zealand reached net-zero long-lived gases (all GHG emissions other than biogenic emissions) by 2050 and reduced methane by a minimum of 24%, participants were asked to identify whether they expected regional output measures to increase or decrease and to estimate the likely magnitude of the changes.

In the responses across all the scenarios, between 2024 and 2050, people expected there to be an increase in total population, forestry land use, horticultural land use and regional gross domestic product (GDP).

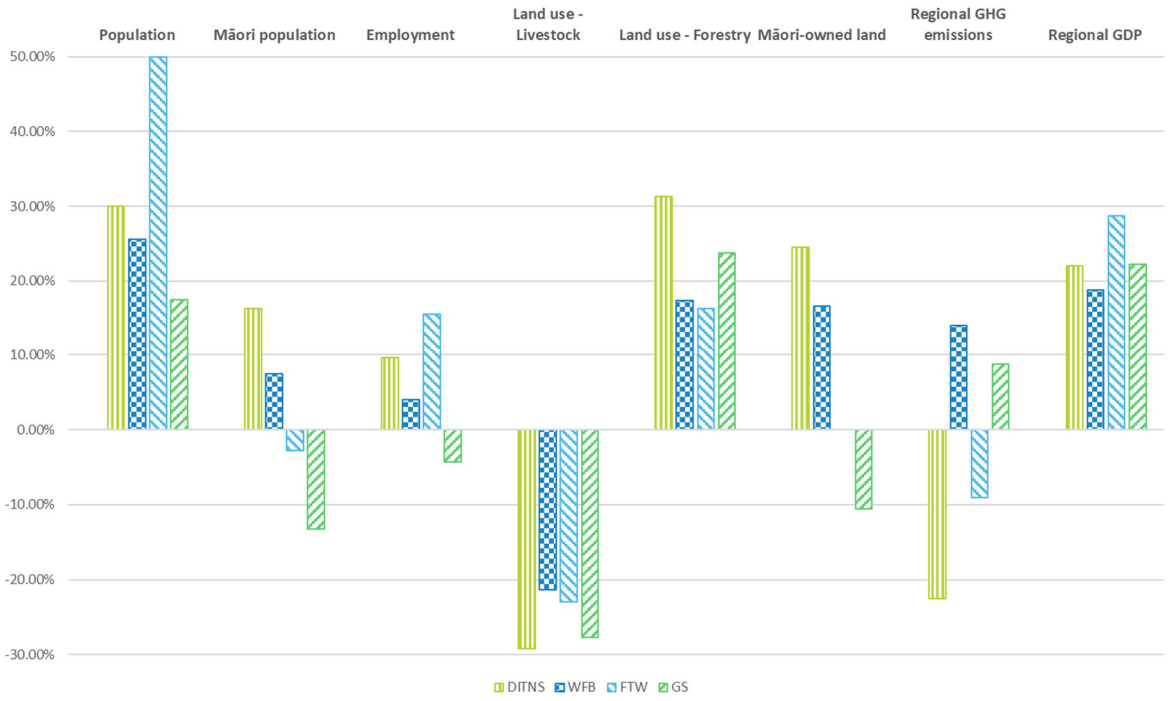
The GS scenario engendered differences in perspective on some impact metrics. Of note, participants generally felt that the Māori population and Māori-owned land would decrease in contrast to all other scenarios. Drivers of these metrics were likely to be a result of the drain of population to urban areas, changes in culture from immigration leading to the decline of Māori protocols and *tikanga* (ways of doing things) and overseas investment lowering the opportunity for Māori land ownership. To further represent differences in the projected changes in impact metrics of potential scenarios, workshop participants quantified the anticipated magnitude of change.

Table 2. Summary of Northland workshop participants expected direction of change for impact metrics in each possible scenario

Tai Tokerau Northland	**Expected direction of change from 2024 to 2050**				
Impact metrics	**Base**	**DITNS**	**WFB**	**FTW**	**GS**
Population	197,000	↑	↑	↑	↑
Māori population	37%	↑	↑	↓	↓
Employment (part or full)	65%	↑	↑	↑	↓
Land use - Livestock	75%	↓	↓	↓	↓
Land use - Forestry	23%	↑	↑	↑	↑
Land use - Horticulture	3%	↑	↑	↑	↑
Māori owned land	140,000 ha (23%)	↑	↑	→	↓
GHG emissions	24.5 t CO_2e	↓	↓	↓	↑
Regional GDP	$44,760/head	↑	↑	↑	↑
Dots= small (0-33%), Diagonal = medium (33%-66%), Horizontal = large (66%-100%)					

Figure 2 represents the amount of change that Northland workshop participants expected for each impact metric against the base values. For all scenarios, livestock land use was expected to decrease between 20 and 30 percent. The drivers of these changes were regional policy changes, overseas investment creating opportunities for alternative land uses, genetic improvements and lower stocking rates, consumer preferences and market dynamics and international decision making. The FTW scenario had a significantly higher population growth driven by large production for overseas markets resulting in attracting people back to the region through training opportunities and new income and market streams.

Figure 6. Comparison of scenario impact metrics for Northland compared to base metrics



The Northland horticulture surge

A key insight from the Northland workshops was the substantial projected increase in horticultural land use across all plausible scenarios. Horticultural land use was excluded from Figure 6 because the projected magnitude of its changes was significantly larger than other impacts in each of the scenario, making the rest of the data difficult to interpret. Starting from a base of just over 17,000 hectares in 2019 (shown by dark bars in Horticultural crops were described by participants as being sensitive to moisture stress at critical times and hence the availability of irrigation water at these times was likely to be a major enabler for this land use change. The post-harvest management of these crops, including packing and processing, also requires water. Continued investment in water storage infrastructure, already begun as part of the Provincial Growth Fund was going to be required.

The implications for labour requirements were considered by the participants at two levels: 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. Immigration settings that support the availability of migrant labour for manual work were required due to insufficient existing domestic labour. Capability building for technical expertise and marketing in the region may require the establishment of a technical institute or centre of excellence.

Participants identified that horticultural systems were likely to be more intensive users of energy in both production and post-harvest stages of the supply chain (e.g. cool storage, refrigeration, processing, and packaging). It was felt that government incentives to support the installation of the more sustainable [low carbon] energy generation such as solar and geothermal would make local energy generation more viable and would not add load to existing energy transmission infrastructure.

The participants felt that more horticulture would result in greater volumes of perishable products that needed to reach the consumers faster than longer-life products such as milk powder. Improved road networks for transport to domestic markets, especially Auckland, and connections to airports, seaports, land ports and rail networks were required to support this land use change.

Figure 7), participants indicated that by 2050, significant (i.e. >350%) shifts toward horticulture were likely. These land use changes in Northland were expected to vary between different scenarios. Projections from participants were based on their understanding of existing land areas that could convert to horticultural production. Workshop participants identified land use change away from livestock to horticultural as a source of GHG reduction for all scenarios.

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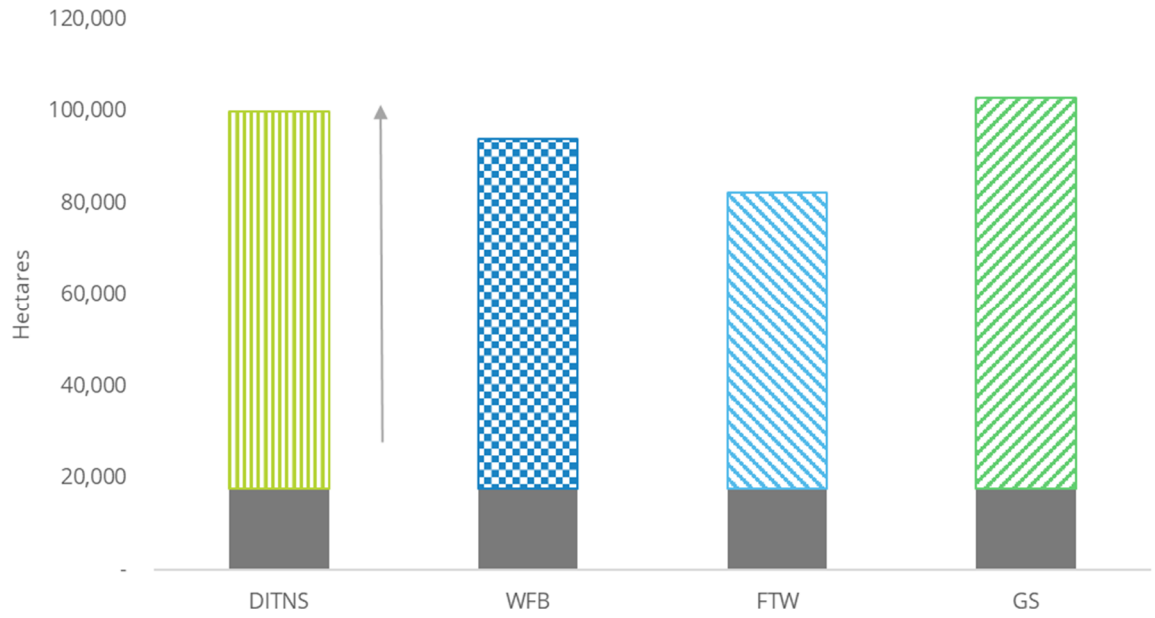
Figure 7. Comparison of Northland participant horticultural land use estimated projections (ha)



The participants considered that more freight trucks on the roads would result in greater carbon emissions unless the freight vehicle fleets were electrified. Technical development would be required and charging infrastructure expanded. Electrification of other forms of transportation – trains, ships, and planes – could reduce emissions.

There were concerns that the introduction of new crops such as tropical fruits might increase biosecurity risks and amplify the importance of protection against incursions of insects and plant-borne diseases. Although important to Northland, participants expected the introduction of new biosecurity strategies to be part of a national policy initiative rather than regionally specific to Northland.

People wanted an opportunity to explore and debate the management of any possible biosecurity risks with genetically modified plants. Some felt that genetic modification was required to remain competitive with other international producers of horticultural crops.

The emissions trade-offs in Northland

Workshop participants were asked to identify possible policy interventions that they believed were required to either deliver potential decreases in biogenic greenhouse gases or mitigate any increases of carbon emissions arising from a plausible scenario. Common themes were distilled from workshop outputs and are reported in Table 3 below.

Table 3. Interventions to capture GHG decreases or mitigate increases in Northland

	Northland theme interventions	DITNS	WFB	FTW	GS
1	Electrification of vehicles	✓	✓	✓✓✓✓✓	
2	Renewable energy generation	✓✓✓✓✓	✓✓✓	✓	
3	Water availability	✓	✓✓	✓	✓
4	Working from home	✓	✓		
5	R&D into new technology	✓✓✓	✓✓✓	✓✓✓	✓✓
6	Improved roading infrastructure	✓	✓✓		
7	Building workforce capacity and capability		✓✓✓	✓✓	✓✓
8	Genetically modified organisms (GMOs)	✓			✓✓✓

Key interventions for Northland identified in workshops

Interventions to encourage the electrification of vehicles were identified for three of the four scenarios in Northland workshops. The suggested electrification of transport was all encompassing and included airplanes, ships, rail, road vehicles and on-farm vehicles.

Renewable or alternative energy was the strongest theme for the DITNS scenario. For the Northland workshops, interventions were suggested to increase investment in solar and geothermal energy generation.

In Northland workshops, participants identified the need for more investment in research and development of new technologies. It was emphasised that further research into alternative plant and insect organism was 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.

Allowing the use of GMO's was a key intervention identified for the GS scenario. Northland participants considered research into the application of GMOs important.

Investment into water storage and better roading infrastructure were identified as important interventions specific to the Northland region. The emergence of working from home employment was possible and this would require improved connectivity.

Workshop results indicated that participants believed it was crucial for individual households to be aware of their GHG emissions. Participants also emphasised the importance of introducing comprehensive food waste reduction initiatives throughout the region to promote environmental sustainability and reduce the overall carbon footprint.

The significance of the changes and mitigations at a regional scale for Northland

Understanding the extent of change required to shift from BAU to each plausible scenario is important for regional development. A 5-point scale was used to assess the degree of change needed for various regional attributes, considering participant input. The total support required reflects the overall level of change anticipated for scenario realisation. Comparatively, a lower total support score indicates less overall change is needed relative to other scenarios. In Northland (Table 4) the GS scenario was considered to require the least regional investment. It was felt in the workshops that people in Northland would prefer this scenario due to its perceived economic benefits, however it was also considered to pose significant accompanying greenhouse gas (GHG) risks, making it an environmentally challenging option for Northland regional communities. On the other hand, the DITNS, which has the greatest community support (highest overall average score), was expected to require substantial investment and social disruption. Early planning and proactive measures would be essential to succeed in this preferred scenario effectively and mitigate the associated challenges, likely to follow should it occur.

Table 4. Scoring of Northland drivers based on the level of change required in each scenario (where 1=minimal and 5=major)

Northland drivers	DITNS	WFB	FTW	GS
Roading	5	1	5	1
Ports/airports	4	1	5	1
Housing	4	3	3	2
Public transport	4	3	2	2
Renewable energy	2	1	1	1
Education	3	4	2	4
International immigration	4	1	3	4
Regional migration	4	3	4	2
Unemployment	1	3	2	2
Land use change	2	5	5	3
Supply chains	5	4	5	4
Processing	5	5	5	4
Transport	5	4	4	1
Exporting	4	5	5	3
Sum of support required	43	41	41	32
Degree of community support	4	2.8	3.8	2

Improvements in supply chains and processing would be required for Northland to maximise successful outcomes across all the possible scenarios (Table 4). Transport and exporting elements and land use change were also common across all the scenarios and required a high level of investment for success in all possible scenarios for the Northland region.

In Table 4, the WFB and FTW scenarios were accompanied by considerable economic disruption due to changes in land use from livestock to arable and horticulture. Among these, overall participant evaluations indicated that the FTW scenario was slightly more preferred given the WFB scenario was considered to lack resilience in a future where environmental adaptation would be required. Northland could prepare for these contingencies by conducting preliminary impact assessments and building flexibility in their regional planning. Engaging the community and maintaining open communication would be required to navigate these transitions, balancing economic, environmental, and social factors for a sustainable future.

Plausible scenarios for Southland

The scenarios in Southland were the same as those presented in Northland, but with a regionally specific narrative. A major opportunity identified for Southland was diversification of the energy sector. Southland is considered to offer unique advantages for wind energy production due to its strong and consistent winds. Southland's geography and infrastructure also could offer opportunities for hydrogen energy production, which could leverage existing industrial facilities and ports for export.

How might each scenario disrupt Southland?

Participants in each of the Phase 2 workshops in Southland were provided with the base impact metrics for their region, as were the people in the workshops in Northland. They also assumed that New Zealand would reach net-zero long-lived gases (all GHG emissions other than biogenic methane) by 2050 and reduce methane by a minimum of 24%. The participants were then asked to identify whether they expected regional output measures to increase or decrease; and to estimate the likely magnitude of the changes.

Table 5 shows the average expected direction of change for each scenario from the base metrics. Changes in livestock was the only land use change measured in Southland (horticulture and forestry were excluded due to data unavailability), however based on qualitative commentary, most of the land use change was expected by participants to move towards horticulture. Participants identified that the WFB scenario could have the most significant reduction in livestock land use, driven by the introduction of various new food products for export markets. A key difference was observed between DITNS which assumed a static population when its results were

compared to the remaining scenarios. A combination of variables preventing population growth were identified with the combination of these suggesting changing trends in agriculture toward less labour-intensive practices, economic shifts, and lifestyle changes. Net GHG emissions were expected to decrease in DITNS and GS with improved efficiencies on farm, smaller population growth and renewable energy. On the other hand, participants expected to see an increase in net GHG emissions in the WFB and FTW possible futures driven by increased machinery for wheat, oat and barley production, land use change, increased production, and population.

Table 5. Summary of Southland workshop participants expected direction of change for impact metrics in each possible scenario

Murihiku Southland	Expected direction of change from 2024 to 2050				
Impact metrics	**Base**	**DITNS**	**WFB**	**FTW**	**GS**
Population	97,467	→	↑	↑	↑
Māori population	15%	↑	↑	↑	↑
Employment (part or full)	70%	↓	→	↑	↑
Land use - Livestock	85%	↓	↓	↓	↓
Māori owned land	93,825 (10%)	↑	↑	↑	↑
GHG emissions (Net)	4,947,505 t CO_2e	↓	↑	↑	↓
Regional GDP	$65,500/head	↑	↑	↑	↓
Dots= small (0-33%), Diagonal = medium (33%-66%), Horizontal = large (66%-100%)					

Population and employment appeared to have minimal expected changes from the base situation in Southland. Livestock land use had a substantial projected decrease in the WFB scenario (reducing to 15-30% of land use in Southland compared to the current 85%). The projection of livestock land use reduction was based on introduction of policy and regulatory changes that could restrict sheep and beef on steeper land use classes and force considerable land use change. Regional GHG emissions were expected to decrease in all possible futures.

The emissions trade-offs in Southland

Changes in land use in Southland, production systems, and supply and value chains were expected to introduce new functionalities, potentially driving both increases and decreases in regional GHG emissions from associated sectors. As in Northland, workshop participants in Southland were asked to identify interventions they believed were required to either deliver potential decreases in biogenic greenhouse gases or mitigate any increases potentially arising from a plausible scenario. Common themes were distilled from workshop outputs and reported in Table 6 with some consistent across both regions and some specific to one region.

Table 6. Interventions to capture GHG decreases or mitigate increases in Southland

	Southland theme interventions	DITNS	WFB	FTW	GS
1	Household emissions management	✓✓✓✓		✓	
2	Alternate energy sources	✓✓✓✓✓✓✓		✓✓	✓✓
3	Workforce capability	✓	✓✓✓	✓✓✓	✓✓
4	Access to capital	✓✓		✓✓✓	✓✓✓
5	Improved battery technology	✓	✓✓	✓	✓
6	R&D into new technology	✓		✓✓✓✓	
7	Genetically modified organisms (GMOs)	✓			✓✓✓✓✓

Key interventions for Southland identified in workshops

Interventions to encourage the electrification of vehicles and improvements in battery technology were identified for all four scenarios in the Southland workshops. The suggested electrification of vehicles was all encompassing and included airplanes, ships, rail, road vehicles and on-farm vehicles. Renewable or alternative energy was identified as the strongest theme for the DITNS scenario. For Southland workshops, the emphasis was on solar, methane, biofuels, and hydrogen.

In Southland, the need for further research was identified most frequently in the FTW scenario and the focus of this research was greenhouse emissions, especially methane. Allowing the use

of GMO's was a key intervention identified for the GS scenario. Southland participants also identified education of the wider public about GMO's as being important.

Workshop results indicated that participants believed it was crucial for individual households to be aware of their GHG emissions. Participants also emphasised the importance of introducing comprehensive food waste reduction initiatives throughout the region to promote environmental sustainability and reduce the overall carbon footprint.

The significance of the changes and mitigations at a regional scale for Southland

Workshop participants described the type and significance of the changes from BAU that they associated with the plausible scenarios. The research team used these results and an analysis of historic social, economic, and environmental settings, to estimate the significance of the changes at a regional scale. In Southland (The DITNS, FTW and GS scenarios all appear to require similar additional investment and change for the scenario realisation, however GS was identified as particularly unfavourable in participant scenario evaluations due to its requirement for large scale overseas ownership. This was deemed likely to introduce significant social disruption. The workshop participants expected that the GS and DITNS scenarios would result in a small decrease in the GHG emissions. The WFB and FTW scenarios were expected to have an overall increased carbon footprint despite efforts to reduce biogenic methane in primary sector activities. If Southland decides to prepare for futures involving the WFB or FTW scenarios, it was considered critical that careful planning was undertaken to ensure interventions would also ensure a low emissions future consistent with current Government policy. Drivers for change such as export, transport, processing, supply chains, renewable energy and land use change were all identified as areas that would require a high level of investment for those scenarios to be realised by 2050. Decision making related to investment in those areas needed to be flexible if the regions were to be able to adapt to likely scenario changes in response to uncontrolled forces.

Table 7), WFB provides for the least disruption from business as usual, however it was expected to be constrained by supply and export markets that would likely limit future product supply. The region was likely to lean toward this scenario, or the DITNS scenario which has the greatest community support. For Southland participants, the DITNS scenario was generally felt to be the most attainable, however it was also associated with higher non-biogenic GHG emissions, which could themselves precipitate a policy intervention. The degree of community support is included to show how drivers compare to community preferences.

The DITNS, FTW and GS scenarios all appear to require similar additional investment and change for the scenario realisation, however GS was identified as particularly unfavourable in participant scenario evaluations due to its requirement for large scale overseas ownership. This was deemed likely to introduce significant social disruption. The workshop participants expected that the GS and DITNS scenarios would result in a small decrease in the GHG emissions. The WFB and FTW scenarios were expected to have an overall increased carbon footprint despite efforts to reduce biogenic methane in primary sector activities. If Southland decides to prepare for futures involving the WFB or FTW scenarios, it was considered critical that careful planning was undertaken to ensure interventions would also ensure a low emissions future consistent with current Government policy. Drivers for change such as export, transport, processing, supply chains, renewable energy and land use change were all identified as areas that would require a high level of investment for those scenarios to be realised by 2050. Decision making related to investment in those areas needed to be flexible if the regions were to be able to adapt to likely scenario changes in response to uncontrolled forces.

Table 7. Scoring of Southland drivers based on the level of change required in each scenario (where 1=minimal and 5=major)

Southland drivers	DITNS	WFB	FTW	GS
Roading	5	1	4	3
Ports/airports	3	2	4	3
Housing	3	2	3	3
Public transport	5	2	2	3
Renewable energy	4	1	4	5
Education	4	3	4	3
International immigration	2	1	1	1
Regional migration	2	1	1	2
Unemployment	2	3	3	5
Land use change	2	4	5	3
Supply chains	5	3	5	4
Processing	5	3	5	4
Transport	5	2	4	4
Exporting	4	5	5	4
Sum of support required	51	33	50	47
Degree of community support	4	2	2.5	2.3

Discussion

Participants across both regions anticipated a significant reduction in the pastoral farming sector due to expected shifts away from livestock. Despite the development of innovative technologies for GHG mitigation, participants did not foresee their widespread adoption, indicating a possible gap in awareness or prioritisation. This shift signals the need for new supply chains and highlights a broader trend consistent with national and regional policy objectives (Blasche 2020; PCE 2024).

The feasibility of increasing horticultural land use in Northland was raised as a critical consideration. Expanding horticultural production requires a comprehensive analysis of soil quality, health, water availability, climate, and other environmental factors. However, participants lacked access to this information, during the study, underscoring the need for further exploration of the practical and environmental constraints related to horticultural expansion.

Regional differences in capacity and capability to implement change mean that devolved decision making and regional investment will be essential. This approach is especially relevant given existing resource constraints in regions like Southland and Northland (Beyond 2025 Southland 2023).

Participants stressed the importance of government support in developing infrastructure and skills needed to adapt to future market and policy signals. This aligns with one of the objectives of the study to identify feasible actions for emissions reduction, highlighting that strategic government intervention in sectors such as transport, energy and education is essential. Existing policy measures may not be adequate, indicating a need for more comprehensive and robust support.

The study also highlighted the role of the Māori economy in low-emissions futures. While all scenarios in Southland projected growth, a risk of reduced Māori involvement in Northland was noted due to urban drift. Engaging *mana whenua* in shaping policies will be crucial for ensuring inclusive and effective strategies for the community.

For Northland, policies to support renewable energy, transportation improvements, and diversified supply chains were priorities. The requirement for investment to support development was also highlighted in the research undertaken as part of the Te Rerenga, Taitokerau Northland's Economic Wellbeing Pathway (NorthlandInc 2024). Central government's role in funding these initiatives and supporting research and development remains critical.

Participants indicated that successful transition requires both government involvement and greater autonomy for regional decision making, highlighting the need for collaboration between industry and government – an opportunity that aligns with one of the study objectives. The

research underscores the importance of identifying the most impactful actions to minimise disruption and maximise benefits (Burrows & Gnad 2018).

Strategic, region-specific decision making is essential for balancing environmental, social and economic goals. Policy makers would be required to appropriately weigh up support for the range of possible scenarios with GHG reductions at some scale but also consider the accompanying infrastructure costs and social and economic disruption. Understanding and responding to these regional differences is key to achieving emissions reduction targets effectively.

Conclusions

The study highlights the need for region-specific, collaborative approaches to achieve New Zealand's emissions reduction goals. While national strategies provide overarching guidance, regional variations in capacity, resource availability, and community needs necessitate localised approaches. Participants across both regions foresaw a decline in pastoral farming due to reduced livestock numbers, even with the availability of GHG mitigation technologies. This shift will require the development of new supply chains, consistent with findings from the PCE (2024) and national policy commitments.

The study also highlighted the importance of regional decision making and the devolution of authority. Regional differences in capacity mean that local solutions are more likely to be effective, particularly when paired with central government support. For regions like Northland, investments in renewable energy, transport infrastructure and diversified supply chains will be critical. Central government support is essential to fund these initiatives and ensure the required research and development are in place.

The Māori economy emerged as a critical component of future low-emissions pathways, with the study emphasizing the importance of Māori engagement in decision making. Risks of reduced Māori involvement due to urban drift in Northland call for targeted efforts to support Māori communities and ensure their active participation in policy development.

The study successfully met its core objectives, capturing community expectations, perspectives, and proposed strategies for navigating social, economic, and structural changes between 2024 and 2050. It revealed how GHG commitments are likely to shape regional economies and how community preferences for possible scenarios can inform regional and national decision-making. Achieving an effective balance between environmental, social, and economic goals will require policymakers to consider regional capacity, investment in infrastructure, and support for community-driven solutions. The combined approach of government intervention and regional autonomy is essential to ensure a just and equitable transition to a low-emissions future.

Limitations

Attendance at workshops in both phases ended up being lower than was expected across both regions. This lower participation in workshops has constrained the number of regional perspectives captured for each scenario, potentially limiting the depth and breadth of insights that reflect community and stakeholder views.

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