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Future Farm Systems: a stocktake of existing research

Prepared for the New Zealand Agricultural Greenhouse Gas Research Centre

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1.0 EXECUTIVE SUMMARY

Purpose

The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) is scoping a potential research programme on 'future farm systems'. A stocktake was commissioned to inform this process.

The stocktake sought to capture:

(i) Farm systems and land use change research currently underway/recently completed in New Zealand and by whom;
(ii) Gaps in that research; and
(iii) Insights as to what 'future farm systems' research could/should look like and what role there might be for the NZAGRC.

This report presents the results of that stocktake. Two key activities were involved:

(i) Interviews with a range of people working in this area in New Zealand, and
(ii) A literature review on farm system and land use change research.

Literature review

The literature review provides historical context for land use and land use change in New Zealand and describes current land use patterns, observes the fragmented nature of current research systems, how they are locked in to supporting current production systems and growth models, and notes that new thinking is required.

It discusses the need to shift the focus of farm systems research away from "primarily production maximisation to production under constraints" and identified a greater role for Government and research in helping 'de-risk' the process of land use change to support the transition to high value/low intensity systems.

It also discusses the barriers to adoption of research, noting a general lack of information to help farmers understand how a given greenhouse gas mitigation (or set of technologies/practices) fits within a farm system and impacts it as a whole.

It concludes that any NZAGRC-funded work on future farm systems could usefully contribute to addressing these barriers by testing and demonstrating the adoption of multiple component greenhouse gas mitigations and technologies in different whole farm systems.

It also highlights, as reflected in the survey responses, that there is strong support both for a multidisciplinary approach for any research carried out, and for the extension of research results, highlighting the need for NZAGRC to work in with industry and farmers in both areas.

Interviews

Fifty-six people were interviewed as part of the stocktake, from research, industry, Government and the private sector, as well as independent agricultural commentators (refer Appendix 1). Each was asked:

- How would you define future farm systems research?
- What farm systems or land use change research currently being carried out are you aware of?
- What are the gaps as you see them?

- What future (low carbon) farm systems research is required?
- In the absence of new technologies (e.g. inhibitors, vaccines), what is needed to meet the required reductions in on-farm greenhouse gas emissions?

The following is a high-level summary of the responses received.

Definition of future farm system research

A range of opinions were offered on this, with most concentrating on a definition of farm systems research, rather than the "future" aspect of this. A summarisation being:

> *Investigation as to how changes in the range of components that make up a farming business (biological, physical, environmental, social, and financial) interact together as a "system whole" to provide the outcomes sought by the landowner. This also combines the influence on the farm system via government regulation, market pressures, and societal acceptance.*

Many also felt that land use change and farm systems research were synonymous; that land use change was a natural component of farm systems research, in the sense that land use change was just another form of a farm system.

There was also some discussion on the use of modelling as a component of farm system research. Many saw modelling as a key component of farm system research, particularly as it is both quicker and cheaper, whereas others felt that modelling is not really farm systems research, but more of a means of demonstrating farm system change.

Gaps in farm system research

This question generated a lot of discussion, much of which was around agricultural research in general, component research, and agri-environmental research, rather than just farm systems research. A relatively long list of "gaps" was compiled (section 4.3), spanning a range of issues.

The extension of research results was also raised by many, who considered that there is a significant amount of "science" that could be/needs to be extended to/adopted by farmers, extension is seen as an integral component of research, and currently there is relatively limited extension being carried out.

Future (low carbon) farm system research required

This question also solicited a wide range of responses. Much of it discussed research at a wider/component level than necessarily relating to farm systems, and also touched on a range of water quality related research. The long list of suggestions is included in section 4.4.

There was some discussion as to the merits of "incremental" versus "quantum change" research (this point is also highlighted in the literature review, see section 3.4). The vast majority (~85%) of respondents felt that the NZAGRC needed to engage in both, in that incremental steps can add up to significant changes over time, and that incremental/component research can often directly indicate bigger changes. There was also a feeling that focussing on incremental change was key to achieving efficiency gains.

Others (15%) argued that incremental research is/would be adequately covered by industry and farmers themselves, and that the NZAGRC should concentrate on the quantum change-type research. They felt that incremental research in itself would not be sufficient for farmers to reach their reduction targets, and therefore the NZAGRC should concentrate on "big bang" research which may give much more significant returns. They also noted that such research was much riskier, and therefore there was a clear role for government funding.

There tended to be somewhat limited ideas as to what "quantum change" farms systems research would encompass, although examples were given such as:

(i) Achieving greenhouse gas reductions of 20-50%
(ii) The vaccine and inhibitor work
(iii) Land use change

There was also some discussion on the need to allow for genetic modification research, particularly on forages.

Recommendation on new investments
Much of the discussion here directly related back to the "gaps" identified in future farm system research. Again, a lot of the discussion was broader than just systems research, with funding of various component research also recommended (some probably outside of the NZAGRC remit). Another, relatively long, list (including extension) is detailed in section 4.4.3.

Achieving on-farm greenhouse gas reductions in the absence of a technological fix
Most felt that in this situation, many pastoral farmers would be forced to reduce stocking rates. Comments from interviewees as to the implications of this varied:

- Some felt that this would accelerate land use change;
- Some felt that there is significant opportunity to increase the efficiency of farms, with gains in reducing both nitrogen (N) leaching and greenhouse gas emissions;
- There would be a reduction in farm inputs – fertiliser, supplementary feed, which would reduce costs;
- Allied to this, some felt that a reduction in stocking rate would not necessarily be a bad thing; farms could achieve similar total production via efficiency gains; and
- There would be significant diversification, both on-farm and across the landscape, including greater level of arable cropping integrated into the farm system.

Others felt that there would need to be continued research into alternative forages, a need to concentrate on genetic gains, investigation of infrastructure on dairy farms (e.g. barns), and that there would be a lot of forestry planted.

Alternative views
Some of the respondents offered differing views, mostly relating to the current farming systems, and the need to consider "macro" changes in the way we farm, including moving up the value chain to achieve higher returns for specialty foods.

Much of this inferred that current commodity-driven systems are in decline, with the future based around specialty/high value-based production, e.g. organic, regenerative ag, and high value cropping (nutraceuticals, blood pressure regulation, health benefits, functional foods etc), alternative proteins, more horticulture, and indoor farming leveraging UV cropping. No specific research was suggested, apart from the inference that New Zealand needed to move towards these systems of farming.

Māori agribusiness
Māori agribusiness was not specifically targeted within this project, as it was included within the more generic definition of farm systems, and the literature review and interviews were not designed to pick up explicit insights or recommendations into Māori research in this area. There is, however, a need for consideration to be given to Māori agribusiness aspirations in the design of any future farm systems research programme, guided by the NZAGRC's Māori Advisory Group.

It should be noted that there has been a NZAGRC programme directly targeting Māori agribusiness over the last 6 years which initially concentrated on case-study farm modelling, investigating the impacts and implications of altering farm systems, coupled with land use change. This programme is continuing, morphing into more of an extension programme targeting Māori agribusiness.

Areas for discussion

Section 5 of this report outlines some areas for discussion for the NZAGRC regarding current and potential farm system research. While there was strong support for the NZAGRC being involved in farm system research, there was some divergence of views as to the degree it should fund "incremental/component" research versus "quantum change/big bang" research.

Similarly, while a range of research gaps were identified, many of the interviewees' suggestions of possible projects to fund were more component or land use change-focused, with very limited ideas of what would constitute a "quantum change" type project.

2.0 BACKGROUND AND APPROACH

Part of MPI and MBIE's current funding for the NZAGRC is for 'integrated solutions' or 'future farm systems' research. Over the previous 10 years, the emphasis has been on investigating the modification of existing farm systems to meet near-term greenhouse gas reduction targets. The NZAGRC is now exploring the potential for the research to be longer-term in its focus, considering what future low-environmental impact farm systems might look like and the pathways to achieve this.

As part of scoping and redeveloping a programme in this area, the NZAGRC initiated a 'stocktake' to understand what farm systems research is currently being undertaken within New Zealand (both in terms of near and longer-term systems), by whom, and to gain an insight as to what future farm systems research could/should look like and what role there might be for the NZAGRC.

This stocktake involved discussion with a range of people (refer Appendix 1) across various industries/organisations, covering five key questions:

(i) How would you define "future farm systems research"?

(ii) What farm systems research currently being carried out are you aware of - who is doing what, what is the aim of the project?

(iii) What are the gaps in the research as you see it? [which then leads onto:]

(iv) What future (low carbon) farm systems research is required?
  - Incremental or quantum[1] change, or both
  - What does incremental change look like?
  - What does quantum change look like?
  - Where would you recommend new investment should be focussed?

(v) In the absence of new technologies (e.g. inhibitors, vaccines), what would be needed to meet the required reductions in on-farm greenhouse gas emissions?

In the end a total of 56 people were interviewed, either face-to-face, on the phone or via video. Interviews lasted anything from 0.5-1.5 hours.

In addition, a literature review on recent publications around farm systems/future of farming research was carried out in conjunction with the interviews. The literature review focussed primarily on New Zealand publications, although some relevant international publications are also included.

This report presents the results of both the literature review (section 3) and the interviews (section 4) and is intended to provide input to the NZAGRC's wider process of scoping and redeveloping its future farm systems programme.

[1] "Quantum is defined here as "large" or "significant" change.

3.0 LITERATURE REVIEW

The literature review assessed recent publications on farm systems and land use change and the 'future of farming' in Aotearoa New Zealand (and relevant international literature).

For the purposes of the literature review, the following definitions were applied:

- **Farm system:** includes the biological, financial, environmental and social factors that determine how a farm is run (from the MPI website[2]);
- **Land use change:** a change from one specific use to another, rather than intensification within a similar system (Journeaux et al, 2017).

3.1 Aotearoa's changing landscapes

Humans have been dramatically altering Aotearoa New Zealand's landscapes since arriving here over 700 years ago (Parliamentary Commissioner for the Environment, 2018). These changes have been brought about over time by Māori agricultural development, the arrival of European settlers and the introduction of grassland pastures, the development of refrigeration technology and the introduction and then removal of Government subsidies, among other things.

In recent decades, the main driver of change in our rural landscapes has been free market forces, with the relative profitability of land use options being of paramount importance (Journeaux et al, 2017; Thorrold, 2010). This has led to, for example, large increases in land under forestry and viticulture, intensification of dairy farming and significant decreases in land under sheep farming.

About half Aotearoa's total land area is now used for agriculture and forestry (MfE & Stats NZ, 2021):

- 40% exotic grassland (unchanged since 2012, although regional changes have occurred)
- 8% exotic forestry
- 2% cropping and horticulture, including viticulture

The MfE & Stats NZ 2021 land report goes on to note:

- A decrease in total area of land used for agriculture and horticulture since 2002, falling by 2% between 2017 and 2019.
- A decrease in the number and size of farms since 2002, although export income from farming products increased in that time, suggesting that fewer farms are producing more on less land (MPI, 2012, 2015, 2020b).
- Dairy cattle numbers have more than doubled since the 1980s, rising from 3 million to almost 7 million in 2015, with more than 6 million in 2019.
- Use of irrigation, especially on land used for dairy farming, has nearly doubled since 2002. In 2019, 5% of agricultural land was irrigated, with dairy farming making up 58% of irrigated agricultural land.
- The area of land covered with native ecosystems continues to shrink, mainly through conversion to agriculture or forestry.

[2] https://www.mpi.govt.nz/agriculture/dairy-farming/farm-systems-change/

The way we use land affects everything – the soil, freshwater, the marine environment, and the climate. The increase in farming over the last two centuries, and in particular the intensification seen in the last two decades, has brought increases in negative environmental impacts. It is now widely recognised that New Zealand's growth model is approaching its biophysical limits (e.g. MacLeod and Moller, 2006; OECD 2017; New Zealand Productivity Commission, 2018; Parliamentary Commissioner for the Environment, 2019; MfE & Stats NZ (2019, 2021); DOC, 2020; Bardsley et al, 2020; Ministry for Primary Industries, 2020a).

3.2 The need for change

New Zealand is not alone in this situation. Humanity's mounting pressure on natural resources around the world, threatening the sustainability of food systems at large and placing global food security in jeopardy, is well recognised (e.g. UN General Assembly, 2015; FAO, 2017; Snapp & Pound, 2017; WRI, 2018).

In particular, agricultural production is both a cause of environmental impacts and stands to be significantly impacted, e.g. climate change, water quality and quantity, biodiversity and ecosystem services etc.

There is growing consensus, at all levels, that drastic action and transformational change is needed if we are to avoid tipping point and rebalance environmental, social, and economic outcomes. This is reflected in an ever broadening and deepening array of environmental agreements, legislation, regulation, and other policies from the global down to the local (New Zealand).

Global examples:

- 2015: United Nations (UN) adoption of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs)
    - Agriculture and food domains are central to many of the SDGs, including no poverty, zero hunger, good health and well-being, responsible consumption and production, climate action and life on land (Hall and Dijkman, 2019).
- 2016: United Nations Paris Agreement on Climate Change
- 2021 (anticipated): UN post-2020 global biodiversity framework

National examples:

- 2018: Essential Freshwater work plan introduced
- 2019: Climate change legislation amended to include 2050 targets for long-lived greenhouse gases (carbon dioxide) and biogenic methane
- 2020: Climate change legislation amended to improve the Emissions Trading Scheme and also to introduce He Waka Eke Noa timeframes
- 2020: National Environmental Standards for Freshwater and National Policy Statement for Freshwater Management
- 2020: Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy; and development of National Policy Statement for Indigenous Biodiversity
- 2020+: Resource Management Act reforms, including proposed National Policy Statement for Highly Productive Land
- 2021: Fit for a Better World – primary sector strategy jointly developed by Government and industry leaders

- 2022 (anticipated): He Waka Eke Noa deadline of 100% of farms to know their annual total on-farm greenhouse gas emissions
- 2025 (anticipated): He Waka Eke Noa deadline of 100% of farms to have a written plan to measure and manage emissions, and all farms participating in a pricing system

Regional/local examples:

- Implementation of Government environmental regulations, e.g. nitrogen caps, winter grazing requirements, farm environment plans, regional biodiversity strategies, discharge of contaminants
- Resource consents relating to intensification of farming, irrigation, land use change and other activities with environmental impact, e.g. effluent storage and disposal, burning and spraying, dumps and offal pits etc

Whereas free-market economics has most recently led agricultural land use change in Aotearoa (Journeaux et al, 2019), the ever-growing policy list outlined above suggests we can now expect it to be increasingly influenced by regulatory requirements.

But how well-placed are New Zealand farmers and growers to respond to this increasingly complex set of drivers? Can our farming systems transition towards true sustainability (Bayne and Renwick, 2021)? And what is the role for research and innovation in supporting the scale of change required?

3.3 Entrenched systems

Commentators argue that the level of transformation needed could be difficult to achieve within current agricultural production and innovation systems around the world, including in New Zealand.

Hall and Dijkman (2019) consider that much of the current global narrative on agriculture remains stuck in a 'productionist and technology-centric perspective, determined by linear and component change logics'. This contributes to agriculture being locked into only incremental change that is 'out of step' with transformational change.

In 2020, Koi Tū, the Centre for Informed Futures based at Auckland University, published a discussion paper on the future of food and the New Zealand primary sector. Its authors (Bardsley et al) observed that the traditional, "more extractive, economically oriented mindset of farming must make way for a focus on the long-term health of the land, animals and people", with a value placed on the environmental externalities associated with agricultural production.

They also stated that "business-as-usual, incremental approaches will not lead to the necessary transformation".

Both Hall and Dijkman and Bardsley et al concur that research and innovation have a critical role to play, but that current research systems – both internationally and in New Zealand – are not well-placed to support the level of change required.

Hall and Dijkman argue that the component technology and piecemeal innovation approach currently in place will be inadequate to ensure sustainability. They see a clear role for research but consider that new ways of thinking are required. Innovation should no longer be viewed as a 'predictable process with simple cause-effect relationships', and instead as a 'systemic, messy and long-term process'.

They push for 'system innovation' as distinct from 'innovation systems'. The former refers to the networks and institutional and policy conditions that enable the development and use of goods and services. In contrast, 'system innovation' refers to the reconfiguration and realignment of a diverse array of societal elements – social, political, technical, institutional and policy – for the realisation of societal outcomes such as sustainable and inclusive growth.

Bardsley et al describe New Zealand's research system as splintered and "driven by a series of mostly short-term projects, disconnected from each other".

Challenges with New Zealand's research system were also identified in a 2018 report by Davies et al (2018) for the Ministry for Business, Innovation and Employment (MBIE). This assessed the 'mega-trends likely to be paradigm-shifting for New Zealand land-based farm systems' and how well New Zealand's research and innovation systems were placed to respond. Its authors concluded that the capability of research organisations needed to be enhanced, 'shifting focus from primarily production maximisation to production under constraints'. They also considered that research needed to 'look beyond the farm', seeking to optimise agriculture at catchment and regional scales.

3.4 Current research

As noted in section 3.3, there is a critical role for research and innovation to support the transition to more sustainable farming systems that can meet not only the plethora of Government requirements but also changing consumer preferences and market demands. But there are inherent issues with New Zealand's current research system. To understand what might need to change, and what future research might be needed, we first need to understand what the current system is delivering – not only in terms of farm systems research, but also research to support land use change.

3.4.1 Farm systems research

According to Stevens et al (2016), farm systems research is a discipline that examines farming systems to understand the relationships between the elements of the system and the outcome as a whole. In their literature review of farm systems research (relating to hill country), they found its origins in the 1950s, increasing steadily through 1980s before tapering off in the 1990s and early 2000s. In this time, there has been a shift from farm systems and farm management research, working within the farm boundary to optimise biophysical parameters and maximise production, to *farming* systems research that encompasses the broader domain of influences beyond the farm gate, such as markets and social needs, and of environmental impacts.

The development and use of modelling within the research also picked up over the same timeframe, enabling insights into the impacts of farming on secondary outputs such as greenhouse gas emissions and nitrates. A recent example is DairyNZ's Pastoral 21 Next Generation Dairy Systems programme[3] (P21) and work by Bicknell et al (2015).

[3] https://www.dairynz.co.nz/about-us/research/pastoral-21/

In considering future farm systems work (in relation to hill country, but applicable to farming in New Zealand more broadly), Stevens et al noted that the development of farm systems research was driven by need – its purpose was to 'provide practical answers to the questions farmers were facing'. However, they advocate for a new, extension-oriented approach – one that combines physical on-farm and farmlet measurement linked with modelling tools and informed by trans-disciplinary partnerships between farmers, agribusiness, and science (noting that this was the approach adopted in DairyNZ's P21 programme). They acknowledge that this approach might 'lose some science precision but adds practical application and innovation'. Uptake of results by farmers may also be improved.

The NZAGRC, together with the Pastoral Greenhouse Gas Research Consortium (PGgRc), has supported farm systems work in the past that aligns with this approach. Three recent projects have addressed:

1. Drivers of reductions in emissions *intensity* (not absolute emissions) on sheep and beef farms (unpublished)
2. Assessing various greenhouse gas mitigation options for dairy systems, leveraging off DairyNZ's P21 programme (unpublished)
3. Case study modelling on both dairy and sheep & beef farms investigating the impact of altering farm systems and/or land use change (Journeaux & Kingi, 2017, 2019, 2020)

Broader searches for publications in farm systems research in New Zealand returned results primarily relating to dairy farming, with a focus on economics, environmental outputs and/or component research, see for example Romera et al (2017), Neal and Roche (2018) and Wanglin et al (2018).

3.4.2 Land use change research and research into future farming scenarios

A review of recent land use change literature in New Zealand found a growing body of (largely modelling-driven) research assessing different land uses in different parts of the country. Often this has been contracted to inform policy development, for example work by:

- Clothier et al (2017), report to NZAGRC
- Dorner et al (2018) for the Biological Emissions Reference Group
- Productivity Commission (2018)
- Parliamentary Commissioner for the Environment (2019)
- Motu (2019) for the Interim Climate Change Committee
- Climate Change Commission (2021)

Literature exploring possible future farming scenarios is limited. The Our Land and Water (OLW) National Science Challenge has produced some work of relevance, including on Next Generation Systems[4] and Land Use Suitability[5]. These focused on future farm systems and associated land use suitability, within given environmental limits. We note that neither directly address greenhouse gas emissions.

Bayne and Renwick's 2021 OLW-funded paper looked at alternative or 'niche' land use systems that could disrupt New Zealand's established farming regimes and thereby speed up the transition towards more sustainable production. They hypothesise that New Zealand's transition would require more diversified farming platforms at regional scale and tested nine

[4] https://ourlandandwater.nz/future-landscapes/next-generation-systems/
[5] https://ourlandandwater.nz/future-landscapes/land-use-suitability/

alternative configurations (e.g. land sharing, land sparing, intensified diversification, mixed farming, patchwork approach and industrial symbiosis). They identified a greater role for Government and research in helping 'de-risk' the process of land use change to support the transition to high value/low intensity systems.

Other OLW-funded papers on next generation systems focused on more specific, regional opportunities, for example:

- Holt et al (2019) looked at the case for novel agroforestry in Rotorua with three landowners considering integration of hazel/gevuina nuts into existing systems
- Renwick et al (2019) looked at factors important to land managers in Canterbury in determining whether or not to change their land use system when provided with an opportunity for transformative change (irrigation via the Central Plains Water Scheme)
- Leftfield Innovation (2020) again worked with Canterbury farmers to identify barriers to unlocking next generation systems and what research was required to help de-risk decision-making.

While such work is valuable, there remains significant hurdles to farmers achieving transformational change.

3.5 Research to support change

Alongside research into farm systems and land use change, is an established body of work on farmer decision-making and barriers to change that cannot be overlooked in the NZAGRC's contribution to transformative research.

In 2015, Small et al looked at adoption of good management practices aimed at increasing agricultural sustainability in New Zealand. They found that "while environmentally-oriented and production-oriented decision-makers are statistically more prepared to take risks, all rural decision-makers are more likely to adopt new technologies and good practices after seeing their relative advantages successfully demonstrated".

This was backed up in a 2018 report by Journeaux et al for the Biological Emissions Reference Group on social and behavioural barriers to adopting greenhouse gas mitigation practices. The authors found a wide range of interacting factors that drive farmer behaviour, which in turn inter-relates with the characteristics of the innovation or changed required, which then affects rate of uptake or adoption.

Greenhouse gas, and other environmental, mitigations can involve complex farm management changes. The authors give the example of a mitigation being to reduce stock numbers and increase per animal performance (with the same amount of feed eaten), which for many farmers would represent a significant change in their farming system. This would require provision of sufficient information and advice, for example in terms of the degree of de-stocking required, grazing management considerations and other changes in farm management (e.g. calving dates, replacement rates etc), as well as the impact on profitability.

The authors found a general lack of information helping farmers understand how a given mitigation (or set of technologies/practices) fits within a farm system and impact it as a whole. They identified challenges with the means of communicating with farmers around environmental issues, in particular those further down the adoption bell curve, and/or where adoption of the mitigation or technology being promoted is complex.

In 2019, Journeaux led a different group of authors to complete an analysis for MPI of drivers and barriers to land use change in New Zealand. They concluded that land use and land use change is complex, ‘strongly driven by economics and a wide range of other factors that are often interlinked.’ In addition to economic, biophysical and regulatory factors, the authors identified available infrastructure, marketing capability, access to information and advice, and personal factors (such as age, experience, family circumstances, appetite for risk), and societal acceptance factors as interlinking issues that affect land use and land use change.

Any NZAGRC-funded work on future farm systems could usefully contribute to addressing these barriers by testing and demonstrating the adoption of multiple component greenhouse gas mitigations and technologies in different whole farm systems. This should extend to assessing the flow-on impacts on other outcomes, e.g. environmental (e.g. freshwater, biodiversity), social etc.

As highlighted in the survey section that follows, there was strong support both for a multidisciplinary approach for any research carried out, and for the extension of research results to landowners, highlighting the need for NZAGRC to work in with industry and farmers in both areas.

4.0 INTERVIEW RESULTS

This section is divided into the different interview questions asked.

4.1 How would you define “future farm systems research”?

There were a range of definitions given in response to this question, but most could be summarised as:

The investigation as to how changes in the range of components that make up a farming business; biological, physical, environmental, social, and financial, interact together as a “system whole” to provide the outcomes sought by the landowner. This also combines the influence on the farm system via government regulation, market pressures, and societal acceptance.

Within this definition, several respondents noted that many people define farms systems with an emphasis on the biological/biophysical aspects, without necessarily including the economic and/or social aspects.

Others noted that farm system research should lead to the optimisation of a new intervention within the system, and any benefits thereof.

Variations on the above definition and general comments around farm system research were:

- How outputs from the farm system adapt/change in response to changes in the wider environment
- About ensuring an efficient farm system as the result of integrating all the components necessary to drive the system
- Involves integration of multifactorial processes, and therefore requires a range of science disciplines
- Is not just about the physical or economic outputs, but must also include analysis of impacts on natural capital (i.e. ecosystem services)
- How component research fits together within a farm system
- How a farmer chooses to use their resources (e.g. land, livestock, labour) to achieve desired outcomes

It is important to note that none of the respondents endeavoured to define “future” farm system research. Rather, they endeavoured to define farm system research in a general sense, with the inference that this would directly apply to any future such research.

Respondents were asked where they saw land use change fitting within the context of farm system research. There were three main types of responses:

(i) Farm system research and land use change are synonymous (each are a sub-set of the other), or

(ii) Farm system research often leads to land use change, or

(iii) Land use is the key driver of the resultant farm system; essentially the farm system is determined by the land use. For example, assume a parcel of land is operated as a dairy farm, then obviously the farm system will be pastoral orientated. If that parcel of land is changed into (say) kiwifruit production, then obviously the farm system will be horticulturally orientated.

In many respects, the majority of views were based around (i) above; that land use change was a natural component of farm systems research, in the sense that land use change was just another form of a farm system.

The use of modelling to analyse farm systems was also discussed, with some varying views:

- Modelling is not really farm systems research, as it is mainly for testing components within a farm system;
- Modelling is very much based on known science, and therefore its key weakness is in capturing "unknowns";
- Modelling is a key component of farm systems research, as it can much more quickly (and cheaply) assimilate a variety of component changes to give an indication of the impact at a whole system level, and from there readily identify gaps requiring further analysis.
- The weakness of modelling is that it is usually based on "the average" and it is therefore difficult to establish a distribution, or extremes. Traditionally, most farm systems research was based around field trials on actual farms, over several years, which allowed for an appreciation of the variability that can arise (e.g. from climatic variation), which is very difficult to simulate using models.
- Models are very useful in demonstrating the impact of changing various components within a system – in this respect they are demonstrations, not research.
- The danger with using models is that the models, and modellers, can become disengaged from reality, and therefore need to be exposed to the real world on a regular basis.
- Farmers are reluctant to make changes based on the output of a model alone. Modelling should be used to "test" a number of farm systems to determine those which are most likely to generate positive outcomes. These should then be tested in a real-life farming scenario.

There was also some comment that NZAGRC should develop a systems framework to guide all research. This is an approach to understanding the nonlinear behaviour of complex systems over time using stocks, flows, internal feedback loops, table functions and time delays (Forrester, 2009), and aligns with the comments by Hall and Dijkamn (2019) noted in the literature review.

Systems thinking provides skills such as the ability to view issues holistically, and the insight to see non-obvious connections between things while understanding why they behave a certain way. In this respect, while component research is an important aspect of any research programme, a systems approach means that there is an appreciation as to how it might/will fit within the system under consideration, even that the systems thinking identified the issue in the first place.

4.2 What farm systems research currently being carried out are you aware of?

This question elicited a range of replies:

- Don't know (7%), to
- Not sure there is much happening (12%), to
- I know/think that (say) AgResearch and DairyNZ are carrying out some work, or should be (17%), to

- A short list of some work they were aware of (57%), to
- A detailed list of work either being carried out by the organisation and/or funded by them (7%).

In other words, there was limited understanding of the research being carried out across the wider respondent list. A number of respondents also included what is largely component research rather than farm systems research. A summary of projects mentioned by respondents is outlined below, noting that this is not necessarily an exhaustive list of work currently underway or about to be commissioned.

Table 1: Farm systems or related research mentioned by respondents

Organisation	Research topic
AgMardt	How to incorporate Mootels into a dairy system
Lincoln University Dairy Farm	High producing dairy farms within a nitrogen leaching restriction
Lincoln University	Centre of Excellence – Future Productive Landscapes
Northland Agricultural Research Farm	Farmlet trials on low GHG systems
Southland Dairy Hub	Low environmental impact dairy systems
NIWA	Impact of irrigation on farm systems
DairyNZ	Evaluating reduced milking practices
	Evaluation of new ryegrass cultivars
	Putting plantain into the farm system
	Farmer attitude to bobby calves - cross sector - impact on the farm business
	Pastures21 (now finished) - reducing the environmental impact of dairy farming
	Reducing N inputs (190kg)
AgResearch	Forages for low nitrate leaching
	Farmer decision making
	Modelling farm systems to mitigate/offset GHG emissions
Our Land and Water	Wide range of work around environmental mitigations and land use change
Manaaki Whenua Landcare Research	Soil carbon measurement and monitoring
Massey University	Intensive winter grazing
	Impacts of weather variability on farm systems
	Simulation model of sheep and beef hill country
	Differing pasture growth on different land classes - environmental implications
Abacus Bio	Economics of genetic gain, implications for farm systems
LIC	Sexed semen - selective breeding
	Low methane genetics
Beef + Lamb NZ	Hill Country Future farm - native plants/legumes for grazing
	Sheep Genetics
NZAGRC	Modelling farm systems to mitigate/offset GHG emissions
	Methane vaccine/inhibitors/animal genetics
Deer NZ	PGP programme - peer to peer learning groups
	Deer management to mitigate water quality impacts
MPI	See accompanying spreadsheet file – covering SLMACC and SFFF projects

Comments from the non-pastoral sectors indicated very limited "systems" research currently being done, although they expressed a desire to be involved in pastoral system research as often there is an overlap. One commentator noted that "we (the horticultural sector) don't have a GHG issue, as comparatively our GHG emissions are very low, and we're seen as the solution rather than the problem".

4.3 What are the gaps in the research as you see them?

This again elicited a wide range of responses, as summarised over the page. Note that some attempt has been made to group these, although the gaps/issues raised by interviewees were wide-ranging.

Table 2: Research gaps and issues

1	Significant complexity in research farm systems, and closely aligned with farm management skills. Universities/research organisations losing farm management skills because of the long timeframe and cost of such research - not very popular in the current "publish or perish" environment
2	Farm system research takes time, usually at least 3-5 years. Quoted McMeekan - more important to do it (FSR) temporally rather than spatially
3	Lack of long term farmlet/farm system research - most is short-term modelling
4	Need very applied research to demonstrate system to farmers, to get them to adopt.
5	Need research as to how we can get faster uptake of new technology
6	Lack of people capability in system research
7	Lack of human resource research - how do we optimise labour input into our farming systems
8	(Relative to land use change) Availability of infrastructure, personnel, track record of the region in question, capability/capacity of people to change.
9	Shortage of systems people with applied agricultural/farming knowledge
10	Best modellers are international - we have a shortage of modellers that understand NZ farming
11	Lack of research around "stacking" mitigations - how well does this work
12	Integration of component research into a systems "whole"
13	Collation of sufficient data to show long-term gain - convince farmers it works
14	What are the long-term efficiency gains we can get from our pastoral systems - what are the gains we need to get
15	Given the multifactorial aspect of farm system research, need to ensure that 1 mitigation does not have unintended consequences elsewhere. [Hort e.g: band placement of N fertiliser may reduce N_2O, but increased tractor running may increase CO_2 emissions]
16	How changes in one sector may affect another - e.g. reduction in livestock numbers has implications for cropping farmers
17	Assessment of sequestration options (above/below ground) and how this could affect farm systems
18	Integration of forestry systems within pastoral farms
19	Regionalisation of farm system research is messy - often farmers need to see localised research
20	Insufficient economic analysis in much farm system research, particularly around understanding production functions and marginal cost relative to marginal revenue
21	Need for more adaptable forage species, i.e. post ryegrass. E.g. use of annuals that are more adaptable- how would these fit within a farm system
22	Need for lifecycle analysis so we understand emissions across the whole system
23	Current mitigation research largely based on ensuring existing systems remain - need to look further out a differing systems/diversification options
24	Investigation of hill country N_2O emissions - using differential grazing to minimise
25	Aspects of the value chain - ability to reward/incentivise positive change
26	Ability of farm system to reduce environmental impact while maintaining profitability
27	Understanding the impact of climate variability on existing/new systems - lack of adaptive research

Table 2 continued

28	Have capacity gap to do large scale trials
29	Evaluation of ecosystem services and how they are impacted by different farm systems
30	Lack of macro-level analysis as to the impact/implications for NZ Inc
31	"Best use of land" via integration of water and GHG constraints
32	The need to demonstrate an improvement in feed efficiency - ability to get more from the same DM
33	Lack of good farm data at a farm level, outside of dairying & sheep & beef. Esepcially long-term data
34	Understanding the links between climate and trade
35	Need to investigate low-input systems, e.g. regen agriculture
36	Need to assess the beef herd for low methane animals
37	How to integrate actions by collectives/catchment groups/multiple farms - "best" result across a larger geographic area
38	Plant genetics - higher ME/lower protien levels
39	Continuing to refine the estimate of N2O emissions form dung and urine
40	Integration of "silo-ised" work, e.g. GHGs, water quality, soil health - need to pull these together as they interact with each other
41	Lack of macro-level analysis as to the impact/implications for NZ Inc
42	"Best use of land" via integration of water and GHG constraints

4.3.1 Extension

As part of the question on research gaps, many respondents raised the issue of extension:

- It was felt that for a number of the mitigations modelled in various studies, i.e. reducing stocking rate/improving productivity, general improvement in the efficiency of the farm system, reducing nitrogen fertiliser/supplementary feed inputs, land use change, there is sufficient "science" already – the main need is to extend this to farmers and assist them in making changes.
- Overall, the degree of "extension" is currently relatively small – essentially some of the industry good bodies, plus the relatively small proportion of farmers using consultants.
- The need to demonstrate mitigations etc to farmers (e.g. monitor or demonstration farms, farmlet trials) – they like to see/hear/touch things, so a direct demonstration of how a mitigation works is usually much more effective than just modelling.
- Many saw research and extension as part of the same continuum.
- Adoption of new farm systems/mitigations can take a long time – a lot of advice on improving farm system efficiency is based on research from the 1960's-1980's. Biological systems take time to change, and therefore it takes time for benefits to manifest.
- Co-development of solutions (by multi-discipline groups, including and especially farmers) directly aids extension efforts. Often this is a missing component of research.
- Need to decide on who the research is trying to inform. Often the automatic thought is that it is landowners, but policy makers just as important.

4.3.2 Adaptive capacity

A comment provided by one of the respondents, relating to the need for both integrated and adaptive research:

Going forward a key focus for our farmers is 'adaptive capacity' – being able to identify changes in the environment and develop strategies and tactics to cope with these (climate change, water regulations, animal health, biodiversity, pandemics, input and output price volatility etc.). Any future farm systems research has to help farmers in this area and result in effective on-farm practice change. As such, we need a systemic research approach that combines hard and soft systems modelling, the involvement of multiple stakeholders (farmers, policy makers, researchers, extension personnel, rural professionals etc. etc.), knowledge about farmer learning and practice change, the role of institutions in innovation, case studies and the integration of knowledge across a wide range of disciplines. At the moment this appears to be happening in a piecemeal approach with little coordination or cooperation across the actors.

4.4 What future (low carbon) farm systems research is required?

This again solicited a wide range of responses, with much of it discussing research at a wider/component level rather than necessarily relating to farm systems. There was also some confusion about research which impacted GHG with some of the respondents referring to research which impacted water quality parameters like sediment. Responses are loosely grouped in table 3.

Table 3: Desired future research

1	More work around N_2O - GWP_{100} captures all of methane, but less than half of N_2O. There is a need to look at N_2O in a systems/field context - what is the relationship between N leaching and N_2O. Technology to reduce N_2O much easier than for CH_4. [Several mentions on increasing N_2O research]
2	Analysis of nitrous oxide from dairy Mootels - very low ammonia output, so probably low nitrous oxide
3	Better understanding of the relationship between N fertiliser applied versus nitrous oxide out (Hort)
4	Comparisons of farm systems - demonstrate that lower stocking rate/lower fixed inputs work. Farmers need confidence this system works.
5	More research into reducing N fertiliser input relative to yield (Arable)
6	What are the opportunities for different land uses [several mentions]
7	Providing transition pathways to new land uses - can't mitigate our way out, so some land use change is inevitable
8	More Lifecycle Analysis to help identify "hotspots"
9	Better understanding of the nitrogen cycle - identify inefficiencies in on-farm use, which often result in negative marginal returns, excessive N leaching.
10	How do you decouple DM consumption from methane production
11	Use of trees for fodder - e.g. grow poplars/willows, coppice every 2-3 years.
12	Quantification of carbon sequestration by woody vegetation/wide-spaced trees - how this can be incorporated into a farm carbon balance
13	Better understanding of forestry economics - carbon farming/production forestry
14	Research into the biological resilience of the soil/pasture interface - soil microbes very important in determining soil carbon gain/loss
15	Understanding of farmer demographics. Likely to see significant change in ownership over next 10-20 years. Are older farmers more resistant to change - has implications for extension.
16	Better models - able to handle variability, and quantify trade-offs between production/profitability/environment

Table 3 continued

17	Need work on water policy - if we want significant land use change into horticulture, most will require water for irrigation. Need much more water storage.
18	More research on integrated systems/landscapes - combination of more diversification on-farm, &/or across the landscape. [Several mentions]
19	More research to feed into Overseer to improve its accuracy across a range of systems
20	Valuation of ecosystem services and how that could fit within the farms' environmental footprint
21	Continuation of the alternative forage research, particularly high tannin feeds
22	Improving soil health to increase its water holding capacity (climate change and drought), carbon (if needed) and nutrient profile to support forages (improved root structure, persistence etc)
23	What is the impact of chemicals such as glyphosate, nitrogen and phosphorous, vet meds on the key soil microbes that contribute to the carbon cycle? How do these chemicals impact the rumen microbiome and methane production?
24	Better more practical means of assessing/selecting low methane animals
25	The need for integrated modelling tools (e.g. Farmax, Overseer, Forecaster) - development of API's so can use the models much more efficiently
26	Systems analysis of all component mitigation research - how cumulative are they
27	Continuation of the alternative forage research, particularly high tannin feeds
28	Improving soil health to increase its water holding capacity (climate change and drought), carbon (if needed) and nutrient profile to support forages (improved root structure, persistence etc)

4.4.1 Incremental research versus quantum change

Respondents were asked their views on whether the NZAGRC should concentrate on either incremental and/or quantum change-type research.

The majority (~85%) suggested that the NZAGRC should be involved in both, in that incremental steps can add up to significant changes over time, and that incremental/component research can often directly indicate bigger changes. There was also a feeling that focussing on incremental change was key to achieving efficiency gains.

Most defined "incremental" in similar ways, as a GHG emission reduction of:

- 1% per year
- As indicated by the modelling work, i.e. 5-10%
- As indicated by the forages work
- As potentially achievable via genetic selection

Whereas "quantum change" was defined as:

- Achieving reductions of 20-50%
- Potentially achievable via the vaccine and inhibitor work
- Land use change

It is important to note that the respondents volunteered no examples of what they thought a "quantum change" research project would look like, other than the current vaccine/inhibitor research.

A number of respondents (~15%) argued that the NZAGRC should not be involved in "incremental" research, as they felt that industry, and farmers themselves, would readily cover much of this. They felt that incremental research in itself would not be sufficient for farmers to reach their reduction targets, and therefore the NZAGRC should concentrate on "big bang" research which may give much more significant returns. They also noted that such research was much riskier, and therefore was essentially a role for government funding.

4.4.1.1 Genetic Modification

Several respondents (10%) mentioned the need to do GM-related research, which they put in the "quantum change" category. This was especially so regarding forage research, e.g. breeding higher lipid content forages. Having done this, research is also needed as to how these forages would fit into, and impact on, the farm system.

While noting the political aspect of such (GM) research, they also noted the high probability of other countries doing this work, introducing the forages into their own farming systems, thereby giving them a competitive edge.

4.4.2 Extension

As discussed in section 4.3.1, extension of research also came up again in relation to the question on "desired research". This presented as a combination of the need for an extensive extension programme to help farmers change, and within this the need for demonstration/farmlet trials, as well as calls for further research into how farmers can be assisted to make changes.

There was also mention that quantum research would only have quantum benefits if it was successfully and rapidly adopted by farmers.

4.4.3 Recommendations of the focus for new investment

Much of the discussion here linked back to the responses on the perceived gaps in future farm system research (see section 4.3). Again, a lot of the discussion was at a wider level than just systems research. Funding of various component research was recommended, some of which might be outside of the NZAGRC's remit.

Some respondents also suggested some splits in the funding, e.g.:

- Portfolio approach: 30% incremental, 30% blue sky, 40% transition from incremental to quantum
- 50:50 split between incremental and quantum research

Table 4: Suggestions on new research investment

1	More research on land use change - options and issues. What are the regulatory issues
2	More case studies to emphasise opportunities - both for farm system change and land use change
3	Diversification - how to better integrate arable crops and livestock more effectively, and reduce reliance on monocultures
4	Modelling of mixed landscapes across catchments - impacts/implications
5	Further research into N_2O in S&B farm systems - develop different emission factors for hill country
6	Continue to investigate on-farm impact of changing a range of variables; stocking rate, feed input, production levels etc
7	Sensitivity of farm systems around deintensification/increased efficiency
8	Options for farmers - what are the consequences of reducing DM eaten - reduce inputs? Take land out of pastoral production?

Table 4 continued

9	Investigate transition pathways - how do we get from high carbon to low carbon. Particularly transition to new land uses - can't mitigate our way out of the present situation. What are the socio-economic implications.
10	How different forages, e.g. plantain, forage rape, fit into farm systems
11	If significant areas are planted in trees, what are the biosecurity risks, what are the fire risks
12	Impact on N_2O emissions of dairy farms if Mootels are incorporated into the system
13	Impact on world dairy prices if NZ reduces production
14	Adaptation research - as the climate changes, farmers will need to adapt. Do scenario analyses based on climate change scenarios
15	Analysis on the efficiency of nitrogen fertiliser use, across all sectors. Generally low on pastoral farms
16	Analysis of emissions between farms - what are the low emitters doing?
17	Investigate synthetic proteins - options, risks, potential
18	Delivery systems for inhibitors - how do we deliver these in a pastoral-based system
19	Better understanding of the biome of the rumen, and the biome of the soil
20	Survey of what work has been done to date - identify what areas need continuance, expansion
21	If horticulture is seen as a solution - need to model labour demand and supply, particularly at a regional level
22	Analysis as to the impact/implications at a national level, particularly socio-economic.
23	How to price in ecosystem services - include these in any analyses
24	Analysis of beef genetics - low methane beef animals
25	Modelling of farm systems whereby boner cows from the dairy industry are finished on beef farms
26	Means to motivate farmers across different farms/farmtypes to work together, share information, understand options
27	Update the LUCAS database
28	Run trials where component research is pulled together into a farm system
29	GM/gene editing for forages
30	Lifecycle analysis such that carbon losses across the whole value chain can be identified and addressed
31	Extension was mentioned by many - some information already available, need to start farmers on the journey. Plus need to demonstrate how to change

4.5 Achieving on-farm reductions in the absence of a technological "fix"

Again, there were a range of views on this:

- Many felt that in the absence of new technologies, many pastoral farmers would be forced to reduce stocking rates. Comment as to the implications of this varied:
  - Some felt that this would accelerate land use change;
  - Some felt that there is significant opportunity to increase the efficiency of farms, with gains in reducing both N leaching and GHG emissions;
  - There would be a reduction in farm inputs – fertiliser, supplementary feed, which would reduce costs;
  - Allied to this, some felt that a reduction in stocking rate would not necessarily be a bad thing; could achieve similar total production via efficiency gains – (quote of the day): *If the average (dairy) farmer got rid of the bottom 20% of their stock, its very likely that the remaining 80%, being fully fed for the first time in their lives, would produce much the same in total;*

    - There would be significant diversification, both on-farm and across the landscape, including greater level of arable cropping integrated into the farm system;
    - There would be a significant increase in forestry;
    - Will drive land values to the next best alternative land use.
- There would be a need to continue research on alternative forages.
- There would be a need to look at infrastructure on dairy farms, e.g. barns – trade-off with intensification, effluent management
- Would need to concentrate on genetic gains.
- Need to understand the implications of offsetting; the economics of this, and the permanency (or otherwise) of the option.

4.6 Alternative views

There were some alternative views expressed, mostly relating to the current farming systems, and the need to consider "macro" changes in the way we farm, including moving up the value chain to achieve higher returns for specialty foods. Comments included:

- It depends on what the future farm is. When I look at the future farm it might not have anything to do with animals – there may be regenerative organic food production that serves small group of consumers that want high value animal protein.

  So the future farm of New Zealand could be; small portion of dairy (powder as a commodity obsolete), high value beef and lamb, forestry, high value cropping (nutraceuticals, blood pressure regulation, health benefits, functional foods etc), alternative proteins, more horticulture, indoor farming leveraging UV cropping.

- There is no common vision that is well understood and how new food systems will be supported and will rise through the sector as the primary sector declines.

- What is our story? e.g. we are a health and wellness provider via food. We don't have a high value vision to which we can all strive for. If we had an overarching vision of the future and the value to the world that went beyond a particular animal protein or crop, we could quickly and collaboratively move up that value chain.

- We need to transition away from commodity agriculture before those sectors become obsolete.

- How much research is going into traditional farm systems components (mastitis, clover etc) vs research to new future foods and agriculture. Our research needs to focus towards the future rather than trying to optimise the current systems. New Zealand is good at research, but not so good at turning it into high value offerings on the farm.

- No GE is limiting people who are working in this space of alternative protein.

- We are trying to answer the wrong question. There will come a time when animal agriculture will not be competitive and cost to operate will be so expensive. It will make this research redundant. E.g. reducing antibiotic use in cows isn't important if milk production shrinks and people use alternative protein sources.

- If we want to be in a commodity market producing at volume with a static number of livestock, we will use vaccines and methane inhibitors and target the lower end of the market (e.g. China). This will work until someone else can produce at the bottom end of the market more cheaply (another country with a lower cost production system or a synthetic alternative).

- If we use vaccines and feed inhibitors it will seal our fate and position in the commodity market because the high-end consumers don't want that kind of stuff.
- The alternative is to create production systems that can create value for higher-end environmentally focused consumers who are focused on food quality but also the "story" around their food (animal welfare, low environmental impact, etc).

- Need to ask how can we farm whilst protecting the planet? We need to turn the question inside out. How do we support our farmers to create really profitable businesses which are carbon negative?

- Recommendation for new investment: Common vision for what new farming would look like

5.0 SUMMARY FOR DISCUSSION

To assist the NZAGRC in its discussions regarding any future farm systems research programme, the following summary of key points has been compiled based on the literature review and interview responses:

- The literature review acknowledged the need for radical transformation in the agriculture sector if it is to meet the increasingly stringent environmental standards imposed by all levels of Government. It identified a critical role for research and innovation and extension to support farmers to transition to sustainability.

- The literature review also found that the current research system is splintered/fragmented and locked in to supporting current production systems and growth models, and that there are gaps in the farm systems (mostly component/incremental) and land use change research being carried out, and significant gaps in the extension of research to farmers.

- The stocktake identified a number of gaps in farm system research in New Zealand, particularly that focused on climate change/environmental issues.

- There was strong support for the NZAGRC to operate in this space.

- The suggestions made during the interviews remained focused on "near to market" mitigation options and/or ongoing component research aimed at tweaking existing systems, plus extension of that type of work.

- The majority (~85%) favoured research on both "incremental" and "quantum/big bang" farm system research, whereas a minority (~15%) suggested the NZAGRC concentrate solely on "quantum" farm system research.

- There were no real suggestions as to what this "quantum" research would be.

- There was a need for catchment/regional scale work as well as farm-level e.g. future solutions may be more easily implemented at scale.

- There was a need for a multidisciplinary approach across institutions and disciplines and involving farmers.

- Concerns were raised in the "alternative views" section around:
    - The need to transition away from commodity agriculture;
    - Risks around reliance on vaccine/inhibitors shutting us out of markets that don't want products produced with this type of intervention (this was also identified in PGgRG workshops).

- While extension of research was raised regularly, the issue is the degree to which NZAGRC gets involved in extension programmes, outside of its current delivery of rural professionals training and development of resources for farmers (e.g. Ag Matters, videos etc). The question of extension in this area is being discussed as part of the He Waka Eke Noa programme, and within MPI's Primary Industry Advisory Services directorate and it is not necessarily the NZAGRC's responsibility to lead investment/work in this area at this time.

- Expansion/outreach of the current Māori agribusiness programme was not directly addressed by interviewees but requires attention.

APPENDIX 1: INTERVIEWEES

Universities

Massey:

- Nicola Shadbolt: Professor of Farm and Agribusiness Management, Climate Change Commissioner
- David Gray: Senior Lecturer in Farm Management
- Dr Simone Pieralli: Senior Lecturer in Farm Management
- Peter Tozer: Associate Professor in Farm Management
- Dr Thiagarajah Ramilan: Senior Lecturer in Agribusiness

Lincoln:

- Alison Bailey: Professor of Farm Management

Industry Good Bodies

FAR:

- Alison Stewart: Chief Executive
- Andrew Pitman: General Manager – Research, Development and Extension

DairyNZ:[6]

- Dave McCall: General Manager, New Systems and Competitiveness

Beef + Lamb NZ:

- Dan Brier: General Manager, Farming Excellence and General Manager, B+L Genetics
- Comments from Suzi Keeling, Sector Science Strategy Manager

Horticulture NZ:

- Ailsa Robertson: Sustainability and Extension Manager

Deer NZ

- Tony Pearse, Producer Manager
- Lindsay Fung, Environmental Stewardship Manager

CRIs

AgResearch:

- Robyn Dynes: Science Impact Leader, Farm Systems & Environment

Our Land and Water:

- Richard McDowell: Chief Scientist

Goverment[7]

MPI:

- John Roche: Chief Science Advisor
- Neil Williams, Manager SFF Futures Fund
- Fiona McLachlan, Senior Investment Advisor

- Jaimie-Leigh Jonker, Senior Investment Advisor
- Gerald Rys: Principal Science Advisor
- Darran Austin, Principal Advisor – Land, Water, and Climate Policy
- Doug Macredie, (ex B+LNZ, now Principal Adviser Māori at Te Uru Rakau)

MBIE:

- Colin Reid: Principal Investment Manager, Strategic Investments
- Neil Dalphin: Investment Manager

Productivity Commission:

- Geoff Lewis: Inquiry Director

Fertiliser

- Ravensdown:
  - Mike Manning, General Manager – Innovation and Strategy
  - Ants Roberts, Chief Scientist
- Ballance
  - Warwick Catto, Science Strategy Manager
- Fertiliser Association:
  - Vera Power, Chief Executive

Industry

- Fonterra:
  - Andrew Millar, Technical Manager for on-farm R&D
  - Comments from Jeremy Hill, Chief Science & Technology Officer
- Pamu:
  - Warren Parker, Chair
  - Lisa Martin, General Manager - Sustainability and Farm Systems
  - Mark Julian, General Manager – Dairy Operations
  - Steve Tickner, General Manager Livestock Operations
  - Paul McGill, Senior Business Manager
- Federated Farmers:
  - Gavin Forrest, Policy Manager
- Zespri:
  - Greg Clark, Technologies Innovation Leader
- Water Strategies:
  - Andrew Curtis, Principal - Policy projects
  - Laura Bunnings, Farm System Consultant

Individuals [8]

- Andy McFarlane, Associate, Macfarlane Rural Business, Director ANZCO, Fonterra
- Jeremy Savage: Director, Macfarlane Rural Business
- Chris Lewis: Director, BakerAg
- James Allen: Managing Director AgFirst
- Tanira Kingi: Senior Scientist, Scion

- Keith Woodford: independent consultant and primary sector commentator, honorary positions as Professor of Agri-Food Systems at Lincoln University and Senior Research Fellow at the Contemporary China Research Centre at Victoria University
- Lee Matheson: Managing Director PerrinAg
- Melissa Clark-Reynolds: Atkins Ranch/Director B+LNZ
- Rosie Bosworth: Future Food Expert
- Sandy Scarrow: Director Fruition Horticulture
- Leander Archer, Horticultural Consultant, AgFirst
- Stuart Ford: Director Agribusiness Group
- Greg Lambert: ex Hill Country systems scientist
- Dave Clark: ex Dairy systems scientist
- Gavin Sheath: ex Hill Country systems scientist

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