SYNTHESIS REPORT: BARRIERS TO ADOPTION OF NO-COST AGRICULTURAL MITIGATION PRACTICES

Motu Note #36 - May 2019
D Fleming, P Brown, S Cortés-Acosta, C de Klein, R Dynes, L Henry, S Kerr, J Knook and B Small

Motu Economic and Public Policy Research
david.fleming@csiro.au, brownp@landcareresearch.co.nz, sandra.cortes-acosta@vuw.ac.nz, cecile.deklein@agresearch.co.nz, robyn.dynes@agresearch.co.nz, loic.henry@inra.fr, skerr@edf.org, jorie.knook@sruc.ac.uk, bruce.small@agresearch.co.nz

SUMMARY HAIKU

Combine better cows
and low stocking to reduce
costs and emissions.

OVERVIEW

For New Zealand to transition to a low-emissions economy, pastoral farmers need to reduce the biological greenhouse gas (GHG) emissions that come from their operations. One way to achieve this is by adopting or expanding the use of practices and/or options that could mitigate biological GHG emissions in dairy and sheep and beef systems. This project focuses on identifying barriers that can curtail farmers' adoption or expansion of these mitigation practices.

One obvious reason not to adopt a practice is financial cost – if a practice reduces farm profits, a farmer will have a low incentive to apply it. However, if a farm practice could be defined as "no-cost" (i.e. one that could lead to both higher, or similar, farm profits and a reduction of GHG emissions), then the cost barrier to adoption would not apply. But which farm practices can be considered no-cost? Is there evidence for this? Are farmers facing barriers to the adoption of these no-cost practices? To address these questions, the project established three general objectives:

- develop a typology of possible reasons (barriers) why under-adoption of no-cost mitigation options occurs;
- test and verify the no-cost status of selected mitigation options; and
- through interviews and a survey with farmers, explore if no-cost options exist, what the barriers are to adoption, and how these could be addressed.

To address these objectives, different research methods and analyses were conducted, which resulted in a range of findings described and discussed in six different papers/reports. This report summarises the main points and findings described in these papers and presents the key messages and policy implications derived from this work. It also includes findings from a final multi-stakeholder symposium, held in March 2019, to discuss the policy implications of the project and to define its final, most important takeaway messages.

A TYPOLOGY OF BARRIERS TO NO-COST ADOPTION

As an initial step in this project, Jaffe (2017) developed a typology of barriers to adoption of potential no-cost agricultural greenhouse gas (GHG) emissions mitigation practices/options. This typology provides a framework for assessing the existence and significance of each barrier.

> *A no-cost option is defined as a set of investments, technologies, or practices that can be applied to reduce the GHG emission footprint of farming without decreasing the profitability of the operation (conventionally defined as financial profitability).*
>
> *Barriers are defined as any factor that might explain why farmers might eschew a no-cost option.*

This report is a synthesis of results from the "Barriers to Adoption of 'No-cost' Mitigation Options" project, funded by the New Zealand Government to support the objectives of the Livestock Research Group of the Global Research Alliance on Agricultural Greenhouse Gases, and executed by Motu with assistance from AgResearch and Landcare Research. We thank farmers who participated in the interviews and survey conducted as part of this project and stakeholders who participated in the final project workshop.

Jaffe (2017) identifies several distinct barriers, which can be categorised in seven groups: “Arguably efficient”, “Information”, “Market structure and institutions”, “Regulation and policy”, “Risk and uncertainty”, “Externalities”, and “Behavioural factors”.

The first category, “Arguably efficient”, includes barriers that reflect cases in which farmers perceive that the financial costs of adopting or expanding a given practice outweigh the benefits, even though analysts describe the practice as no cost. This perception can be a product of two effects: formal financial profitability tests fail to measure the economic impact of the practice on the farmer correctly; and/or the farmer might incorrectly perceive a net financial cost to a practice when in reality it would be profitable to apply/expand it. The barriers in the “Arguably efficient” category thus straddle both financial and non-financial aspects as they stem either from unconsidered or mismeasured financial costs or overstated benefits in modelling scenarios, or from incorrect perceptions of financial costs versus benefits.

“Information” barriers occur when adoption is not implemented because of imperfect availability of information. “Market structure and institutions” barriers refer to failures in these areas that inhibit adoption, e.g. a lack of training programmes or extension, or poorly developed supply chains. “Regulation and policy” barriers are those that derive from existing or potential constraints in public policy or the law. These last two groups are generally external barriers to adoption in farming contexts, as the farmer does not have the power to change them, e.g. biosecurity regulations that unnecessarily delay the introduction of a new crop, or food safety regulations that do not develop fast enough to be applied to new products. In contrast, “Risk and uncertainty” covers the perceptions of farmers who may think that moving to less intensive GHG emissions operations is risky.

“Externalities” are barriers in which the full costs and benefits of an action are not exclusively borne by the decision-maker. If the social benefit from adoption was included in the assessment of the practice as no cost, yet the farmer does not value this social benefit, then he or she is less likely to adopt the practice. For example, if farmers do not regard mitigation policies such as including agriculture in the New Zealand Emissions Trading Scheme as being credible in either the short or long term and thus do not fully internalise the GHG cost, actual adoption rates will fall short of those modelled. Finally, “Behavioural factors” relate to intrinsic barriers that farmers may develop as part of their formation, experience, and culture. Among these, barriers such as “First-cost bias” (when decision-makers tend to place a disproportionately large weight on the initial cost) or “Habitual behaviour” (when farmers may perceive that transitioning is too disruptive to existing routines) can limit adoption.

A more in-depth list of each barrier within each category, along with brief definitions, is provided in Table A1 in the appendix.

DEFINING NO-COST AGRICULTURAL MITIGATION PRACTICES

Multiple farm management practices have been proposed by scientists as options to reduce biological GHG emissions (methane, CH4, and/or nitrous oxide, N2O) of livestock operations (e.g., Reisinger & Clark 2016; de Klein & Dynes 2017; Reisinger et al. 2018). However, if changed management practices increase the costs of running a farm business without changing its revenues, their implementation will not be considered in normal circumstances.

AgResearch has conducted an assessment of current farm practices and farm management GHG mitigation options in New Zealand that in theory could be framed as no-cost. An initial qualitative assessment of options that could be both practical/adoptable and no-cost produced a list of five different practices, presented in Table 1. These practices are fully described in de Klein & Dynes (2017).

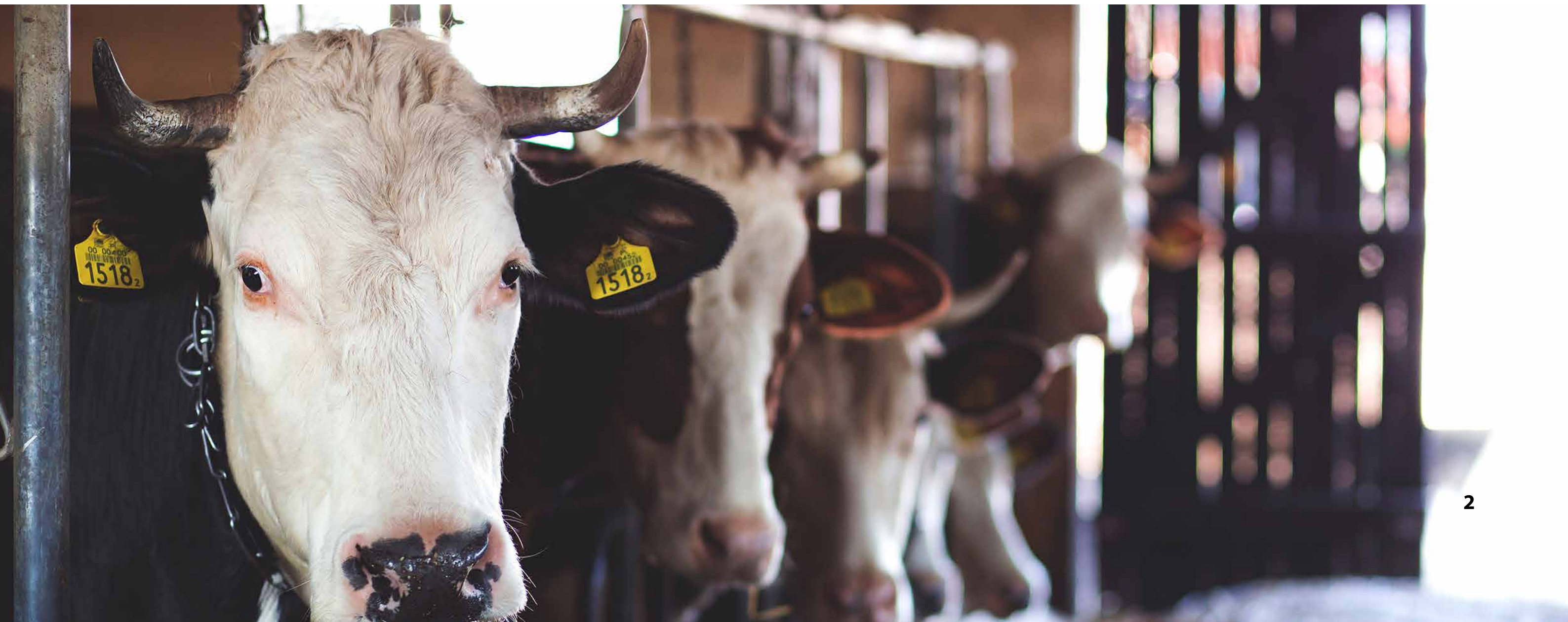


Table 1. No-cost mitigation practices, and brief description

Farming practice	Description
Dairy systems	
Reduce stocking rate and high-breeding-worth cows (increased per cow performance)	A reduced stocking rate means fewer cows per hectare, which translates into a less intensive system, which reduces the carbon footprint of the farm. Cows with a high breeding worth are more efficient at converting dry matter into milk. This means that the same amount of milk can be produced with fewer cows and thus less dry matter is required to meet the maintenance requirements of the cows. As CH4 emissions are directly related to dry matter intake, fewer, more efficient cows can reduce CH4 emissions per unit of milk produced.
Reduce replacement rates (fewer heifers)	Improved reproductive performance of the herd results in less involuntary culling and lower replacement rates. Replacement and other non-milk-producing animals produce CH4 without contributing to milk production.
Reduce N fertiliser use/ replace some pasture with lower N feed	Instead of applying N fertiliser to pasture to grow extra pasture dry matter, the diet is supplemented with bought-in low-N feed, e.g. the incorporation of bought-in maize or cereal silage into the diet as a replacement for N-boosted pasture to reduce the amount of excreta N returned to soil.
Sheep and beef systems	
Increase scanning percentage (better feeding/feed utilisation)	The scanning percentage of ewes is driven by both the genetics of the ewe and her weight at mating. It can be very difficult in many parts of New Zealand for ewes to gain weight between weaning their lambs in summer and mating in autumn. The higher the scanning percentage, the more lambs will be born and therefore weaned. This also means that there are more lambs to be fed in spring and early summer, which can increase feed utilisation (feed eaten/feed grown) at a time when this can be lower.
Increase live-weight gain in lambs (better feeding/feed utilisation)	Better feeding of high-quality feed will reduce total intake in lambs. Because CH4 emissions are calculated from intake of dry matter, those from young stock will be reduced.

Following this assessment, de Klein and Dynes (2017) conducted an analysis to assess the no-cost potential of one of these options: “Reduce stocking rate and high-breeding-worth cows”. The findings suggest that a system where inputs of nitrogen fertiliser and/or bought-in supplements are reduced and the system carries fewer cows of greater genetic merit led to reductions in total GHG emissions and GHG emissions intensities, ranging between 2–16% and 3–14%, respectively. The reduction potential generally increased with increasing milk solids production.

However, systems that carry fewer cows of higher genetic merit are more complex to run, requiring advanced management skills across the farming system. In addition, the profitability of the less intensive system was highly dependent on the milk pay-out price. The use of “Reduce stocking rates and high-breeding worth cows” had co-benefits of reduced nitrogen (N) emissions to water.

Fleming, Kerr and Lou (2019) explored the likely implications of reducing stocking rates and improving animal productive performance on emissions and profits using a farm-level dataset. A summary of this analysis and results are provided in the next section.

CASH, COWS, AND CLIMATE: TESTING A NO-COST MITIGATION OPTION WITH CROSS-FARM DATA

Making use of the New Zealand Farm Monitor Data – a dataset that was compiled and cleaned for analysis as part of this project (Henry, Lou and Fleming 2017) – Fleming, Kerr and Lou (2019) explored the cost-effectiveness of two mitigation options to reduce biological GHG emissions on farms: reduce stocking rate (number of cows per effective hectare of dairy land) and increase animal performance (measured by production of milk solids per cow). This last variable was used as a proxy for high-breeding worth animals (this data is not available in the New Zealand Farm Monitor Data). The analysis explored if the selected practices, when applied independently or in conjunction (as suggested by de Klein and Dynes (2017)), can support biological GHG emissions reduction without negatively impacting farm profits. In other words, the analysis explored the no-cost status of the first practice listed in Table 1. The evaluation of the effect of these mitigation options was carried out on four main variables:

- milk profitability of the farm (cash operating surplus/ton of milk solids produced),
- profitability per hectare (cash operating surplus/effective hectare),
- emissions intensity (ton CO2 eq/ton of milk solids produced), and
- the value of emissions (cash operating surplus/ton CO2 eq).

The analysis was conducted in an unbalanced panel of 222 observations (144 distinct dairy farms across three years, 2009–12). The results in Table 2, and in other tables reported in Fleming, Kerr and Lou (2019), show two distinct patterns. First, high animal performance farms in general have significantly lower emissions intensities and higher profits (both cash operating surplus per ton of milk solids and per hectare), and they achieve higher profits per unit of GHG emitted. Thus, animal performance appears to be a strong no-cost option to mitigate emissions intensity. An increase in milk solids per cow by one standard deviation (60 kg) could lead to a gain of $618 per hectare in profit but an increase of 1.6 ton of GHGs per hectare.

Second, a higher stocking rate on a farm is significantly associated with a lower emissions intensity, is not significantly associated with milk profitability (cash operating surplus per ton of milk solids), but is positively associated with profit per hectare. For the most part, stocking rate was also shown to be not significantly associated with the value per unit of GHGs.

Given these findings, can it be claimed that the combination of a low stocking rate and high animal performance is likely to be an effective option to mitigate GHGs and maintain (or improve) profits on the farm? Higher levels of animal performance clearly seem to reduce the GHG intensity of the farm and increase profit – a "no-cost" option. However, unless either the stocking rate or area of dairy farming decrease, an increase in milk solids per cow will lead to an increase in absolute emissions. Fleming, Kerr and Lou (2019) tested this by checking how much it would cost to mitigate the extra total emissions that an increase of one standard deviation of animal performance could bring. Mitigating emissions could cost $397/hectare if stocking rate is reduced, but around $174/hectare if farms with the lowest "value of emissions" (profits generated per unit of GHG) are removed from dairy production in the Zealand Farm Monitor Data sample. Both values are lower than the profits that would be generated by the increase in animal performance ($618/hectare).

Thus, the two options – low stocking rate and high animal performance – when combined do seem to constitute a no-cost combination. However, the same mitigation could potentially be achieved with an even smaller loss of profit by reducing the total area of dairy land through encouraging changes in land use on the least-efficient farms, while maintaining high stocking rates and increasing the performance of the animals on the remaining dairy land.

Table 2. **Emissions intensity (kg CO2-e/ton milk solids), milk profitability (Cash Operating Surplus/ton milk solids), profit per hectare (Cash Operating Surplus per effective ha), and value of emissions (Cash Operating Surplus/ton CO2-e) and mitigation options (SR and AP)**

	Emissions intensity	Milk profitability	Profit per hectare	Value of emissions
Stocking rate (SR)	-1.110***	-111.981	972.728***	18.077
	(0.157)	(103.715)	(111.560)	(12.239)
Milk solids per cow (AP)	-13.475***	2,308.734**	10,779.174***	521.149***
	(1.692)	(1,121.194)	(1,206.003)	(125.292)
Use of irrigation	0.184	227.275	-48.090	5.372
	(0.545)	(361.002)	(388.309)	(20.340)
Use of feed pad	0.079	-61.451	-85.828	-10.031
	(0.221)	(145.612)	(156.627)	(13.800)
Use of DCD	-0.674**			29.092
	(0.297)			(24.243)
Feed expenses, per cow	-0.001	-3.118***	-3.059***	-0.267***
	(0.001)	(0.497)	(0.534)	(0.052)
Animal health expenses, per cow	-0.001	-6.206***	-6.220***	-0.577***
	(0.003)	(1.957)	(2.105)	(0.187)
Depreciation, per cow	0.001***	0.514***	0.502***	0.036*
	(0.000)	(0.153)	(0.165)	(0.019)
No. of feed supplements imported	-0.053	107.276***	89.540**	11.346***
	(0.058)	(38.459)	(41.368)	(3.878)
Log of total effective area	-0.063	-383.566***	-383.092**	-36.869**
	(0.216)	(142.856)	(153.662)	(15.224)
Constant	14.677***	4,003.194***	-1,009.959	293.845**
	(2.031)	(1,345.961)	(1,447.771)	(134.707)
R-squared	0.660	0.731	0.780	0.712

Notes: Regressions are estimated for all observations (N = 222) and are conducted with additional controls, which include: rainfall, temperature, topography, soil type and regional dummies. Standard errors are in parentheses. Asterisks denote statistical significance at: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Feed expenses include hay and silage.

Source: Fleming, Kerr and Lou (2019)

PERCEPTIONS OF PRACTICES "NO-COST" STATUS AND BARRIERS TO ADOPTION: EVIDENCE FROM NEW ZEALAND PASTORAL FARMERS

To identify the incidence of barriers on farmers' decision-making in relation to the adoption of no-cost mitigation practices, two approaches were undertaken: a survey of 167 (84 dairy and 83 sheep and beef) farmers across the country (Fleming, Brown and Knook, 2019); and semi-structured interviews with 10 dairy farmers and four sheep and beef farmers (Cortés-Acosta et al., 2019).

The analysis focused on the five no-cost practices listed in Table 1. However, two alternative practices for New Zealand pastoral farms were also included. These are not defined as no-cost, but have been suggested as valid options to reduce emissions (Reisinger & Clark 2016; Reisinger et al. 2018):

- the use of dairy beef animals to replace beef cows (for sheep and beef systems); and
- the adoption of a once-per-day milking system (for dairy farms).

Awareness and perceptions of the no-cost status of practices

The vast majority of farmers were familiar with the studied practices. However, most of the interviewees were not aware, or were hesitant to believe, that these practices could contribute to a reduction in on-farm emissions – a lack of "mitigation awareness". For example, one interviewee said:

> *"Well the experts say that it [increase scanning percentage] reduces greenhouse gas. Well, it's more efficient. How do you rate that? Every little helps I would say. But I mean there's no… how do you actually measure it? Which is the problem. You don't know. Nobody knows unless you put it in a chamber and measure the gases that are released into a sealed chamber. Very hard to do in a farm.*

In the survey, farmers were initially asked whether they thought each practice could be applied or expanded for farms similar to theirs while improving (or maintaining) current farm profits. Responses to this question are shown in Table 3.

Table 3. **Percentages of agreement with the statement that the practice can be applied or expanded while improving (or maintaining) current farm profits**

Practice (as stated in the Survey)	Agree	Disagree	Unsure
Increase live-weight gains in lambs/calves N-C	98%	2%	0
Increase scanning percentage N-C	86%	6%	8%
Use dairy beef animals to replace beef cows	39%	36%	25%
Reduce current stocking rates N-C	60%	29%	11%
Limit the use of N fertiliser in favour of other practices N-C	43%	33%	24%
Adopting a once-per-day milking system	29%	49%	22%

Note: N-C denotes practices defined as no-cost by de Klein and Dynes (2017), as reported in Table 1. The option 'reduce replacement rates' was not consulted in the survey.

Source: Fleming, Brown and Knook (2019)

The relatively high percentage of sheep and beef farmers who believe that increasing live weight gains in lambs and calves and increasing scanning percentages are no-cost is worth noting. Another important point is that a lower proportion of dairy farmers believe that reducing the current stocking rate and limiting the use of N fertiliser in favour of other practices are no-cost. These points suggest that there is room for improving awareness of the potential no-cost nature of these two practices.

Fewer farmers agreed that using dairy beef animals to replace beef cows and adopting a once-per-day milking system are no-cost practices, compared to the other practices. However, 39% and 29% of farmers, respectively, perceived that these practices are no-cost. This suggests there is space to grow the adoption of these practices. More and better evidence with respect to the potential profitability of these practices should therefore be assessed and promoted.

In relation to the perception of "no-cost" status, the survey asked farmers whether they believe that agriculture should act to mitigate GHG emissions and 47.5% stated "no". Despite this, when subsequently asked "If clear technology options to reduce your greenhouse gas emissions at no additional financial cost for your farm existed, how interested would you be in implementing them on a voluntary basis?", approximately 80% of farmers responded that they would be interested in applying "no-cost" mitigation practices.

Another important finding was that more than half of farmers who think reducing stocking rates is no-cost are not currently adopting the practice. This is in remarkable contrast to the other evaluated practices, which had been adopted by three-quarters of farmers. Also, as shown below, this practice was associated with the largest number of identified barriers in the interviews. These points signal that addressing barriers to the adoption of lower stocking rates is important when encouraging less intense dairy systems.

Barriers to adoption identified from the survey

Among the farmers who considered a practice to be no-cost in the survey, different barriers causing under-adoption were identified. These were identified in three sub-groups of farmers, who:

(i) have used the practice in the past but do not do so anymore;

(ii) have not yet adopted the practice but state that they do so will in the future; and

(iii) state that they will not (or were unlikely to) adopt the practice at all.

Fleming, Brown and Knook (2019) found four barriers for group (i), five barriers for group (ii), and eight barriers for group (iii).

In group (iii), the barrier "Unsureness about practicality" was most frequently selected by farmers overall, while "Salience bias" and "Principal-agent or split-incentive problems" were the barriers most frequently selected for sheep and beef farmers and dairy farmers, respectively.

It is important to note that barriers were identified by farmers who believed the practice was no-cost, so in most cases financial barriers can be ruled out. However, the frequency observed in "Unsureness about practicality" to some extent links to "Variable farming landscape" (a financial barrier), as well as "Complex interactions". This is because these farmers are convinced that in a farm similar to theirs the practice could be no-cost, but they are unsure if it will work on their own farm. A list of all identified barriers, for each studied practice, is provided in Table 4.

Barriers identified in interviews

The interviews resulted in the selection of more than 40 quotes from which barriers were identified. These are fully listed in tables 3–8 in Cortés Acosta et al. (2019) – a curated set of examples is provided in Table 4. Most identified barriers fell into the three categories "Arguably efficient", "Information" and "Behavioural factors".

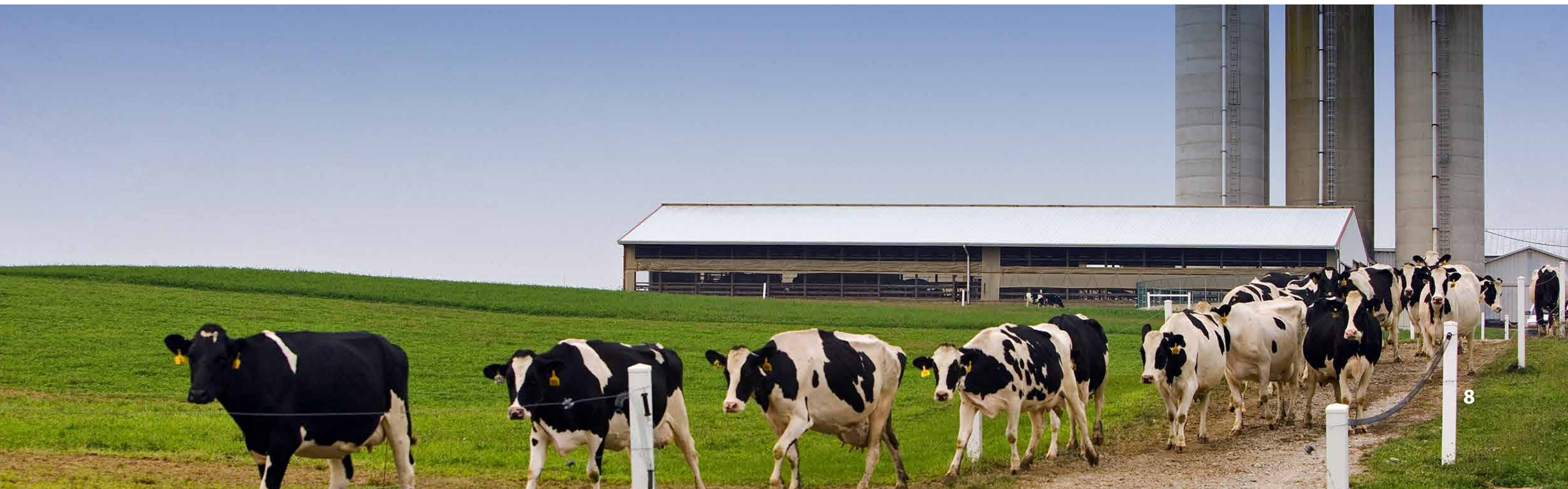
Within the "Arguably efficient" category, three barriers were identified: "Modelling mismatch" (when the practice has higher operational costs than benefits), "Variable farming landscape" (same as modelling mismatch, but only in the context of particular farms), and "Learning and adjustment" (when the learning process is too expensive). This result shows that, for at least some farmers, some practices (reduced stocking rate and high-breeding worth animals in particular) are perceived to have a financial cost that outweighs the benefits. This constrains their further adoption.

The barriers "Complex interactions" (farmers are not sure how well the practice would mesh with other farm processes) and "Inadequate managerial capability" (the farmer perceives that there is a lack of skills to manage the practice comprehensively) were also among the most frequently identified. The former was identified eight times across three different practices, while the latter was identified four times in three practices. The respective practices linked to these barriers are shown in Table 4.

Several behavioural barriers were consistently identified across all evaluated practices, but they were particularly important for the practice of reducing current stocking rates and/or high-breeding worth animals, where seven behavioural barriers were identified in the interviews. "Habitual behaviour" and "Salience bias" were the other two most frequently identified behavioural barriers.

Among the no-cost practices investigated, reduced stocking rate and/or high-breeding worth animals was the practice with the largest number of non-financial barriers to adoption (16 distinct barriers). This points to multiple embedded factors affecting the decision-making of farmers, thus increasing the barriers to the use of reduced stocking rate and high-breeding worth animals in New Zealand agriculture.

Practice	Identified barriers: From survey	Identified barriers: From interviews	Example of quotes (and related identified barrier(s))
Dairy systems			
Reduce current stocking rates and/ or increase high-breeding-worth animals*	Unsureness about practicality Learning and adjustment Principal-agent or split-incentive problems **Inadequate managerial capability** **Habitual behaviour**	Modelling mismatch Variable farming landscape Learning and adjustment Unsureness about practicality Complex interactions Principal-agent or split-incentive problems Capital market failure Inappropriate or inadequate extension Risk and uncertainty **Behavioural factors** (all seven barriers in the category)	*"… if you were a normal farmer [talking about a Māori farm] and you ever chose to sell your herd, obviously you can ask a higher value for those cows if they've got a better breeding and production worth, because they obviously produce more milk, so you get more outputs out of her. You're paying more for her… but then, why to have less cows per ha if you can have a large capital [number of cows] in the same land?"* (Barriers: "Modelling mismatch" and "**Loss aversion**") *"… at the end, the decision of a particular stocking rate is coming from advisors".* (Barrier: "**Trust or credibility**")
Reduce replacement rates	(Not evaluated)	Modelling mismatch Complex interactions Unsureness about practicality Risk and uncertainty **Inadequate managerial capability** **Habitual behaviour**	*"If you don't have the cow to replace a cow that dies unexpectedly, you need to buy the replacement from another farm, and people do not want to do that."* (Barrier: "**Habitual behaviour**") *"This is definitely something that we target, but is very difficult to achieve… There is just too many details to follow during mating… it is hard."* (Barrier: "Complex interactions")
Limit the use of N fertiliser in favour of other practices	Unsureness about practicality Principal-agent or split-incentive problems Inappropriate or inadequate extension Risk and uncertainty **Inadequate managerial capability** **Habitual behaviour**	**Salience bias**	*"Changing the fertiliser regime is a longer-term investment, and it might be 10 years before you start to get the full benefit of that."* (Barrier: "**Salience bias**") *"Lack of time. Putting on N is quick."* (Barriers: "**Habitual behaviour**" and "Unsureness about practicality")
Adopt a once-per-day milking system**	Principal-agent or split-incentive problems	Unsureness about practicality Risk and uncertainty **First-cost bias** **Habitual behaviour** **Trust or credibility**	*"Yes, people say that after 3–4 years they can recover volume to what they have with twice a day, but what they miss is that with twice a day you keep also improving your numbers, so you will never know how much you are missing."* (Barriers: "Unsureness about practicality" and "**Trust or credibility**")

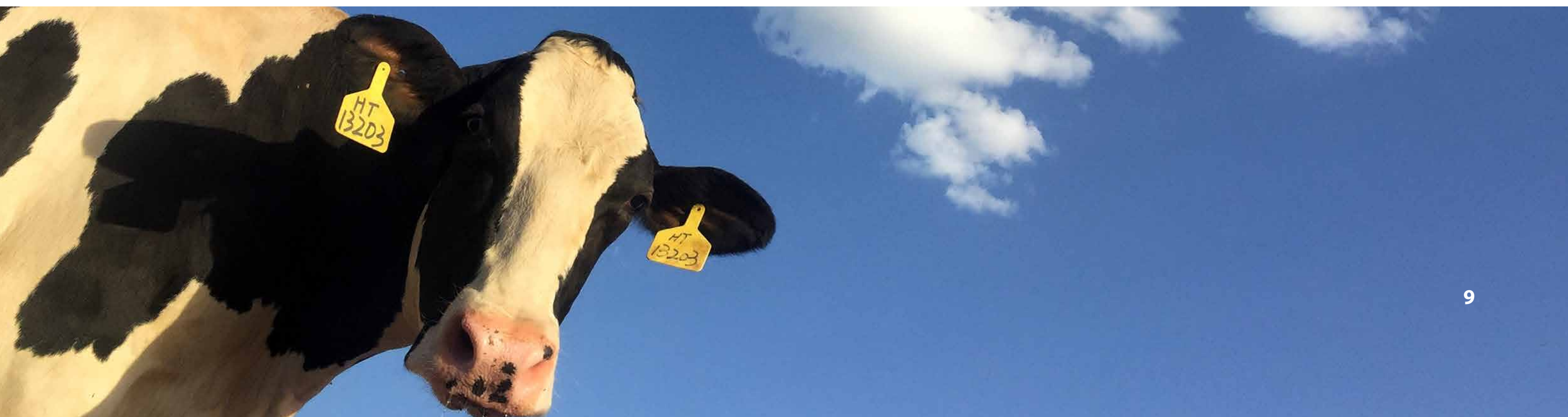


Practice	Identified barriers: From survey	Identified barriers: From interviews	Example of quotes (and related identified barrier(s))
Sheep and/or beef systems			
Increase scanning percentage	Option value Complex interactions **Salience bias** **Inadequate managerial capability** **Habitual behaviour**	Variable farming landscape Unsureness about practicality **Salience bias** **Habitual behaviour**	*"I think for me, when I look at scanning and growing animals faster, I can't see why people wouldn't do it, so it probably comes down to the fact that they just can't be bothered. Probably comes back to the fact that it's just not what we do, and we don't have the energy to do it, I suppose."* (Barrier: "**Habitual behaviour**")
Increase live-weight gains in lambs/calves	Unsureness about practicality Inadequate managerial capability Complex interactions Inappropriate or inadequate extension **Salience bias** **Habitual behaviour**	Modelling mismatch Learning and adjustment Unsureness about practicality Complex interactions Insufficient diversity of offerings Capital market failure Risk and uncertainty **First-cost bias** **Inadequate managerial capability** **Habitual behaviour**	*"We decided we are going to start using a new forage and there were a lot information about it, but the management of this forage is different to the one we had… the manager we had was doing reasonably well, but the forage was not growing well. After several years, just when we were about to stop having this new forage, the manager left and the new manager we got had more experience with this new forage… without a dramatic change in management, but changing a couple of those key things, he improved the yield of the forage dramatically, so instead of stopping producing it we increased it to double to what we had!"* (Barrier: "**Inadequate managerial capability**")
Use dairy beef animals to replace beef cows**	Option value Complex interactions Risk and uncertainty **Inadequate managerial capability** **Habitual behaviour**	Complex interactions Supply chain failure **Habitual behaviour**	*"This does not depend only on the beef farmer, but we need more beef genetics in the dairy industry, which is a change for the dairy farmer, it is a bit of a change in their thinking, so there is a limitation there. And it is also a change for the beef farmer."* (Barrier: "Supply chain failure")

Notes: Behavioural barriers are highlighted in bold, and quotes from the survey or interviews are given in italics. The survey analysis did not include the "Reduce replacement rates" practice. * Cortés Acosta et al. (2019) identified barriers for both – reduce stocking rats and increase high breeding worth animals, separately, while Brown and Knook (2019) only identified barriers for the reduction of stocking rate practice. ** Denotes practices not defined as no-cost by de Klein and Dynes (2017). Justification for the respective barriers identified in quotes in fourth column are described in Cortés-Acosta et al. (2019) or Fleming, Brown and Knook (2019). **Source: adapted from Cortés-Acosta et al. (2019) and Fleming, Brown and Knook (2019)**

Finally, in line with the findings from the literature review also reported in Cortés-Acosta et al. (2019), there was no evidence of some of the barriers listed in Jaffe (2017)'s typology. Of course, the fact that these barriers were not mentioned by farmers is not evidence of their absence. In particular, no barriers in the category "Regulation and policy" were recorded. This may have been because practices were discussed from a production angle and did not include aspects of potential future GHG emissions regulation. However, when discussing the role of agriculture in climate change with farmers, more than one mentioned that regulation would require or compel changes in farmers' behaviour:

> *"Yeah, I think for me, probably I think we need more regulation. For right or wrong, I think it is essential to change a lot quicker than letting farmers change on their own accord. I guess I just think New Zealand farming, at the moment, we're not doing enough to change on our own."*



DISCUSSION, IMPLICATIONS, AND FINAL TAKEAWAY MESSAGES

In this final section we provide a brief discussion and suggest the policy implications of the different key findings of the project. This also incorporates insights received from participants in the final workshop of this project, held in March 2019.

No-cost practices are available, but more evidence is needed

Farmers expect more evidence of the profitability-enhancement potential of no-cost practices in different scenarios. Farmers wanted more effort put into clarifying the costs of the practices (especially in the form of the farmers' time) in specific contexts and over varying timescales. They also wanted opportunity costs in respect to their currently used practices to be identified. To address this a co-development approach to research would be beneficial, where farmers could more directly engage with scientists to implement and evaluate potential no-cost practices in different contexts.

There is also a strong need to develop better-quality longitudinal farm-scale data, collected on the same farms over many years (to account for the effects of variation in milk payouts and weather). A randomly selected, statistically balanced, longitudinal dataset with high-quality emission estimates, accurate measures of farm practices related to mitigation, and financial data, and, even better, the use of randomised control trials structured to assess financial impacts as well as emission impacts, could generate strong, robust estimates of the true costs of proposed mitigation options.

Land-use change could be more efficient

The combination of reduced stocking rates and high-performing animals operates as a no-cost mitigation option, but potentially the same mitigation could be achieved with lower loss of profit by reducing the area of dairy land. This could be realised by encouraging changes in land use on the least-efficient farms (farms that generate the lowest value (profit) per unit of GHG emitted), while maintaining stocking rates and increasing the performance of the animals on the remaining dairy land. This finding implies that policies that promote land-use change (i.e. moving some dairy land to other, less GHG-intense activities) could be a practical solution to reduce agricultural GHG emissions.

Mitigation awareness is an issue

The five no-cost practices studied in this project were widely known to farmers. However, most had no knowledge that the practices could mitigate on-farm GHG emissions. In the project workshop, it was mentioned that most farmers do not know their current baseline of emissions or what their ideal target should be. In other words, they lacked "mitigation awareness". More public campaigns could be targeted at informing farmers of mitigation options and providing them with more information on their level of emissions.

Some farmers were sceptical that the practices would result in lower GHG emissions. One approach to reduce the scepticism of farmers to mitigation alternatives could be to support agents of diffusion who could transmit the mitigation potential of practices and promote their use (Brown et al., 2016).

Several "Behavioural factors" barriers affect the adoption of no-cost practices, but "Information" barriers seem more predominant

"Behavioural factors", were important in all the evaluated no-cost practices. Remarkably, all seven behavioural factors were identified in the practice "Reduce stocking rate and/or high-breeding-worth animals", which implies that to achieve systems with lower stocking rates, different behavioural factors need to be taken into consideration. Our suggestions in this area include:

- supporting an increase and improvement in training programmes for farm managers, with a special focus on mitigation options and targeted to different contexts.
- providing more information about cost savings and rewarding farms that strategically opt for practices involving lower environmental costs.
- special programmes targeting farm advisors who are seen as trusted could prove useful in promoting and increasing the adoption of mitigation practices.

Barriers from the category “Information” were frequently found in both the interviews and survey studies. Within this category, the barrier “Unsureness about practicality” and “Complex interactions” were frequently identified. Furthermore, these barriers seem to be interconnected, as the complexity of interactions increases the riskiness of the outcome and makes it difficult for farmers to see whether the mitigation option is practical. This lack of information indicated by farmers signals the need for more and better-applied extension programmes that could help to reduce the uncertainty that farmers might face when confronted with adoption decisions.

Farmers do not necessarily have the power to change some barriers

The barrier “Inappropriate or inadequate extension” was identified in three different practices. This could be addressed with training or programmes for rural professionals to give them the in-depth knowledge required to provide advice on GHG reductions within the complexity of decision-making. Extension services must also be able to bridge the void between the farmer making decisions today and the seemingly distant effects that climate change can bring in the future. Addressing this will also help overcome the “Inadequate managerial capability” behavioural barrier.

“Insufficient diversity of offerings”, although identified only for one practice (“Increase live-weight gain in lambs/calves”), is also an external barrier that farmers cannot necessarily change. It is important to identify clearly these external barriers, as they may need policy interventions to reduce their incidence and increase adoption.

Once-per-day milking and replacing beef cows with dairy beef animals are options that could be adopted more

Even though once-per-day milking and replacing beef cows with dairy beef animals are not considered “no-cost” practices by de Klein and Dynes (2017), the proportions of surveyed farmers perceiving them as no-cost show that there is space to grow their adoption. More and better evidence with respect to their potential profitability could be assessed and promoted.

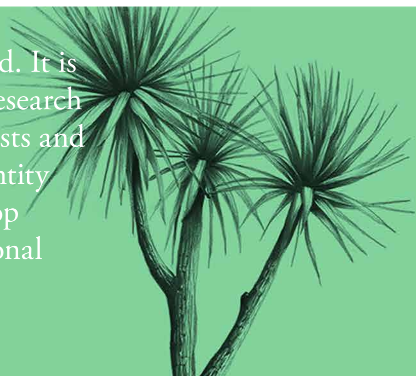
However, these practices do face barriers to adoption. In both cases, some barriers identified were from the “Market structure and institutions” category, which are not within the farmer’s control. For example, regarding the use of dairy beef animals to replace beef cows, it was pointed out by farmers that better integration is needed between the dairy and sheep and beef industries. This issue, which we identify mainly as the barrier “Supply chain failure” (as dairy animals for the beef industry are not necessarily easily accessible), goes beyond the willingness of the farmer, and instead points to a space where industry could try to improve the alignment of interests and mitigation efforts between parties.

The why, what, and how

It is important to emphasise that farmers need to know the “why”, “what” and “how” of on-farm mitigation. It is vital that farmers understand and believe that farming practices can reduce greenhouse gas emissions. If farmers are more informed about the potential for mitigation on their farms, there would be more interest in adopting no-cost practices. For this to be achieved, however, it is important to establish clear approaches that allow farm-level GHG levels to be measured and transmitted to the farmer. In the same fashion, more and better information needs to be developed to show the amounts of GHG reduction that different mitigation options can provide and the associated costs and production benefits.

To help address these last points, Motu researchers have developed a tool that allows farmers to test the financial implications of barriers to the adoption of low stocking rates. The model is freely available online at https://moturesearch.shinyapps.io/FarmTool.

FOR MORE INFORMATION ON THIS PAPER GO TO HTTP://MOTU.NZ OR CALL US ON 04 939 4250



REFERENCES

Papers and reports from this project

Cortés-Acosta, Sandra, David Fleming, Loïc Henry, Edmund Lou, Sally Owen and Bruce Small (2019). Identifying barriers to adoption of "no-cost" greenhouse gas mitigation practices in pastoral systems. Motu Working Paper 19-10. Wellington: Motu Economic and Public Policy Research.

de Klein, Cecile and Robyn Dynes (2017). Analysis of a New Zealand-specific no-cost option to reduce greenhouse gas emissions from dairy farms. AgResearch report to Motu.

Fleming, David, Pike Brown and Jorie Knook (2019). Barriers to adoption of win-win mitigation farm practices: Evidence from New Zealand pastoral farmers. Motu Technical Paper. Wellington: Motu Economic and Public Policy Research.

Fleming, David, Susy Kerr and Edmund Lou (2019). Cows, cash and climate: Low stocking rates, high performing cows and profitability across New Zealand farms. Motu Working Paper 19-11. Wellington: Motu Economic and Public Policy Research.

Henry, Loïc, Edmund Lou, and David Fleming (2017). New Zealand Monitor Farm Data. Motu Technical Paper. Wellington: Motu Economic and Public Policy Research.

Jaffe, Adam (2017). Barriers to Adoption of No-Cost Options for Mitigation of Agricultural Emissions: A Typology. Motu Note #24. Wellington: Motu Economic and Public Policy Research.

Other references used in this report

Brown, Pike, Georgina Hart, Bruce Small, and Oscar Montes de Oca Munguia. 2016. Agents for Diffusion of Agricultural Innovations for Environmental Outcomes. Land Use Policy, 55:September, pp. 318–26.

Reisinger, Andy, and Harry Clark. 2016. "Modelling Agriculture's Contribution to New Zealand's Contribution to the Post-2020 Agreement." MPI Information Paper No: 2016/02.

Reisinger, Andy, Harry Clark, Ross Abercrombie, Mark Aspin, Peter Ettema, Mark Harris, Andrew Hoggard, Matthew Newman, and Greg Sneath. 2018. "Future Options to Reduce Biological GHG Emissions On-Farm: Critical Assumptions and National-Scale Impact." Report to the Biological Emissions Reference Group (BERG).

Small, Bruce, Pike Brown, and Oscar Montes de Oca Munguia. 2016. "Values, Trust, and Management in New Zealand Agriculture." International Journal of Agricultural Sustainability 14 (3): 282–306.

APPENDIX: DEFINITIONS OF BARRIERS

Table A1. Definitions of barriers to adoption of no-cost practices, following Jaffe (2017)

Barrier	Definition
Arguably efficient	
Modelling mismatch	Incorrect assumptions in modelling mean it is not no-cost in a real situation
Option value	A “value” of waiting to get a lower price
Variable farming landscape*	The possibility that a no-cost option works for some farms but not others due to heterogeneity
Learning and adjustment	If adaptation costs are high enough or the learning period is long enough, the eventual benefit may not justify bearing these costs
Information	
Awareness	Farmers are not aware of the existence of no-cost options
Unsureness about practicality	Information on context-specific performance might be weak
Complex interactions	Farmers do not know the bottom-line impact or are not sure about some unintended consequences due to a complex interaction during adoption
Market structure and institutions	
Principal-agent or split-incentive problems	Lack of the right incentive to adopt mitigation options
Insufficient diversity of offerings	The market offers an insufficient number of variants
Capital market failure	Inability to finance investments
Supply chain failure	External factors (e.g. demands from up or down the supply chain) may preclude the use of some options
Inappropriate or inadequate extension	Extensions may fail to meet the needs of farmers
Regulation and policy	
Safety or other verifications	Some regulations may require costly verification when a new option is introduced
Environmental regulations	An option may have environmental side effects that are restricted by the existing regulations
Demand for new regulatory regime	A new option may need some new regulatory structure before implementation
Inadequate or inappropriate regulation	Existing regulation may be a disincentive to the adoption of a new option
Risk and uncertainty**	The benefits and costs of an option may vary over different conditions
Externalities	Farmers may not get (or pay) the modelled benefits (or costs)
Behavioural factors	
First-cost bias	Farmers may put a considerably large weight on the initial cost
Salience bias	Potential cost savings may be overlooked by farmers
Loss aversion	Farmers may put disproportionate weight on avoiding losses
Inadequate managerial capability	Using a new option may require some specific skills
Social norms and prestige***	Adoption of certain no-cost options may go against social norms or prestige
Habitual behaviour	Farmers may be reluctant to change their old ways of doing things
Trust or credibility	The source of information about no-cost options is untrustworthy

Notes: * Includes the barriers “Heterogeneity of preferences or conditions” and “Variability and model incompleteness”, as defined by Jaffe (2017). ** Includes the barriers “Risk aversion”, “Uncertainty of regulatory constraints”, “The benefits and costs of an option may vary over different conditions” and “There may be fundamental uncertainty about the magnitude of the overall net benefit”, as defined by Jaffe (2017). *** Also includes the barrier “Standard practice”, as defined by Jaffe (2017).