ON-FARM GREENHOUSE GAS MITIGATIONS

A report prepared for Westpac New Zealand.

Journeaux Economics

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1. EXECUTIVE SUMMARY

This report analyses the impact of a range of greenhouse gas (GHG) mitigation scenarios on 4 farm types:

- North Island Hill Country Sheep & Beef
- South Island Intensive Sheep & Beef
- Waikato Dairy
- Canterbury Irrigated Dairy

The three key drivers of greenhouse gas emissions at a farm level are:

(i) The amount of dry matter (DM) consumed by the livestock. There is a direct correlation between DM consumed and methane production, and a strong correlation with nitrous oxide emissions.

(ii) The amount of protein in the diet. This is a strong driver of nitrous oxide emissions.

(iii) The amount of nitrogen fertiliser used. While there are some direct emissions of N_2O and CO_2 when applying nitrogen fertiliser, the key objective for applying nitrogen fertiliser is to grow more DM, which then relates back to point (i).

The scenarios modelled were aimed at reducing DM consumption, while endeavouring to maintain the profitability of the system.

The modelling was based on the statistical average for the specific farm system, utilising the Dairy Statistics, Dairy NZ Economic Survey, and the Beef + Lamb NZ Economic Survey data. The modelling was carried out using Farmax.

All of the mitigation scenarios reduced GHG emissions to varying degrees, with variable impact on farm profitability. For dairying, GHG reductions were in the order of 0% to -19%, while for the sheep & beef farms the reductions varied from 0% to -10% (excluding forestry).

Reducing stock numbers on their own, with no compensating increase in animal productivity, will certainly reduce GHG emissions, but also has a major negative impact on farm profitability. A key lesson from this is that if stock numbers are reduced, then an improvement in animal productivity is necessary to ensure farm financial viability.

For the sheep & beef farms, a scenario was analysed whereby 10% of the farm was planted into forestry (pines). This had a major impact in offsetting total GHG emissions from the farm (40-60%), although overall profitability was either unchanged or reduced.

The analysis also investigated the impact of a significant increase in the amount of bought-in supplementary feed into the dairy farms, as a measure of intensifying the operation. The impact was:

- Emission intensity (kg CO_2e/kg milk solids) decreased by 4-6%
- Total GHG emissions increased by 24-25%
- The amount of the emissions levy the farm would pay therefore also increased by 24-25%

This reinforces the fact that while intensification will reduce emission intensity, it also increases total emissions, which is what the levy will be based on. Strategies to reduce total emissions generally also reduced emission intensity.

Calculation of the proposed emission levy was carried out, using the prices suggested by the Waka Eke Noa in their proposal to the government, given that actual prices are yet to be announced.

This analysis shows that sheep & beef farms are more vulnerable to the levy, given that often their total emissions are higher, while profitability is much less compared to dairying.

Using modelling to investigate possible mitigation options can be useful, but the implications of the scenarios still need to be considered on a working farm. There are two key aspects to the scenarios modelled:

(i) It is much easier to maintain pasture quality at a higher stocking rate. Given that many of the scenarios operated around a lower stocking rate, it is imperative that grazing management improves to ensure no loss of quality. If pasture quality is reduced, then production will be quickly lost, directly impacting on profitability.

(ii) The scenarios modeled leverage the use of complex farm systems, most of which would not be used currently on a majority of working farms. It is likely these working farms would require improvements in farm management systems which could take years to garner results.. In particular some of the scenarios would involve a more complex farming system, which could well take some time (i.e. years) to come to fruition – in most instances there are no quick fixes.

2. BACKGROUND

Westpac New Zealand commissioned this report to provide information for their Rural Managers on green-house gas (GHG) mitigations at a farm level. The brief was to:

(i) Analyse a range of mitigation options across 4 representative farm types:

- North Island Hill Country Sheep & Beef
- South Island Intensive Sheep & Beef
- Waikato Dairy
- Canterbury Irrigated Dairy

The intent is to show the impact in terms of changes in biological GHG emissions and on-farm profitability. The cost of the carbon levy is also calculated for each scenario, using the proposed He Waka Eke Noa pricing.

(ii) Compare the emission intensity/total emissions for high input dairy farms (Waikato/Canterbury), along with the associated carbon levy cost.

(iii) Discuss the farm management implications of the mitigation scenarios.

3. METHODOLOGY

The representative farms were based on industry statistics;

(i) The Waikato and Canterbury dairy farms are based on the mean of the respective regions from the Dairy Statistics.

(ii) The North Island Hill Country farm is based on the weighted mean of the Beef + Lamb NZ Class 3 farm (North Island Hard Hill Country) and Class 4 (North Island Easy Hill County), and the South Island Intensive farm is based on the mean of the Beef + Lamb NZ Class 7 farm (South Island Finishing).

These farms were set up in the Farmax[1] farm system model, which allows for the farm system to be manipulated and shows (a) whether the farm system is feasible from a feed supply/demand perspective, (b) the greenhouse gas emissions, and (c) changes in farm profitability.

For the high input modelling, the base Waikato/Canterbury dairy farm models were used whereby the number of cows was increased slightly (6-7%) and bought-in supplement was increased significantly, resulting in higher per-cow production.

1 www.farmax.co.nz

3.1 Modelling scenarios.

The scenarios and resulting impacts run for the dairy models were:

- Reduce stock numbers by 10%, no improvement in productivity
- Reduce stock numbers 10%, improve productivity (i.e. per cow milk solids production)
- Remove Reduce use of nitrogen fertiliser to 50% of original volume nitrogen fertiliser being applied to the pasture
- Remove all bought-in supplements
- Reduce the replacement rate to 15% (from 23%)
- Increase stock numbers and bought-in supplements (high-input scenario only)

The scenarios and resulting impacts run for the Sheep & Beef were:

- Reduce stock numbers by 10%, no improvement in productivity
- Reduce stock numbers 10%, improvement in productivity (i.e. lambing/calving %, slaughter carcass weights)
- Replace breeding cows with finishing bulls/steers (Hill Country)
- Reduce breeding ewes by 20%, increase lambing % (Hill Country)
- Alter the sheep:cattle ratio (SI Intensive)

Note these scenarios are to illustrate the principles behind farm system GHG mitigations – they are not an exhaustive list.

4. MODEL FARMS

4.1 Dairy.

The physical parameters of the farms are:

Table 1: Dairy model physical parameters

	Waikato Dairy	Canterbury Dairy*
Effective Area (ha)	129	234
Cows Wintered	371	810
R 2 Heifers	85	182
R 1 Heifers	88	186
MS Production (kg)	141,100	352,800
kg MS/Cow	380	436
kg MS/ha	1,096	1,506
Area in crop	5	8
kg N/ha Applied	131	179
Tonnes Supplement (DM) (Bought-in + made on farm)	477	721

*Irrigated farm

For both farms, replacement heifers are sent out to graze as weaners in December, returning to the farm at the end of May as rising 2-year olds.The milk solids payout was based on the Fonterra 2021/22 payout, with farm operating expenses based on the 201/22 Dairy NZ economic survey.

4.2 Sheep and beef farms.

The physical parameters of the farms are:

Table 2: Sheep and beef model physical parameters

	North Island Hill Country	South Island Intensive
Effective area (ha)	548	256
Breeding ewes (head)	1,754	2,400
Replacement ewe hoggets (head)	438	0
Other sheep (head)	26	77
Breeding cows (head)	164	0
Rising 1-year cattle (head)	120	77
Other cattle (head)	123	0
Stocking rate (stock unit/ha)	9.6	13.3
Ewe lambing (%)	129	131
Calving %	82	0

The schedules and expenses used were based on the Beef + Lamb NZ Economic Survey for 2021/22.

5. MODELLING RESULTS

5.1 Dairy.

Dairy modelling focused on reducing the amount of dry matter consumed by; to achieve this cow numbers were reduced, while endeavouring to hold per cow milk solids production as per the base farm.

Table 3: Physical parameters of scenarios (dairy)

Canterbury	Area (ha)	Cows Wintered 1 July	Cows Milked 15 December	Stocking rate (Cows/ha)	Total Milk solids Production	Milk solids/ pastoral ha	Milk solids/ peak cow
Base model	233	810	796	3.5	352,695	1,514	443
Reduce SR 10%, no improvement in productivity	233	729	713	3.1	317,854	1,364	446
Reduce SR 10%, Increase per cow production	233	729	713	3.1	351,712	1,509	493
1/2 Nitrogen fertiliser	233	761	747	3.3	331,439	1,422	444
No Bought-in Supplement	233	713	701	3.1	311,471	1,337	444
Reduce Replacements to 15% (down from 23%)	233	810	796	3.5	353,431	1,517	444
Waikato	**Area (ha)**	**Cows Wintered 1 July**	**Cows Milked 15 December**	**Stocking rate (Cows/ha)**	**Total Milk solids Production (Kg)**	**Kg Milk solids/ pastoral ha**	**Kg Milk solids/ peak cow**
Base model	129	371	359	2.9	141,239	1,095	393
Reduce SR 10%, no improvement in productivity	129	334	323	2.6	127,295	987	394
Reduce SR 10%, Increase per cow production	129	334	323	2.6	139,919	1,085	433
1/2 Nitrogen fertiliser	129	352	340	2.7	133,936	1,038	394
No Bought-in Supplement	129	300	289	2.3	113,675	881	393
Reduce Replacements to 15% (down from 23%)	129	371	359	2.9	141,469	1,097	394

Table 4: Dairy GHG emissions

Canterbury	CH_4 emissions (T CO_2e/ha)	N_2O emissions (T CO_2e/ ha)	Total CO_2e emissions (T/ha)	Total GHG % change from Base	EBITDA ($ha/ yr)	EBITDA % change from Base model
Base model	10.0	3.1	13.1		$8,273	
Reduce SR 10%, no improvement in productivity	8.9	2.8	11.7	-11%	$7,386	-11%
Reduce SR 10%, Increase per cow production	9.4	2.9	12.3	-6%	$8,523	3%
1/2 Nitrogen	9.3	2.6	11.9	-9%	$7,876	-5%
No Bought-in Supplement	8.6	2.7	11.3	-14%	$7,703	-7%
Reduce Replacements to 15%	9.9	3.1	13	-1%	$8,356	1%
Waikato	**CH_4 emissions (T CO_2e/ha)**	**N_2O emissions (T CO_2e/ ha)**	**Total CO_2e emissions (T/ha)**	**Total GHG % change from Base**	**EBITDA ($ha/ yr)**	**EBITDA % change from Base model**
Base model	9.0	2.7	11.7		$6,100	
Reduce SR 10%, no improvement in productivity	8.2	2.5	10.7	-9%	$5,255	-14%
Reduce SR 10%, Increase per cow production	8.7	2.6	11.3	-3%	$6,085	0%
1/2 Nitrogen	8.9	2.4	11.3	-3%	$5,756	-6%
No Bought-in Supplement	7.2	2.3	9.5	-19%	$5,581	-8%
Reduce Replacements to 15%	9.0	2.7	11.7	0%	$6,040	-1%

5.1.1 Discussion on scenarios.

(i) As can be seen in Table 4, a 10% reduction in stock numbers gives an almost linear reduction in GHG emissions, but also results in a significant reduction in farm profitability as indicated by EBITDA[2]. Within this scenario, a significant amount of dry matter (DM) is simply wasted.

(ii) In the "Reduce SR 10%, Increase per cow production" scenario, the surplus DM generated by reducing stock numbers is largely consumed by the remaining cows, in order to increase their per cow milk solids production. This creates a trade-off; reducing the number of cows reduces the amount of DM eaten, thereby reducing GHG emissions. Increasing the per cow amount of DM eaten by the remaining cows, in order to increase milk solids production, increases the per cow GHG emissions. Overall, total GHG emissions have reduced, largely due to the loss of the maintenance cost of the culled cows.

(iii) The impact of the reduced nitrogen fertiliser/no bought-in supplement scenarios will depend on the degree the farming system depends on these inputs. The greater the dependence, the greater the impact. Essentially these scenarios are again taking out DM from the system, with cow numbers again reduced to meet the new, lower, feed supply.

(iii) Reducing the replacement rate has a relatively marginal effect; the number of stock involved is small, and therefore the overall impact, on both GHG emissions and farm profitability is small. It is important to note that if this strategy is utilised, then cow death rates need to be low, and in-calf rates high, otherwise reducing replacement rates will adversely affect genetic gain within the herd.

2 EBITDA = Earnings before interest, tax, depreciation, and amortisation

5.1.2 High input farms; impact on emission intensity.

Emission intensity relates to the amount of CO2e produced per kilogram of product. For New Zealand, the emission intensity of our agricultural product is relatively low – amongst the best in the world. In this respect, there is some opinion that New Zealand should continue to concentrate on reducing its agricultural emission intensity.

The issue that arises is that often the easiest way to reduce emission intensity is to intensify the farm system. While this approach will reduce emission intensity, it usually also increases total or absolute emissions, which is what the proposed carbon levy will be based on.

A scenario was run on each of the dairy farm models, whereby the current farm system was intensified by (a) increasing the stocking rate slightly, and (b) increasing the amount of bought-in supplement.

- For the Canterbury farm, stocking rate was increased from 3.5 cows/ha to 3.7 cows/ha, and the bought-in supplement doubled from 15% of feed offered to 30%.
- For the Waikato farm, stocking rate was increased from 2.9 cows/ha to 3.1 cows/ha. And bought-in supplement again doubled from 21% of feed offered to 41%.

Table 5: Impact of intensifying the farm system

Canterbury	Cows Wintered 1 July	Stocking rate (cows/ ha)	Milk solids /peak cow	Total CO_2e emissions (T/ha)	Total GHG % change from Base	EBITDA ($ha/yr)	EBITDA % change from Base	Emission Intensity (kg CO2e/kg MS)	% Change from Base
Base model	810	3.5	443	13.1		$8,273		8.7	
High Input	860	3.7	516	16.4	25%	$10,095	22%	8.2	-5.7%
Waikato									
Base model	371	2.9	393	11.7		$6,100		10.8	
High Input	396	3.1	458	14.5	24%	$6,531	7%	10.4	-3.7%

What this shows is that intensifying the farm system has reduced the emission intensity by 4-6%, whereas total emissions, and therefore the levy, have increased by 24-25%.

It is important to note that the "reduce cows by 10%/increase productivity" scenario also reduced emission intensity, down to 8.1kg CO_2e/kg milk solids for Canterbury, and 10.4kg CO_2e/kg MS for Waikato. All of the scenarios which endeavoured to reduce total emissions also reduced emission intensity.

5.2 Sheep and beef.

Sheep and beef modelling focused on reducing the amount of dry matter consumed. To achieve this stock numbers were reduced, while endeavouring to improve animal productivity and to ensure the financial viability of the farm business.

Table 6: Physical parameters of scenarios (sheep and beef)

NI Hill Country	Pastoral Area (ha)	Forestry Area (ha)	Stocking Rate (SU/ha)	Breeding Ewes	Breeding Cows	Lambing %	Calving %	Av Lamb CW (kg)	Finished Cattle CW (kg)
Base	548		9.6	1,754	164	129	82	18.2	321
Reduce SR 10%	548		8.6	1,579	148	129	82	18.2	321
Reduce SR 10% Increase productivity	548		8.8	1,579	148	135	86	19.5	335
Reduce Breeding Ewes 20%, Increase Lamb %	548		8.9	1,403	164	160	82	18.1	330
Replace Breeding cows with finishing bulls	548		9.6	1,754		129		18.2	305
Replace Breeding cows with finishing bulls (lower Stocking Rate)	548		8.9	1,754		129		18.2	305
Plant 10% of farm in forestry (pines)	493	55	10.1	1,666	156	129	82	18.2	321

SI Intensive	Pastoral Area (ha)	Forestry Area (ha)	Stocking Rate (SU/ha)	Breeding Ewes	Dairy Grazers	Lambing %	Av Lamb CW (kg)		
Base	256		13.3	2,400	77	131	18.4		
Reduce SR 10%	256		12.0	2,160	69	131	18.4		
Reduce SR 10% Increase productivity	256		12.4	2,160	77	136	20.6		
Alter Sheep: Cattle Ratio	256		13.1	1,900	160	131	18.4		
Plant 10% of farm in forestry (pines)	230	26	13.3	2,160	69	131	18.4		

Table 7: Sheep and beef GHG emissions

	CH_4 emissions (TCO_2e/ha)	N_2O emissions (TCO_2e/ha)	Forestry Offset (T CO_2e/ forest ha)	Total CO_2e emissions (T/ha)	Total GHG % change from Base	EBITDA ($ pastoral ha/yr)	EBITDA % change from Base model
NI Hill Country							
Base	2.73	0.64		3.4		$363	
Reduce SR 10%	2.47	0.58		3.1	-9%	$285	-22%
Reduce SR 10% Increase productivity	2.50	0.59		3.1	-8%	$372	2%
Reduce Breeding Ewes 20%, Incr Lamb %	2.55	0.6		3.2	-7%	$387	7%
Replace Breeding cows with finishing bulls	2.75	0.62		3.4	0%	$660	82%
Replace Breeding cows with finishing bulls (lower Stocking Rate)	2.53	0.57		3.1	-8%	$568	56%
Plant 10% of farm in forestry (pines)	2.88	0.68	22.1	1.3	-60%	$363*	0%
SI Intensive							
Base	3.62	0.85		4.5		$990	
Reduce SR 10%	3.26	0.77		4.0	-10%	$829	-16%
Reduce SR 10% Increase productivity	3.32	0.79		4.1	-8%	$1,087	10%
Alter Sheep: Cattle Ratio	3.63	0.84		4.5	0%	$1,250	26%
Plant 10% of farm in forestry (pines)	3.62	0.85	18.9	2.6	-43%	$887*	-10%

*Includes annuity from forestry

5.2.1 Discussion on scenarios.

5.2.1.1 North Island hill country.

(i) Reduce stock numbers by 10%. As per the dairy scenario, stock numbers were reduced by 10%, with no change in per animal productivity. The result is a somewhat linear reduction in GHG emissions and a significant reduction in farm profitability.

(ii) Reduce stock numbers by 10%, increase productivity. The increase in productivity was reflected via:

- Increase in lambing % from 129% to 135%
- Increase in calving % from 82% to 86%
- Increase in average lamb carcass weight of 1.3kg
- Increase in finished cattle carcass weight of 14kg.

In the first component of this scenario, the result was relatively good reduction in GHG emissions, while holding the level of farm profitability.

(iii) Reduce breeding ewe numbers by 20%, increase lambing % (from 129 to 160). This scenario achieved a reasonable reduction in GHG emissions, while providing a small lift in farm profitability. While this scenario is feasible, it would involve a range of changes in farm management, discussed in Section 7.

(iv) Replace breeding cows with finishing bull beef. There are two sides to breeding cows; on the negative side they are a large animal requiring a lot of maintenance feeding, with a relatively low productivity level (i.e. producing 0.8-0.9 calf/year). On the positive side they are a very good means of controlling pastures and maintaining pasture quality. The scenario is about replacing them with a much more productive animal, and within this there are two aspects to the scenario:

- The changes resulted, the farm finishes 344 bulls to an average weight of 305 kg CW (buys in 100kg LW weaners in November/December, finishing them as rising 2-year-olds before their second winter). In this scenario, the stocking rate of the farm is the same as the base farm. As can be seen in Table 7, there is no difference in GHG emissions, but farm profitability has increased significantly.
- This raises an important issue with mitigating GHG emissions on-farm; namely that stocking rate is key rather than stock type. A stock unit is an animal which eats 6,000 megajoules of metabolisable (MJME) energy per year. So if a farm changes its stock type, but the stocking rate remains the same, then total DM consumed remains the same, as does GHG emissions.
- In the second component of this scenario, the stocking rate was reduced (finishing 294 bulls), thereby achieving a reduction in GHG emissions, while still lifting farm profitability.

5.2.1.2 South Island intensive.

(i) Reduce Stock numbers with/without change in productivity. This shows the same results as per the North Island Hill Country scenario. The changes in the "increase productivity" scenario were:

- Lift lambing % from 131 to 136
- Increase lamb CW by 2.2 kg

This scenario again gave a modest reduction in GHG emissions, while improving profitability.

(ii) Changing the sheep to cattle ratio involved changing it from 86:14 to 70:30, with breeding ewes reduced to 1,900, and dairy grazers increased from 77 to 160. The resultant stocking rate was (essentially) the same as the base farm which meant no change in GHG emissions, while farm profitability increased.

5.2.1.3 Forestry as an offset.

For both sheep & beef models, 10% of the pastoral area of both were assumed to be planted in pines, as a carbon offset. Note the "10%" is an arbitrary figure used to illustrate the issue. It does not equate to "carbon neutral", which is a different issue.

For the NI Hill Country farm, the forest was planted on the less productive steeper area of the farm, such that a 10% planting resulted in a 5% reduction in stock numbers, whereas for the SI Intensive farm, being much smaller, the forestry area was assumed to be planted on fully productive land, hence a 10% planting resulted in a 10% reduction in stock numbers.

For the NI Hill Country farm, the forestry planting meant that the stocking rate on the remainder of the pastoral area actually increased, resulting in an increase in GHG emissions per pastoral hectare, but a reduction over the whole farm.

The carbon sequestration rate for each farm was based on the MPI look-up table for each region, assuming the averaging regime which came into place as of 1 January this year. Which means that the carbon sequestration from the forest can be claimed for only 16 years.

As can be seen from Table 7, assuming a direct offset, net GHG emissions reduced by 60% on the NI Hill Country farm, and 43% on the SI Intensive farm. Note that the EBITDA for each farm, for this scenario, also included an estimated annuity return from the forest as a production forest.

The profitability of forestry is very site-dependent, depending where on the farm it is located, which impacts on roading and harvesting costs, and the distance of the farm to a mill or port, which impacts transport costs. Excluding the value of carbon, the returns from production forestry in some instances can be higher than for pastoral returns, particularly on low pastoral productive hill country, whereas planting forestry on higher pastoral productive land often results in a lower return compared to the pastoral operation.

Note: using forestry as a carbon offset under the ETS is that it is a very technical area, and farmers would be strongly recommended to seek expert advice.

5.3 Emission intensity.

Emission intensity is the amount (kg) of CO_2e emitted per kilogramme of product and is a direct indication of the "carbon efficiency" of production. New Zealand pastoral production is among the most efficient in the world with respect to emission intensity.

However, while emission intensity is important, reducing GHG emissions at a farm level requires a reduction in total (or absolute) emissions. Care is needed, as per the discussion in Section 6.1.2 where intensifying the farm system gave a reduction in emission intensity, but a large increase in total emissions.

The impact of the various scenarios modelled on emission intensity are shown in Table 8 and indicate a poor relationship between changes in absolute emissions and emission intensity, but as a generalisation, many strategies to reduce total emissions also tend to reduce emission intensity.

5.3.1 Emission intensity – energy and protein corrected milk.

Whilst the New Zealand dairy industry measures milk production in "milk solids" (MS) and as a result related emission intensity to this measure, many other countries use "Energy and Protein Corrected Milk" (EPCM). Many countries, and as an international comparison, use "Energy and Protein Corrected Milk" (EPCM).

The basis for EPCM is milk with a fat content of 4% and a protein content of 3.3%. On average, New Zealand milk solids are 4.9% fat, and 3.8% protein. The conversion ratio to convert to EPCM is 1.3213.

This means the base emission intensity per kg EPCM for the Waikato farm is 8.2 kg CO_2e/kg, and for Canterbury it is 6.6 kg CO_2e/kg.

Table 8: Emission intensity figures

Dairy	Waikato			Canterbury		
Scenario	Emission Intensity (kg CO_2e/kg MS)	% Change from Base	% Change from Base (Total Emissions)	Emission Intensity (kg CO_2e/kg MS)	% Change from Base	% Change from Base (Total Emissions)
Base model	10.8			8.7		
Reduce SR 10%, no improvement in productivity	10.9	0.9%	-9%	8.7	0.0%	-11%
Reduce SR 10%, Increase per cow production	10.5	-2.8%	-3%	8.3	-4.6%	-6%
1/2 Nitrogen	10.6	-1.9%	-3%	8.4	-3.4%	-9%
No Bought-in Supplement	10.9	0.9%	-19%	8.6	-1.1%	-14%
Reduce Replacements to 15%	10.8	0.0%	0%	8.7	0.0%	-1%
High Input	10.4	-3.7%	24%	8.2	-5.7%	25%

Sheep & Beef	NI Hill Country			SI Intensive		
Scenarios	Emission Intensity (kg CO_2e/kg CW)*	% Change from Base	% Change from Base (Total Emissions)	Emission Intensity (kg CO_2e/kg CW)*	% Change from Base	% Change from Base (Total Emissions)
Base	22.1			17.9		
Reduce SR 10%	22.3	1%	-9%	17.9	0%	-10%
Reduce SR 10% Increase productivity	21.0	-5%	-8%	16.0	-11%	-8%
Reduce Breeding Ewes 20%, Increase Lamb %	20.8	-6%	-7%			
Replace Breeding cows with finishing bulls	14.1	-36%	0%			
Replace Breeding cows with finishing bulls (lower Stocking Rate)	15.1	-32%	-8%			
Plant 10% of farm in forestry (pines)	22.6	2%	-60%	18.0	0%	0%
Alter Sheep: Cattle Ratio				16.9	-6%	-43%

*CW = carcass weight

5.4 Impact of proposed carbon levy.

The government is proposing that agricultural emissions be priced at a farm level from 2025 onwards. Currently the pricing for this has not been promulgated, so for the purposes of this analysis, the prices proposed by He Waka Eke Noa in their proposal to government have been used. These are:

- 2025: 11c/kg/CH_4, and \$4.25/T CO_2e for N_2O
- 2030: 17-35c/kg CH_4, and \$13.80/T CO_2e for N_2O

The suggested pricing formula is: A+B-I-C, where:

A = price for methane

B = price for nitrous oxide

I = an incentive payment for using new mitigation technologies

C = value of forestry offset, priced at the ETS price

Table 9: Levy impact dairy farms

	Total Tonnes CH_4	Total Tonnes N_2O (as CO_2e)	2025 Levy	2030 levy (low CH_4)*	2031 levy (High CH_4)**
Canterbury					
Base model	93.2	722.3	$13,322	$25,812	$42,588
Reduce SR 10%, no improvement in productivity	82.9	652.4	$11,897	$23,104	$38,035
Reduce SR 10%, Increase per cow production	87.6	675.7	$12,509	$24,218	$39,987
1/2 Nitrogen	86.7	605.8	$12,109	$23,095	$38,697
No Bought-in Supplement	80.2	629.1	$11,490	$22,307	$36,735
Reduce Replacements to 15%	92.3	722.3	$13,219	$25,653	$42,262
High Input	118.4	862.1	$16,684	$32,019	$53,324
Waikato					
Base model	46.4	348.3	$6,589	$12,701	$21,061
Reduce SR 10%, no improvement in productivity	42.3	322.5	$6,025	$11,644	$19,260
Reduce SR 10%, Increase per cow production	44.9	335.4	$6,364	$12,260	$20,341
1/2 Nitrogen	45.9	309.6	$6,367	$12,080	$20,346
No Bought-in Supplement	37.3	294.1	$5,348	$10,392	$17,098
Reduce Replacements to 15%	46.4	348.3	$6,589	$12,701	$21,061
High Input	57.8	425.7	$8,166	$15,699	$26,102

*Low=17c/kg **High=35c/kg

Table 10: Levy impact sheep and beef farms

	Total Tonnes CH_4	Total Tonnes N_2O (as CO_2e)	Forestry* Credits (2025)	Forestry Credits (2030)	Net 2025 Levy	Net 2030 levy (low CH_4)**	Net 2031 levy (High CH_4)***
NI Hill Country							
Base	59.8	350.7			$8,073	$15,013	$25,784
Reduce SR 10%	54.1	317.8			$7,306	$13,590	$23,336
Reduce SR 10% Increase productivity	54.8	323.3			$7,402	$13,778	$23,642
Reduce Breeding Ewes 20%, Incr Lamb %	55.9	328.8			$7,546	$14,040	$24,101
Replace Breeding cows with finishing bulls	60.3	339.8			$8,075	$14,936	$25,787
Replace Breeding cows with finishing bulls (lower Stocking Rate)	55.5	312.4			$7,428	$13,738	$23,721
Plant 10% of farm in forestry (pines)	56.8	335.2	$103,434	$167,929	-$95,762	-$153,648	-$143,425
SI Intensive							
Base	45.8	217.6			$5,002	$9,305	$15,977
Reduce SR 10%	41.3	197.1			$4,510	$8,395	$14,404
Reduce SR 10% Increase productivity	42.1	202.2			$4,599	$8,570	$14,690
Alter Sheep: Cattle Ratio	45.8	215.0			$5,003	$9,287	$15,977
Plant 10% of farm in forestry (pines)	41.1	195.5	$41,714	$67,724	-$37,219	-$59,364	-$53,369

*Assumes the forestry credits are sold at $85/NZU in 2025, $138/NZU in 2030
**Low=17c/kg ***High=35c/kg

As can be seen from Tables 9 and 10, the various scenarios only have a relatively modest impact on the levy – in proportion to the reduction in GHG emissions.

In Table 10, the addition of forestry credits significantly offsets the carbon levy. Under the averaging regime, carbon credits from pine forests are available for 16 years. After this, the ability to offset is finished. One option would be to only sell sufficient credits to pay the levy within that year, keeping the remaining credits in the "bank". Under this approach, the credits would cover the levy for 30+ years.

Another aspect of the proposed levy is to consider it as a proportion of EBITDA.

Table 11: Dairy farms: Levy as a proportion of EBITDA

	2025 Levy as a % of current EBITDA	2030 (low) Levy as a % of current EBITDA	2030 (high) Levy as a % of current EBITDA
Canterbury			
Base model	0.7%	1.3%	2.2%
Reduce SR 10%, no improvement in productivity	0.7%	1.3%	2.2%
Reduce SR 10%, Increase per cow production	0.6%	1.2%	2.0%
1/2 Nitrogen	0.7%	1.3%	2.1%
No Bought-in Supplement	0.6%	1.2%	2.0%
Reduce Replacements to 15%	0.7%	1.3%	2.2%
High Input	0.7%	1.4%	2.3%
Waikato			
Base model	0.8%	1.6%	2.7%
Reduce SR 10%, no improvement in productivity	0.9%	1.7%	2.8%
Reduce SR 10%, Increase per cow production	0.8%	1.6%	2.6%
1/2 Nitrogen	0.9%	1.6%	2.7%
No Bought-in Supplement	0.7%	1.4%	2.4%
Reduce Replacements to 15%	0.8%	1.6%	2.7%
High Input	1.0%	1.9%	3.1%

Table 12: Sheep and beef farms: Levy as a proportion of EBITDA

	2025 Levy as a % of current EBITDA	2030 (low) Levy as a % of current EBITDA	2030 (high) Levy as a % of current EBITDA
NI Hill Country			
Base	4.1%	7.5%	12.9%
Reduce SR 10%	4.7%	8.7%	14.9%
Reduce SR 10% Increase productivity	3.6%	6.8%	11.6%
Reduce Breeding Ewes 20%, Incr Lamb %	3.6%	6.6%	11.4%
Replace Breeding cows with finishing bulls	2.2%	4.1%	7.1%
Replace Breeding cows with finishing bulls (lower Stocking Rate)	2.4%	4.4%	7.6%
SI Intensive			
Base	2.0%	3.7%	6.3%
Reduce SR 10%	2.1%	4.0%	6.8%
Reduce SR 10% Increase productivity	1.7%	3.1%	5.3%
Alter Sheep: Cattle Ratio	1.6%	2.9%	5.0%

The key thing to note from Tables 11 and 12 is that sheep & beef farms are proportionally much more exposed to the proposed carbon levy. While sheep & beef farms have a lower per hectare GHG emission compared to dairy farms, they have many more hectares. For the national average sheep & beef farm, total GHG emissions are 67% higher than the total emissions from the national average dairy farm, whereas the profitability of the average sheep & beef farm is 20-30% of the average dairy farm. Hence the greater vulnerability to the carbon levy.

6. FARM MANAGEMENT CONSIDERATIONS

While the modelling shows there are a range of possible mitigation options, it is also important to consider the impact of these at a actual farm level.

6.1 Pasture quality.

It is often much easier to maintain pasture quality at a higher stocking rate. As many of the emissions mitigation options involve reducing stocking rates, the requirement for better grazing management as a means to maintain high pasture quality is crucial. If pasture quality drops, then production will decrease markedly in line, meaning that farm profitability will also reduce.

In some of the modelling outside of this analysis, a lower pasture quality was simulated by reducing pasture metabolisable energy (ME) over the spring by 10%. In this instance production dropped such that it was very difficult to even achieve similar production to the base farm scenario.

Better pasture management would mean a combination of such things as; faster rotation, more/better subdivision, dropping surplus feed out of the rotation to be made as supplement, or topping pastures.

6.2 Overall farm management.

Many, if not all of the mitigation options would require changes in farm management to ensure the new system operated well. A good example of this is the "reduce breeding ewes by 20%/increase lambing%" for the NI Hill Country farm.

This option would require significant changes to ensure it is implemented successfully. For example:

- The breeding ewes would need to be of sufficient genetic worth to lamb at 160%
- Replacement ewe hoggets would need to be grown through to achieve target liveweights
- Ewes would need to be in good condition at tupping
- The increased lambing % would mean a lot of multiples at lambing, meaning that feeding ewes sufficiently would be a prerequisite to ensure good lamb growth.
- Even with good feeding over lambing, the multiple lambs would be at a lower liveweight at weaning compared to singles, which in turn means that weaned lambs would need to go onto very good feed to ensure good liveweight gains.
- Having a lot of multiple lambs over lambing would mean the system is more vulnerable to climatic events such as storms or cold snaps, and therefore good shelter would be necessary.

Therefore, while the new system is more profitable with a lower GHG profile, it is also riskier. Many farms could take up to 5-10 years to ensure the implementation of such a system – many of the GHG mitigation options would take time to successfully implement, so there are seldom any overnight fixes.

In many respects the objective is to operate a more efficient farm system at a lower stocking rate, and each farm is different in its response to such options, depending on the current intensity of the farm system, and how it is managed.

7. CONCLUSION

Overall, farm system adjustments can result in a reduction in GHG emissions. Changes to stocking rates are the most common/successful/impactful way to influence GHG emissions by way of reducing DM intake. As per the scenarios modelled in this report, GHG emissions can be reduced by up to 10%, with variable impacts on farm profitability.

Reducing stocking rate on its own is unlikely to be successful unless the farm is drastically overstocked, as it has a major negative impact on farm profitability. If a "lower stocking rate" approach is considered, then it is imperative that the productivity of the remaining animals be improved in order to maintain profitability.

Forestry as a carbon offset can be considered, particularly on hill country farms, which are very likely to have lower pastoral productive areas which could be planted up. It is less of an option on smaller more intensive farms and dairy farms, where there are often limited areas of lower productive land. Certainly, forestry as an offset can have a significant impact, particularly on the cost of the levy. As noted, this is a technically complex area, and good advice is recommended.

The carbon levy due to be introduced in 2025 will have some impact, but until the prices are known it is difficult to be too definitive. Certainly, as noted in this report, sheep & beef farms will be more vulnerable to the levy.

Lastly, but of critical importance, is the need to think through and implement improvements in farm management if mitigation options are going to result in system changes. As noted earlier, pasture management under a lower stocking rate requires a definite improvement, otherwise the system could go backwards rapidly. It also takes time to make such system changes, so there are no quick fixes, and every farm will react differently depending on the starting level of intensity and efficiency.

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