Is it worth It?

Costs and benefits of reducing greenhouse gas emissions on sheep and beef farms.

Kellogg Rural Leadership Programme | Course 50 2023

Tim Bathgate

I wish to thank the Kellogg Rural Leadership Programme Investing Partners
for their continued support.

Strategic Partners

Programme Partners

Service Partners

Disclaimer

In submitting this report, the Kellogg Scholar has agreed to the publication of this material in its submitted form.

This report is a product of the learning journey taken by participants during the Kellogg Rural Leadership Programme, with the purpose of incorporating and developing tools and skills around research, critical analysis, network generation, synthesis and applying recommendations to a topic of their choice. The report also provides the background for a presentation made to colleagues and industry on the topic in the final phase of the Programme.

Scholars are encouraged to present their report findings in a style and structure that ensures accessibility and uptake by their target audience.

This publication has been produced by the scholar in good faith on the basis of information available at the date of publication. On occasions, data, information, and sources may be hidden or protected to ensure confidentially and that individuals and organisations cannot be identified.

Readers are responsible for assessing the relevance and accuracy of the content of this publication & the Programme or the scholar cannot be liable for any costs incurred or arising by reason of any person using or relying solely on the information in this publication.

This report is copyright, but dissemination of this research is encouraged, providing the Programme and author are clearly acknowledged.

Scholar contact details may be obtained through the New Zealand Rural Leadership Trust for media, speaking and research purposes.

Executive Summary

Why should sheep and beef farmers decrease their on-farm greenhouse emissions and what is the cost in doing so?

Climate change is directly linked to greenhouse gas emissions and is something that cannot be ignored. Major weather events, affecting the primary sector have highlighted the need for change. 50% of NZ emissions come from the agriculture sector, but at what cost will emissions reduction have on the farmer? Will the potential economic benefits outweigh the costs of current mitigation methods?

This report seeks to inform sheep and beef farmers, which of the current mitigation methods have the least effect on profitability and what economic benefits they may gain in doing so. The focus is on the cost and benefits of on-farm profitability, so concentrates on costs, income streams and potential premiums linked to the reduction on on-farm emissions.

Scenario analysis has been used to model greenhouse gas reduction methods that are currently available on sheep and beef properties, other literature was reviewed to compare methodology and results. A literature review was also used to assess benefits of reducing emissions.

While planting forestry offsets and reducing stocking rates are the mostly available methods, the scenario analysis also explored a combination of both, combined with increases in reproductive rates of the remaining stock units on hand.

Plantation forestry is an opportunity for sheep and beef farmers to use lesser productive areas of their property and along with reducing emissions, provides another revenue stream.

Reducing stocking rates is a solution which requires little initial investment but unless production per head is increased, has a large impact on profitability. A combination of forestry and reduced stocking rates, has the largest emissions reduction but the potential earnings from forestry will not be realised unless production has been increased. This may be unachievable depending on the underlying features of the property.

The demand for reduced emissions is mainly from leadership in organisations such as governments, processors and banks. This is driven by obligations to provide feedback to stakeholders on environmental objectives and align with targets of the Paris Agreement. There is no huge demand for low-emissions meat from consumers as they place greater importance on other factors such as the quality of meat.

An introduction of an on-farm emissions levy or introduction of Agriculture in the emissions trading scheme, in order for NZ to achieve their Paris Agreement obligations would be the greatest incentive to currently reduce emissions.

Based on the analysis, it is recommended that the following is taken into consideration when adopting a method to reduce on-farm emissions:

- ✖ the saving of an emissions levy that the method would provide;
- ✖ if the cost of the mitigation method is more than the expected emissions levy price;
- ✖ reviewing the cost of mitigation on the basis of kilogram of meat produced on farm to determine what premium would be required;
- ✖ if planting forestry, assessment of the expected return on investment and minimum return per hectare required to achieve this;
- ✖ if reducing stocking rates, the ability and extra costs of increasing production per head;
- ✖ demand for reduced emissions from organisations that directly affect the farm business, and
- ✖ consumer demand for low emissions products and their willingness to pay a premium.

Acknowledgements

I appreciate the support from my employers, Gaye Cowie, Susie Johnstone and Jim Johnstone at Shand Thomson for supporting me and allowing time to complete the project and my colleague Karen Morgan for her expertise.

Thanks to the time from Erica van Reenan and Louis Batley from AgFirst and Kellogg Cohort 49 Scholar, Duane Redward for assisting with this topic.

Thanks Patrick Aldwell, Lisa Rogers, Scott Champion, Annie Chant and the team from Rural Leaders for providing with the opportunity to participate in the Kellogg Programme and complete this report.

Special thanks to everyone in Kellogg Cohort 50 who have heightened my experience of the leadership programme and supported me in the completion of this project.

Table of Contents

1 Introduction

It seems to be a common rhetoric in New Zealand that approximately 50% of our greenhouse gas emissions (GHG) come from the agricultural sector (Guenther et al., 2023).

It is also commonly accepted that our grass-fed systems make us one of the most carbon efficient food producers in the world and that most of the emissions come from methane which is a short-lived gas. This report concentrates on sheep and beef farms and the chart below shows the breakdown of emissions showing that sheep contribute 11.8% and beef cattle 9.0% to NZ's greenhouse gas inventory (New Zealand Agricultural Greenhouse Gas Research Centre, 2022). 88% of this is methane with the balance being nitrous oxide.

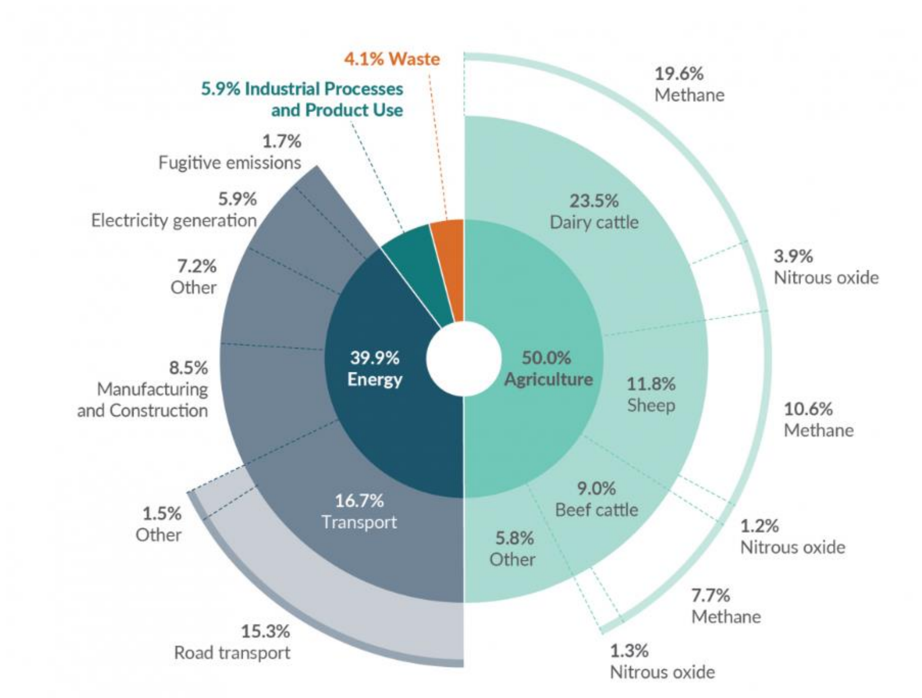


Figure 1 : Breakdown of each sectors contribution to NZ Greenhouse Gas Inventory (Source: New Zealand Agricultural Greenhouse Gas Research Centre, 2022)

The parliamentary commissioner for the Environment told the New Zealand Agricultural Climate Change Conference "It is not a credible negotiating position to say that our largest contribution to warming is off limits when we have the option to reduce it" (Upton, 2023). NZ has set its targets under the Paris Agreement but have the policy makers considered the impact on farm profitability?

There has been much publicity regarding NZ being a global leader when it comes to agricultural emissions and NZ products marketed as low emissions, but are consumers actually interested in the emissions footprint of their food?

While the wider social and environmental impacts of climate change are important, farming cannot survive without profitability. Farmers may be unwilling to make emissions reductions if there is no long-term gain for themselves in doing so. This report examines what it may cost to reduce on-farm emissions and if there is enough benefit in doing so.

2 Objectives

This report seeks to inform sheep & beef farmers (particularly in the Clutha District), of some of the most efficient ways to reduce on-farm greenhouse gases and what economic effects this may have on their business.

Why should farmers decrease their on-farm emissions and at what cost?

A cost-benefit analysis helps decision-makers determine whether a proposal is economically justified and whether the benefits outweigh the costs.

The purpose of this report is to:

- evaluate some current methods available to reduce greenhouse gas emissions;
- assess the costs and potential income from various reduction methods;
- review the reasons why a farmer may want to, or be required to reduce greenhouse gas emissions, and
- determine if the benefits outweigh the current cost of reducing emissions

This report considers cost and benefits on farm from an economic perspective and does not consider the long-term impacts of reducing emissions or plantation forestry on society or the economy as a whole.

The methods focus on forestry and livestock reduction and do not consider changing fertiliser or fuel use to reduce emissions. While there are methane-reducing technologies in development, these have not been considered for the purposes of this report.

3 Methodology

3.1 Scenario Analysis

Section one involves economic modelling, using a hypothetical sheep and beef property based on Clutha District averages to determine the potential outcomes of various suggested scenarios. Scenario analysis is a technique used to assess the potential outcomes of different future situations. The details of the base farm and the several scenarios are detailed in appendix 1 and the results are discussed in section 4.3.

The purpose of the scenario analysis is to determine which of the emissions reduction methods are the most cost efficient. This compares the percentage change in economic returns to the changes in greenhouse gas emissions.

To assess the economic return, Net Present Value (NPV) has been calculated. The NPV is the value of the cash flow if a particular discount rate is applied to all future costs and revenue. The discount rate used for this analysis is 5% which is common in other literature and is the recommended rate by NZ Treasury.

The on-farm emissions for livestock farming have been calculated using the Beef and Lamb NZ (BLNZ) emissions calculator (Beef & Lamb New Zealand, 2023). Most of the greenhouse gases used on farm are methane and nitrous oxide (New Zealand Agricultural Greenhouse Gas Research Centre, 2022). The calculator uses criteria for proposed emissions pricing to convert methane and nitrous oxide to carbon dioxide equivalents (CO_{2e})[1]. This is a figure used in international targets and allows for comparisons when considering carbon dioxide sequestration to offset on-farm emissions.

Any offsets from forestry against these emissions and the removal of carbon at the year of harvest were calculated based on the carbon lookup tables for the emissions trading scheme (Ministry for Primary Industries, 2023). The carbon sequestration has been calculated for each year of the forestry cycle and the deforestation at year 28 has been determined by adjusting for the safe level of carbon still available with the residual wood and below ground roots

[1] Tonne of CO2e = tonne methane x 25 and tonne Nitrous Oxide x 298

(Ministry for Primary Industries, 2023). This method is known as the carbon stock change method and was until recently used to calculate emissions under the emissions trading scheme (ETS).

The scenario analysis has limitations as it relies on many assumptions. The limitations are listed in section 3.4 and the assumptions for each scenario are included in appendix 1.

3.2 Literature reviews

The literature review for section four will be used to investigate other research completed on this topic to:

- ✖ review greenhouse gas reduction methods available on sheep and beef properties including those beyond the scope of the scenario analysis;
- ✖ evaluate methodology for scenario analysis including discount rates, and
- ✖ compare and contrast results from the scenario analysis and different literature

These results will be compared to the results of the scenario analysis to identify any trends in reduction methods.

The literature review for section five will identify any global trends demanding lower greenhouse gas emissions on farm, including demand for premium products, market and trade access and access to capital.

3.3 Thematic Analysis

Thematic analysis is applied to both the scenario analysis and literature reviews to identify themes relating to methodology using the six steps outlined in Braun & Clarke (2006). A mind map used to develop the themes is in appendix 6.

3.4 Limitations

- ✖ The base farm is established based on industry average area, stocking rate, lambing percentage and earnings before interest and tax (EBIT). This is based on average figures across the 2020-2022 years and sourced from Shand Thomson (2022).
- ✖ Linear assumptions have been made regarding changes in profitability e.g. the decreased EBIT as a result of reduced stocking rate is calculated relative to the remaining stock units on farm.
- ✖ Estimated yields and prices for forestry have been sourced from MPI (Ministry of Primary Industries, 2023) but will depend on the location of the forest and market prices at the time of harvest.
- ✖ Assumptions are made with regard to forestry costs involved and are detailed in appendix one. While these have been sourced from local forestry consultants and harvesters, costs will vary depending on location and accessibility. Some sensitivity analysis has been performed based on net return per hectare.
- ✖ Each scenario determines the present value over a 28-year cycle. In reality the forester may choose to extend the cycle longer than 28 years.
- ✖ The forestry scenarios only consider the potential return and emissions from the first cycle. A longer term approach would also consider this over the following cycles.
- ✖ Sequestration is based on carbon lookup tables calculated for the purposes of the ETS. In some emissions reduction schemes more scientific approaches are used to measure sequestration.
- ✖ Fertiliser inputs remain the same throughout each of the scenarios but in reality this will change year-on-year, particularly in the scenarios which involve increasing production.
- ✖ The livestock reconciliations are linear and do not account for large changes in numbers year-on-year (except if selling capital livestock). The reconciliations account for deaths and missing of 5% while in reality, this will change depending on seasonality.

4 Cost of Emissions Reduction Methods

4.1 Literature Review

The purpose of this literature review was to define on farm options to reduce GHG emissions, review methodologies, compare and contrast results of existing work and determine any mitigation options that are beyond the scope of this scenario analysis.

4.1.1 Evaluation of Methodologies Used

Literature was reviewed to compare methodologies for calculating returns and greenhouse gas emissions.

van Reenen (2019) considered scenarios on sheep and beef farms on East Coast of the North Island, Central North Island and Otago and Journeaux & Kingi (2020) investigated mitigation methods for two case study farms in Central North Island. While these were actual properties used as case studies, Reisinger et al. (2017) varried this by developing a base farm based on BLNZ Economic Survey data.

In all instances, foretsry returns were calculated as Net Present Value.

Reisinger et al. (2017) recognised that the profitability of a forest operation needed to be converted to an equivalent annual return on investment and is reflected in the discount rate used. The discount rate of 5% was used to recognise that climate change investments have a high and long-term societal benefit.

van Reenen (2019) also uses a discount rate of 5% to calculate net present value to overcome the long-term timeframe from a forestry investment and Journeaux et al. (2022) applied a discount rate of 5% to all future costs and revenue.

The return over a 28-year cycle was also a common analysis across the literature. In all instances, scenarios were designed using software and the MPI forestry carbon lookup tables for sequestrtaion offsets.

Literature involving solely forestry was also reviewed to compare methodology. Journeaux et al. (2022) developed representative farms in Northland and Hawkes bay also based on BLNZ averages and used a 5% discount rate to calculate net present value.

Journeaux & Kingi et al. (2022) calculates carbon sequestration based on the new averaging scheme for the ETS. The modelling by Reisinger et al. (2017) allowed for "safe carbon" sequestration by trees as this was commonly used before the recent introduction of the averging method.

4.1.2 Forestry

Planting a portion of a property to plantation forestry is an option that has been considered in other literature. Reisinger et al. (2017) found that placing 10% of the farm area into forestry would reduce net emissions on the South Island hill country farm by 14%.

In this case, it was considered that the forestry area would take out a portion of productive land, therefore there would be a reduction in EBIT from the pastoral operations. A scenario involving the introduction of forestry on marginal land only, resulted in emissions reductions of 7%-12%. It was noted however that due to variable profitability across sheep and beef farms, those who have lower existing production, the addition of forestry would probably improve overall profitability.

van Reenen (2019) assessed an extensive sheep and beef in Otago however the only option considered was retiring a significant area to native vegetation. This resulted in a reduction in a 46% reduction in GHG emissions and EBIT by 8.8%. While this is specific to the region, it cannot be compared to this reports scenario analysis, as native forestry is not harvested and has different emissions offsets.

van Reenen (2019) also considered retiring farm land to production forestry on North Island hill country properties. The East Coast scenario reduced emissions by 12% and increased profitability by 7%. The Central North Island scenario resulted in a 57% reduction in emissions but with a 0.7% increase in profitability.

These variable changes recognise the difference in land use capabilities and the change in profitability varies depending on the underlying base profitability and operations of the farm.

Journeaux & Kingi (2020) analysed planting 13% of the farm area to forestry on both properties. As this was a large area for each of the properties, the reduction in emissions was significant (105%-108%) while both resulted in a reduction in EBIT (7%-15%). The large emissions reduction was also as a result of the use of averging for emissions offsets as mentioned above and no emissions deficit as a result of deforestation at year of harvest.

4.1.3 Reduce Stocking Rates

For both properties assesed in Journeaux & Kingi (2020) a 10% decrease in stocking rate saw a decrease in GHG emissions ranging from 7%-12% but without any change in production, this resulted in a decrease in EBIT. Increasing production, while decreasing stocking rate increased profitability by 14% for one property but decreased 3% for the other, demonstrating this comes down to what is achievable for the specific aspects of each property.

Modelling by Reisinger et al. (2017) considered icnreasing the per-head performance (lambing percentage and young stock growth rates) while reducing stock. For the South Island properties, increasing productivity while reducing stock units by 8% reduced GHG emisions by 5% but increased profitability by 16%. In comparison, if there was no allowance for increased production the GHG emissions reduction would be 10% while profitability would decline by 26%. Decreasing stocking rate without improving productivity reulsted in signficiant reductions in profit (Batley et al., 2022).

While Journeaux et al. (2022) focused on forestry developents, the effects on EBIT and emissions as a result of fewer stock on the total property were considered. A 10% reduction in productive area resulted in 4%-5% change in profitability from the base and 30% reduction in area gave a 20%-30% change. In this case, returns per hectare increased as the stocking rate per effective hectare increased. GHG emissions per hectare increased with intensity however total emissions decreased (before considering offsets) due to the areas removed from forestry.

4.1.4 Other Methods

In addition to decreasing stocking rates and considering forestry plantations, Reisinger et al. (2017) also modelled replacing breeding cows with bought in beef, altering the sheep to cattle ratio and male to female cattle ratio and changing breeding cows and replacement heifers to purchase 3-month weaner bulls. The removal of Nitrogen fertiliser was considered but not modelled based on the South Island property scenarios.

Another option to consider is replacing beef breeding cows with a finishing cattle from the dairy industry. Reisinger et al. (2017) considered replacing breeding cows with bought in 3-month finishing bulls. For the South Island scenarios, emissions reductions were minor, however profitability increased by greater than 50%. It is however recoginsed that the skills required to manage beef finishing systems are specific and rely on the knowledge base on the farmer involved.

While changes to sheep/cattle and/or male/female ratios were considered by Reisinger et al. (2017), the reduction in emissions is negligible and was therefore not considered a signficant mitigation option despite the productivity increases.

van Reenen (2019) considered increasing the sheep to cattle ratio which resulted in a decrease in profitability for the East Coast property but an increase in the Central North Island property. It was recognised that the regional difference depended on land use capability but also the market and the number of animals sold to store markets. In both instances, the change saw a minimal reduction (1%-4%) in GHG emissions.

4.2 Scenarios, Results and Discussion

The scenarios reviewed in this analysis, and results are as follows:

1. Convert half of the unproductive area of the base farm to forestry
2. Convert half of the unproductive area of the base farm to forestry and decrease stocking rate by 1 stock unit/ha
3. Decrease stocking rate by 1 stock unit/ha
4. Decrease stocking rate by 1 stock unit/ha and increase lambing by 10% (over 3 years)
5. Convert half of the unproductive area to plantation forestry, decrease stocking rate by 1 stock unit/ha and increase lambing percentage by 10%

Table 1: Net present value and greenhouse gas emissions over the period and percentage change from base

Scenario	NPV	% Change	Total tonne CO2e over period	% Change
Base	$4,850,515		81,676	
1	$4,956,751	2%	67,750	-17%
2	$4,490,099	-7%	54,165	-34%
3	$4,383,863	-10%	70,604	-14%
4	$4,779,141	-1%	71,198	-13%
5	$4,939,467	2%	54,737	-33%

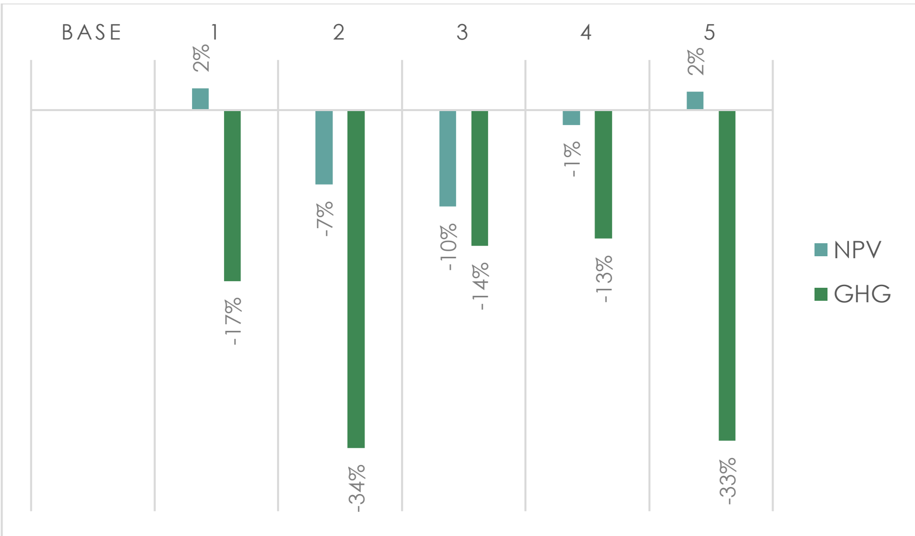


Chart 1: Percentage change in profitability and GHG Emissions Compared to the base farm

Chart 1 shows the percentage changes in profitability and GHG emissions compared to the base farm. This analysis calculates the change in profitability based on earnings before interest and tax (EBIT), which considers farm working expenses and depreciation but not the cost of debt servicing.

Results of the five scenarios tested here were mostly consistent with other literature. In the case of forestry, planting trees on marginal land resulted in either a negligible increase or a decrease in profitability together with a moderate decrease in GHG emissions. Reduction in stocking rate has the largest effect on profitability ranging from 10%-15% drop based on the above analysis and the literature review.

Scenarios two and five demonstrate that using forestry and stock reduction would result in the largest reduction in emissions. This has not been considered in any of the literature but given both methods result in moderate reduction in emissions it is expected that the emissions reduction would be significant.

Scenario's four and five shows that an increase in production of sorts, would be required to maintain the profitability of the base property. Achieving a higher lambing percentage while decreasing stocking rates and planting an area in forestry is probably the most unachievable scenario in a practical farming sense. Some of the factors to consider have been detailed in the next sections.

4.2.1 Forestry

Due to the larger unproductive areas on sheep and beef properties, particularly hill country, land use change to forestry on a proportion of the farm can be less detrimental to farm profitability than it would be on a dairy or arable property.

The model base farm is based on the Clutha District Averages (Shand Thomson, 2022). Based on this, the average ineffective area is 132ha per farm which is 6.45% of the farm area of 1,023ha. This relies on information provided by the farm owners and has not been independently measured. The Clutha District extends from Lawrence to the Catlin's, and has various land use capabilities (LUC) however most of the sheep and beef country is either LUC 3 which is cultivatable with restrictive crop types or LUC 4 which is arable but very limited crop types (Landcare Research, 2023). Most of the flat, more productive land in the Clutha District is used for dairy farming. There is therefore potential to convert part of the unproductive area on a sheep and beef farm without reducing stocking rates on farm.

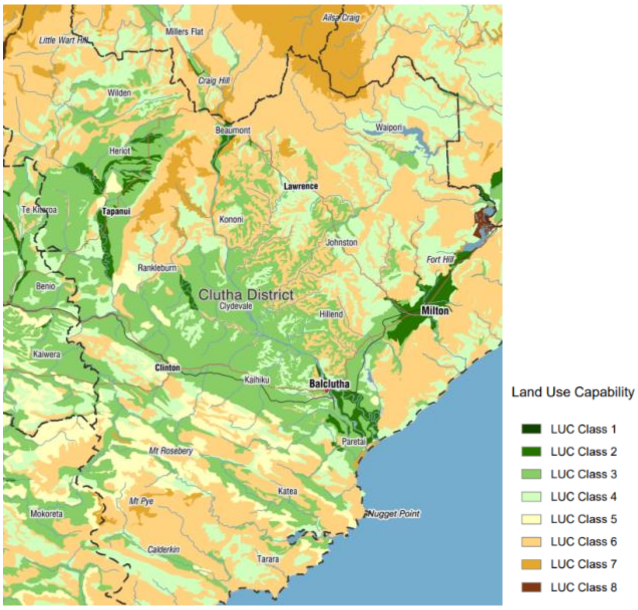


Figure 2: Land Use Classes for Clutha District (Source :Landcare Research, 2023)

Native woody vegetation is also common in the district but its presence has not been considered for this report. The base farm is assumed to have very little vegetation on non-productive land.

Three of the scenarios involved the conversion to forestry of 66ha being half of the productive area, recognising that not all of the unproductive area is suitable for planting trees.

Scenarios one, two and five all consider forestry as a potential mitigation option. Based on this analysis, scenarios one and five are more financially favourable as they show an increase in net present value with a decrease in GHG emissions. Both of these scenarios incorporate forestry into their systems, adding another income stream while reducing emissions.

The scenarios rely on the assumption that the land planted has not been used for any farming purposes while in reality it may be productive, although not at the optimum stocking rate. Scenario two incorporates a decrease in stocking rate, which may be a reality as a result of planting an area of the farm in forestry if that area was not currently completely unproductive. This scenario shows an even greater reduction in emissions from scenario one however the lower stocking rate results in a reduction in profitability of 7%.

While this results in a decrease in profitability, the decrease is not as dramatic as a reduction in stocking rates alone in scenario three. This shows that if the livestock numbers are required to be decreased for environmental reasons, there is an opportunity to offset the potential loss in income by considering on-farm forestry plantations.

Both the GHG reduction and return depend on the area that has been planted in forestry. The results in the literature review assessed the impacts on profitability of planting a portion of the property in forestry (e.g. 10%) rather than considering the unproductive area. Despite this, the results were similar, showing a moderate reduction in GHG emissions and a small increase in net present value.

One of the largest barriers to on-farm forestry is the initial investment. In the scenario, the cost of planting trees totals $141,900 ($2,150/ha) which excludes any cost of clearing existing vegetation such as broom or gorse. This is a large capital cost in the first year and other than the potential premiums received from a reduction in emissions, the only return from this investment is received at year 28.

There are however large reductions in the short term despite very little reduction in total emissions. Chart 2 shows the difference in emissions and profitability in between years one and 27 for both the forestry and reduced stocking rate scenarios. Year 28 has been left out of the chart as it is such an outlier for the forestry scenarios. If the goal was to reduce emissions within a 10-year time frame, the on-farm emissions at year 10 in the forestry scenario would be 68% less than the year one.

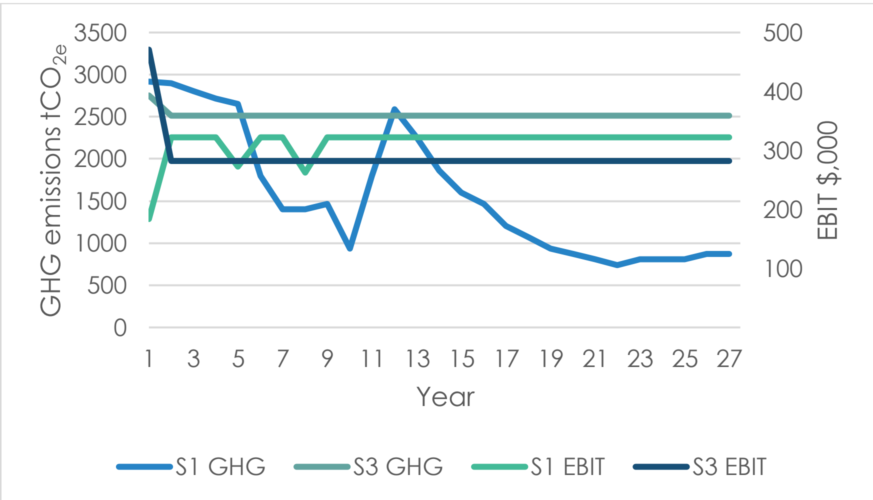


Chart 2: Change in GHG emissions and EBIT over the period

The GHG emissions offsets for the forestry scenario are based on the lookup tables for the emissions trading scheme in the Otago region. The line for scenario one in Chart 2 emphasises that trees do not grow exponentially and emphasises the estimate used in the lookup tables.

Lookup tables are used for forestry plantations less than 100ha. Areas over 100ha use a field measurement approach to provide a much more accurate representation of sequestration on farm. A similar approach has also been used for those participating in zero-carbon beef trials with Silver Fern Farms (Silver Fern Farms, 2022). Feedback from those who have used this approach is the lookup tables provide a conservative estimate of the sequestration effect (sometimes actual sequestration is twice as much), however they have been used in this analysis for simplicity purposes.

Chart 2 shows the effects on profitability and emissions without considering the large profit and emissions deficit at year 28. If forestry is in on an unproductive area but difficult to harvest, permanent forestry is an option that would result in the lowest GHG number long-term. The cost of this is significant due to the large capital investment at year one, and the economic gains from emissions reduction would need to exceed the long-term cost involved. Chart 2 also shows that emissions reduction plateau after year 22 therefore in order reduce emissions following this year would require further mitigation methods.

Predicting the market for logs in 28 years is a challenging task. For the scenario analysis, a log price of $192/tonne[2] was used. The Forestry and Wood Processing Industry Transformation Plan (Te Uru Rakau NZ Forest Service, 2022) suggests the demand for wood products is expanding from export logs to other wood products such as biofuels and domestic wood products as wood is considered sustainable alternative. Local manufacturers are replacing their coal boilers with wood energy to meet their scope one and two emissions.

The costs of harvest, roading and transport were sourced from a local forestry harvester however vary depending on the location of the forest. The nearest port that exports logs is Dunedin which is 160km from the southern boundary of the Clutha District. When considering local markets, Daiken Southland in Mataura is a nearby option for the production of wood products. Additionally, there are several factories and schools in the region which are transitioning from coal boilers to wood.

Access to the forest may also be a challenge when harvesting and therefore roading costs can vary. Correspondingly if steep land has been used to grow the trees the harvesting rates would vary due to the requirement of specialised equipment. An unproductive area may not be the most practical area to grow trees when it comes to harvest, and this factor needs to be taken into consideration.

The estimated income is based on pruned logs and a cost of pruning has been included in years five and eight. Approximately 61% of NZ Pinus Radiata forestry is now under an unpruned management regime (Forest Owners Associaton, 2022). The expected export prices for unpruned logs are less than pruned however there would be no pruning costs at years five and eight.

In this case the return per hectare (based on the scenario one assumptions) at year 28 was $21,712. Sensitivity analysis showed that if the revenue at harvest was approximately $15,000 there would be no difference in profitability between scenario one and the base scenario. If net return was $10,000/ha, the difference would be $91,000 less. There is however potential for a much higher return. If the net income was $30,000/ha, the difference would be approximately $245,000. Results from the sensitivity analysis are summarised in chart 3 and detailed in appendix 5.

[2] 12 month average export rate for pruned logs as at 30 June 2023 (Ministry of Primary Industries, 2023).

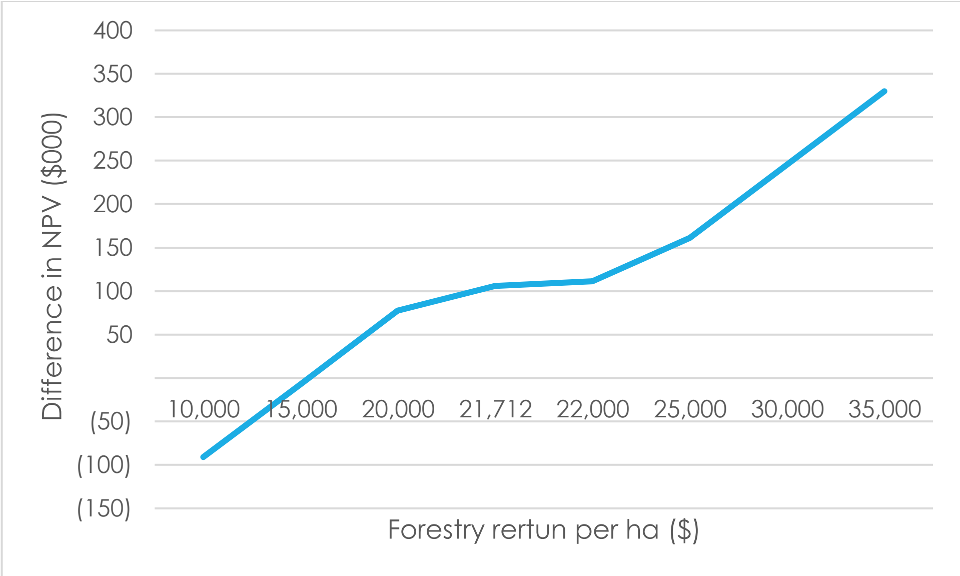


Chart 3: Sensivity of the difference in net present value from the base farm compared to forestry return per hectare

Another option to diversify income streams is by registering forestry in the emissions trading scheme (ETS). While plantation forestry relies solely on income from trees, the emissions trading scheme allows participants to claim units for carbon sequestered from forestry and to sell these to emitters. The averaging scheme introduced in January 2023 allows for participants to trade emissions units without having to surrender or repay units up on harvest. However, when measuring emissions for a purpose, including carbon offset and emissions pricing proposals, ETS registered forests are not usually counted for sequestration purposes as the benefits of emissions trading have already been received. The potential economic benefits of registering in the emissions trading scheme were therefore not considered as part of this analysis.

4.2.2 Discount Rate

Net present value is the value of cash flow if a particular discount rate is applied to all future costs and revenue. This is effectively the amount that could be paid for land at the start of the project while still obtaining an expected return on investment (Journeaux et al., 2022).

The appropriate discount rate depends on factors specific to the scenario. The discount rate of 5% was selected after reviewing similar literature for forestry scenarios and considering the long-term nature of forestry investment. While the change in profitability is based on earnings before interest and tax (EBIT) and does not consider debt servicing, the discount rate can factor in the cost of capital.

The selection of the discount rate should be specific to the farmers required return on investment. As mentioned earlier, a farmer may be required to borrow funds to plant areas to plantation forestry, therefore the discount rate should incorporate the cost of capital. If funds are not borrowed, it reflects the opportunity cost of returns that could be received from alternative investment.

Sensitivity analysis has been used to compare the change in profitability for forestry scenarios, based on the discount rate used. Sensitivity analysis for scenario one, which involved solely a forestry plantation shows that as the discount rate increased, the return on investment fell. If the discount rate used was 3%, the net present value would be much higher whereas if 8% was used the net present value would be lower.

Chart 4 shows how the percentage change in NPV between the base farm and scenario one, is affected by the discount rate used.

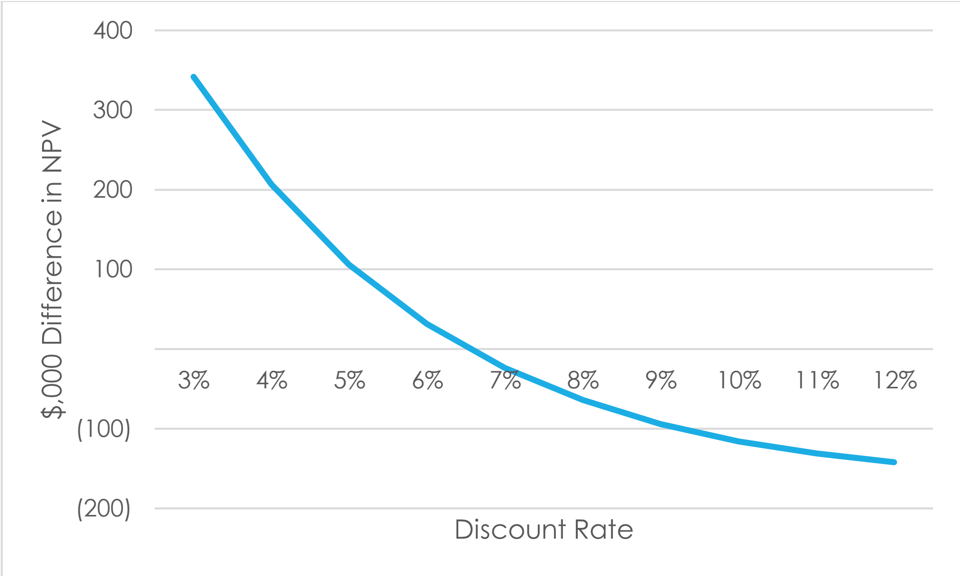


Chart 4: Sensivity of the difference in net present value from the base farm compared to different discount rates used

Where the line intercepts the axis is the breakeven point for the discount rate for this scenario. If the expected rate of return on the investment is greater than approximately 6.8%, the base scenario would be a preferable option.

4.2.3 Reduce Stocking Rates

Reducing livestock stocking rates without any increase in performance would be a costly method to reduce on farm emissions. A lower stocking rate would likely result in more available feed and therefore some production increases per head. The saving in greenhouse gas emissions is the maintenance cost of the animals removed to reduce stocking rate, plus the marginal improvement in efficiency per animal (New Zealand Agricultural Greenhouse Gas Research Centre, 2022).

There are several ways that production per head can be increased. An increase in dry matter intake per lamb would increase the lamb weight per head or allow for lambs to be sold earlier in the season to receive a premium. Alternatively, if there are fewer ewes on hand there may be the opportunity to fatten lambs over winter and sell at larger weights for a premium at the start of the following season.

The other way to increase production is to increase calving or lambing percentage. If there is more feed available in the autumn, extra liveweight on ewes or cows increases their productive chances and therefore their successful lambing or calving percentage. Additionally, the selection of suitable sires and genetics can also improve reproductive performance.

For simplicity purposes, scenarios four and five consider increasing production by increasing lambing percentage by 10% and therefore selling 10% more lambs each season. Increasing liveweights or capturing 'out of season' premiums may have a similar effect but this is beyond the scope of this analysis.

Increasing lambing percentage occurs over several years and in practice comes down to a number of factors including the ability of farm manager, growing conditions for the season and the genetics of sires purchased. Many farmers have already plateaued with lambing percentage and would find it difficult to improve results. This scenario involves slowly increasing to 10% more lambing over 3 years with an increase of 5% at year two, 7.5% at year three and 10% by year four.

Scenarios two to five involve selling capital livestock at year one resulting in an increased EBIT in the first year. Following this, the EBIT is reduced in proportion to the number of stock units.

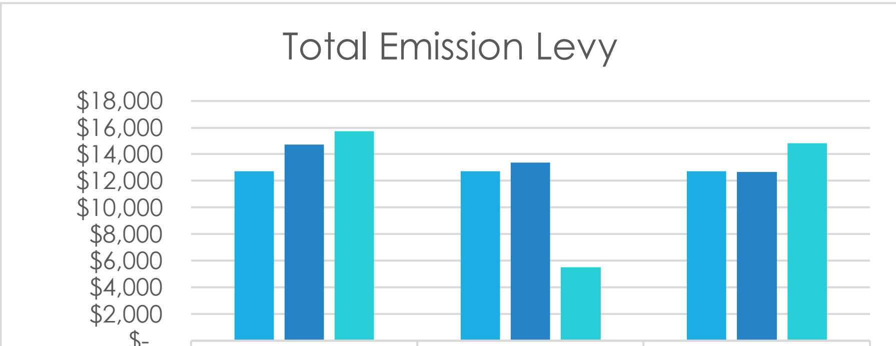
Increasing production may also require further fertiliser inputs. This would not only affect the profitability due to the cost involved but also increases the GHG emissions. For simplicity purposes, fertiliser inputs have remained the same in the GHG emissions calculator. In reality the GHG reduction is probably overstated in scenarios four and five as further fertiliser inputs would be required to increase production.

4.2.4 Emissions Levy

A cost that has not been considered in any of the scenarios or the literature is an on-farm emissions levy. The BLNZ calculator used to calculate the GHG emissions for each scenario was designed in consideration of He Waka Eke Noa (HWEN), a partnership that formed a proposal for a split-gas levy to be imposed on farmers, recognising sequestration on-farm. All of the above scenarios would be subject to the emissions levy, which would encourage further reductions in on-farm emissions and impose further costs on the forestry scenarios one, two and five due to the large liability upon harvest at year 28.

The impact of an on-farm levy has been applied to each of the scenarios based on the following assumptions:

- 80% of emissions are methane, 20% are nitrous oxide
- Levy for methane of $0.11 per kg
- Tonnes of CO_{2e} have been converted to kg of methane
- Levy for nitrous oxide at emissions price of $85/tonne CO_{2e}.
- Discount for emissions price starting at 95% and decreasing by 1% each year



	Base	S1	S3
Year One	$12,747	$12,747	$12,747
Year Five	$14,731	$13,398	$12,691
Year Ten	$15,723	$5,528	$14,827

Chart 5: Cost of annual emissions lev at year 1, 4, 10 for each scenario

The introduction of an emissions levy has implications on the cost of carbon reduction. For example, in scenario one, the levy at year 10 would be $10,195 different to the base farm. The difference in profit at year 10, between the base and scenario one is $3,300 therefore the benefit of reducing emissions would net $6,895 which is the saving in levy less any costs of achieving this.

The same approach can be applied to the destocking scenarios. If you were to apply the carbon levy to scenario three which involved destocking without any increase in production, the difference in year 10 EBIT between base and scenario three is $43,389, while the difference in emissions levy would be $896. The cost of reducing emissions would therefore net $42,493 per year.

If the reason for reducing emissions is to reduce the emissions levy payable, it should be considered if it is more cost efficient to pay the levy. The levy for the base farm at year five would be $14,731 therefore in the case of reducing stocking rate, the levy is cheaper than the scenario three reduction in profit of $43,389. While the forestry scenario shows that the reduction in profit is less than the emissions tax saving, the EBIT at year 10 hasn't considered the capital cost of planting the forest which if borrowed may likely take 10 years to repay.

The proposal from HWEN is to start with a 95% discount on the current carbon price for agriculture. The discount is expected to reduce as the scheme progresses, phasing down by 1% per annum which has been reflected in the calculations in chart 5 (further detail in Appendix 4). Chart 5 shows that in the case of the destocking which has fixed emissions from year three onwards, the emissions levy will increase with the decreasing discount. It will also depend on the changes to emissions price of $85 and methane rate of $0.11. Increased rates would have a much greater effect on the farm levy and incentivise further reductions.

As mentioned in section 4.2.1, the emissions trading scheme is another way to diversify farm income however any ETS registered forests cannot be used for carbon sequestration for the purposes of He Waka Eke Noa. If the carbon price is much greater than the proposed emissions levy, higher returns may be achieved by registering the forestry in the ETS, collecting and selling emissions units and paying the emissions levy. For example, at year 10 on scenario one, 1,980 emissions units would be allocated. If these were sold for $85/unit the income would be $168,300. The emissions levy without the forestry offset would be $15,723 (at year 10), much less than the income received.

4.2.5 Cost per Unit of Output

The scenarios have explored the absolute emissions for a typical sheep and beef property, which are the total emissions produced by an enterprise or entity. Emissions intensity is the volume of emissions produced per unit of product, for sheep and beef farming this comes down to the emissions per kilogram of meat produced (New Zealand Agricultural Greenhouse Gas Research Centre, 2022).

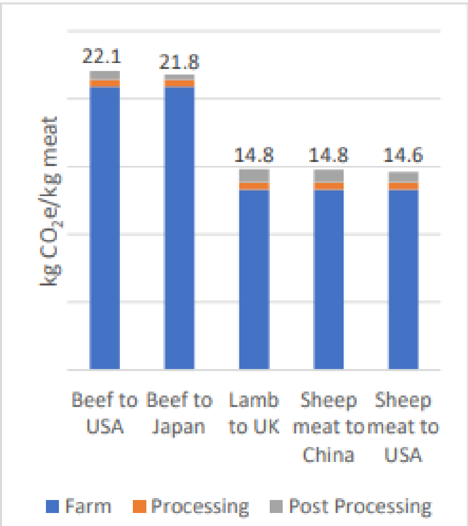


Figure 3: Emissions intensity for export meat products (Source: Meat Industry Assn, 2019)

The carbon cycle footprint for a kilogram of beef is approximately 21.9 kg CO_{2e} and sheep meat is approximately 14.7kg CO_{2e}. While this includes processing and transport, 90%-95% of the emissions are from on-farm activities as evidenced in figure 3 (Meat Industry Association, 2019).

In this case, the total meat production of both lamb, mutton and beef for the base farm was calculated as 140,033kg per year [3]. The total on-farm emissions for the year (absolute emissions) are 2,917, therefore the average emissions intensity is 20.83kg CO_{2e}. There is increasing demand for reporting of emissions which is explored further in section five, as part of this, it would be beneficial to know both the absolute emissions for a business and emissions intensity for unit of output.

Section 5.5 studies the possibilities of receiving premiums for a reduction in emissions. It is useful to break down the cost of each method to per kilogram (kg) of meat produced to determine if the premium received per kg is greater than the cost involved. If we apply this to reduction in stocking rate (scenario three), the cost per kg of meat produced would be $0.36.

[3] Based on the district averages (Shand Thomson, 2022) which relies on some estimates provided by the participants involved in the benchmarking data.

So far only premiums have only been offered for carbon neutral products. Neither of the scenarios reduce emissions to the extent that the farm is carbon neutral therefore the cost per kilogram of meat to become carbon neutral may be far more than the premium received.

4.2.6 Carbon Cost of Mitigation

Another consideration is to compare the cost of a scenario to the carbon emissions price. While He Waka Eke Noa's proposal is for a split-gas levy there is a possibility of agriculture being subject to the emissions trading scheme.

The carbon cost of mitigation, expressed in dollars per tonne of CO_2 equivalents ($/t$CO_{2e}$), is calculated as the amount of emissions reduction achieved by a reduction method divided by the net economic cost (or benefit) to farmer. If the carbon cost of mitigation for a method is lower than an emissions price, this indicates that this mitigation method would be less costly than the farmer not changing and simply paying the price on emissions (Reisinger et al., 2017).

In this case, the change difference in NPV for each scenario has been divided by the difference in total emissions to determine the cost of mitigation over the whole 28-year cycle.

The results for each scenario are summarised in chart 6 below:

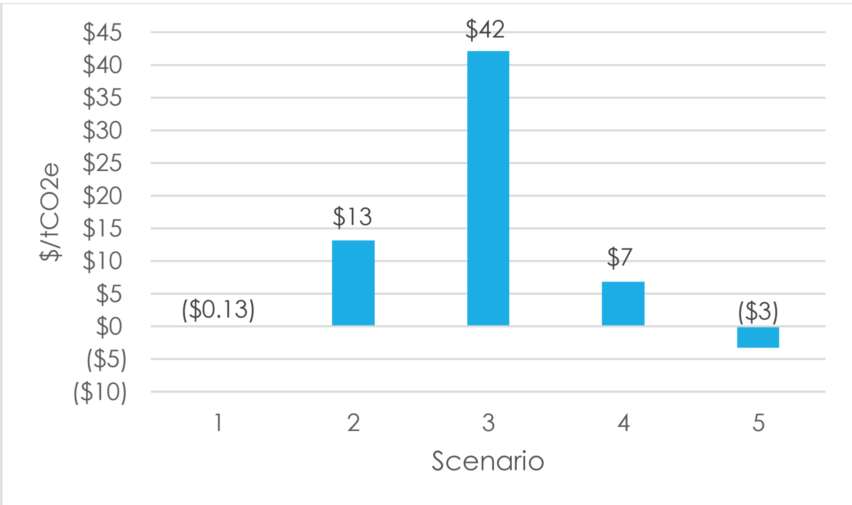


Chart 6: cost of mitigation per tonne of CO_{2e} for each scenario

As scenarios one and five increased the net present value, the cost of mitigation are slightly negative. Scenario three which involved reducing stocking rate without any increase in production costs $42 per tonne of CO_{2e} therefore if the carbon price was less than $42 it would be cheaper to purchase emissions units to offset.

It is worth noting that carbon price fluctuates and will do so throughout the 28-year cycle, therefore at times it may be economical to reduce stocking rates depending on the carbon markets. Adopting an intervention is a long-term approach and cannot be changed as often or easily as the fluctuation in carbon credit markets.

5 Benefits of Reducing Emissions

5.1 Background

In December 2015, a legally binding international UN treaty known as the Paris Agreement was adopted by 196 parties. Its goal was to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." (United Nations, 2023)

Participants in the Paris Agreement are required to submit to the United Nations their climate action plans known as Nationally Determined Contribution (NDC).

Figure 4: Siging of the Paris Agreement (Source: United Nations, 2023)

New Zealand is a party to the agreement along with several of our trading partners. Our NDC is to “reduce net greenhouse gas emissions to 50 percent below gross 2005 levels by 2030, and to achieve net zero by 2050. This includes targets to reduce biogenic methane emissions by 10% by 2030 and 24%– 47% by 2050 relative to the 2017 level; and to reduce all other gases to net zero by 2050” (NZ Government, 2021). This has been legislated in the Climate Change Response (Zero Carbon) Amendment Act which amended the Climate Change Response Act 2002.

The general public is increasingly educated regarding climate change, and both consumers and investors are demanding change. In February 2023, Cyclone Gabrielle hit the East Coast of the North Island causing extensive damage. Following this, the World Weather Attribution showed that heavy rainfall events have become four times more common in NZ which is likely due to the climate crisis (Mishra, 2023). Internationally the European heatwave in July 2023 has been attributed to increased greenhouse gas emissions. The impact of these events results in changing perceptions of climate change and more pressure from consumers and investors.

Legal opinions in UK, Australia, NZ and Canada have suggested that directors’ duty of care requires them to factor climate change into their business decisions and that understanding climate risk is key to mid-long term strategy and resilience (Chapman Tripp, 2020). This is as a result of increased pressure from stakeholders’ view to long-term sustainability and thinking more widely than solely on economic returns. A company director has a duty of reasonable care which is increasingly including the need to consider climate-related risks.

In response to this, the Climate Leaders Coalition has been formed to unite NZ businesses and accelerate transition towards a zero carbon and climate resilient future. The coalition has been signed by over 70 CEOs of NZ companies including, ANZCO, Silver Fern Farms, Countdown and Foodstuffs. Collectively, signatories’ companies create around 32% of NZ’s GDP. One of the initial requirements for signing is for the companies to proactively enable suppliers to reduce emissions (Climate Leaders Coalition, 2023).

Each company has emissions targets known as scope one, two and three emissions. Scope one emissions are direct emissions caused by assets owned or controlled by an organisation such as buildings or vehicles. Scope two emissions are created by the production of energy that an organisation uses (e.g. can they source green generation from their electricity company). Scope three emissions are produced by customers or suppliers. It is scope three emissions that are the most difficult to control and the largest part of an organisation’s carbon footprint (Read, 2022).

According to MPI (2023), meat and wool exports totalled $11,940,000 in 2023. The largest export partner was China (37%) followed by US (20%) and EU (12%). NZ is unique to other farming nations ins that a large portion of our product is exported, the markets therefore are reliant on the policies and consumer views of trading partners as they are on domestic regulation.

5.2 Food Processors

Globally food retailers are increasingly focusing on scope three emissions as a result of government regulation, increased customer pressure and director responsibility.

UK supermarket Tesco has targeted to reduce scope three emissions by 17% by 2030 (from a base year of 2015). They have written to each of their supplier partners requesting they disclose their current emissions, establish a net zero ambition and set science based targets to support delivery of their ambition. Tracking emissions progress on farms would be a requirement for supplying Tesco's" (Uys, 2022).

Locally, NZ supermarket chain Countdown had invited all suppliers to take part in a programme to measure and report emissions in response to its commitment to reduce its supplier emissions by 19% (Uys, 2022).

Many international food and beverage companies are setting ambitious emissions targets and increasingly mandating their suppliers to provide a product that meets the company's stated climate goals. Scope three emissions targets for these companies occur in the supply chain which includes the emissions associated with the production of raw materials. Food retailers are looking for reduced emissions in their supply chains to help them to deliver on their commitments (Leahy et al., 2020).

Some of the emissions targets for global food producers include:

- ✖ Danone – reduce scope 3 emissions intensity by 50% of 2015 levels by 2030
- ✖ Mars Inc. – reduce total emissions by 27% of 2015 levels by 2050
- ✖ Nestle – reduce scope 3 emissions by 8% by 2020 from base year 2014
- ✖ General Mills Inc. – reduce absolute GHG emissions across the full value chain by 2025

As a result, over the past six years' companies like Nestlé, Mars and Danone announced they will only buy from suppliers who achieve significant emissions cuts (Leahy et al., 2020).

Figure 5 shows a summary of what global food companies emissions targets are their deadlines. It shows the trends are either smaller reductions in short term or in the long-term net-zero. Most of these companies will have both short and long-term targets for the reductions in emissions.

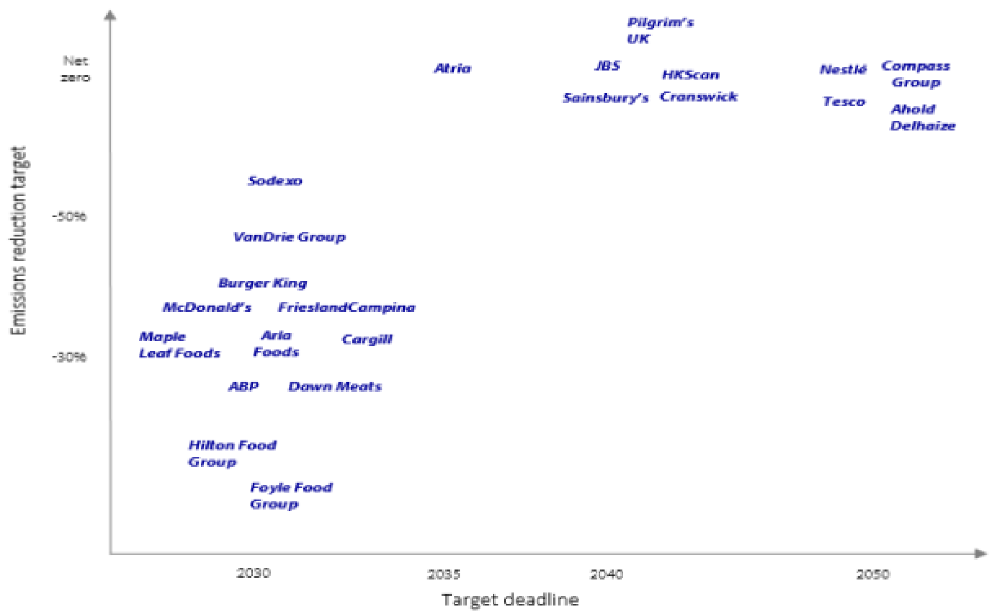


Figure 5: emissions targets and deadlines for major food retailers (Source: Raboresarch 2022)

Most international meat processing companies have an environmental sustainability statement which includes a commitment to reduce emissions. In many cases, this is to reach net zero emissions within a specified timeframe.

This already looks good for NZ producers, as despite our geographical isolation compared to overseas markets, our grass-based pastoral livestock systems are seen as some of the best in the world. The Global Warming Potential for New Zealand beef and sheep, shipped either chilled or frozen to markets in Asia, Europe and America is low and is on the bottom range of published values for global beef and sheep production, despite our distance from markets (Meat Industry Association, 2019). There are however still requirements to show an intention to reduce emissions further as other international competitors also change their practices.

In a recent interview, Climate Commissioner Rod Carr warned against complacency, saying while New Zealand was once the most efficient, other countries, who have different farming practices (e.g. animals in barns) are quickly catching up. Noting that "We may be best in class, but in a class that is rapidly changing," (Johnston, 2023),

5.3 International Trade

NZ is heavily dependent on its agricultural exports, accounting for 65% of total trade with a value of NZ$45 billion in 2023 (Guenther et al., 2023).

Free trade agreements allow for market access without trade tariffs. In 2023 Agribusiness Agenda (KPMG, 2023), a priorities survey amongst sector leaders, signing high quality trade agreements was the second ranked priority. Globally, environmental regulations are also becoming a stronger focus and being reflected in free trade agreements, regulations, investment programmes and product sourcing trends. Environmental credentials are likely to be contested to a greater extent in global trade negotiations over time. (Ministry of Primary Industries, 2023)

NZ has recently signed a trade agreement with the European Union (EU), our third biggest trading partner for meat and wool. The EU has a new approach to trade agreements to promote green growth by including Trade and Sustainable Development chapters in each of their trade agreements. This was the first trade agreement from the EU to promote green and just growth a commitment made in June 2022. The trade and sustainable development chapters in the NZ-EU FTA include a sustainable food systems section which includes the carbon footprint of food production and consumption (Johnston, 2023).

The trade agreement includes a commitment to both parties' commitments to the Paris Climate Agreement and will apply trade sanctions to any material breaches of the EU'S NDC which is a net reduction of at least 55% in GHG emissions by 2030 compared to 1990 (European Union, 2022). Likewise, any products imported from EU to NZ are required to align with our NDC under the Paris Agreement. If New Zealand cannot reduce GHG emissions by 30% by 2030, it could be sanctioned or cut off by the EU.

In addition to this, the EU have announced a proposal to put levies on imported goods that are not subject to carbon pricing in their home countries. This will initially focus on manufactured goods that are subject to the NZ emission trading scheme (New Zealand Foreign Affairs & Trade, 2023).

5.4 Consumers

The Agribusiness and Economics Research Unit at Lincoln University (AERU) was involved in a four-year research programme from 2017-2022 to determine international customers' willingness to pay for certain attributes. The survey revealed that for some customers, carbon reduction can play a significant role in their choice of product.

The UK market was tested for NZ Lamb and Beijing China for Beef. In the UK 39% of consumers indicated they were willing to pay a premium of 13% for carbon neutral lamb. In China, 15% of beef consumers were willing to pay on average 70% more for carbon neutral beef.

	UK	CHINA	US
1	Quality of Meat	Quality of Meat	Quality of Meat
2	Animal Welfare standards	Healthiness	Price
3	No-added hormones	Antibiotic-free	Healthiness
4	Price	No-added hormones	No-added hormones
5	Healthiness	Grass-fed	Antibiotic-free

Figure 6: highest raked attributes for red meat (Source: MPI, 2020)

Ministry for Primary Industries also surveyed China, UK and US to determine what qualities they place importance on when purchasing NZ beef. For all markets, the most important attribute when purchasing was the quality of meat. Environmentally sustainable production was not amongst the top 5 attributes considered and was rated well below grass-fed. There was however significant support for a carbon neutral scheme with all markets suggesting a willingness for a 10%-15% premium (Ministry for Primary Industries, 2020).

BLNZ performed a product attribute study in 2017 studying the importance consumers place on different product attributes in Shanghai China and California USA. Carbon neutral production was important to 43% of consumers in Shanghai and 17% of consumers in California. In both markets, carbon neutral production rated lower than food security attributes such as antibiotic free, GM feed free, and no added growth hormones (O'Malley, 2018).

Our largest export market for red meat and wool is China with 37% of exports. China is one of the 196 countries that signed the Paris agreement. China's NDC is to reach peak CO_2 emissions before 2030 and achieve carbon neutrality before 2060. Most of China's focus has been to reduce GHG emissions by changing energy systems, transportation and using offsets domestically (Transition China, 2021). While moving to lower emissions foods is not part of their NDC, environmental awareness is changing consumer behaviours.

The AREU Unlocking Export Prosperity survey in 2021 ranked China as placing more importance on environmental conditions when purchasing food products than the UK or Japan. Similar to the MPI survey, the environmental condition was ranked lower than quality of product. When considering environmental conditions, the Chinese consumer placed importance on other factors such as biodiversity, water quality and air quality, as much as they did on GHG emissions (Lincoln University Agribusines & Economics Research Unit, 2023).

5.5 Premium Products

Despite demand, there have been very few low-carbon food products available to consumers however niche markets have now emerged for Carbon Neutral products. Silver Fern Farms, one of NZ's largest meat processors developed a Net Carbon Zero product for the US Beef market. Net Carbon Zero recognises that, for every pound of product sold, the equivalent amount of emissions need to be removed by vegetation occurring on the group of farms that supply the product.

Emissions are independently measured and certified by Toitu Envirocare, a NZ government subsidiary which is an internationally recognised environmental certification organisation. The product is labelled and marketed as zero-carbon (Silver Fern Farms, 2022).

The trial for the zero-carbon beef specifically measured sequestration on farm, including some vegetation that would not be eligible for the ETS. Regardless of this, it would be unachievable for some properties to reach net-zero emissions as evidenced by the costs involved in the scenario analysis.

Figure 7: Net carbon-zero beef (Source: Silver Fern Farms, 2022)

A risk of labelling products as carbon neutral is that consumers are increasingly becoming aware of carbon neutral claims and the concept of "greenwashing". Greenwashing is when an organisation makes false or misleading claimed in relation to their environmental credentials (KPMG, 2022).

In response to greenwashing claims, the EU have introduced rules that will outlaw claims that products are carbon neutral or have reduced environmental impacts thanks to emissions offsetting. This also extends to sustainability labels which are not based on certification schemes (Morrison, 2023). Greenwashing affects niche carbon neutral products such as zero-carbon beef as consumers become sceptical regarding carbon neutral claims and therefore less likely to pay a premium.

5.1. Finance

Access to capital is a major barrier to entry of sheep and beef farming. Internationally investors are demanding sustainability which impacts the cost of capital. As at 30th June 2023, total NZ debt across sheep and beef properties is approximately $15 billion (Laming, 2023).

The Financial Sector (Climate-related Disclosure and Other Matters) Amendment Bill was assented in October 2021 and required banks to disclose the impact of climate change on their business and how they would manage climate-related risks and opportunities. This will include the emissions and reduction plans of their customers (KPMG, 2022).

Financers are required to have an environmental, social and governance (ESG) policy which requires them to update investors. Increasingly investors have expectations with regards to these areas.

The Sustainable Agricultural Finance Initiative (SAFI) was launched in 2021 to provide a consistent framework for the finance sector to integrate sustainability considerations into funding for the NZ Agri Sector. Environmental aspects included in the SAFI guidance include climate change and mitigation (The Aotearoa Circle, 2021).

In addition to this, the United Nations has led the Net Zero Banking Alliance (NZBA) which is a group of banks aiming to transition their lending and investment portfolios to net-zero emissions by 2050. NZBA membership is estimated to be 41% of global banking assets (United Nations Environment Programme, 2023).

As at June 2023, the share of the agri-debt market was mostly held by five banks (Laming, 2023);

- ANZ 25%
- ASB 17%
- BNZ 22%
- Rabobank 20%
- Westpac 14%

Although there has been much talk about sustainability-linked farming loans, BNZ is the only bank which has implemented this product thus far. The have developed a loan allows for farmers to set a series of sustainability linked key performance indicator's (KPI) (including a GHG emissions reduction KPI) and prices the cost of debt based on performance against these KPIs. These are aligned with the above criteria for the sustainable agricultural finance initiative. BNZ have disclosed their first set of targets to the Financial Markets Authority which includes dairy. They have indicated that sheep and beef will be published next year (BNZ, 2023).

ANZ have focused their sustainability policy on good energy home loans and are starting to provide sustainability linked loans for business customers (ANZ, 2022). Their largest business loan in NZ has been $320 million sustainability linked working capital facility with Silver Fern Farms (Ministry of Primary Industries, 2023). While this may not directly impact on-farm interest rates, there may be pressure for Silver Fern Farms to reduce scope three emissions which includes suppliers.

Rabobank is Dutch owned and has committed to the Dutch Climate Agreement along with the NZBA. They have focused on their own business operations but assess non-financial performance indicators of customers and are increasingly requiring their clients to have farm environment plan's (Rabobank New Zealand, 2023).

ASB and Westpac have both introduced business sustainability loans which support businesses by providing a special interest rate on loans for eligible environmental purposes. Both of these loans extend to farming clients who are keen to change to resilient agricultural practices (KPMG, 2022)

5.2. Implications

The various pressures that influence climate change and the reduction of greenhouse gas emissions on farm are summarised in figure 8.

The top layer of the diagram shows the public pressure regarding climate change from all stakeholders including consumers, lobbyists and investors. Such pressure, along with scientific advice has resulted in the Paris Agreement which is also in this layer as it is an overriding feature of all environmental legislation.

The next layer represents the responsible parties as a result of public pressure. This includes government and policy which as a result of the top layer has resulted in the introduction of Nationally determine contributions and policies such as the Climate Change Response Act and the Financial Sector (Climate-related Disclosure and Other Matters) Amendment Bill. Environmental pressure from stakeholders also has an impact on directors' duty of care.

The next layer represents the various alliances that have been formed between organisations, of which membership strengthens the importance they place on environmental factors. Those listed in the diagram are some examples of local and government alliances that relate to the primary sector. The fourth layer are processors (either exporters or retailers) and financers that directly have an impact on the farm.

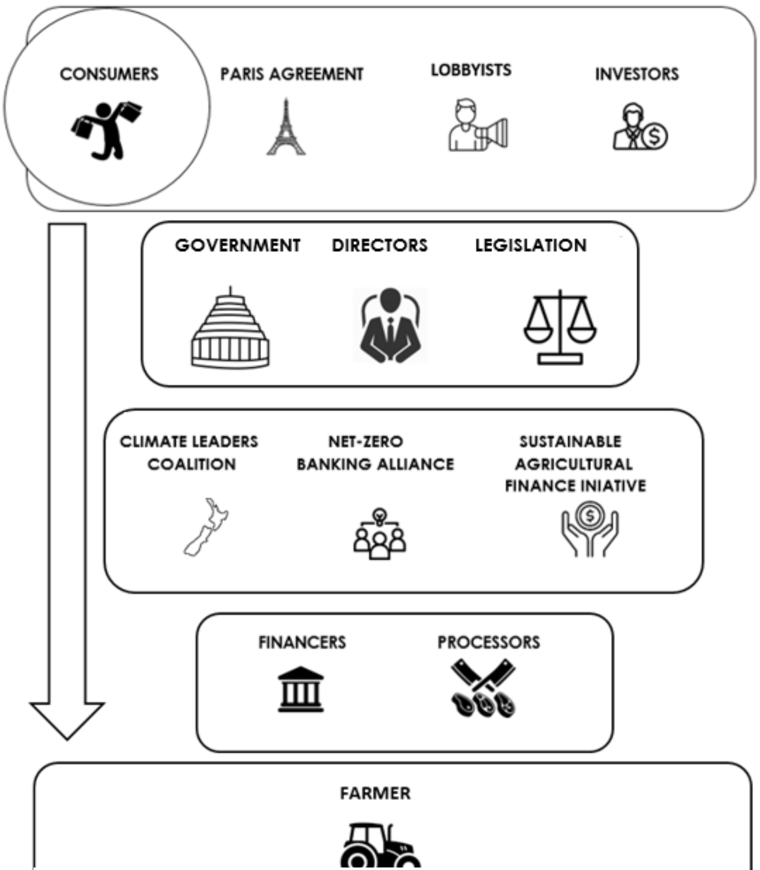


Figure 8: pressures on a farmer to reduce GHG emissions

The arrow on the left hand side also shows that farmers are ultimately responsible to consumers. While the organisations in the middle layers' place importance on environmental factors it is the end consumers which matter the most.

Currently most of the demand for emissions reduction is from retailers, processors and financers wanting to reduce scope 3 emissions as part of their ESG polices (the three middle layers). The demand from consumers is low, as they mostly favour other factors over the carbon footprint of their red meat.

Aside from the emissions trading scheme, which rewards tradable carbon credits for the sequestration of carbon emissions, reasons to consider reducing GHG emissions on farm include:

- contributing towards NZ's climate change plan under the Paris Agreement;
- gaining access to markets which have import related obligations as part of their commitment to the Paris Agreement;
- fulfilling the requirement of a customer or financer to meet their scope three emissions targets;
- reducing the potential emissions levy liability under the proposed He Waka Eke Noa scheme;
- attracting capital investment either through financers or equity partners by aligning to their sustainability policies and targets producing a premium product targeted at the green consumer markets, marketed as low-emissions, or
- achieving an emission reduction based KPI through a sustainability linked loan to achieve a discounted interest rate.

6 Conclusions

The purpose of this report was to determine the costs of greenhouse gas emissions reduction on sheep and beef properties and review some of the reasons why farmers should consider emissions reduction.

Reducing stocking rates and planting forestry as offsets to other emissions created on the farm are currently available mitigation methods but in most instances come at a cost. Based on the scenario analysis, plantation forestry on unproductive areas is an option to reduce emissions and diversify farm income resulting in a very small increase in net present value. Other literature showed a decrease in cost, emphasising that it depends on specific factors to the property and operations.

When assessing which mitigation method to use, the reasons for mitigation should be considered and the time frame for the emissions reduction goal. Additionally, a breakdown of the cost per kilogram of meat produced and the cost of reduction in terms of tonnes of CO_2 equivalents should also be considered to determine the minimum expected premium or maximum emissions price.

In some instances, paying the proposed emissions levy would be a more cost-efficient option than the reduction method.

As a result of increased stakeholder pressure and commitment under the National Standard Contribution under the Paris Agreement, organisations are reporting on sustainability and have emissions reduction goals. This includes international food producers and financers, both of which are critical to a sheep and beef operation.

Despite this there been very little activity regarding low-emissions meat or sustainability linked loans so far and overseas consumers have indicated that carbon neutrality is not the determining factor when purchasing red meat.

Based on this, the most likely short term benefit to reducing emissions is to reduce the anticipated emissions levy under the He Waka Eke Noa proposal. Applying the pricing proposal to the scenario analysis demonstrated that in many instances, the cost of reducing emissions would be less than the proposed levy but would ultimately depend on the circumstances of the farming operation.

7 Recommendations

Much analysis is required to determine if a method of reducing greenhouse gas emissions on a sheep and beef property is worth pursuing. The scenario analysis used is an approximation of the results for a hypothetical property based in the Clutha District, however a much customised approach must be applied for each farm to be able to determine whether to adopt these forms of mitigation.

When a farmer and/or their advisors are assessing the suitability of a mitigation option, they should consider:

- ✖ the impact of emissions levies on the expected cost by factoring the saving that the method would provide on the emissions pricing levy;
- ✖ if the cost of the mitigation method is more than the expected emissions levy price and therefore paying the levy would be a more cost efficient option;
- ✖ reviewing the cost of mitigation on the basis of kilogram of meat produced on farm to determine the minimum premium required to ensure there is a benefit from the mitigation;
- ✖ based on the existing land use, harvesting cost and expected return on investment assessing if the forestry plantation would be profitable when harvesting;
- ✖ their ability and the potential for their property to increase production, while reducing stocking rate and the costs (including fertiliser emissions) that may be incurred to achieve this;
- ✖ scope 3 emissions policies of the organisations that have a direct impact on their farming businesses, and
- ✖ demand from international and domestic consumers for low emissions products and their willingness to pay a premium.

References

ANZ Bank. (2022). *ESG Supplement.*

Batley, L., Stantaill, J., & Matheson, L. (2022). *A literature Review on Expected Climate Change Impacts and Farm System and Land Use Changes and their Associated Economic Outcomes for New Zealand Farmers, with a Focus on the Te Tai Tokerau Northland and Murihiku Southland regions.* A report prepared for the New Zealand Agricultural Greenhouse Gas Research Centre.

Beef & Lamb New Zealand. (2023). Greenhouse Gas Emissions Calculator. Retrieved from: https://yardstick.beeflambnz.com/

BNZ. (2023). *Sustainability Linked Loans*. Retrieved from BNZ Agribusiness: https://www.bnz.co.nz/business-banking/partners/agribusiness/sustainability-linked-loans

Braun, V., & Clarke, V. (2006). Using Thematic Anlaysis in Psychology. *Qualitative Research in Psychology*, 77-101.

Climate Leaders Coalition. (2023). *Annual Plan 2023/24.*

European Union. (2022), Comision Unveils New Approach to Trade Agreements to Promote Green and Just Growth. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3921

Guenther, M., Tait, P., & Saunders, J. (2023). The Value of Carbon Neutral to New Zealand. *NZIPIM The Journal*, 3-7.

Johnston, K. (2023, August 19). *Crown vs Cow Part Three: Why farming reneged on its deal to cut emissions*. Retrieved from rnz.co.nz: https://www.rnz.co.nz/programmes/in-depth-special-projects/story/2018903090/crown-vs-cow-part-three-why-farming-reneged-on-its-deal-to-cut-emissions

Journeaux, P., & Kingi, T. (2020). *Farm Systems Modelling for GHG Reduction on Maori Owned Farms: Achieving the zero-carbon targets. Prepared for NZAGRC.* Agfirst. Scion

Journeaux, P., Kingi, T., Praat, J.-P., Hanford, P., Lloyd-Bird, C., Scarrow, S., . . . Tamep, R. (2022). *Takahuri Whenua : Approchased to Systems and Land Use Change to Reduce GHG Emissions.*

Journeaux, P., Praat, J.-P., Hanford,P., & McDonald, G. (2022). *Forestry on Farms : Implications for Farm Sustainability and Regional Impact. A report prepared for the Fertiliser Association of New Zealand.* AgFirst.

Kaldermis, D., & Swan, N. (2020). *Managing Climate Risk in New Zealand in 2020; A tool kit for directors.* Chapman Tripp.

KPMG. (2022). *Mobilising capital for impact.* KPMG

KPMG. (2023). *Agribusiness Agenda.* KPMG

Laming, A. (2023). *The NZAB Banking Dashboard: To June 2023*. Retrieved from NZAB: https://blog.nzab.co.nz/the-nzab-banking-dashboard-to-june-2023

Landcare Research. (2023). *Land Use Capability Map*. Retrieved from Our Environment: https://ourenvironment.scinfo.org.nz/maps-and-tools/app/Land%20Capability/lri_luc_main

Leahy, S., Clark, H., & Reisinger, A. (2020). Challenges and Prospects for Agricultural Greenhouse Has Mitigation Pathways Consistent with the Paris Agreement. *Frontiers in Sustainable Food Systems*.

Lincoln University Agribusiness & Economics Research Unit. (2023). *Unlocking Export Prosperity: Annual Survey (2015-2021)*. Retrieved from AERU: https://www.aeru.co.nz/data/uepannualsurvey

Meat Industry Association. (2019). *Carbon Footprint of New Zealand Beef and Sheep Exported to Different Markets.* BLNZ.

Ministry for Primary Industries. (2020, September). *Carbon Neutral Beef? China, the United States and the United Kingdom*

Ministry for Primary Industries. (2023, June). *Historic Indicative New Zealand Radiata Pine Log Prices.* Retrieved from mpi.govt.nz: https://www.mpi.govt.nz/forestry/forest-industry-and-workforce/forestry-wood-processing-data/historic-indicative-new-zealand-radiata-pine-log-prices/

Ministry for Primary Industries. (2023). *Situation and Outlook for Primary Industries.*

Ministry for Primary Industries. (2023). Carbon Tables for Calcaultiong Carbon. Retrieved from https://www.mpi.govt.nz/forestry/forestry-in-the-emissions-trading-scheme/emissions-returns-and-carbon-units-nzus-for-forestry/calculating-the-amount-of-carbon-in-your-forest-land/carbon-tables-for-calculating-carbon/

Mishra, S. (2023, March 14). *Climate change made New Zealand's Cyclone Gabrielle flooding 'four times more common'*. Retrieved from independent.co.uk: https://www.independent.co.uk/climate-change/news/climate-change-cyclone-gabrielle-new-zealand-b2300138.html

Morrison, O. (2023, September 21). *Companies Need to Re-Asses the way they Communicate about their Purchase of Carbon Credits: EU agrees ban on 'climate neutral' claims by 2026.* Retrieved fromhttps://www.foodnavigator.com/Article/2023/09/21/Companies-need-to-re-assess-the-way-they-communicate-about-their-purchase-of-carbon-credits-EU-agrees-ban-on-climate-neutral-claims-by-2026

New Zealand Agricultural Greenhouse Gas Research Centre. (2022, July). Greenhouse Gas Emissions on New Zealand Farms: A companion guide to the climate change seminar series for rural professionals.

New Zealand Forest Owners Associaton Inc. (2022). *Facts & Figures 2021/22 New Zealand Plantation Forestry Industry.*

New Zeland Foreign Affairs and Trade. (2023). EU to Begin Implementing the Carbon Border Adjustment Mechanism. Retrieved from: https://www.mfat.govt.nz/en/trade/mfat-market-reports/eu-to-begin-implementing-the-carbon-border-adjustment-mechanism-september-2023/

New Zealand Government. (2021). Submission Ender the Paris Agreement New Zealand's first Nationally Determined Contribution.

New Zealand Trade & Enterprise. (2022, December 21). *Sustainability Reporting Requirements for the UK and the EU*. Retrieved from: https://my.nzte.govt.nz/article/sustainability-reporting-requirements-for-the-uk-and-the-eu

O'Malley, S. (2018). *Carbon Neutral Red Meat Brand Vision and Viability.* Rural Leaders

Rabobank New Zealand. (2023). *Sustainability Progress Report.*

RaboReserach. (2022, June). *Global Beef Quarterly Q2 2022.* Rabobank.

Read, S. (2022, September 20). *You've Probably Heard of Scope 1, 2 and 3 Emissions, but What are Scope 4 Emissions?* Retrieved from https://www.weforum.org/agenda/2022/09/scope-4-emissions-climate-greenhouse-business/

Reisinger, A., Clark, H., Journeaux, P., Clark, D., & Lambert, G. (2017). *On-Farm Options to Reduce Agricultural GHG Emissions in NZ. Report to the Biological Emissions Reference Group.* NZ Agricultural Greenhouse Gas Research Centre.

Shand Thomson. (2022). Clutha District Sheep & Beef Statistics >3500 Stock Units .

Silver Fern Farms. (2022, December). *Climate Change Related Disclosure.*

Te Uru Rakau NZ Forest Service. (2022, November). *Te Ara Whakahou – Ahumahi Ngahere Forestry and Wood Processing Industry Transformation Plan.* MPI

The Aotearoa Circle. (2021). *Sustainable Agriculture Finance Initiative: Phase one guidance for sustainable agriculture finance for livestock.*

Transition China. (2021, November). China's Updated Nationally Determined Contributions. Rerieved from https://transition-china.org/mobilityposts/chinas-updated-nationally-determined-contributions-ndcs/

United Nations. (2023, August). *The Paris agreement*. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement

United Nations Environment Programme (2023). Net-Zero Banking Alliance. Retrieved from: https://www.unepfi.org/net-zero-banking/

Upton, S. (2023, March 1). Some Observations from the Parliamentary Commissioner for the Environment. New Zealand Agricultural Climate Change Conference, Wellington, NZ.

Uys, G. (2022, December 19). *Tesco's warning to New Zealand Farmers*. Retrieved from stuff.co.nz: https://www.stuff.co.nz/business/farming/130784599/tescos-warning-to-new-zealand-farmers

van Reenen, E. (2019). *Final Report - GHG costs and benefits on different land classes.* AgFirst.

Appendix 1 Assumptions

Base Farm

- Total stock units 6,682
- Total area 1,023, effective area 894
- Stocking rate 7.5 stock units/ha
- Lambing 128%
- Calving 81%
- Fertiliser per year
  - Non-urea Nitrogen 3,196kg
  - Urea with N Inhibitor 9,660kg
  - Urea without N Inhibitor 3,672kg
  - Lime 210 tonne
  - Dolomite 52 tonne
- Total EBIT $325,579

Scenario One

- Convert 50% of unproductive area to forestry (66ha)
- Pinus Radiata, cost of planting $2,100/ha
- 28 Year cycle, harvest at year 28
- Production 184 tonne/ha – based on yield tables pruned, non-production thinning
- Income $192/tonne
- Costs of harvest – sourced from local forestry contractor
  - Harvesting $35/tonne
  - Roading $10/tonne
  - Transport $29/tonne
- Ongoing administration costs $50/ha/year
- Pruning costs – year 5 $750/ha, year 8 $900/ha

Scenario Two

- Convert 50% of unproductive area to forestry, decrease stocking rate by 1 stock unit/ha to 6.5/ha
- Forestry costs as above
- Sale of capita livestock in year one of 676 breeding ewes and 36 cows at national average market values set by Inland Revenue Department
- Total Stock Units 5,792 (86.7% of base farm stocking rate)
- Reduction in EBIT of $43,389 to $282,190

Scenario Three

- Decrease stocking rate by 1 stock unit/ha
- Reduction in stocking rate and EBIT as in scenario two without any forestry

Scenario Four

- Decrease stocking rate by 1 stock unit/ha and increase lambing by 10% (over 3 years)
- Reduction in stocking rate and EBIT as in scenario two
- Increase lambing percentage in year one by 5%, year two by 7.5% and year three onwards by 10%

Scenario Five

- Convert half of the unproductive area to plantation forestry, decrease stocking rate by 1 stock unit/ha and increase lambing percentage by 10%
- Forestry as in scenario one
- Reduction in stocking rate and EBIT as in scenario two
- Increase in lambing percentage as in scenario four

Appendix 2 Livestock Reconciliations

Base Farm

	Opening stock	Age up	Age up	Bred	Sold	Brought	Closing Stock	Deaths & Missing
Lambs			(1,270)	5,576	(4,306)			
Hoggets	1,270	1,270	(1,270)				1,270	
2 Tooth Ewes	1,221	1,270	(1,221)				1,221	49
Mixed Age Ewes	2,017	1,221	(1,124)				2,017	97
Older Ewes	1,124		1,124		(1,050)		1,124	74
Rams	37					10	37	10
Total	**5,668**	**3,761**	**(3,761)**	**5,576**	**(5,356)**	**10**	**5,668**	**230**
Rising 1 Heifers	38		(38)	38			38	
Rising 2 Heifers	33	38	(33)				33	5
Mixed Age Cows	136	33			(28)		136	5
Rising 1 Steers	19		(19)	99	(80)		19	
Rising 2 Steers	21		19		(18)		21	1
Breeding Bulls	2					1	2	1
Total	**250**	**71**	**(71)**	**137**	**(126)**	**1**	**250**	**12**

Decrease stocking Rate – Year One

	Opening stock	Age up	Age up	Bred	Sold	Brought	Closing Stock	Deaths & Missing
Lambs			(1,270)	5,576	(4,306)			
Hoggets	1,270	1,270	(1,270)				1,270	0
2 Tooth Ewes	1,221	1,270	(1,221)				1,221	49
Mixed Age Ewes	2,017	1,221	(1,124)				2,017	97
Older Ewes	1,124	0	1,124		(1,726)		448	74
Rams	37					10	37	10
Total	**5,668**	**3,761**	**(3,761)**	**5,576**	**(6,032)**	**10**	**4,992**	**230**
Rising 1 Heifers	38	0	(38)	38			38	0
Rising 2 Heifers	33	38	(33)				33	5
Mixed Age Cows	136	33			(64)		100	5
Rising 1 Steers	19		(19)	99	(80)		19	0
Rising 2 Steers	21		19		(18)		21	1
Breeding Bulls	2					1	2	1
Total	**250**	**71**	**(71)**	**137**	**(162)**	**1**	**214**	**12**

Decrease stocking Rate – Year Two

	Opening stock	Age up	Age up	Bred	Sold	Brought	Closing Stock	Deaths & Missing
Lambs			(1,270)	4,712	(3,442)			
Hoggets	1,270	1,270	(1,270)				1,270	
2 Tooth Ewes	1,221	1,270	(1,221)				1,221	49
Mixed Age Ewes	2,017	1,221	(1,124)				2,017	97
Older Ewes	448	0	1,124		(1,050)		448	74
Rams	37	0	0			10	37	10
Total	**4,992**	**3,761**	**(3,761)**	**4,712**	**(4,492)**	**10**	**4,992**	**230**
Rising 1 Heifers	38		(38)	38			38	0
Rising 2 Heifers	33	38	(33)				33	5
Mixed Age Cows	100	33			(29)		100	4
Rising 1 Steers	19		(19)	70	(51)		19	0
Rising 2 Steers	21		19		(18)		21	1
Breeding Bulls	2					1	2	1
Total	**214**	**71**	**(71)**	**108**	**(98)**	**1**	**214**	**11**

Appendix 3 Income Forecasts

Scenario one

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Forestry (Costs) Income	(141,900)	(3,300)	(3,300)	(3,300)	(52,800)	(3,300)	(3,300)	(62,700)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)
Adjusted EBIT	183,679	322,279	322,279	322,279	272,779	322,279	322,279	262,879	322,279	322,279	322,279	322,279	322,279	322,279
Emissions (Livestock)	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917
Less Offsets	0	(20)	(112)	(198)	(264)	(1,122)	(1,518)	(1,518)	(1,452)	(1,980)	(1,122)	(330)	(660)	(1,056)
Total Emissions	2,917	2,897	2,805	2,719	2,653	1,795	1,399	1,399	1,465	937	1,795	2,587	2,257	1,861

Year	15	16	17	18	19	20	21	22	23	24	25	26	27	28
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Forestry (Costs) Income	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	1,432,992
Adjusted EBIT	322,279	322,279	322,279	322,279	322,279	322,279	322,279	322,279	322,279	322,279	322,279	322,279	322,279	1,758,571
Emissions (Livestock)	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917	2,917
Less Offsets	(1,320)	(1,452)	(1,716)	(1,848)	(1,980)	(2,046)	(2,112)	(2,178)	(2,112)	(2,112)	(2,112)	(2,046)	(2,046)	22,506
Total Emissions	1,597	1,465	1,201	1,069	937	871	805	739	805	805	805	871	871	25,423

NPV (Base)	$4,850,515	
NPV (New)	$4,956,751	
Difference	$106,236	33%
Total Emissions (Base)	81,676	
Total Emissions (New)	67,750	
Difference	13,926	17%

Scenario Two

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales	97,344													
Extra Cow Sales	48,024													
Forestry Costs	(141,900)	(3,300)	(3,300)	(3,300)	(52,800)	(3,300)	(3,300)	(62,700)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)
Forestry Income	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decrease EBIT		(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	329,047	278,889	278,889	278,889	229,389	278,889	278,889	219,489	278,889	278,889	278,889	278,889	278,889	278,889
Emissions	2753	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513
Less Offsets	0	(20)	(112)	(198)	(264)	(1,122)	(1,518)	(1,518)	(1,452)	(1,980)	(1,122)	(330)	(660)	(1,056)
Total Emissions	2,753	2,493	2,401	2,315	2,249	1,391	995	995	1,061	533	1,391	2,183	1,853	1,457

Year	15	16	17	18	19	20	21	22	23	24	25	26	27	28
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales														
Extra Cow Sales														
Forestry Costs	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	1,432,992
Forestry Income	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decrease EBIT	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	278,889	278,889	278,889	278,889	278,889	278,889	278,889	278,889	278,889	278,889	278,889	278,889	278,889	1,715,181
Emissions	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	2513	
Less Offsets	(1,320)	(1,452)	(1,716)	(1,848)	(1,980)	(2,046)	(2,112)	(2,178)	(2,112)	(2,112)	(2,112)	(2,046)	(2,046)	22,506
Total Emissions	1,193	1,061	797	665	533	467	401	335	401	401	401	467	467	22,506

NPV (Base)	$4,850,515	
NPV (New)	$4,490,099	
Difference	($360,415)	-7%
Total Emissions (Base)	$81,676	
Total Emissions (New)	$54,165	
Difference	$27,511	34%

Scenario Three

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales	97,344													
Extra Cow Sales	48,024													
Decrease EBIT		(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	470,947	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189
Emissions	2,753	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513
Total Emissions	70,604													
Difference	-11072	-14%												

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales														
Extra Cow Sales														
Decrease EBIT	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189	282,189
Emissions	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513	2,513
Total Emissions														
Difference														

NPV (Base)	$4,850,515	
NPV (New)	$4,383,863	
Difference	($466,652)	-10%
Total Emissions (Bas	81,676	
Total Emissions (Nev	70,604	
Difference	70,604	

Scenario Four

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales	97,344													
Extra Cow Sales	48,024													
Increase EBIT		14,887	22,330	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773
Decrease EBIT		(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	470,947	297,076	304,519	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963
GHG	2,753	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales														
Extra Cow Sales														
Increase EBIT	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773	29,773
Decrease EBIT	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963	311,963
GHG	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535

Total GHG	71198	
Difference	-10,478.00	-13%
NPV (Base)	$4,850,514.65	
NPV (New)	$4,779,141.30	
Difference	($71,373.34)	-22%

Scenario Five

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
EBIT	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579	325,579
Extra Ewe Sales	97,344																											
Extra Cow Sales	48,024																											
Forestry Costs	(141,900)	(3,300)	(3,300)	(3,300)	(52,800)	(3,300)	(3,300)	(62,700)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	(3,300)	1,432,992
Increase EBIT		16,924	25,386	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847	33,847
Decrease EBIT		(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)	(43,389)
New EBIT	329,047	295,813	304,275	312,737	263,237	312,737	312,737	253,337	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	312,737	1,749,029
GHG (Livestock)	2,753	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	2,535	
GHG (Offset)	0	(20)	(112)	(198)	(264)	(1,122)	(1,518)	(1,518)	(1,452)	(1,980)	(1,122)	(330)	(660)	(1,056)	(1,320)	(1,452)	(1,716)	(1,848)	(1,980)	(2,046)	(2,112)	(2,178)	(2,112)	(2,112)	(2,112)	(2,046)	(2,046)	22,506
Total GHG	2,753	2,515	2,423	2,337	2,271	1,413	1,017	1,017	1,083	555	1,413	2,205	1,875	1,479	1,215	1,083	819	687	555	489	423	357	423	423	423	489	489	22,506

Total GHG	54737	
Difference	26,939.00	33%
NPV	$4,939,467.15	
Difference	$88,952.51	27%

Appendix 4 Emissions Levy Calculation

Base Scenario

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Methane (kg)	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344	93344
Nitrous Oxide (t)	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4	583.4
$0.11/kg	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268	$ 10,268
$85 at discount	$ 2,479	$ 2,975	$ 3,471	$ 3,967	$ 4,463	$ 4,959	$ 5,455	$ 5,951	$ 6,447	$ 6,942	$ 7,438	$ 7,934	$ 8,430	$ 8,926	$ 9,422	$ 9,918	$ 10,414	$ 10,910	$ 11,405	$ 11,901	$ 12,397	$ 12,893	$ 13,389	$ 13,885	$ 14,381	$ 14,877	$ 15,373	$ 15,868
	$ 12,747	$ 13,243	$ 13,739	$ 14,235	$ 14,731	$ 15,227	$ 15,723	$ 16,219	$ 16,714	$ 17,210	$ 17,706	$ 18,202	$ 18,698	$ 19,194	$ 19,690	$ 20,186	$ 20,682	$ 21,177	$ 21,673	$ 22,169	$ 22,665	$ 23,161	$ 23,657	$ 24,153	$ 24,649	$ 25,145	$ 25,640	$ 26,136
Discount	95%	94%	93%	92%	91%	90%	89%	88%	87%	86%	85%	84%	83%	82%	81%	80%	79%	78%	77%	76%	75%	74%	73%	72%	71%	70%	69%	68%

Scenario one

Methane (kg)	93344	92710.4	89753.6	87008	84896	57440	44768	44768	46880	29984	57440	82784	72224	59552	51104	46880	38432	34208	29984	27872	25760	23648	25760	25760	25760	27872	27872	813536
Nitrous Oxide	583.4	579.44	560.96	543.8	530.6	359	279.8	279.8	293	187.4	359	517.4	451.4	372.2	319.4	293	240.2	213.8	187.4	174.2	161	147.8	161	161	161	174.2	174.2	5084.6
$0.11/kg	$10,268	$10,198	$ 9,873	$ 9,571	$ 9,339	$ 6,318	$ 4,924	$ 4,924	$ 5,157	$ 3,298	$ 6,318	$ 9,106	$ 7,945	$ 6,551	$ 5,621	$ 5,157	$ 4,228	$ 3,763	$ 3,298	$ 3,066	$ 2,834	$ 2,601	$ 2,834	$ 2,834	$ 2,834	$ 3,066	$ 3,066	$ 89,489
$85 at discount	$ 2,479	$ 2,955	$ 3,338	$ 3,698	$ 4,059	$ 3,052	$ 2,616	$ 2,854	$ 3,238	$ 2,230	$ 4,577	$ 7,037	$ 6,523	$ 5,695	$ 5,158	$ 4,981	$ 4,288	$ 3,998	$ 3,664	$ 3,554	$ 3,421	$ 3,266	$ 3,695	$ 3,832	$ 3,969	$ 4,442	$ 4,590	$ 138,301
Emissions Levy	$12,747	$13,153	$13,211	$13,269	$13,398	$ 9,370	$ 7,541	$ 7,778	$ 8,394	$ 5,528	$10,896	$16,143	$14,467	$12,245	$10,780	$10,138	$ 8,515	$ 7,761	$ 6,962	$ 6,620	$ 6,255	$ 5,868	$ 6,529	$ 6,665	$ 6,802	$ 7,508	$ 7,656	$ 227,790
Discount	95%	94%	93%	92%	91%	90%	89%	88%	87%	86%	85%	84%	83%	82%	81%	80%	79%	78%	77%	76%	75%	74%	73%	72%	71%	70%	69%	68%

Scenario Three

Methane (kg)	93344	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416	80416
Nitrous Oxide	583.4	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6	502.6
$0.11/kg	$ 10,268	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846	$ 8,846
$85 at discount	$ 2,479	$ 2,563	$ 2,990	$ 3,418	$ 3,845	$ 4,272	$ 4,699	$ 5,127	$ 5,554	$ 5,981	$ 6,408	$ 6,835	$ 7,263	$ 7,690	$ 8,117	$ 8,544	$ 8,971	$ 9,399	$ 9,826	$10,253	$10,680	$11,107	$11,535	$11,962	$12,389	$12,816	$13,244	$13,671
	$ 12,747	$ 11,409	$11,836	$12,263	$12,691	$13,118	$13,545	$13,972	$14,399	$14,827	$15,254	$15,681	$16,108	$16,536	$16,963	$17,390	$17,817	$18,244	$18,672	$19,099	$19,526	$19,953	$20,380	$20,808	$21,235	$21,662	$22,089	$22,516
	95%	94%	93%	92%	91%	90%	89%	88%	87%	86%	85%	84%	83%	82%	81%	80%	79%	78%	77%	76%	75%	74%	73%	72%	71%	70%	69%	68%

Appendix 5 Sensitivity Analysis

Discount rate & forestry income per ha – Difference NPV

Discount Rate Used

Forestry return per ha ($)

106,236	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
10,000	3,838	(51,150)	(90,949)	(119,491)	(139,688)	(153,697)	(163,124)	(169,162)	(172,701)	(174,405)
15,000	148,074	58,897	(6,768)	(54,933)	(90,055)	(115,446)	(133,573)	(146,279)	(154,940)	(160,588)
20,000	292,309	168,945	77,413	9,625	(40,422)	(77,194)	(104,022)	(123,396)	(137,179)	(146,771)
21,712	341,695	206,625	106,236	31,729	(23,428)	(64,097)	(93,904)	(115,561)	(131,098)	(142,040)
22,000	350,003	212,964	111,085	35,448	(20,569)	(61,893)	(92,202)	(114,242)	(130,075)	(141,245)
25,000	436,544	278,993	161,594	74,183	9,211	(38,943)	(74,471)	(100,512)	(119,418)	(132,954)
30,000	580,780	389,040	245,775	138,741	58,843	(691)	(44,920)	(77,629)	(101,657)	(119,138)
35,000	725,015	499,088	329,955	203,299	108,476	37,560	(15,369)	(54,746)	(83,896)	(105,321)

Appendix 6 Thematic Analysis