Market forces or market failure?

An analysis into the opportunity for expanded milling wheat production in New Zealand

Report prepared by:

Perrin Ag Consultants Ltd

For:

New Zealand Agricultural Greenhouse Gas Research Centre

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Executive summary

"Market forces or market failure? An analysis into the opportunity for expanded milling wheat production in New Zealand" is the first in a series of reports prepared for the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC). These reports examine potentially viable diverse land uses in New Zealand that could provide alternatives to the largely monoculture and ruminant-dominated pastoral agriculture systems across our landscapes at a more expansive farm systems perspective.

This report builds on the recommendations derived from earlier work, on the potential for expanding the production of milling wheat, which identified a number of potential supply chain challenges for the commercial expansion of milling wheat New Zealand farms.

Increasing the area of milling wheat production in New Zealand has a number of potential benefits, including food security and reduced methane and nitrous oxide emissions from growing wheat on land currently exclusively used for livestock production. However the devil is, as they say, in the detail.

There are several challenges associated with expanding the volume of milling wheat grown domestically in New Zealand. To support expanded domestic production the farm gate price needs to be:

- sufficiently high for the milling wheat to compete with alternative land uses under the yield expectations of the location and account for the integration of this crop into existing farm systems.
- sufficiently low to allow domestic supply to be competitive with (or the preferred option over) imported Australian grain for the domestic mills.
- sufficiently stable to justify the scale required and capital investment a farmer needs to make into the plant and equipment necessary to support production.

There are numerous factors that influence these three key pillars, but two appear the most significant, depending on the location of the potential domestic production.

The yield potential and existing harvest and storage infrastructure in the South Island make this area the logical location in which to expand production, but the cost of transporting grain to the North Island appears to have been prohibitive. Despite this, in the current environment the price to transport grain from Christchurch to Auckland at $105/t is sufficient to make South Island wheat at a $550/t farm gate price competitive with that from Australia. However, at the price level that had prevailed in earlier years for imported grain (say $450/t), South Island produced grain would still not have been competitive with these imports even if transport was free. While there is work being undertaken on examining the opportunities to extract efficiencies within the domestic transport network, a sustained increase in global (and therefore Australian) grain prices is ultimately required to create the market environment where mills will commit to contracts with South Island growers that work for both parties after accounting for domestic freight.

Secondly, while there is likely to be suitable areas to grow milling wheat in the North Island, the lower expected average yields (8 t/ha) relative to the South Island (10 t/ha) significantly reduce the expected profitability of this enterprise, even with a premium for their closer location to their customer mills. As a result, growing milling wheat in the North Island struggles to be competitive with the livestock enterprises it might supplant or the alternative arable crops that could be used to diversify exclusively livestock systems (such as growing maize for silage). Even when considering the expected financial impact of pricing methane (and nitrous oxide) emissions at the farm level, milling wheat in the North Island seems unable to outperform the lamb or bull beef finishing enterprises it could replace at grain yields less than 10 t/ha and is not even close to being competitive with pastoral dairying. So unless North Island grain yields could reliably achieve 10 t/ha, the investment in post-harvest infrastructure required to support expansion of the industry into the North Island is a moot issue and it seems unlikely that significant areas of milling wheat would be grown in the North Island.

From a true food [nutrition] security point of view, New Zealand would seem to have an annual deficit of as much as 30,000 ha of milling wheat. While wheat from Australia remains available to import, the farm gate price for milling wheat in the South Island only needs to be $110/t lower than the landed price of wheat from Australia (based on current domestic freight prices) to be competitive at the mill. Whether this price is sufficiently high enough to deliver the volumes required by the mills is not clear. This pre-condition is more or less met by current market conditions, but domestic production in 2022 is still only going to deliver 30% of expected annual requirements. This suggests a much higher price, potentially accompanied by more favourable contract terms, would be required to encourage more area to be planted. This situation would also be supportive of North Island expansion, but the improvement in grain yields under North Island conditions is the primary precursor of this occurring.

In summary, the observed limits in the expansion in the quantity of milling wheat grown in New Zealand seem to be evidence of market forces working as they should, at least from the perspective of delivering cost effective milling wheat to New Zealand domestic consumers. The current situation seems unlikely to change until a combination of the following make the domestic production of milling wheat a substantively more profitable land use than its current alternatives:

- improved yield potential in the North Island.
- a structural reduction in access to Australian grain.
- increases in the efficiency of the domestic internal transport networks.
- a significant imposition from the cost of climate change externalities on pastoral farming.

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1 Introduction

The New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) has initiated and funded a Future Farm Systems Research Programme. It has two key parts – the first looking at case studies and co-designed solutions for the primary sector transitioning to a low emissions future [Part 1] and a second part envisioning what that low emissions future might look like [Part 2].

"Market forces or market failure? An analysis into the opportunity for expanded milling wheat production in New Zealand" is the first in a series of reports prepared for the NZAGRC programme that examines potentially viable diverse land uses in New Zealand that could provide alternatives to the largely monoculture and ruminant-dominated pastoral agriculture systems across our landscapes at a more expansive farm systems perspective.

This report builds on recommendations for potential further analysis derived from the initial summary, which identified a number of potential supply chain challenges for the commercial expansion of milling wheat New Zealand farms.

Milling wheat supply in New Zealand has declined over the past decade and beyond (AIMI, 2022). The key opportunities to upscale the milling wheat industry were identified as the establishment of suitable contract terms with millers and growers; overcoming the barriers to transportation between the North and South Islands and growing milling wheat production to commercial scale in the North Island. Factors in the milling wheat industry which contribute to the supply chain are the international ownership of NZ mills, profitability of land use and suitability of milling wheat as an enterprise for farm integration.

Despite having growing conditions highly suited for wheat, New Zealand imports approximately 70% of its grain requirements from Australia (Tait *et al.*, 2019). Domestic consumption of bread and other wheat products in New Zealand could be met by domestic wheat production, but reliable supply of and demand for domestic grain in the market drives industry success. Most milling wheat is currently grown in Canterbury but **the Wairarapa, Manawatū-Whanganui and Hawkes Bay are also suitable for milling wheat production and could support an expansion of milling wheat planting**. The Arable Food Industry Council has set a goal of achieving increased domestic wheat supply in milling wheat by 2025.

Flour and wheat products are staples for New Zealand consumers. The main type of bread consumed in New Zealand is soft plastic packaged loaves in white or light grain; making up 80% of consumption (Ministry of Health, 2022). Recent consumer research identified that local consumers would be willing to pay a premium of at least 20 cents per loaf of locally grown bread (Tait *et al.,* 2019; Tait *et al.,* 2022). Although, despite being a product with inelastic demand, with the recent spike in inflation a consumer's willingness to pay a further premium for domestically grown wheat in bread is likely to diminish.

Freighting costs and transport logistics in New Zealand pose a challenge to industry upscaling. The Foundation for Arable Research (FAR) is currently investigating the logistics of utilising railway carriages, increased ferry services and coastal freighting to move grain from the South Island to North Island centres. Currently it costs $80-100/tonne to ship wheat from Canterbury to Auckland. When compared to an historical shipping cost from Sydney to Auckland of $50/tonne, importing from Australia has been more cost effective than sourcing wheat from the South Island.

International ownership of mills decreases flexibility in negotiations with farmers. Businesses operating on this level of scale require grain at a specific quality standard for consistency in bakery operations. Cost of goods is the fundamental driver for sourcing raw materials. Therefore, the price of New Zealand grown wheat delivered to the mills needs to be cost competitive with that of Australian wheat. Historically, this has not been possible. However, the current and future global wheat trade environment may facilitate this. Shipping costs from Australia have recently reached $200/tonne due to decommissioned shipping routes and competition for shipping. Future drivers of high grain prices will include fuel prices, shipping space and decreasing global wheat supply with increasing demand for Australian wheat from Northern Hemisphere nations.

Current forward contract structures may limit farmer uptake on milling wheat supply agreements because these contracts often don't specify a delivery date and growers can be left to store wheat on farm for several months after harvest for free. Additionally, forward contracts are challenging in a volatile cost environment. For example, growers observed on farm inflation increase by >20% in the 2021/22 financial year. However, contracts signed in May 2021 were for the appropriate pricing ($430/tonne) at the time. By May 2022, the open market price had increased to $630/tonne, reflecting the impact of the increasing costs. Contracts are beneficial for managing supply and demand between millers and growers but should be remodelled to better incentivise milling wheat production. This could be through compensation for storage on farm or increasing the farm gate price to reflect the investment and expertise required for producing milling quality wheat grain.

Finally, an arable crop such as milling wheat readily fits a rotational pasture-crop cycle and can be integrated into farm systems for pasture renovation, decreasing methane production and provide an alternative income stream. Most often arable crops are outcompeted for land use based on profitability. However, diversification of farm systems reduces financial risk, with additional ecosystem and environmental benefits. **There are clear opportunities to incorporate milling wheat into other existing farm systems**. By-products such as straw provide additional feed source or biofuel possibilities.

2 Requirements for sustainable industry expansion

The Foundation for Arable Research reported that a further 27,000 ha (at a yield of 10 tonne/ha) of milling wheat is required to supply domestic demand that is currently being fulfilled by importing Australian grain. McDowell, Herzig, van der Weerden, Cleghorn and Kaye-Blake (2022) recently estimated that a further 2,522 ha of area in [milling] wheat or [malting] barley production (7,566 ha of total land in a wheat/barley rotation) would be required to provide sufficient nutrition to New Zealanders as part of an optimised healthy diet over and above the quantities of these grains already grown or imported. On this basis, the potentially required additional area of milling wheat to provide domestic food security for New Zealand in this staple food source might be between 27,000 and 30,000 ha per annum.

Currently, milling wheat forms part of a well-established arable industry in Canterbury. Milling wheat production is most commonly integrated into a mixed cropping system which operates on a six-year rotation, based on pest and disease minimisation, nutrient balancing and crop performance. Risk is balanced through diversified income streams. However arable land use has been largely less profitable and has resulted in significant trends away from arable cropping.

Figure 1 illustrates the clear challenges associated with the profitability of milling wheat relative to other commodities, where the prices have gradually diverged since the late 1990's. Over the 20 years illustrated by Pangborn and Woodford (2011), milling wheat experienced little growth in value compared to that of lamb, steer and milksolids production which exceeded 2000 points on the commodity index. This effect was amplified after the removal of subsidies from primary production and products that were most competitive in export markets became more valuable at the farm gate. New Zealand milling wheat is not competitive in a global trade environment, which limits the opportunity to achieve value from international demand.

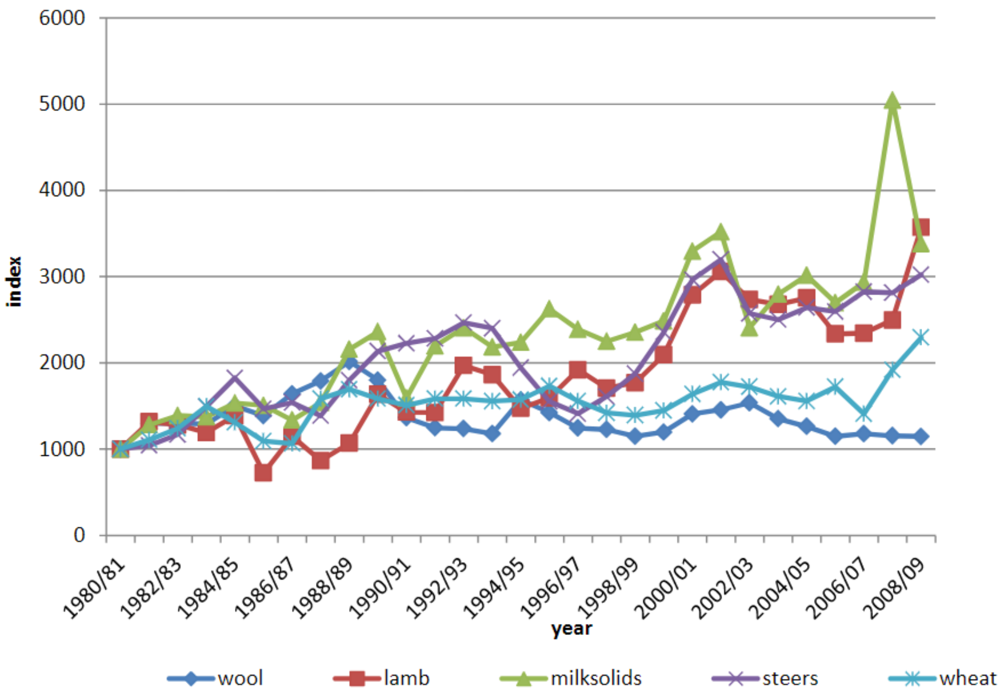

Figure 1: Inflation adjusted indices of agricultural commodity prices (1980-81 to 2007-08). From Peel (2013), originally adjusted from Pangborn and Woodford (2011).

Farm system integration in the North Island

A summary of factors which have supported the successful development of the Canterbury arable industry are presented in Table 1 and provides considerations for increasing milling wheat in new areas in the North Island. When considering the development of an existing arable crop in a new area, it is important to understand where the crop will fit and how this changes the existing farm systems.

Table 1: Success factors for a 'Canterbury' milling wheat supply chain and opportunities for North Island production systems.

Success factors for arable cropping in Canterbury	Opportunities for development in the North Island
• Hot dry summers, with early moisture requirements met by winter sowing or irrigation if needed • Farm scale (> 200 ha) justifies large machinery ownership • Locality to grain merchants and mills • Flat topography, roading networks • Demand for feed grains (dairy, poultry, pig industries) • Mixed cropping rotational system, spreading risk across multiple crops and income streams in a given year	• Cultivars suited to environment and fungal pathogen resistant • Improve access to industry expertise • Syndicates for shared infrastructure development • Develop freight networks for delivery of grain to large centres

A milling wheat rotation could be incorporated as a cash crop to existing sheep, beef or dairy operations. Incorporating a permanent arable rotation to a farm system is likely to be accompanied by a reduction in production of meat, milk or wool, unless efficiency gains are made. However, the associated profit lost could be offset from the new arable income stream.

Most livestock-crop systems have a rotation of two to four years of crop production followed by two to four years of subsequent grazing of grass-clover swards. During the cropping phase, soil properties are degraded but the grazed pasture phases under legume and grass improves soil aggregate quality, soil porosity and soil earthworm population (Haynes & Francis, 1990). This restores soil properties and soil fertility to a degree.

While the Manawatū and Hawkes Bay regions are predominantly cash cropping with barley or maize grain, there is opportunity to increase milling wheat production in the North Island in these areas. This is a matter of achieving suitable returns for the grower that outcompetes other land uses, and matching cultivars to region.

Physical farm characteristics such as access through tracks and lane ways for large machinery, size of existing paddocks and gateways affect the efficiency of planting and harvesting operations required for milling wheat on farm. For example, areas where a tractor and drill can access, may not be accessible to a combine harvester. This could be overcome by planning to transport the head of the combine separately until reaching the paddock and removing again before exiting. Additionally, adjusting gateways and lanes may be required in order to minimise time wasted on manoeuvring heavy equipment. Typically, mixed cropping farm systems are characterised by large open paddocks with minimal permanent fencing and large double gateways and tracks for machinery access. Any predominantly stock based farm considering integration of an arable crop should undertake planning to mitigate any challenges associated with accessibility.

Milling wheat can be successfully grown on rolling slopes without significant effect to yield and quality (pers comms. Ivan Lawrie August 2022). A farm with paddocks limited by slope could experience decreased efficiencies in crop production and harvest, but consistency and frequency of rainfall is a key contributing factor to crop success in these environments.

In the North Island, spring sown wheat could follow a winter forage crop, in lieu of other catch crops such as oats or annual grasses. In the South Island, where rainfall is less reliable, wheat is often sown prior to winter in order to allow extra growth and development prior to periods of moisture stress in summer. Wheat sown in winter would likely be more exposed to fungal diseases in the North Island, where this is not a concern in Canterbury. Additionally, the spring season is adequately warmer for plant growth and development in the North Island. However, observed yields are lower in current North Island production systems (see below). This is possibly through the challenges associated with managing pests and diseases at critical points, as well as the suitability of given cultivars to the specific region. There has been a significant amount of research and development into the success and improvement of milling wheat cultivars for the Canterbury growing environment. This has not been as prevalent for North Island growing conditions.

Yield, cost of production and competitiveness with alternate land uses

The yield of the crop has a significant effect on the overall gross margin. Predominantly this is driven by the effects of the season and challenges faced with crop performance. A grower is always going to be inclined to apply the required amount of nutrients in order to maximise the possibility of achieving a crop of 10 tonne or greater. In general, a yield of 10 tonne is typical in Canterbury, but a yield of 8 tonne/ha is more realistic in the North Island (AIMI, 2022). Other costs do not substantially increase as a result of increased tonnage per hectare, which sees the revenue from every extra tonne of grain yield substantially contribute to profit.

Understanding the barriers to achieving greater yields on a per hectare basis in the North Island would be beneficial. This could be the development of cultivars more suited to the region and adaptive towards increasing CO_2 levels and an increased temperature environment.

Under the current input cost environment (Foundation for Arable Research, 2022), an indication of a breakeven price required for milling wheat production at a yield of 10 t/ha is $400/t (Table 2), while an 8 t/ha crop would require a grain price of $500/t to break even (Table 3). A full gross margin, with detailed expenses is appended in Table A 12.

Table 2: Sensitivity of milling wheat gross margin at a yield of 10 tonne/ha.

Milling wheat breakeven price at 10 t/ha			
Wheat Price ($/tonne)	Income ($/ha)	Costs ($/ha)	Gross margin ($/ha)
$250.00	$2,500	$3,879	-$1,379
$350.00	$3,500	$3,888	-$388
$400.00	$4,000	$3,893	$107
$450.00	$4,500	$3,897	$603
$550.00	$5,500	$3,906	$1,594
$650.00	$6,500	$3,915	$2,585
$750.00	$7,500	$3,924	$3,576
$850.00	$8,500	$3,933	$4,567

In order to compete on a per hectare profitability basis against other primary land uses, a gross margin of $1,500/ha or greater is required. With the current cost environment, this requires a wheat price of $550/ha for a 10 tonne crop (Table 2) compared to $675/ha if a crop only yields 8 tonne (Table 3).

Table 3: Sensitivity of milling wheat gross margin at a yield of 8 tonne/ha.

Milling wheat breakeven price at 8 t/ha			
Wheat Price ($/tonne)	Income ($/ha)	Costs ($/ha)	Gross margin ($/ha)
$250.00	$2,000	$3,757	-$1,757
$350.00	$2,800	$3,764	-$964
$400.00	$3,200	$3,768	-$568
$450.00	$3,600	$3,771	-$171
$550.00	$4,400	$3,778	$622
$650.00	$5,200	$3,786	$1,414
$750.00	$6,000	$3,793	$2,207
$850.00	$6,800	$3,800	$3,000

Integration into sheep and beef farm systems

To start to understand the potential impact of introducing milling wheat (with an assumed baseline grain yield of 8 t/ha) into suitable North Island farming operations, two variations of a 200 ha finishing farm in the Manawatū area were modelled in Farmax Red Meat, where one base model was primarily lamb finishing and the other base model was beef finishing (Friesian bulls). The model farm was aligned with the parameters for the average 2022 Beef & Lamb NZ Class 5 finishing farm in Taranaki-Manawatū (Beef and Lamb NZ, 2022). On the basis that it was considered unlikely that any milling wheat enterprise smaller than 15 ha or greater than 50 ha would suit a farm operation that predominantly relies on stock for income, an area of 35 ha was included into the existing farm systems. This area was considered sufficient to achieve some scale of production on a mixed enterprise.

The accompanying changes to total stock numbers were estimated as being those sufficient to maintain the same underlying levels of pasture cover at key times of the year.

Table 4 presents the effect on total greenhouse gas emissions for the modelled farm systems. Little change was observed in emissions intensity (kg CO_2-e/kg product) between systems, but incorporating milling wheat decreased greenhouse gas emissions by 13% in the lamb finishing model and 18% in the bull finishing model. The emissions intensity of sheep meat is consistent with that of the findings of Beef and Lamb NZ (2022) where this was estimated at 13.32 kg CO_2-e/kg sheep meat.

Limitations of Farmax include the inability to measure the N_2O and CO_2 emissions from the arable proportion of the farm system, primarily being from the application of urea to milling wheat. Literature suggests that the additional CO_2 emissions from the added 35 ha of arable production would have a limited impact on the farm's overall greenhouse gas portfolio. Estimated on-farm emissions for a milling wheat production system are 280 kg CO_2-e/ tonne of wheat (Barber and Stenning, 2021), say 2,800 kg CO_2-e/ha, including the associated emissions from electricity, fuel and the manufacture of fertiliser. Field emissions from nitrogen fertiliser application are likely to account for a third of total emissions (Barber *et al*. 2011), say 924 kg CO_2-e/ha. On this basis, the incorporation of 35 ha of milling wheat will increase N_2O emissions by 32.3 t CO_2-e from those presented in Table 4.

Table 4: Farmax Red Meat output for lamb and beef finishing enterprises where 35 ha of milling wheat was added to the farm system

	Production		GHG Emissions					
Farm System Type	Effective Area (ha)	kgDM eaten/kg product	Emissions intensity (kg CO2e/product)	CH_4 (t CO_2e/ha)	N_2O (t CO_2e/ha)	Total (t CO_2e/ha)	Total (t CO_2e/Farm)	% Change
Lamb finishing	202	20.7	12.5	3.5	0.8	4.3	870.6	
LF + milling wheat	202	21.2	12.9	3.3	0.8	4.1	818.1	-6%
Bull finishing	202	16.7	11.3	3.9	0.8	4.6	937.3	
BF + milling wheat	202	17.0	11.5	3.5	0.7	4.2	840.3	-10%

Table 5 demonstrates the changes in profitability between current systems where an expected initial farm-level methane emissions levy of \$0.11/kg CH_4 and N_2O pricing of \$4.25/kg CO_2-e was incorporated. Integrating a milling wheat enterprise within both existing farm systems resulted in a decrease in operating profit (as measured by EBITRm[1]) essentially due to the lower gross margin from milling wheat than the livestock enterprises. When the levy (as calculated from the emissions reported in Farmax output) was accounted for, including milling wheat in the system reduced the reduction in EBITRm from -10% to -9% in the beef finishing model. However, once the impact of the N_2O emissions associted with the wheat production are accounted for, the fiscal impact is likely to be close to neutral.

Table 5: Profitability of modelled lamb and beef finishing enterprises, accounting for milling wheat in the system and an agricultural emissions levy of \$0.11/kg CH_4 and \$4.25/ t CO_2-e

	Profitability without levy		Cost of levy		Profitability including levy		
Farm system type	Farm EBITRm (\$)	Change (%)	Levy (\$/ha)	Total levy (\$)	Farm EBITRm (\$)	EBITRm (\$/ha)	Change (%)
Lamb finishing	\$200,209		\$19	**\$3,806.19**	\$196,403	\$972	
LF + milling wheat	\$189,225	-5%	\$18	**\$3,576.92**	\$185,648	\$919	-5%
Bull finishing	\$226,149		\$20	**\$4,100.40**	\$222,049	\$1,099	
BF + milling wheat	\$204,648	-10%	\$18	**\$3,676.20**	\$200,972	\$995	-9%

From a farm systems perspective, the milling wheat area integrated better with the lamb finishing scenario than with that of the bull finishing model. This is primarily a result of the bull finishing system structured to benefit from high periods of growth in spring and early summer and being compromised

[1] Earnings before interest, tax, rent and the wages of management

from the reduction in available feed with the loss of land to wheat. Subsequently the bull finishing with milling wheat scenario suffered a greater loss in profit compared to the base model. Conversely, the introduction of a large milling wheat crop to a lamb finishing operations across a period where pasture management is difficult to keep on top of provided some benefit to the system and essentially transferred feed quality to the autumn.

Integration into dairy farm systems

There is some evidence for crop-dairy complementarities across systems in New Zealand and Australia Dynes *et al.,* 2010; Villano *et al.*, 2010) and globally.

Figure 2 illustrates a possible framework for a crop-dairy integrated system where resources are shared amongst the two operations. For example, the effluent from the dairy operation could be processed and applied to the cropping operation as a source of nutrients while residual forage such as straw, introduced back to the dairy operations as supplementary feed. The exports are the crop product itself and milk and meat products off the dairy operation. Further to that, with the increased development of biofuel production in New Zealand, avenues will be available for the wheat straw as a biofuel source, if not utilised back in the farm system for stock feed or bedding.

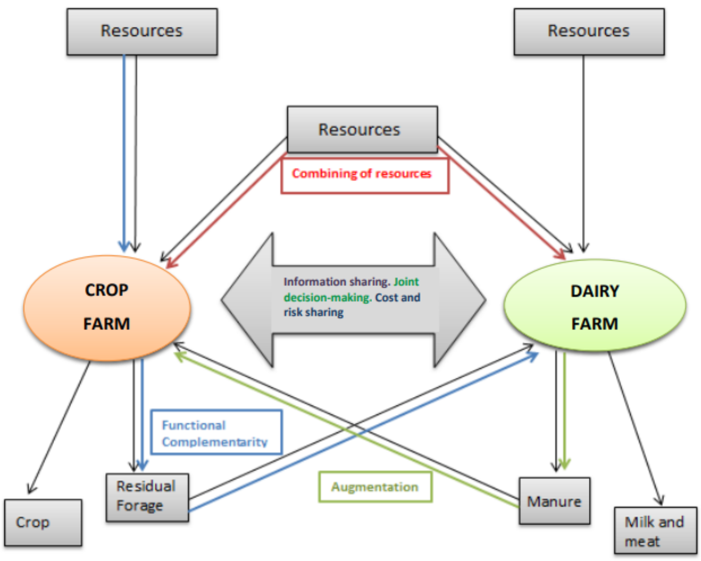

Figure 2: Proposed synergies between crop and dairy based on the framework from Villano et al., (2010) and adapted by Peel, S. (2013)

Most dairy farm operations use land intensively for the purposes of grass growing for milk production, and typically rely on imported feed, harvesting conserved supplement only in periods of feed surplus. Grazing in periods of feed deficit is supported by winter cropping, utilisation of run-offs or grazing off agreements with other farmers.

The environment for dairy farms is evolving and increasing rules and regulations will continue to add to the complexity of farming. Subsequently, a reduction in the numbers of the overall dairy herd in New Zealand might be required to meet emissions and water quality targets. Where winter grazing becomes less possible, reducing stocking rate or implementing covered systems in winter may become more common practice. Interest has been renewing for dairy systems to become fully closed systems and be self-sufficient in feeding. Accounting for this means managing the annual stocking rate to enable the farm to be appropriately stocked for the winter. In Canterbury, most dairy farms are characterised by the ownership of a run-off block which is primarily used for dairy cow and heifer grazing and also achieves other sources of income through dairy-beef or cash cropping (Richards, 2006).

Integrating cash cropping onto the dairy platform complements a reduction in cow numbers for emissions and water quality purposes. Additionally, during periods of feed surplus, pasture quality could be managed by growing a cash crop over area that is not required for the milking platform under a lower stocking rate. This has added benefits of opportunities for increased pasture renewal but also providing an additional source of stock feed in straw, as modelled by Peel (2013).

To explore the potential impact of integrating milling wheat into a North Island dairy farm system, a 126 ha Manawatū dairy farm was modelled in Farmax Dairy based on the 2020/21 DairyNZ Economic Survey data for lower North Island owner-operators. Two scenarios were analysed, one with 10 ha of milling wheat and one with 20 ha.

As with the two sheep & beef farm systems modelled, greenhouse gas emissions (as calculated from the Farmax software) reduced as a result of the reduction in total dry matter consumption and stock numbers. Again, this net reduction is likely overstated given the nitrous oxide emissions associated with the wheat production that aren't calculated by the software. However, at 2.3 t CO_2-e the per hectare N_2O emissions from the modelled dairy farm system are twice as high as might be expected from a hectare of milling wheat.

Table 6: Farmax Dairy output for a 126 ha dairy farm operation where either 10 or 20 ha of milling wheat was added to the farm system

	Production		GHG Emissions						
Farm system type	Effective Area (ha)	total kg MS	Emissions intensity (kg CO2e/kg MS)	CH_4 (t CO_2e/ha)	N_2O (t CO_2e/ha)	t CO_2 from N Fertiliser/ha	Total t CO_2e/ha	Total t CO_2e/Farm	Change (%)
Dairy	126	131378	10	7.6	2.3	0.2	10.1	1272.6	
Dairy + milling wheat (10 ha)	126	126065	10	7.3	2.2	0.2	9.6	1204.6	-5%
Dairy + milling wheat (20ha)	126	124055	10	7.2	2.1	0.1	9.4	1181.9	-7%

Unlike the two sheep & beef farm systems analysed, the estimated loss in profitability with the inclusion of milling wheat in the farm system was greater than the proportionate reduction in emissions (Table 7). This is simply the result of the significantly higher gross margin associated with dairying relative to milling wheat production. Furthermore, despite dairying having a significantly higher emissions profile than either of the two sheep & beef systems analysed, at the assumed level of intial farm level emissions prices the impact on the levy of milling wheat's inclusion within the farm system was negligible. Pricing the N_2O emissions associated with the wheat crop would reduce the impact further.

Table 7: Profitability of modelled dairy farm scenarios, accounting for milling wheat in the system and an agricultural emissions levy of \$0.11/kg CH_4 and \$4.25/ t CO_2-e

	Profitability without levy		Cost of levy		Profitability including levy	
Farm system type	Farm EBITRm ($)	Change (%)	Levy ($/ha)	Total levy	Farm EBITRm ($)	Change (%)
Dairy	$591,899		$44	**$5,552.19**	$586,347	
Dairy + milling wheat (10 ha)	$526,444	-11%	$42	**$5,256.59**	$521,187	-11%
Dairy + milling wheat (20 ha)	$502,813	-15%	$41	**$5,158.13**	$497,655	-15%

Access to required infrastructure and equipment

In current high density cropping regions, harvest and transport networks are well established. For example, trucks are able to pick up grain from farms with minimal transportation to local mills in Christchurch. This provides little barriers to accessibility. However, areas where there is less dominance of arable land use, such as in the North Island, supply of milling wheat will be more fragmented.

Mixed arable farms often have significant scale which justifies the ownership of most of the plant and equipment required for all arable operations. This includes paddock preparation, drilling and harvesting equipment, with some spraying and fertiliser applications contracted out. Additionally, large arable farms will have multiple silos for storage, units for grain cartage off the paddocks, and some will have driers on farm or use grain merchants for drying as required.

Developing a cash cropping regime on farm requires further investment in infrastructure that is otherwise not largely utilised in ruminant based farm systems. This comes at a large investment to the business. Table 8 presents some of the capital costs expected for farm businesses that would be above and beyond current farm infrastructure. Additionally, a farm would expect to have to upgrade access to cropping paddocks to enable large machinery such as combine harvesters and drills to enter the paddocks.

Table 8: Estimated capital costs of new arable infrastructure on farm (Source Gough Agritech, 2022)

Arable on farm infrastructure			
Item	**Cost/unit**	**Example**	**Notes**
Simple Auger 8"	$ 15,000	$ 15,000	simple auger but operates both ways
Grain trailer 12 t	$ 50,000	$ 50,000	could be purchased second hand or modified
Silo 45 t	$ 18,000	$ 112,000	requires 6 silos for ~280 tonnes
Concrete pad	$ 2,080	$ 12,942	16m2 at $130/m2
Total	**$ 85,080**	**$ 189,942**	

There are existing arable contractors in the Manawatū - Whanganui area (Arable Solutions, 2022), due to large production levels of feed barley, some wheat and maize. Therefore implements and skilled operators required for drilling, spraying, fertiliser and harvesting are available. However, with any increase in milling wheat production, an increase in the need for machinery and skilled operators would be expected. Developing the industry could involve encouraging contracts with grain drying and storage providers such as those located in Marton and Glen Orua, with potential expansion of services offered.

Additionally to relying on contractors, farmer syndicates for machinery have been popular across New Zealand and globally. Syndicates that are well structured with good management are successful with increased efficiency in machinery utilisation and spreading capital cost across farms (Stewart, 1973). An example of this could include a shared investment in equipment for cultivating, drilling and harvesting while utilising contractors for fertiliser spreading and spray applications. Successful syndicates often operate with a person designated to be responsible for machinery maintenance and employing skilled operators on syndicate machinery.

This theory could also apply to shared use of drying and storage facilities where wheat is pooled for storage on a collected basis. If grain is pooled together at a storage facility, it will be important to set up appropriate settings for quality assurance and traceability back to the farmer. It is likely that grain being stored in such a shared arrangement be tested on arrival. At this point ownership could be transferred to the mills who would then carry the cost of storage and management or be pooled together in a shared agreement with other farmers.

Utilising discounted cash flow analysis, the return on investment was estimated for the new storage infrastructure required for a farm producing 20 ha of milling wheat at a yield of 8 t/ha and a grain price of $550/t. It was assumed the equipment depreciated at rate of 17% per annum. This assumed that the farm contracted out all growing expenses, including drilling, spraying, fertiliser applications and harvest. As such the analysis did not include the potential investment required, should a farmer wish to complete some contracting activities such as sowing, spraying or harvesting themselves.

Table 9: Five year discounted cash flow analysis on capital infrastructure required when grower invests 100% of costs for a 20 ha milling wheat enterprise yielding 8 t/ha

Milling wheat infrastructure cashflow analysis: 100% grower investment						
Year	**0**	**1**	**2**	**3**	**4**	**5**
			Revenue $/ha			
Harvest income		$4,400	$4,400	$4,400	$4,400	$4,400
Land Value:						
Total Revenue/ha:	**0**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**
			Expenditure $/ha			
Capital: Grain auger	-$429					$169
Capital: Grain trailer	-$1,429					$563
Capital: 45t silo	-$3,200					$1,260
Capital: concrete pad	-$4,437					$1,748
Capital: farm infrastructure upgrade	-$200					
Growing and harvest costs		-$3,778	-$3,778	-$3,778	-$3,778	-$3,778
Total Expenditure/ha:	**-$9,694**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$38**
Annual Cashflow:	**-$9,694**	**$622**	**$622**	**$622**	**$622**	**$4,362**
Net present value (at 5% discount rate)	**-$2,847**					
Internal rate of return (IRR)	**-8%**					

Table 10: Ten year discounted cash flow analysis on capital infrastructure required (per ha) when grower invests 100% of costs for a 20 ha milling wheat enterprise yielding 8 t/ha

Milling wheat infrastructure cashflow analysis: 100% grower investment											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
						Revenue $/ha					
Harvest income		$4,400	$4,400	$4,400	$4,400	$4,400	$4,400	$4,400	$4,400	$4,400	$4,400
Land Value:											
Total Revenue/ha:	**0**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**	**$4,400**
						Expenditure $/ha					
Capital: Grain auger	-$429										$66
Capital: Grain trailer	-$1,429										$222
Capital: 45t silo	-$3,200										$497
Capital: concrete pad	-$4,437										$688
Capital: farm infrastructure upgrade	-$200										
Growing and harvest costs		-$3,778	-$3,778	-$3,778	-$3,778	-$3,778	-$3,778	-$3,778	-$3,778	-$3,778	-$3,778
Total Expenditure/ha:	**-$9,694**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$3,778**	**-$2,305**
Annual Cashflow:	**-$9,694**	**$622**	**$622**	**$622**	**$622**	**$622**	**$622**	**$622**	**$622**	**$622**	**$2,095**
Net present value (at 5% discount rate)	**-$3,987**										
Internal rate of return (IRR)	**-3%**										

In both the five year and ten year discounted cash flow analysis (Table 9 and Table 10), the capital investment in infrastructure at 100% grower investment did not pay off, as evidenced by both the negative net present value (NPV) for both scenarios at the assumed discount rate of five percent and the negative internal rates of return. Farmers could mitigate high capital infrastructure costs by purchasing second hand equipment such as grain trailers, or changing the size of a silo to make gains in economies of scale. However, when the infrastructure is destined for the single use of milling wheat storage, the result did not justify sole investment in grain storage infrastructure for the scale considered. With a potential period of greater than 10 years before the capital expenditure pays off, the grain price needs to remain consistent each year.

As expected, the investment returns do improve significantly as scale increases, as can be see in Table 11, when a 35 ha annual area of milling wheat at 10 tonne/ha delivers a positive NPV, given the plant and equipment is more fully utilised.

Table 11: Ten year discounted cash flow analysis on capital infrastructure required when grower invests 100% of costs for a 35 ha milling wheat enterprise yielding 8 t/ha

Milling wheat infrastructure cashflow analysis: 100% grower investment											
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	Revenue $/ha										
Harvest income		$5,500	$5,500	$5,500	$5,500	$5,500	$5,500	$5,500	$5,500	$5,500	$5,500
Land Value:											
Total Revenue/ha:	**0**	**$5,500**	**$5,500**	**$5,500**	**$5,500**	**$5,500**	**$5,500**	**$5,500**	**$5,500**	**$5,500**	**$5,500**
	Expenditure $/ha										
Capital: Grain auger	-$429										$66
Capital: Grain trailer	-$1,429										$222
Capital: 45t silo	-$3,200										$497
Capital: concrete pad	-$4,437										$688
Capital: farm infrastructure upgrade	-$200										
Growing and harvest costs		-$3,906	-$3,906	-$3,906	-$3,906	-$3,906	-$3,906	-$3,906	-$3,906	-$3,906	-$3,906
Total Expenditure/ha:	**-$9,694**	**-$3,906**	**-$3,906**	**-$3,906**	**-$3,906**	**-$3,906**	**-$3,906**	**-$3,906**	**-$3,906**	**-$3,906**	**-$2,433**
Annual Cashflow:	**-$9,694**	**$1,594**	**$1,594**	**$1,594**	**$1,594**	**$1,594**	**$1,594**	**$1,594**	**$1,594**	**$1,594**	**$3,067**
Net present value (at 5% discount rate)	**$3,515**										
Internal rate of return (IRR)	**11%**										

Contracts for supply

At present, there is a strong disconnect between mills and growers, which results in contracts that are not fit for purpose for the current market environment. Figure 3 illustrates the decline in contracted milling wheat from 2012 to 2022. This decline in the volume of contracted wheat reflects the overall trend in the large decrease in total milling wheat harvested in New Zealand. Over this time, the estimated total harvest tonnage has decreased from 140,000 tonnes in 2012 to between 60,000 – 90,000 tonnes between 2020-2022. It would appear that only 17% of the total grain harvest was contracted in the 2021/2022 season.

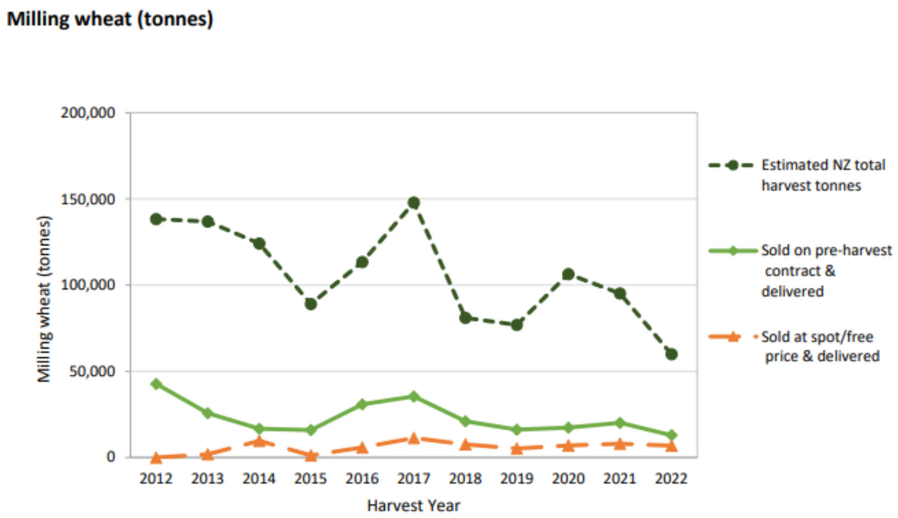

Figure 3: NZ harvest tonnage and sales channels for milling wheat (tonnes) as estimated on July 1st each year. From AIMI (2022)

In the arable sector, the high risk herbage and vegetable seed industry often employs forward contracting as a means to manage supply and provide better certainty to growers.

Historically, small scale growers would deliver wheat in sacks to mills in their local towns which were paid for upon delivery. There were fewer contracted arrangements but this arrangement suited the grower and the miller. However as scale increased, it became natural for farmers to develop infrastructure on farm in order to be able to store grain at harvest. As this increased, the practice became normal. Mills changed to international ownership and expanded to be primarily distributed in main centres. This was driven by the need to increase efficiency in the sector and manage value lost through inefficiencies of running large numbers of small mills.

Figure 4 illustrates the current locality of commercial mills in New Zealand. As an example, MAURI mills are a Division of George Weston Foods (GWF). Today GWF is one of Australia and New Zealand's largest food manufacturers employing over 6,000 people across 58 sites. GWF is itself a wholly owned subsidiary of Associated British Foods plc (ABF), a diversified international food, ingredients and retail group with operations across sugar, agriculture, retail, grocery and ingredients, employing over 100,000 people in 46 countries (Mauri, 2022).

Figure 4: Existing commercial mills in New Zealand

It suits the mills to have grain stored on farm for delivery when it suits the production lines. This arrangement appears to have become common place, but has evolved to a degree where farmers have little control over or certainty as to when product is delivered and paid for.

A successful forward contracting model should carefully account for the requirements of both parties and is largely relationship based. Both members of the agreement need to trust the other party and meet contract terms (Goodhue and Simon, unkn). The most important aspect of the agreement for the mills is the quality parameters of the wheat at harvest and in storage, while for farmers it is primarily about risk mitigation and accounting for volatility in costs. Additionally, being appropriately compensated for storing wheat on farm for a long period of time and maintaining quality during this period is important. Having this framework in place prevents the need for mills to invest further in storage on site and minimizes risk for loss of grain quality, if the grain remains under the care of the grower for months post-harvest.

In recent years the contracts offered have been largely centred around grain quality for mills, but do not appear to account for the inputs required to produce such a high quality grain. Further, contracts for milling wheat have been similar to the value of feed wheat contracts which have no quality parameters and more immediate delivery and payment terms. The feed wheat industry does support milling wheat industry development by improving the feasibility of production for growers; should a wheat crop fail to meet milling requirements, there is still a valuable side-stream in supplying on the spot market to the feed wheat buyers. However, the skill and input requirements of producing milling wheat to a quality suitable for milling should be rewarded and achieve a price significantly higher than that of feed wheat, in the interests of a sustainable domestic grain supply.

Figure 5 illustrates the effect that current global market conditions have had on the domestic spot prices offered for milling wheat this year, after almost three years of flat pricing. However, those growers with existing contracts will not have benefitted from the jump in the milling wheat spot price, based on the contracts that were signed in May 2021 for delivery in 2022 at $420 - $450/tonne.

From 2019 until early 2022, the milling wheat spot price had remained steady with a slight decrease from $450/tonne to $400-$420/tonne in early 2022. During this time period the feed wheat price started at approximately $425/tonne in 2019, remaining steady around $400-425/tonne before gradually increasing during 2021 to meet the milling wheat spot price in early 2022.

This shows there has been little to no differentiation between the milling and feed wheat spot prices over the past three years, which is a likely contributor to the decline in milling wheat production.

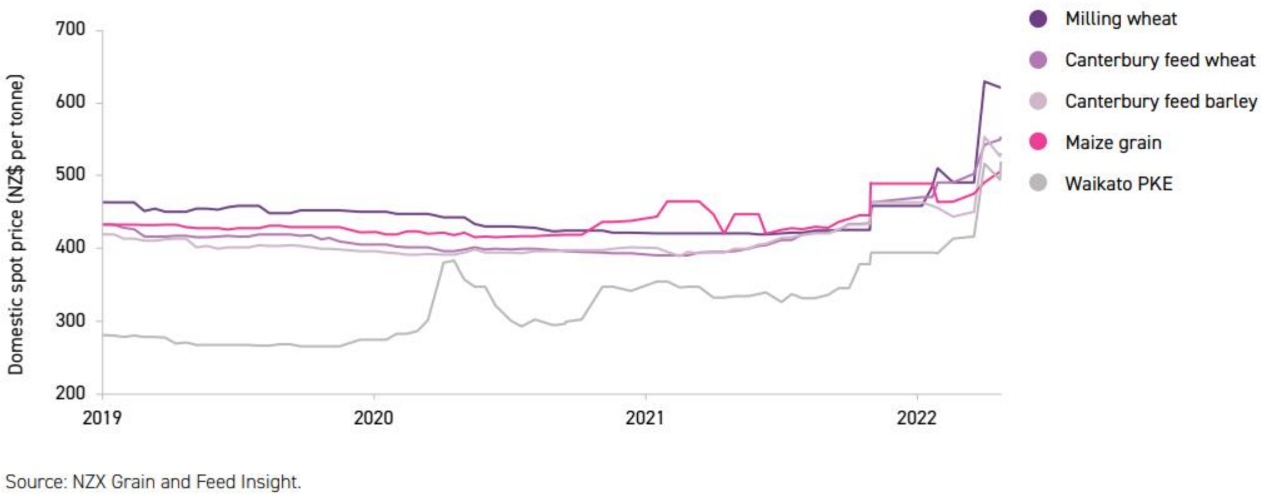

Figure 5: Jump in milling wheat price which exceeds contract pricing for feed wheat. From NZX Grain and Feed Insight (2022)

Contracts offered in 2022 for delivery in 2023 were driven by the uncertainty faced in the global scene for wheat supply and availability. In reflection of this, mills have been offering up to $630/tonne (Smith, 2022) which has been reflected in higher uptake of contracts and milling wheat area planted increasing to 11,113 ha in New Zealand, an increase in the area planted of 11% on the prior year. However contract terms still do not appropriately account for the risk and impact on the balance sheet that on-farm storage causes for growers. There has been some disruption in contract terms of the past years, with the introduction of an eight cent/tonne/day storage reimbursement for any crops remaining on farm after the end of April following harvest (Champion Flour Milling, 2020).

The response of the market to the higher contract prices offered would indicate that higher prices are an effective driver to encourage farmers to contract production to the mills. If global grain and freight prices (see below) remain high and/or volatile, there seems a greater likelihood that mills will offer higher priced and more favourable contracts and that farmers will respond by entering into them.

Competitiveness of domestic production

Cost of freight

The key variable that affects the price of freight between Auckland delivery and Christchurch delivery is the amount of value lost in freight and transport costs.

New Zealand domestic freight costs (pers. comms Mark Wareings, 2022) are largely made up of:

- Wages (20%)
- Fuel (17%) as a base rate. With current fuel prices extremely high, a freight adjustment factor (FAF) is applied to cover added fuel costs. Currently the FAF is 21% above standard freight rate.
- Road user charges (16%) are passed to the consumer. The dynamic charge of approximately 61 cents/km is dependent on the mileage travelled and tonnage of freight carried
- Depreciation (12%)
- Repairs and maintenance (excluding tyres) (12%)
- Tyres 3%

These factors are largely inelastic and out of the control of the trucking companies. Due to the recent significant increase in fuel prices, companies have had to apply a 'fuel adjustment factor' to freight charges. It is not viable for freight companies to front this added expense. Therefore it is subsequently passed to the consumer. Additionally, road user charges increase often and are directly charged to the consumer. Therefore decreasing the cost of freighting is challenging. Opportunities may arise through increasing efficiencies by using new transport mechanisms and diminish the effect of freighting cost on the price of milling wheat at the mills. This would involve better utilisation of ferry services, locomotives and coastal shipping.

Accessibility

Accessing equipment to move everything at harvest time is an issue in Canterbury. The allocation of trucks is appropriate 50% of the time, while the other 50% is made up of some over allocated periods and some under allocated periods. When trucks and trailers are fully loaded, the full capacity is 40 tonnes (pers. comms Mark Wareings, November 2022). Depending on demand, often trucks are run without the trailer or run half full. There is little to no back loading which occurs, decreasing efficiency in the transporting network. Further to that, in Canterbury more than 50% of the time truck drivers are expected to operate augers and suction to get grain into trucks. This is also considered a health and safety risk for the drivers.

Counter freighting is a possible method for better utilising freight and minimising cost. Opportunities are available in the agricultural freight industry to increase the occurrence of backloading when making deliveries or picking up product from farm. This takes advantage of existing freight networks established by farm suppliers. Examples of bulk freight deliveries that could be backloaded with milling wheat off farm include palm kernel extract, grains, shingle or woodchip. Better understanding of how this may look from a operational feasibility perspective is an opportunity for further research.

Storage

Milling wheat is harvested in Australia anytime from October or November, whereas the New Zealand harvest season is primarily December to February. This changes the aspect of supply to mills. In the absence of additional storage, there may be a requirement for early season wheat to continue to be imported from Australia to fulfil milling requirements on a consumer demand basis.

Grain can be stored under optimal conditions for months, but must be kept in cool, dry conditions. Grain should be coming into storage with a moisture content of no more than 12.5%. Where this is not achieved, drying facilities are required to meet the moisture content requirements. Drying can add approximately $36/tonne (Foundation for Arable Research, 2022) to the cost of milling wheat production. This can often happen when the harvesting season has been unpredictable and harvest under below optimal conditions is required in order to preserve quality. A key risk associated with grain production on farm is the weather being unpredictable and challenging at harvest time.

There is limited storage available at mills, but most mills operate under capacity during the year. There is little to no incentive to increase storage capacity at the mills, because these businesses are trying to maximise utilisation of existing infrastructure. For example, a mill that would process 50,000 tonnes of milling wheat per year, is more likely to store and process 5,000 tonnes of grain through the same silos ten times over rather than have infrastructure available to store all 50,000 tonnes on site post-harvest. While this is a good business proposition from the mills' perspective, should New Zealand hope to meet all domestic demand through domestic milling wheat supply, some arrangement may need to be made to enable storage of the increased supply of grain. Improved distribution and/or satellite storage options could incentivise increased production of milling wheat in given areas.

The multinational businesses which own the mills in New Zealand changes the aspect of demand and supply for milling wheat in New Zealand. Both large companies which own the mills in New Zealand could integrate with Australian colleagues to manage supply and demand for importing Australian grain. While the baseline cost of importing grain from Australia remains cheaper than sourcing domestic grain, these factors contribute to the convenience of importing Australian grain.

Price competitiveness with Australia

Grain currently produced in the South Island does not move north because of the cost of crossing the Cook Strait relative to the net cost of importing wheat directly from Australia. Current projects are underway with FAR to measure the feasibility of different transportation options in order to improve access.

There are two key factors influencing the price and supply-demand dynamics of wheat grain in NZ:

- A price that is competitive for mills to outcompete Australian import wheat
- A price that is sustainable for growers to have a successful farming business.

Figure 6 and Figure 7 illustrates the relationship between Australian imported wheat and domestically grown wheat before the effect of the Covid-19 pandemic. The overall trend for the milling wheat price in New Zealand was decreasing between 2015 and 2017, with a consistent difference between the prices of milling wheat in Christchurch and Auckland. Some volatility was expressed in 2018 when the price of milling wheat collapsed. After 2018, the price returned to 2016 levels and is trending upwards again. Figure 6 shows that in 2015, New Zealand grown milling wheat delivered to Christchurch (NZ MWht CHCH) increased from $450/tonne to $475/tonne over the course of the year. Figure 7 shows that during 2015, New Zealand grown milling wheat delivered to Auckland (NZ MWht AUK) started at $555/tonne and increased to $575/tonne over the year.

The primary driver for the difference in price delivered between the two islands is the cost of freight for wheat produced in the South Island to be delivered to the North Island. The cost of crossing the Cook Strait has consistently held at approximately $80/tonne, with the remaining $25/tonne made up of freighting costs through the North Island to Auckland.

Figure 6: Historical pricing (NZD) for domestic milling and feed wheat compared to Australian milling and feed wheat delivered to Christchurch. Period from the 1/01/2015 to 1/09/2020. From Foundation for Arable Research (2022)

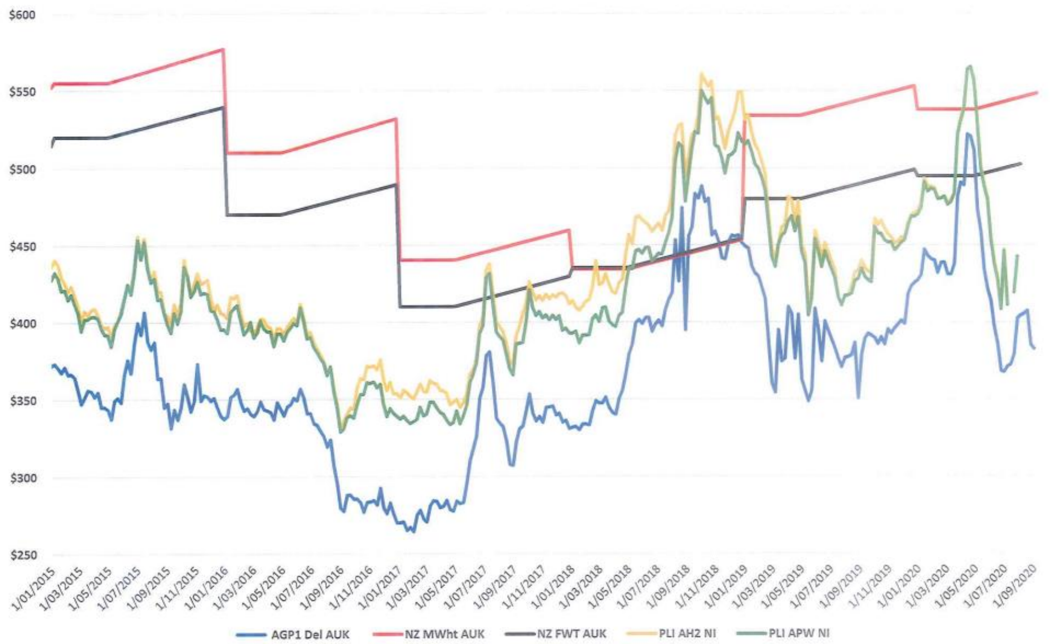

Figure 7: Historical pricing (NZD) for domestic milling and feed wheat compared to Australian milling and feed wheat delivered to Auckland. Period from the 1/01/2015 to 1/09/2020. From Foundation for Arable Research (2022)

[AGP1 is Australian General Purpose 1; NZ MWht is NZ milling wheat; NZ FWT is NZ feed wheat; PLI AH2 is Australian Hard Wheat; PLI APW is Australian White Premium Wheat.]

Given the considerable impact that relative freight costs have on the preference of North Island mills for North Island, South Island or Australian produced wheat, analysis on these relationships has been completed and is presented in Table 12.

There appears to be no direct correlation between the New Zealand freight price and the Australian import price. As the New Zealand freight price decreases, there is little effect on the competitiveness of New Zealand grain against Australian grain. There is more of an effect on the competitiveness of New Zealand grain laterally, as the Australian grain price increases. Given the volatility in the market and the increasing global demand for wheat, the Australian grain price will have more elastic characteristics than the New Zealand freight price, due to the difference in factors which influence domestic freight costs and global grain prices. At the status quo price of $105/tonne to cross grain on the Cook Strait, South Island produced milling wheat, based on minimum grower returns (>$550/t) and price to mills, becomes competitive with Australian produced wheat when there is a net cost $700/tonne or more to import wheat from Australia.

Table 12: Farm-gate price at which South Island wheat can compete against Australian wheat for delivery to Auckland mills in the North Island.

Cost of freight across Cook Strait and up North Island	Landed price at mill ex Australia: 400	475	550	625	700	775	850
75	320	395	470	545	620	695	770
90	305	380	455	530	605	680	755
105	290	365	440	515	590	665	740
120	275	350	425	500	575	650	725
135	260	335	410	485	560	635	710

Further analysis of North Island and South Island farm gate wheat prices required to deliver wheat at a competitive rate to Australia are provided below under a range of domestic freight scenarios. Because North Island wheat is not faced with the cost of crossing the Cook Strait, there is a premium (relative to South Island grain prices) applied to North Island grown wheat sold to North Island mills. However, it is likely that North Island growers will experience lower yields. Fragmentation of supply will challenge freighting efficiencies and a higher requirement for agronomic support is also required in these areas.

The simple analysis provided in Table 13 identifies that with a static freight cost across the Cook Strait, and an increasing Australian wheat price, New Zealand wheat becomes more competitive in North Island mills.

Table 13: Farmgate price to compete with Australian wheat under a volatile market. Australian wheat price (freight included) price increasing up to $700/tonne for milling wheat landed in Auckland, with a static freight price in New Zealand.

	Freight price				
AUS-AKL	$ 500	$ 550	$ 600	$ 650	$ 700	$ 750
CHCH-WLG	$ 80	$ 80	$ 80	$ 80	$ 80	$ 80
WLG-AKL	$ 25	$ 25	$ 25	$ 25	$ 25	$ 25
	Price at farmgate to beat Australia				
South Island	$ 395	$ 445	$ 495	$ 545	$ 595	$ 645
North Island	$ 475	$ 525	$ 575	$ 625	$ 675	$ 725
	Cost to mills				
South Island	$ 500	$ 550	$ 600	$ 650	$ 700	$ 750
North Island	$ 500	$ 550	$ 600	$ 650	$ 700	$ 750

Table 14 illustrates that at an $80/tonne cost to shipping over the Cook Strait, a $25/tonne shipping from Wellington to Auckland, and an historic price of $450/tonne from Australia, the competitive farm gate price for South Island produced wheat was $340 and was $420 for North Island produced wheat. This provides insight to the challenges that have been faced in the industry, where importing Australian wheat has proven more cost effective over time. Even if the cost to cross the Cook Strait and travel up the North Island decreased to a total of $45/t, the farmgate price at which NZ milling wheat was competitive ($400 for the South Island and $430 for the North Island produced) would not be sufficient from a farm profitability perspective. While it seems unlikely that the Australian imported grain price will drop to $450/tonne in the short term, this has been the average import price to Auckland over the period of 2015 – 2020 (Figure 7).

Table 14: Farm gate price to compete with Australian wheat at historical pricing levels. Australian freight price consistent at $450/tonne for milling wheat landed in Auckland, with a decreasing freight price in New Zealand.

	Freight price					
AUS-AKL delivered	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450
CHCH-WLG	$ 80	$ 70	$ 60	$ 50	$ 40	$ 30
WLG-AKL	$ 25	$ 23	$ 21	$ 19	$ 17	$ 15
	Price at farmgate for competitiveness with Australian wheat					
South Island	$ 340	$ 352	$ 364	$ 376	$ 388	$ 400
North Island	$ 420	$ 422	$ 424	$ 426	$ 428	$ 430
	Cost to mills					
South Island	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450
North Island	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450

The price of Australian wheat increasing, together with a decreasing freight cost across New Zealand, presents the best opportunity for New Zealand sourced wheat to meet the country's domestic requirements. Table 15 illustrates milling wheat becomes competitive with Australia and viable for New Zealand growers when the Australian wheat price increases to $600/tonne and the freight costs in New Zealand decrease to $69/tonne.

Table 15: Farm gate price to compete with Australian wheat under a volatile market. Australian wheat price (freight included) price increasing up to $700/tonne for milling wheat landed in Auckland, with a decreasing freight price in New Zealand.

	Freight price					
AUS-AKL delivered	$ 450	$ 500	$ 550	$ 600	$ 650	$ 700
CHCH-WLG	$ 80	$ 70	$ 60	$ 50	$ 40	$ 30
WLG-AKL	$ 25	$ 23	$ 21	$ 19	$ 17	$ 15
	Price at farmgate for competitiveness with Australian wheat					
South Island	$ 340	$ 402	$ 464	$ 526	$ 588	$ 650
North Island	$ 420	$ 472	$ 524	$ 576	$ 628	$ 680
	Cost to mills					
South Island	$ 450	$ 500	$ 550	$ 600	$ 650	$ 700
North Island	$ 450	$ 500	$ 550	$ 600	$ 650	$ 700

The effect of increasing Australian milling wheat prices is to also increase competitiveness for New Zealand produced milling wheat, despite increases in New Zealand based freight costs. Table 16 illustrates that at a New Zealand freight price of $133/t (CHCH-AKL), and an Australian wheat price of $650/tonne, New Zealand milling wheat can still achieve feasible farm gate prices for the grower and achieve price competitiveness with Australian grown wheat. Therefore there is potential for the New

Zealand grain industry to be able to compete with Australian prices at current domestic freight costs, provided the cost of importing grain from Australia remains inflated.

Table 16: Farm gate price to compete with Australian wheat under a volatile market. Australian wheat price (freight included) price increasing up to $700/tonne for milling wheat landed in Auckland, with an increasing freight price in New Zealand.

Freight price						
AUS-AKL delivered	$ 450	$ 500	$ 550	$ 600	$ 650	$ 700
CHCH-WLG	$ 80	$ 85	$ 90	$ 95	$ 100	$ 105
WLG-AKL	$ 25	$ 27	$ 29	$ 31	$ 33	$ 35
Price at farmgate for competitiveness with Australian wheat						
South Island	$ 340	$ 383	$ 426	$ 469	$ 512	$ 555
North Island	$ 420	$ 468	$ 516	$ 564	$ 612	$ 660
Cost to mills						
South Island	$ 450	$ 500	$ 550	$ 600	$ 650	$ 700
North Island	$ 450	$ 500	$ 550	$ 600	$ 650	$ 700

Opportunity to leverage off specific consumer requirements

Wheat for bread supply as a staple product

The largest proportion of bread supply in New Zealand is in loaves, packaged at large scale bakeries and sold at the supermarkets. Bread as a staple product has a relatively inelastic demand. Consumers will tend to pay what they need to in order to be able to purchase the product, but as price goes beyond a certain threshold their willingness to pay for other credence attributes could diminish. While consumers indicated that the total amount of money paid for bread had increased in the past year, this was primarily due to increasing costs, above that of changing to a more expensive type of bread (Tait *et al.,* 2022).

Wheat for bread supply in artisan bakeries

While there is limited New Zealand specific understanding of this; the concept of local grain economies and feeding communities from local producers is increasingly of interest to consumers (pers. Comms Angela Clifford, October 2022; Tait *et al.*, 2022). Therefore, when considering the upscaling of the milling wheat industry in New Zealand, it is potentially important to differentiate artisan bakers from factory bakers. Differentiation of product categories for wheat flour can increase the scope of revenue streams for growers who could choose to produce wheat for a specific purpose. Similar to other commodity value add projects in the primary industries, there is an opportunity to develop a value-add aspect for milling wheat to supply grain into niche markets.

Local food economies are well established in European culture where artisan bread is purchased almost on a daily basis, most often produced from local grain growers, millers and bakers (Galli *et al.*, 2015). Models that currently exist in New Zealand include that of Minchin's Milling who stone mills flour from wheat produced on farm in the Waimakariri. This flour is marketed with a point of difference being the unique characteristics each harvest season brings, which changes the food quality attributes of the wheat. Additionally, artisan bakers across all of the major cities sell bread based off quality and value based differentiation. Artisan bakers can market bread based off credence attributes, such as being locally produced, higher quality and fresh. This requires a source of flour which aligns with the credence attributes marketed in the bread sold, and which achieves high quality standards.

Recent consumer research highlighted the consumer willingness to pay for New Zealand grown flour as a bread ingredient (~ 20 cents extra per loaf). The survey achieved a response from 942 people, where there was some over representation of higher income brackets and tertiary education. Consumption of specialty breads is recorded as being approximately 0.5 loaves per person per fortnight, which is a quarter of the consumption of typical loaves of bread at 2.0 loaves per person per fortnight. When undertaking the study, using a latent class model, it was identified that consumers preferred bread loaves that cost less. However, it was also shown that for most respondents, if given a New Zealand alternative over flour of Australian origin, this would be preferred (Tait *et al.*, 2022).

Therefore, there is some opportunity to capitalise on consumer desires for locally grown bread. From the previous Tait *et al.,* (2019) study, it was found that 17% of the survey respondents found that the local producer economy was important, which has increased to 44% of respondents in the 2022 survey (Figure 8). Of the consumers that responded that origin of bread was important, reasons included were to support a local bread economy (44%), perception a higher quality produce (17%), health reasons (11%) and low environmental impact food production (10%). Remaining reasons were made up of those relating to food safety and environmental standards.

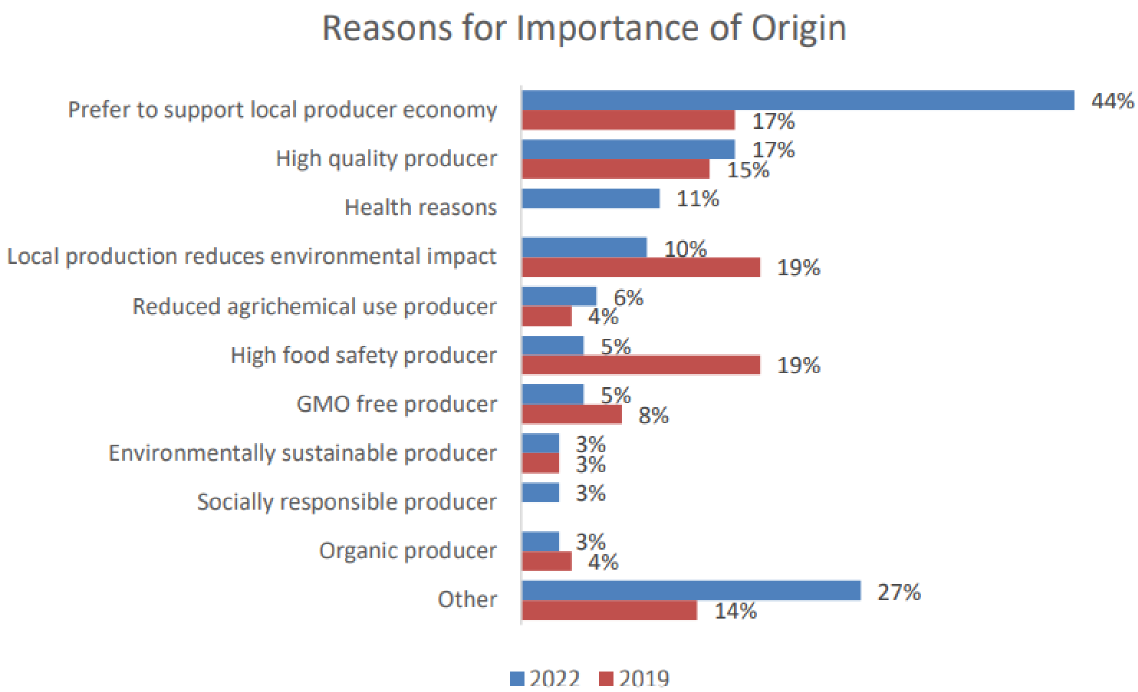

Figure 8: Reasons for importance of origin. Respondents' reasons from survey in 2019 cf. reasons from 2022 survey. From Tait *et al.*, (2022)

Table 17 presents a SWOT analysis to better understand the feasibility of expanding the artisan baking and local food economy opportunities for wheat flour in New Zealand.

There are a number of strengths and opportunities for the development of a value added wheat flour industry. The main aspects of this include having strong traceability back to the grower and being able to provide evidence of the production methods of the wheat production for food safety and environmental purposes. Strategic placement of stores or increasing accessibility through online delivery has proven to be successful for the development and expansion of niche businesses in the past. This is an opportunity for isolated producers and bakers to remain close to the source of grain but also access potential consumers who are more likely to be based in cities.

Table 17: Strengths, weaknesses, opportunities and threats analysis for the development of a local food economy based on artisan bakers in New Zealand

Strengths:	**Weaknesses:**
• 'Authentic food' • Local food economy • Environmental values • Flexibility with quality parameters based off seasonal characteristics • Flexibility with production lines and trialling new products	• Elastic demand – when cost of living is high, sales likely to decrease • Competing against 'convenience of supermarkets. • Efficiencies decreased – higher cost of production requiring higher returns
Opportunities:	**Threats:**
• Small-scale, value-added wheat production with a direct connection to a baker may incentivise small scale land use change on farms • Target affluent communities/ offer delivery service • Develop specialty products which are not found in supermarkets	• Cost of living decreasing demand and resulting in cost competition with supermarket loaves • Quality and price point of imported grain from Australia

A local premium?

While this analysis suggests that there is some capacity for the market to sustain some premium for locally sourced flour, the extent to which this might support the expansion of milling wheat production in New Zealand, particularly in the North Island, is unclear. Given the value of wheat in standard loaf of bread has in recent years been worth approximately $0.40, if a $0.20/loaf premium was all associated with the grain provenance and fully passed back to the producer, a significant uplift in domestic grain price (say +50%) is implied. However, the recent increases in grain price from say $430/t to $630/t have essentially resulted in this increase in the value of grain in a standard loaf simply because of supply and demand (McQuillan-Reese, 2022). On the basis that bread consumption hasn't significantly changed because of this, it would seem that demand is inelastic, and the market is capable of sustaining a higher price if needed. However, whether this would truly apply in a situation where "local" bread at a price premium was offered along aside "imported" bread at a relative discount is untested.

Future research could include some consumer analysis on perspectives towards purchasing bread and accessibility options to improve the competitiveness of locally produced grains against that of supermarket loaves. The proportion of commodity based wheat consumption compared with differentiated wheat consumption in different locations across New Zealand could be a point for further research. Some farmers may be driven by the opportunity to be more connected with the local consumer and look to get involved with small scale investments in mills on a community scale. However, such direct sourcing of high credence flour by artisanal bakers appears to operate outside the conventional supply chain and likely to be limited in size and scale. As such, we see little to no significant role for this specific market channel to support the expansion of domestically grown milling wheat.

3 Other considerations with changing land use to milling wheat

Land use driven by emissions pricing and environmental regulation

Under the Climate Change Response (Zero Carbon) Amendment Act 2019 there is a requirement for the agricultural industry to reduce gross methane emissions by 10% by 2030 and between 24-47% by 2050, and an independently set methane price will be a driver for this should methane targets not be met.

Under the NZ government's current farm level pricing proposal, the effects of pricing methane and nitrous oxide emissions is expected to result in a reduction in production and revenue from the pastoral sector (Table 18), with this impact increasing as methane price increased. This ranged from a decrease in lamb production of between 18-24%, to variability in beef production with an increase of 8-5% in the low and medium scenarios, compared to a decrease of 14% in the high pricing scenario. A decrease in production for the dairy sector from 6-7% across the low to high pricing scenarios was also estimated. These changes resulted in a net methane emissions reduction of 10% (low) to 15% (high).

The decreased lamb and beef production under the medium and high pricing scenarios is likely to be associated with a reduction in pastoral area and the adoption of alternative land uses. This is primarily due to the need to maintain the stocking rates appropriate to different farming systems on residual pastoral areas to prevent the loss of pasture quality and its subsequent impacts on the farm system.

Table 18: Predicted impacts of methane pricing on agricultural production in New Zealand. Adapted from MfE and MPI (2022).

	Methane price		
	Low	Medium	High
Farm level levy			
Methane ($/t CO_2e)	2.9	3.9	5.0
Methane (c/kg CH_4)	8.0	11.0	14.0
Nitrous oxide ($/t CO_2e)		10.9	
Emissions reductions			
Methane (%)	12	13	15
Nitrous oxide (%)	3	5	5
Total (%)	10	11	12
Change in net sector revenue			
Dairy (%)	-6	-6	-7
Sheep and Beef (%)	-18	-21	-24
Other (%)	-1	-1	0
Total (%)	-4.0	-5.0	-5.0
Change in agricultural production			
Milk solids (%)	-4	-4	-5
Lamb (%)	-16	-18	-20
Beef (%)	8	5	-14
Wool (%)	-16	-18	-20
Venison (%)	-13.0	-15.0	-17.0

Emissions risk varies for each individual farm. Compared with dairy, the sheep and beef sector emit more greenhouse gases relative to the sector's overall net revenue. This results in emissions pricing expected to have a more severe impact on the sheep and beef sector (Ministry for the Environment and Ministry for the Primary Industries, 2022).

However, on a multiple contaminant basis, where water quality and nitrous oxide are increasingly important, dairy production is more vulnerable.

Milling wheat could be incorporated into farming systems as a means to reduce gross methane emissions and minimise revenue and profitability loss. As demonstrated above, current sheep and beef enterprises that incorporated milling wheat as a cash crop decreased greenhouse gas emissions relative to that of the status quo enterprise.

At an assumed methane pricing of $0.11/ kg CH_4 and a grain yield of 8 t/ha, replacing 35 hectares of livestock production with milling wheat did not significantly improve the EBITRm of the farm. However, as the methane levy increases, the benefits of earning income with no methane risk become clear (Table 19). There is no adjustment for an increase in gross revenue for milling wheat in Table 19, where the baseline assumption of a milling wheat price of $550/tonne is used. However, as presented above, when the price increases to $650/tonne, the margin for milling wheat at 10 tonne/ha increases to $2,585/ha (Table 2) and $1,414/ha (Table 3) at 8 t/ha yield. This could increase the competition between arable land uses and ruminant land uses.

Table 19: Sensitivity analysis on the gross margin profitability of different farm systems under an increasing methane levy

		Gross margin ($/ha)			
		Lamb finishing	Beef finishing	Milling wheat (10 t/ha)	Milling wheat (8 t/ha)
Methane price ($/kg CH_4)	**$0.11**	$1,226	$1,389	$1,594	$622
	$0.40	$1,189	$1,350	$1,594	$622
	$0.70	$1,151	$1,309	$1,594	$622
	$1.00	$1,113	$1,268	$1,594	$622
	$1.30	$1,075	$1,227	$1,594	$622
	$1.60	$1,037	$1,186	$1,594	$622
	$1.90	$999	$1,146	$1,594	$622

Additionally, the price competitiveness of milling wheat against other non- ruminant arable land uses, such as maize (silage or grain) should be considered in the interest of domestic wheat supply. An indicative gross margin for standing maize silage shows that at a yield of 18 t DM/ha, the gross margin achieved is $1,321/ha (see Table A 13). This method of cropping may outcompete milling wheat on a land use basis, in a North Island scenario where yields of 18 t DM/ha or greater can be achieved from this C4 crop, and there is an existing market established. Additionally, standing silage requires similar, if not greater inputs, but is subject to lower risk at harvest time. Maize for silage (or grain) is not a straight swap for milling wheat and will have differing farm system implications. But with no requirement for specialist on-farm infrastructure and the potential for improving yields (relative to wheat) from climate change (see below), as an alternative to exclusive livestock systems, maize could be better placed in the North Island than temperate cereal crops like wheat.

Wider environmental impacts

It would not be desirable to deliver worse environmental outcomes for a farm by introducing a cropping rotation which increases net emissions and/or nutrient losses to groundwater or streams. The non-GHG effects on the farm environmental footprint of integrating milling wheat into North Island livestock systems, such as nitrogen losses from the cropping unit, were not assessed in this analysis but it is widely recognised that arable production systems can have negative impacts on the receiving environment, particularly under poor nitrogen and crop management practices.

Mitigations to prevent increased nitrogen loss to water and increased CO_2 losses under a rotational cropping regime as opposed to permanent pasture should be implemented.

Strategic nitrogen (N) application is important in wheat cropping systems to minimise unnecessary N losses, but also maximise grain quality (Craigie and Gillam, 2017). In an example of a dairy system with a milling wheat rotation included, total N losses to water may increase due to high N inputs for the grain crop and any associated mineralisation of soil organic matter. However, in New Zealand, research into the appropriate timing of N fertiliser in wheat crops has been largely adopted, minimising unnecessary losses of N from arable systems.

NZ trials have shown that minimising cultivation in arable systems where soil structure is fragile does not limit grain yield (Francis, Cameron and Swift, 1987). However where soils are heavy or compacted, cultivation can improve yield performance (Ellington, 1986). Aiming to achieve minimal tillage in arable systems is favourable, from the perspective of maintaining soil structure and health. There is also evidence to suggest that minimal tillage practices decrease losses of soil carbon from production systems (Barber, Pellow and Barber, 2011). Reducing passes and tractor hours for the crop would also reduce fuel consumption and associated CO_2 emissions.

The carbon footprint of New Zealand grown wheat and Australian imported wheat was analysed using Life-Cycle Analysis (LCA) methodology (Barber and Stenning, 2021). This report found that NZ grown milling wheat had lower carbon emissions because there was less transportation involved to get the grain from harvest to mill. On a production basis, there was little change between emissions from Australian and New Zealand milling wheat production systems.

Impacts from expected climate change

Figure 9 illustrates the **mid-range** climate variability prediction for New Zealand (Ministry for Primary Industries, 2020). The shorter term annual mean precipitation change for between 1980-1999 to between 2030-2049 showed that most western areas of New Zealand are predicted to observe increases in precipitation, while areas like Canterbury and the east coast of the North Island are likely to experience decreases in precipitation. In the longer-term forecasting, there is more of a development of extremes across the Marlborough and Canterbury, to east coast of the North Island and in Northland, where more severe decreases in precipitation (up to -10%) are likely to be observed.

Across the entirety of New Zealand, it is expected that the climate will become warmer than the 1980-1999 period by up to 1°C within the shorter-term analysis of 2030-2049. Longer term during 2080-2099 this increases to > 2 °C, across the northern part of the South Island and the North Island.

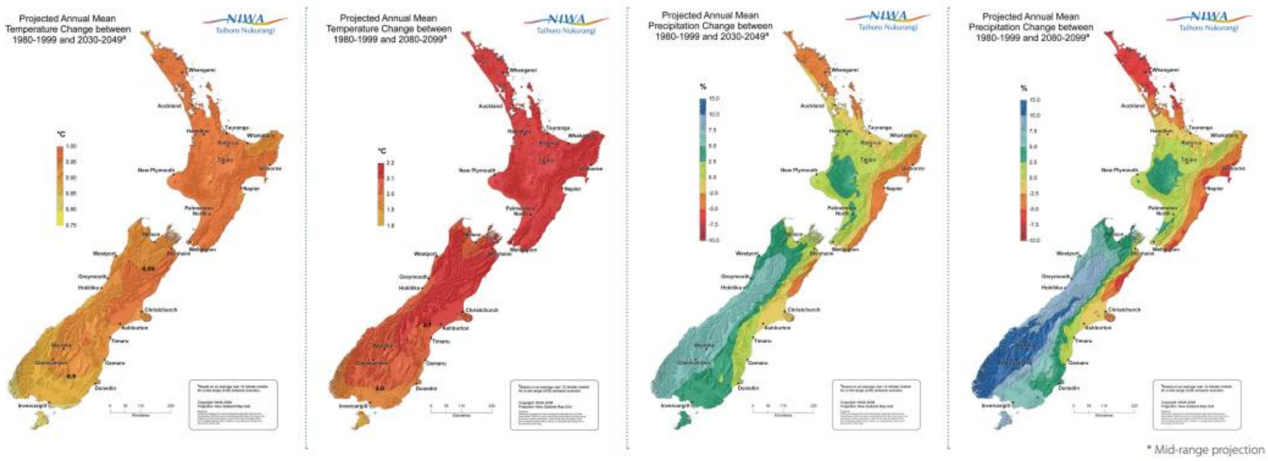

Figure 9: Mid-range climate variability prediction for New Zealand. From MPI (2020)

In New Zealand, assuming adequate water and soil nutrient supply, potential yields of temperate cereal crops could increase by as much as 20% under future temperature and CO_2 concentrations. This is due to the boost in photosynthesis from extra CO_2 and higher temperatures, which would offset any negative impacts from shorter growth lengths caused by faster crop development. A warming climate causes more rapid accumulation of heat units in arable systems, which result in a shorter cropping cycle and an earlier harvest (MAF, 2010). There is a risk involved that plants grow more rapidly and don't photosynthesise sufficient stores of carbon back to the plant, for improved yields. However, growth boosts from increased levels of CO_2 in the atmosphere are also likely to be observed. Nutrient inputs will need to increase in conjunction with expected growth predictions in order to maintain yield.

In particular, water availability is a threat to wheat production systems and while CO_2 fertilisation associated with climate change is expected to be positive for yield, changes in precipitation may not (Batley & Stantiall, 2022). Where irrigation is necessary, use of more efficient irrigators will improve crop yields, particularly in light soils with low water storage capacity. This is of particular relevance to areas that are already under water stress over summer, such as Canterbury, Hawkes Bay and Malborough.

Continuing to develop cultivars with characteristics that suit the more challenging environments for wheat production such as the Manawatū or Hawkes Bay increases the resilience of the total yield. Additionally, breeding cultivars for better nitrogen use efficiency and production under high CO_2 environments is important.

Climate change is likely to severely affect the world's grain supply, predominantly through drought. Therefore, with the risk of lowered yields and demand expected to increase, wheat prices are unlikely to fall. When a single area is affected the impact is lesser but once multiple areas are impacted simultaneously, this is important. Australia is likely to see increased demand for wheat, with increased grain prices of between 3 and 24% modelled for 2050 (Hughes, Lu *et al.,* 2021). Because of the political relationship between NZ and Australia, it is unlikely that New Zealand will lose out on milling wheat supply if other nations become more demanding. However, New Zealand is likely to be equally as exposed to global wheat price increases.

Change in labour requirements

Being a competent arable producer requires a great understanding of crop husbandry and agronomy. Arable farmers work closely with key stakeholders such as agronomists, soil scientists, seed traders and other specialists to set rotations and ensure that the conditions for production are optimal.

For sheep and beef, the most labour intensive periods in the year can be over summer, with lamb finishing operations focussing on weaning, animal health management, weighing and shearing. This is often also compounded by pasture conservation making. In farm operations that also have breeding cattle; calf marking, weighing and drenching becomes important, while bull finishers are likely to be operating high intensity systems in order to optimise weight gain in bulls. The summer period is a busy period and adding arable crop management to the list of tasks could require re-organising staff priorities on farm. Additionally, balancing relationships with key industry partners is a critical for success for integrating land use diversification into an existing sheep, beef or dairy system.

Arable operations can obviously be successfully integrated with animal based production systems. This has often been through farm conversions into dairy production where the grower has maintained some cropping in a diversification and risk management strategy. Additionally, forage cropping has increasingly become a part of ruminant based production systems, where farmers grow a crop designed to be consumed by the stock on farm. This has predominantly been to manage feed supply in periods of deficit by growing crops that are more resilient to drought, or produce high dry matter over colder months. The development of forage cropping in ruminant systems has been supported by industry experts and technical officers, who could support expansion in the arable cropping space too.

It could be value to undertake further analysis to understand the effects of decreased stock numbers on farm and how incorporating an arable crop would change full-time equivalent labour requirements for farms of given sizes. A finishing farm would typically employ one full time staff member for every 2,000 stock units (SU) (Beef and Lamb NZ, 2022) whereas a larger scale breeding farm would employ one staff member per 3,500 – 4,000 SU. A 20% decrease in sheep numbers on any type of sheep and beef farm would have an effect on full time equivalent staff members required on farm.

Similarly in dairy, approximately one full time equivalent person is employed for every 200 cows. As farm systems change and increase in complexity, the typical job descriptions and expectations of the 'roles' of farm employees and those who are responsible for farm operations will change. An increase of arable production in the Manawatū-Whanganui or Hawkes Bay would put increased pressure on existing contracting operations. This would require more staff to be brought into the area for the harvesting period, because arable is largely more labour intensive at harvest.

4 Conclusions

Increasing the area of milling wheat production in New Zealand has a number of potential benefits. As well as providing a mechanism to address the potentially significant food security challenge imposed by New Zealand currently importing 70% of its current milling wheat requirements, the low methane footprint of the crop provides a viable option for the agricultural sector to reduce its methane emissions. The nitrous oxide emissions from the production of wheat are also lower (per hectare) than many dairy farm operations, with the partial conversion of dairy land to milling wheat likely to be positive for achieving the current net zero long lived greenhouse gas targets. With the location of the majority of New Zealand's population (and flour consumption) in the North Island, expanding production into the North Island would reduce the impact of the cost of freight across the Cook Strait. However the devil is, as they say, in the detail.

There are several challenges associated with expanding the volume of milling wheat grown domestically in New Zealand. To support expanded domestic production the farm gate price needs to be:

- sufficiently high for the milling wheat to compete with alternative land uses under the yield expectations of the location and account for the integration of this crop into existing farm systems.
- sufficiently low to allow domestic supply to be competitive with (or the preferred option over) imported Australian grain for the domestic mills.
- sufficiently stable to justify the scale required and capital investment a farmer needs to make into the plant and equipment necessary to support production.

There are numerous factors that influence these three key pillars, but two appear the most significant, depending on the location of the potential domestic production.

The yield potential and existing harvest and storage infrastructure in the South Island make this area the logical location in which to expand production, but the cost of transporting grain to the North Island appears to have been prohibitive. Despite this, on the basis that the prevailing market conditions are sufficient to support the existing level of South Island production, in the current environment the price to transport grain from Christchurch to Auckland at $105/t is sufficient to make South Island wheat at a $550/t farm gate price competitive with that from Australia. However, at the price level that had prevailed in earlier years for imported grain (say $450/t), South Island produced grain would still not have been competitive with imports if transport was <u>free</u>. While there is work being undertaken on examining the opportunities to extract efficiencies within the domestic transport network, **a sustained increase in global (and therefore Australian) grain prices is ultimately required** to create the market environment where mills will commit to contracts with South Island growers that work for both parties after accounting for domestic freight.

The global price of wheat has a greater impact in setting the price for domestic producers than might be expected in a market where domestic production is insufficient to meet domestic demand. This appears to be due to the fact that imported grain is physically undifferentiated from domestic product (compared, say, with domestic fresh milk versus imported milk powder) and the cost of shipping across the Tasman Sea (2,156 km) is not 21 times greater than that for the 100.6 km Cook Strait. The latter phenomenon is essentially mirrored in the observed cost of transport across Bass Strait from Hobart to Sydney (pers comms Lee Matheson, November 2022)

Secondly, while there is likely to be suitable areas to grow milling wheat in the North Island, the lower expected average yields (8 t/ha) relative to the South Island (10 t/ha) significantly reduce the expected profitability of this enterprise, even with a premium for their closer location to their customer mills. As a result growing milling wheat struggles to be competitive with the livestock enterprises it might supplant or the alternative arable crops that could be used to diversify exclusively livestock systems (such as growing maize for silage). Even when considering the expected financial impact of pricing methane (and nitrous oxide) emissions at the farm level, milling wheat in the North Island seems unable to outperform the lamb or bull beef finishing enterprises that it would be partly replacing. This effect is particularly important at grain yields less than 10 t/ha and the gross margin of milling wheat currently does not come close to being competitive with pastoral dairying. So unless **North Island grain yields could reliably achieve 10 t/ha,** the investment in post-harvest infrastructure required to support expansion of the industry into the North Island is a moot issue and it seems unlikely that significant areas of milling wheat would be grown in the North Island.

From a true food [nutrition] security point of view, New Zealand would seem to have an annual deficit of as much as 30,000 ha of milling wheat. While wheat from Australia remains available to import, the farm gate price for milling wheat in the South Island only needs to be $110/t lower than the landed price of wheat from Australia (based on current domestic freight prices) to be competitive at the mill. Whether this price is sufficiently high enough to deliver the volumes required by the mills is not clear. This pre-condition is more or less met by current market conditions, but domestic production in 2022 is still only going to deliver 30% of expected annual requirements. This suggests a much higher price, potentially accompanied by more favourable contract terms, is required to encourage more area to be planted. This situation would also be supportive of North Island expansion, but the improvement in grain yields under North Island conditions is the primary precursor of this occurring.

In summary, the observed limits in the expansion in the quantity of milling wheat grown in New Zealand seem to be evidence of market forces working as they should, at least from the perspective of delivering cost effective milling wheat to New Zealand domestic consumers. The current situation seems unlikely to change until a combination of improved yield potential in the North Island, a structural reduction in access to Australian grain, increases in the efficiency of the domestic internal transport networks and a significant imposition from the cost of climate change externalities on pastoral farming make the domestic production of milling wheat a substantively more profitable land use than its current alternatives.

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Appendices

Appendix 1: FARMAX Red Meat Modelling Assumptions

Intensive finishing base model

Pasture

- Farmax Red Meat is utilised for the physical modelling. If specific assumptions have not been listed below then the standard farm inputs were used.
- The long-term modelling function was used to create a status quo system.
- The farm was not separated by specific blocks. Crops rotated through the whole farm.
- Pasture quality assumptions described in Table A 1

Table A 1: Pasture Quality assumptions in intensive finishing FARMAX Red Meat model

FARMAX

Pasture Quality for NZAGRC D10

Jul 22 - Jun 23

Date	kgDM/ha (End of Month)				Total Cover
	Green	Dead	Stem	Total	MJME/kgDM
Start	1,054	225		1,280	9.5
Jul 22	1,109	196		1,304	9.7
Aug 22	1,261	223		1,484	10.0
Sep 22	1,568	277		1,844	10.8
Oct 22	1,904	414	57	2,375	10.7
Nov 22	1,605	474	290	2,369	10.6
Dec 22	1,361	563	344	2,268	9.9
Jan 23	1,306	706	165	2,176	9.8
Feb 23	1,223	687	51	1,961	9.8
Mar 23	1,254	606		1,860	9.3
Apr 23	1,205	460		1,665	9.5
May 23	1,147	336		1,483	9.7
Jun 23	1,057	226		1,283	9.5

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- Pasture growth rates were calculated by using default regional assumptions, inputting the physical data for the 2020/2021 year and adjusting pasture growth rates until pasture covers at key times of the year replicated those typically observed on farms in the area. This adjustment resulted in a total of 9 t DM/ha pasture production on farm.
- Key periods in the year included being short on pasture supply in early spring and finishing with average covers of approximately 2200 kg DM/ha in June.
- Supplement fed was 100 bales of baleage over winter

Financial

- Farm operating expenses were adjusted as per the schedule below using Beef and Lamb NZ assumptions for the 2020-2021 financial year, with **bold text** denoting the application of the costs to the modelled scenarios.

Table A 2: North Island intensive finishing base model expenses.

FARMAX — **NI Intensive Finishing 1 2020-21**
NZAGRC D10 : NI Intensive Finishing 1, Jul 22 - Jun 23

($/year)		Model (tick to use)		Timing	$ Total	$ / ha (202)	$ / SU (2,639)
Wages	Wages			Monthly	18,180	**90.00**	6.89
	Management Wage			Monthly	**0**	0.00	0.00
	Total Wages				**18,180**	**90.00**	**6.89**
Stock	Animal Health	**7,800**	☑	As Incurred	468	2.32	0.18
	Shearing	**23,687**	☑	As Incurred	0	0.00	0.00
	Velveting	**0**	☑	As Incurred	0	0.00	0.00
	Total Stock				**468**	**2.32**	**0.18**
Feed, Crops & Grazing	Conservation	**6,570**	☑	As Incurred	0	0.00	0.00
	Cash Crops	**0**	☑	As Incurred	0	0.00	0.00
	Forage Crops	**17,630**	☑	As Incurred	0	0.00	0.00
	Purchased Feeds	**0**	☑	As Incurred	0	0.00	0.00
	Regrassing	4,100	☐	Monthly	6,088	**30.14**	2.31
	Grazing	**0**	☑	As Incurred	0	0.00	0.00
	Total Feed/Crops/Grazing				**6,088**	**30.14**	**2.31**
Fertiliser	Fertiliser (Excl. N & Lime)			Oct, Apr	26,113	**129.27**	9.90
	Nitrogen	**0**	☑	As Incurred	0	0.00	0.00
	Lime			Oct, Apr	1,897	**9.39**	0.72
	Total Fertiliser				**28,009**	**138.66**	**10.61**
Other Farm Working	Irrigation Charges			Custom	408	**2.02**	0.15
	Weed & Pest Control			Monthly	3,557	**17.61**	1.35
	Vehicle Expenses			Monthly	8,708	**43.11**	3.30
	Fuel			Monthly	6,531	**32.33**	2.47
	Repairs & Maintenance			Monthly	20,085	**99.43**	7.61
	Freight & Cartage			Monthly	6,518	32.27	**2.47**
	Electricity			Monthly	3,246	16.07	**1.23**
	Other Expenses			Monthly	**0**	0.00	0.00
	Total Other Farm Working				**49,052**	**242.83**	**18.59**
Standing	Administration Expenses			Monthly	8,541	**42.28**	3.24
	Insurance			Monthly	4,874	**24.13**	1.85
	ACC Levies			Jul, Jan	996	**4.93**	0.38
	Rates			Jul, Oct, Jan, ...	10,037	**49.69**	3.80
	Total Standing Charges				**24,448**	**121.03**	**9.27**
Total Farm Working Expense					**126,246**	**624.98**	**47.84**
Depreciation				Monthly	16,105	**79.73**	6.10
Total Farm Expenses					**142,352**	**704.71**	**53.95**
Other	Rent/Lease			Monthly	8,104	**40.12**	3.07
	Interest			Monthly	24,343	**120.51**	9.23
	Principal			Monthly	**0**	0.00	0.00
	Drawings			Monthly	**0**	0.00	0.00
	Taxation			Jul, Oct, Jan, ...	**0**	0.00	0.00
	Total Other Expenses				**32,447**	**160.63**	**12.30**
	Total Expenses				**174,799**	**865.34**	**66.24**

Farmax Red Meat 8.2.0.16

Summary of Profit and Loss for intensive finishing base models

Table A 3: North Island intensive finishing base model profit and loss statements

FARMAX — **Compare Forecast Profit and Loss**

Jul 22 - Jun 23

			Lamb finishing BASE 2	Beef finishing BASE	Difference
Revenue	Sheep	Sales - Purchases	331,596		-331,596
		Wool	9,829		-9,829
		Total	**341,425**		**-341,425**
	Beef	Sales - Purchases	27,725	374,768	347,043
		Total	**27,725**	**374,768**	**347,043**
	Crop & Feed	Surplus Feeds	28,000	23,400	-4,600
		Total	**28,000**	**23,400**	**-4,600**
	Total Revenue		**397,150**	**398,168**	**1,018**
Expenses	Wages	Wages	18,180	18,180	
	Stock	Animal Health	7,800	6,439	-1,361
		Shearing	23,687		-23,687
	Feed/Crop/Grazing	Conservation	6,570	7,118	548
		Forage Crops	17,630	17,630	
		Regrassing	6,088	6,088	
	Fertiliser	Fertiliser (Excl. N & Lime)	26,113	26,113	
		Lime	1,897	1,897	
	Other Farm Working	Irrigation Charges	408	408	
		Weed & Pest Control	3,557	3,557	
		Vehicle Expenses	8,708	8,708	
		Fuel	6,531	6,531	
		Repairs & Maintenance	20,085	20,085	
		Freight & Cartage	6,518	6,237	-281
		Electricity	3,246	3,106	-140
	Standing Charges	Administration Expenses	8,541	8,541	
		Insurance	4,874	4,874	
		ACC Levies	996	996	
		Rates	10,037	10,037	
	Total Farm Working Expense		**181,465**	**156,544**	**-24,921**
	Depreciation		16,105	16,105	
	Total Farm Expenses		**197,571**	**172,649**	**-24,921**
Economic Farm Surplus (EFS)			**199,579**	**225,519**	**25,939**
Other Expenses		Rent/Leases	8,104	8,104	
		Interest	24,343	24,343	
Farm Profit before Tax			**167,132**	**193,071**	**25,939**
Farm Profit per ha before Tax			**827**	**956**	**128**

EFS is a measure of farm business profitability independent of ownership or funding, used to compare performance between farms.

EFS should include an adjustment for unpaid family labour and management. This can be added to the expense database as management wage.

Farmax Red Meat 8.2.0.16

Table A 4: North Island intensive finishing base model gross margins

FARMAX — **Compare Gross Margin**
Jul 22 - Jun 23

			Lamb finishing BASE 2	Beef finishing BASE	Difference
Revenue	Sheep	Sales - Purchases	331,596		-331,596
		Wool	9,829		-9,829
		Total Sheep	**341,425**		**-341,425**
	Beef	Sales - Purchases	27,725	374,768	347,043
		Total Beef	**27,725**	**374,768**	**347,043**
	Crop & Feed	Surplus Feeds	28,000	23,400	-4,600
		Total Feed	**28,000**	**23,400**	**-4,600**
	Total Revenue		**397,150**	**398,168**	**1,018**
Expenses	Crop & Feed	Conservation	6,570	7,118	548
		Forage Crops	17,630	17,630	
		Regrassing	6,088	6,088	
		Total Crop & Feed	**30,288**	**30,836**	**548**
	Stock Costs	Animal Health	7,800	6,439	-1,361
		Shearing	23,687		-23,687
		Total Stock Costs	**31,487**	**6,439**	**-25,048**
	Interest on Capital (livestock & feed)		24,430	26,021	1,591
	Total Variable Expenses		**86,205**	**63,296**	**-22,909**
Gross Margin			**310,945**	**334,872**	**23,928**
Gross Margin per Farm ha			**1,539**	**1,658**	**118**

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Intensive finishing with milling wheat

Pasture

- Because stocking intensity was adjusted accordingly with the introduction of 35 ha of milling wheat, there was no change to pasture quality and growth assumptions under the milling wheat scenario.

Table A 5: North Island intensive finishing base model pasture quality

FARMAX — **Pasture Quality for NZAGRC D10**
Jul 22 - Jun 23

Date	kgDM/ha (End of Month) Green	Dead	Stem	Total	Total Cover MJME/kgDM
Start	1,091	233		1,324	9.5
Jul 22	1,114	197		1,310	9.7
Aug 22	1,249	220		1,469	10.0
Sep 22	1,558	275		1,833	10.8
Oct 22	1,859	404	56	2,320	10.7
Nov 22	1,582	467	286	2,335	10.6
Dec 22	1,333	552	337	2,222	9.9
Jan 23	1,195	646	151	1,992	9.8
Feb 23	1,249	700	52	2,001	9.8
Mar 23	1,374	664		2,038	9.3
Apr 23	1,349	515		1,864	9.5
May 23	1,246	365		1,611	9.7
Jun 23	1,091	233		1,325	9.5

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Financial

- With the added milling wheat infrastructure assumed on farm, depreciation was assumed at 13% for a 15.5 depreciation period (Lincoln University Financial Budget Manual, 2022). This increased depreciation by $8.00/ha in expenses.

- Repairs and maintenance were increased by 10% to account for increased machinery and infrastructure utilisation
- Wages were maintained at the same level but measured on a per hectare basis. This increased the cost of wages on a per stock unit basis.
- The cost of the added milling wheat crop is illustrated in 'cash crop' expenses and derived from FAR (2022).

Table A 6: North Island Intensive finishing and milling wheat model expenses

FARMAX — **NI Intensive Finishing 1 2020-21**
NZAGRC D10 : NI Intensive Finishing 1, Jul 22 - Jun 23

($/year)		Model (tick to use)		Timing	$ Total	$ / ha (202)	$ / SU (2,452)
Wages	Wages			Monthly	18,180	**90.00**	7.41
	Management Wage			Monthly	**0**	0.00	0.00
	Total Wages				**18,180**	**90.00**	**7.41**
Stock	Animal Health	**7,420**	☑	As Incurred	517	2.56	0.21
	Shearing	**23,111**	☑	As Incurred	0	0.00	0.00
	Velveting	**0**	☑	As Incurred	0	0.00	0.00
	Total Stock				**517**	**2.56**	**0.21**
Feed, Crops & Grazing	Conservation	**4,500**	☑	As Incurred	0	0.00	0.00
	Cash Crops	**132,230**	☑	As Incurred	0	0.00	0.00
	Forage Crops	**17,630**	☑	As Incurred	0	0.00	0.00
	Purchased Feeds	**0**	☑	As Incurred	0	0.00	0.00
	Regrassing	32,800	☐	Monthly	6,088	**30.14**	2.48
	Grazing	**0**	☑	As Incurred	0	0.00	0.00
	Total Feed/Crops/Grazing				**6,088**	**30.14**	**2.48**
Fertiliser	Fertiliser (Excl. N & Lime)			Oct, Apr	26,113	**129.27**	10.65
	Nitrogen	**0**	☑	As Incurred	0	0.00	0.00
	Lime			Oct, Apr	1,897	**9.39**	0.77
	Total Fertiliser				**28,009**	**138.66**	**11.42**
Other Farm Working	Irrigation Charges			Custom	408	**2.02**	0.17
	Weed & Pest Control			Monthly	3,557	**17.61**	1.45
	Vehicle Expenses			Monthly	8,708	**43.11**	3.55
	Fuel			Monthly	6,531	**32.33**	2.66
	Repairs & Maintenance			Monthly	22,113	**109.47**	9.02
	Freight & Cartage			Monthly	6,058	29.99	**2.47**
	Electricity			Monthly	3,017	14.93	**1.23**
	Other Expenses			Monthly	**0**	0.00	0.00
	Total Other Farm Working				**50,391**	**249.46**	**20.55**
Standing	Administration Expenses			Monthly	8,541	**42.28**	3.48
	Insurance			Monthly	4,874	**24.13**	1.99
	ACC Levies			Jul, Jan	996	**4.93**	0.41
	Rates			Jul, Oct, Jan, ...	10,037	**49.69**	4.09
	Total Standing Charges				**24,448**	**121.03**	**9.97**
Total Farm Working Expense					**127,633**	**631.85**	**52.04**
Depreciation				Monthly	17,776	**88.00**	7.25
Total Farm Expenses					**145,409**	**719.85**	**59.29**
Other	Rent/Lease			Monthly	8,104	**40.12**	3.30
	Interest			Monthly	24,343	**120.51**	9.93
	Principal			Monthly	**0**	0.00	0.00
	Drawings			Monthly	**0**	0.00	0.00
	Taxation			Jul, Oct, Jan, ...	**0**	0.00	0.00
	Total Other Expenses				**32,447**	**160.63**	**13.23**
	Total Expenses				**177,857**	**880.48**	**72.52**

Farmax Red Meat 8.2.0.16

Summary of profit and loss for all red meat farm scenarios

- Increased costs associated with depreciation, repairs and maintenance and cash crop expense are reflected in the profit and loss results for the farms with added milling wheat.
- Assumptions on profitability of milling wheat was based on achieving $550/tonne at a yield of 8 tonne/ha. The milling wheat was planted on 35 ha of the farm area, which resulted in decreases in stock related income.

Table A 7: North Island intensive finishing and milling wheat model scenario profit and loss statements

FARMAX **Compare Forecast Profit and Loss**
Jul 22 - Jun 23

			Lamb finishing BASE 2	Lamb finishing MW2	Beef finishing BASE	Beef finishing mw2
Revenue	Sheep	Sales - Purchases	331,596	303,731		
		Wool	9,829	9,524		
		Total	**341,425**	**313,255**		
	Beef	Sales - Purchases	27,725	27,725	374,768	326,547
		Total	**27,725**	**27,725**	**374,768**	**326,547**
	Crop & Feed	Cash Crops		154,000		154,000
		Surplus Feeds	28,000	23,400	23,400	23,400
		Capital Value Change		0		
		Total	**28,000**	**177,400**	**23,400**	**177,400**
	Total Revenue		**397,150**	**518,379**	**398,168**	**503,947**
Expenses	Wages	Wages	18,180	18,180	18,180	18,180
	Stock	Animal Health	7,800	7,420	6,439	5,873
		Shearing	23,687	23,111		
	Feed/Crop/Grazing	Conservation	6,570	4,500	7,118	
		Cash Crops		132,230		132,230
		Forage Crops	17,630	17,630	17,630	17,630
		Regrassing	6,088	6,088	6,088	6,088
	Fertiliser	Fertiliser (Excl. N & Lime)	26,113	26,113	26,113	26,113
		Lime	1,897	1,897	1,897	1,897
	Other Farm Working	Irrigation Charges	408	408	408	408
		Weed & Pest Control	3,557	3,557	3,557	3,557
		Vehicle Expenses	8,708	8,708	8,708	8,708
		Fuel	6,531	6,531	6,531	6,531
		Repairs & Maintenance	20,085	22,113	20,085	22,113
		Freight & Cartage	6,518	6,058	6,237	5,593
		Electricity	3,246	3,017	3,106	2,785
	Standing Charges	Administration Expenses	8,541	8,541	8,541	8,541
		Insurance	4,874	4,874	4,874	4,874
		ACC Levies	996	996	996	996
		Rates	10,037	10,037	10,037	10,037
	Total Farm Working Expense		**181,465**	**312,008**	**156,544**	**282,154**
	Depreciation		16,105	17,776	16,105	17,776
	Total Farm Expenses		**197,571**	**329,784**	**172,649**	**299,930**
Economic Farm Surplus (EFS)			**199,579**	**188,595**	**225,519**	**204,018**
Other Expenses		Rent/Leases	8,104	8,104	8,104	8,104
		Interest	24,343	24,343	24,343	24,343
Farm Profit before Tax			**167,132**	**156,148**	**193,071**	**171,570**
Farm Profit per ha before Tax			**827**	**773**	**956**	**849**

EFS is a measure of farm business profitability independent of ownership or funding, used to compare performance between farms.
EFS should include an adjustment for unpaid family labour and management. This can be added to the expense database as management wage.

Farmax Red Meat 8.2.0.16

Table A 8: North Island intensive finishing and milling wheat model scenario gross margins

FARMAX

Compare Gross Margin
Jul 22 - Jun 23

			Lamb finishing BASE 2	Lamb finishing MW2	Beef finishing BASE	Beef finishing mw2
Revenue	Sheep	Sales - Purchases	331,596	303,731		
		Wool	9,829	9,524		
		Total Sheep	**341,425**	**313,255**		
	Beef	Sales - Purchases	27,725	27,725	374,768	326,547
		Total Beef	**27,725**	**27,725**	**374,768**	**326,547**
	Crop & Feed	Cash Crops		154,000		154,000
		Surplus Feeds	28,000	23,400	23,400	23,400
		Capital Value Change		0		
		Total Feed	**28,000**	**177,400**	**23,400**	**177,400**
	Total Revenue		**397,150**	**518,379**	**398,168**	**503,947**
Expenses	Crop & Feed	Conservation	6,570	4,500	7,118	
		Cash Crops		132,230		132,230
		Forage Crops	17,630	17,630	17,630	17,630
		Regrassing	6,088	6,088	6,088	6,088
		Total Crop & Feed	**30,288**	**160,448**	**30,836**	**155,948**
	Stock Costs	Animal Health	7,800	7,420	6,439	5,873
		Shearing	23,687	23,111		
		Total Stock Costs	**31,487**	**30,531**	**6,439**	**5,873**
	Interest on Capital (livestock & feed)		24,430	23,284	26,021	23,403
	Total Variable Expenses		**86,205**	**214,263**	**63,296**	**185,224**
Gross Margin			**310,945**	**304,116**	**334,872**	**318,723**
Gross Margin per Farm ha			**1,539**	**1,506**	**1,658**	**1,578**

Farmax Red Meat 8.2.0.16

Appendix 2: Farmax Dairy Modelling Assumptions

Lower North Island DairyBase model

Pasture

- Farmax Dairy is utilised for the physical modelling. If specific assumptions have not been listed below then the standard farm inputs were used.
- The long-term modelling function was used to create a status quo system.
- The farm was not separated by specific blocks. Crops rotated through the whole farm.
- Pasture quality described below

Table A 9: Lower North Island DairyBase model pasture quality

FARMAX **Pasture Quality for NZAGRC D10 Dairy**
Jun 22 - May 23

Date	kgDM/ha (End of Month)				Total Cover
	Green	Dead	Stem	Total	MJME/kgDM
Start	2,028	292		2,320	11.1
Jun 22	2,115	174		2,289	11.4
Jul 22	2,140	113		2,253	11.7
Aug 22	1,942	102		2,045	11.8
Sep 22	1,821	146		1,967	11.3
Oct 22	2,316	272	132	2,720	10.7
Nov 22	1,886	243	302	2,431	10.4
Dec 22	1,828	374	317	2,519	10.1
Jan 23	1,926	617	209	2,752	9.9
Feb 23	1,874	648	67	2,589	9.7
Mar 23	2,021	590		2,611	9.9
Apr 23	2,025	433		2,458	10.4
May 23	2,029	293		2,322	11.0

Farmax Dairy 8.2.0.23

- Pasture growth rates were calculated by using default regional assumptions.

Financial

- The base dairy farm operating expenses were according to the Farmax 2022-23 operating expenses.
- In the dairy wheat model, depreciation was increased accordingly at a rate of 13% over a 15.5-year period, which increased depreciation by $12.74/ha. Additionally Repairs and Maintenance expenses increased by 10%.
- Wages remained the same across all three scenarios.

Table A 10: Lower North Island DairyBase model expenses

FARMAX

Default 2022-23

NZAGRC D10 Dairy : Default, Jun 22 - May 23

($/year)		Model (tick to use)		Timing	$ Total	$ / ha (126)	$ / Cow (321)	$ / kg MS (130,087)
Wages	Wages			Monthly	**150,000**	1,190	467	1.153
	Management Wage			Monthly	44,619	354	**139**	0.343
	Total Wages				**194,619**	**1,545**	**606**	**1.496**
Stock	Animal Health	**25,498**	☑	As Incurred	25,498	202	79	0.196
	Breeding	**0**	☑	As Incurred	0	0	0	0.000
	Farm Dairy	**5,154**	☑	As Incurred	5,154	41	16	0.040
	Electricity			Monthly	13,161	104	**41**	0.101
	Total Stock				**43,813**	**348**	**136**	**0.337**
Feed	Pasture Conserved	**32,520**	☑	As Incurred	32,520	258	101	0.250
	Cash Crop	**0**	☑	As Incurred	0	0	0	0.000
	Feed Crop	**99,400**	☑	As Incurred	99,400	789	310	0.764
	Bought Feed	**20,263**	☑	As Incurred	20,263	161	63	0.156
	Calf Feed	**4,937**	☑	As Incurred	4,937	39	15	0.038
	Total Feed				**157,120**	**1,247**	**489**	**1.208**
Grazing	Grazing	**0**	☑	As Incurred	0	0	0	0.000
	Run-Off Lease			Monthly	44,604	**354**	139	0.343
	Owned Run-Off Adjustment			Monthly	9,828	**78**	31	0.076
	Total Grazing & Run-Off				**54,432**	**432**	**170**	**0.418**
Other Working	Fertiliser (Excl. N)			Oct, Apr	**90,000**	714	280	0.692
	Nitrogen	**28,550**	☑	As Incurred	28,550	227	89	0.219
	Irrigation			Monthly	7,938	**63**	25	0.061
	Regrassing	**3,600**	☑	As Incurred	3,600	29	11	0.028
	Weed & Pest			Monthly	4,284	**34**	13	0.033
	Vehicles			Monthly	12,222	**97**	38	0.094
	Fuel			Monthly	9,576	**76**	30	0.074
	R&M Land & Buildings			Monthly	35,280	**280**	110	0.271
	R&M Plant & Equipment			Monthly	**0**	0	0	0.000
	Freight			Monthly	6,678	**53**	21	0.051
	Other Expenses			Monthly	**0**	0	0	0.000
	Total Other Farm Working				**198,128**	**1,572**	**617**	**1.523**
Overheads	Administration			Monthly	14,742	**117**	46	0.113
	Insurance			Jul, Jan	8,694	**69**	27	0.067
	ACC			Jul, Jan	3,402	**27**	11	0.026
	Rates			Jul, Oct, Jan, A...	13,734	**109**	43	0.106
	Total Overheads				**40,572**	**322**	**126**	**0.312**
Depreciation				Monthly	53,298	**423**	166	0.410
Total Operating Expenses					**741,982**	**5,889**	**2,311**	**5.704**
Other	Rent/Lease			Monthly	**0**	0	0	0.000
	Interest			Monthly	**0**	0	0	0.000
	Principal			Monthly	**0**	0	0	0.000
	Drawings			Monthly	**0**	0	0	0.000
	Taxation			Monthly	**0**	0	0	0.000
	Total Other Expenses				**0**	**0**	**0**	**0.000**
Total Expenses					**741,982**	**5,889**	**2,311**	**5.704**

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Comparison of profit and loss statements between the different dairy modelled systems

Table A 11: Lower North Island Dairy milling wheat model profit and loss statement

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Compare Forecast Profit and Loss

Jun 22 - May 23

			Base Dairy Farm	Dairy farm +10ha milling wheat	Dairy farm + 20ha milling wheat
Revenue	Stock	Net Milk Sales - this season	1,018,697	977,579	961,916
		Net Milk Sales - last season	217,037	208,261	204,943
		Net Livestock Sales	51,261	47,358	49,362
		Change in Livestock Value			-1,528
		Total	1,286,994	1,233,198	1,214,693
	Crop & Feed	Cash Crops		44,000	88,000
		Capital Value Change	2,268	6,394	4,094
		Total	2,268	50,394	92,094
	Total Revenue		**1,289,262**	**1,283,592**	**1,306,787**
Expenses	Wages	Wages	150,000	150,000	150,000
	Stock	Animal Health	25,498	24,465	24,067
		Farm Dairy	5,154	4,946	4,864
		Electricity	13,161	12,628	12,423
	Feed/Crop	Pasture Conserved	32,520	34,500	31,860
		Cash Crop		45,980	91,960
		Feed Crop	99,400	94,800	94,800
		Bought Feed	20,263	20,468	19,185
		Calf Feed	4,937	4,732	4,665
	Grazing	Run-Off Lease	44,604	44,604	44,604
		Owned Run-Off Adj.	9,828	9,828	9,828
	Other Farm Working	Fertiliser (Excl. N)	90,000	90,000	90,000
		Nitrogen	28,550	26,043	23,475
		Irrigation	7,938	7,938	7,938
		Regrassing	3,600	13,120	21,320
		Weed & Pest Control	4,284	4,284	4,284
		Vehicle Expenses	12,222	12,222	12,222
		Fuel	9,576	9,576	9,576
		R&M Land/Buildings	35,280	35,280	35,280
		R&M Plant/Equipment		9,450	9,450
		Freight & Cartage	6,678	6,776	6,666
	Overheads	Administration Expenses	14,742	14,742	14,742
		Insurance	8,694	8,694	8,694
		ACC Levies	3,402	3,402	3,402
		Rates	13,734	13,734	13,734
	Total Farm Working Expenses		**644,064**	**702,212**	**749,038**
	Depreciation		53,298	54,936	54,936
	Total Farm Expenses		**697,362**	**757,148**	**803,974**
Economic Farm Surplus (EFS)			**591,899**	**526,444**	**502,813**
Farm Profit before Tax			**591,899**	**526,444**	**502,813**
Farm Profit per ha before Tax			**4,698**	**4,178**	**3,991**

EFS is a measure of farm business profitability independent of ownership or funding, used to compare performance between farms.
EFS should include an adjustment for unpaid family labour and management. This can be added to the expense database as management wage.

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NB: Wages of management have been excluded from this analysis.

Table A 12: Milling wheat gross margin. Adapted from Foundation for Arable Research (2022)

		Milling Wheat Gross Margin 2022-23							
		Example: Ashburton District, Canterbury Plains. Irrigated							
	Harvest Year:	2023			Area:	35	ha		
	Date prepared:	Jun-22			Previous crop:				
			Background plant available N expected:			100	kgN/ha to 60cm depth		

Income per hectare

Product				Yield	Unit	Cost/Unit	Income/ha	Sub-total	Total
Grain		Duchess		10	t/ha	$550	$5,500		
Straw					bales	$30	$0		
Grazing					kgDM		$0		
Storage increment									
								$5,500	$5,500

Expenses per hectare

Category	Date	Operation	Product	Rate	Unit	Cost/Unit	Cost/ha	Sub-total	Total
Seed		Seed	Wheat Raxil Combi	120	kg	$1,750	$210		
		Cartage	Self	120	kg	$0	$3	$213	
Establishment		Herbicide	Glyphosate360	4	L	$14	$56		
		Herbicide	Pulse	0.1	L	$37	$4		
		Herbicide application	Own sprayer	1	x	$18	$18		
		Cultivation	Topdown (contractor)	1	x	$160	$160		
		Cultivation	Medium disc (contractor)	1	x	$90	$90		
		Cultivation	Medium disc (contractor)	1	x	$90	$90		
		Cultivation	Camb roll (contractor	1	x	$55	$55		
	1st May	Drill	Disc drill (contractor)	1	x	$125	$125		
								$597	
Herbicide	Pre-emergence	Herbicide	Firebird	0.5	L	$151	$75		
	GS24	Herbicide	Rexade	0.1	kg	$700	$70		
	GS24	Penetrant	Contact	0.25	L	$28	$7		
	GS32	Herbicide	Image	1.75	L	$48	$84		
	GS39	Herbicide	Twinax	0.3	L	$300	$90		
	GS39	Penetrant	Hasten	1	L	$11	$11		
		Herbicide application	Sprayer (contractor)	2	x	$24	$48		
								$385	
Pesticide	GS21	Aphicide	Transform	0.1	L	$300	$30		
	GS24	Aphicide	Transform	0.1	L	$300	$30		
		Pesticide application	Sprayer (contractor)	1	x	$24	$24		
								$84	
Fertiliser		Soil test	Nutrient test	1	x	$52	$1		
		Soil test	Mineral-N (Deep N)	1	x	$45	$1		
		Soil test	HWEN-N	1	x	$36	$1		
	per annum provision	Fertiliser	Lime (cart & spread)	800	kg	$0	$40		
	Base	Fertiliser	15% pot super	325	kg	$0	$157		
	Base	Fertiliser	Magnesium Oxide	50	kg	$1	$29		
	GS31	Fertiliser	Ammo 31	150	kg	$1	$173		
	GS32	Fertiliser	Urea	120	kg	$1	$172		
	GS33	Fertiliser	Urea	120	kg	$1	$172		
	GS39-51	Fertiliser	Urea	120	kg	$1	$172		
		Fertiliser applic	Contract spreader	1	x	$14	$14		
		Fertiliser applic	Own spreader	4	x	$9	$36		
		Fertiliser	Cartage	0.885	t	$23	$20		
								$988	
Fungicide		Disease Test	Diagnostic test		x	$130			
	GS31	Fungicide	Proline	0.4	L	$81	$32		
	GS31	Fungicide	Sportak	1	L	$31	$31		
	GS32	Fungicide	Aviator Xpro	1	L	$92	$92		
	GS32	Fungicide	Phoenix	1.5	L	$24	$36		
	GS39	Fungicide	Adexar	1.25	L	$77	$96		
	GS39	Fungicide	Opus	0.4	L	$35	$14		
	GS61	Fungicide	Amistar	0.75	L	$58	$44		
	GS61	Fungicide	Prosaro	1	L	$62	$62		
		Fungicide applic	Sprayer (contractor)	4	x	$24	$96		
								$503	
PGR	GS31	PGR	Cycocel	1.25	L	$10	$13		
	GS31	PGR	Moddus	0.1	L	$92	$9		
		PGR applic	Sprayer (contractor)	0	x	$24	$0		
								$22	
Irrigation		Irrigation	Lateral	200	mm	$2	$350		
		Soil moisture monitoring		1	site	$1,200	$34		
Other operations		Roll	Heavy roll		x	$35			
		Pollination	Bees			$15			
		Rogue	Roguing			$25			
								$75	
Harvest		Desiccant							
		Penetrant							
		Herbicide applic							
		Harvest	Combine cereal (contractor)	1	ha	$390	$390		
		Harvest	Cartage to silo	10	t	$5	$50		
		Harvest	Weighbridge fees	0.433333	weigh	$20	$9		
		Harvest	Rake, bale (6 string)	0	bales	$25	$0		
								$449	
Post Harvest		Cooling	Cooling			$1			
		Drying	Drying (inward weight)			$36			
		Dressing	Dressing & bags			$0			
		Dressing	Auger in & out			$2			
		Dressing	Cartage to seed dresser			$33			
		Storage	Storage	10	t	$10	$100		
		Insecticide	Actellic dust	10	t	$4	$40		
		Storage	Auger in & out	10	t	$2	$20		
		Delivery	Grain cartage to Chch.	10	t	$25	$250		
								$410	
Other costs		Marketing	Agent commissions	10	t	$10	$100		
		Levies	FAR levies	10	t	$0	$50		
		Levies	UWG levies	10	t	$3	$30		
		Seed Testing	Seed certification						
		Seed Testing	Seed quality						
		Crop insurance							
		Agronomic advice							
		Interest on crop inputs						$180	$3,906
							Gross margin ($/ha)		**$1,594**
							Cost of production ($/tonne of grain)		**$391**
							Expenditure : Income		**71%**

Table A *13*: Maize silage gross margin at a yield of 18 t DM/ha (Source: Perrin Ag)

Maize silage gross margin ($/ha and c/kg DM)		
Revenue	**$/ha**	**c/kg DM**
Maize silage off the paddock	**$4,847**	**$0.27**
Growing Cost	**$/ha**	**c/kg DM**
Chicken manure	$270	$0.02
Glyphosate & 2,4-D	$88	$0
Spray out	$58	$0
Base fertiliser	$319	$0.02
Starter fertiliser	$343	$0.02
Fert cartage	$19	$0
Seed	$815	$0.05
Seed levy	$14	$0
Planting, fertiliser spreading, cultivation	$572	$0.03
Pre-emergence	$81	$0
Pre-emergence spraying	$59	$0
SustaiN (side-dressing)	$309	$0.02
Side-dress spreading	$115	$0.02
Total growing cost	**$3,062**	**$0.17**
Harvesting Cost		
Harvesting	$464	$0.03
Total harvest cost	**$464**	**$0.03**
Total Cost	**$3,526**	**$0.20**
Gross Margin	**$1,321**	**$0.07**