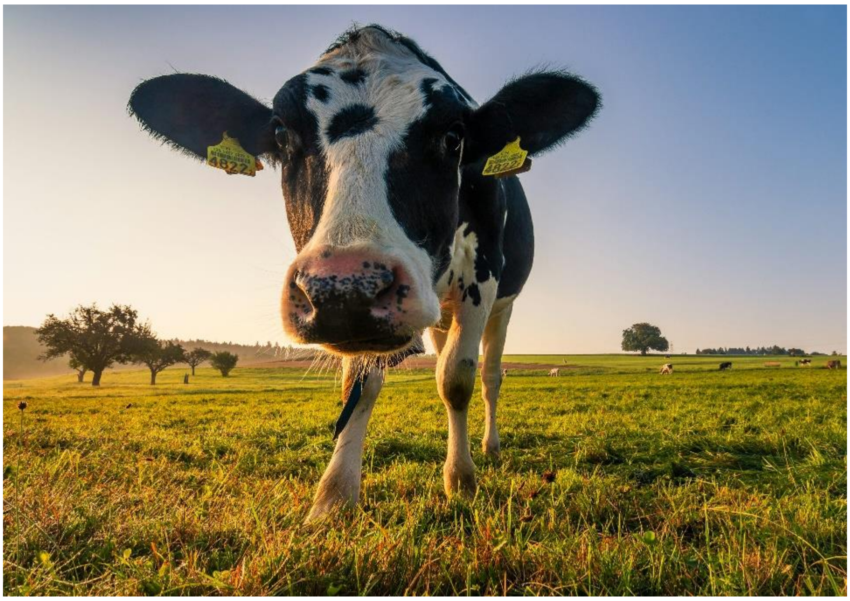

Collars, Costs and Returns: Assessing the Value of Cow Wearables in NZ Pasture Systems

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Executive Summary

New Zealand dairy farming is globally recognised for its predominantly pasture-based, low-input systems. As individual cow monitoring technologies such as Halter and Sensehub become more prominent, questions remain about whether the aspects of the technologies originally designed for housed systems (behavioural monitoring) can deliver sufficient financial returns in New Zealand's unique grazing environment. This research assessed the financial viability of these technologies using three large-scale case study farms, each milking more than 700 cows and performing at or above industry averages for pasture and crop harvested and reproductive performance.

Scenario modelling was undertaken for two dominant and representative players in the New Zealand market, Halter (behavioural monitoring + virtual fencing) and Sensehub (behavioural monitoring only). Financial results were calculated by applying modelled labour, reproductive, pasture utilisation, and animal health benefits against the capital and subscription costs of each system. While both technologies produced clear biological and operational improvements, none of the baseline scenarios delivered a positive financial return on investment for the case study farms, predominantly due to the baseline performance of the subject farms. Sensitivity testing showed that modest changes in cost or performance, such as a 25% reduction in hardware cost, greater improvements in animal health metrics or increased pasture utilisation, could shift several farm scenarios into positive territory, highlighting that financial outcomes are highly dependent on baseline performance and structure.

Wearable technologies offer genuine value in animal monitoring, labour efficiency, heat detection, and staff safety. However, their financial performance depends heavily on the baseline performance of each farm, the nature of existing constraints, and the extent to which labour savings can be realised within practical operational limits. For many New Zealand farms, particularly those already performing strongly, alternative investments in infrastructure, stockmanship, or system improvements may provide more reliable or higher financial returns than wearable adoption.

Key Findings

- **Financial returns were negative across all baseline scenarios** for both Halter and Sensehub when applied to the three high-performing case study farms.
- **Labour efficiency was the largest driver of benefit**, particularly for Halter, but real-world labour restructuring is limited by minimum milking staff requirements, roster sustainability, and capability needs.
- **Animal health improvements provided meaningful but not transformative gains**. Early detection reduced cost and severity, but prevention (infrastructure, cow flow, staff capability) remains a more powerful driver of economic return.
- **Reproductive gains were modest**, largely because all farms already achieved high heat detection efficiency.
- **Pasture utilisation benefits were limited** to non-flat land and only for Halter; impacts were modest due to all farms already carrying out regular pasture monitoring.
- **Technology costs are a major determinant of ROI**. A 25% reduction in hardware cost was sufficient to shift several farm scenarios into positive outcomes in sensitivity testing.

- **Wearables deliver non-financial value** including improved safety, reduced cognitive load during mating, better traceability, and potential for reduced bull power. These may justify adoption for some businesses even when financial ROI is marginal.
- **Farms with poorer baseline performance would likely see higher benefits**, meaning ROI is strongly farm-specific rather than technology-specific.

Recommendations

1. **Adopt wearable technologies only where clear, quantifiable performance gaps exist**, particularly in lameness, mastitis, reproductive performance, labour efficiency, or contour-limited pasture utilisation.
2. **Prioritise system improvements before technology investment**—for example, cow flow, races, yard surfaces, transition management, and staff competency, as these often produce higher returns than detection tools.
3. **Evaluate labour savings realistically**, ensuring roster sustainability, minimum shed staffing, and leave cover can be maintained without compromising staff wellbeing or animal welfare.
4. **Compare wearables against alternative investments** such as automatic cup removers, drafting improvements, additional subdivision, pasture monitoring tools, or track upgrades, which may deliver more reliable returns.
5. **Expect transparent sales practices from technology providers**, seeking clear differentiation between product features and scientifically validated financial benefits; require scenario-based modelling using farm-specific baseline data.
6. **Reassess technology viability periodically**, recognising that hardware cost reductions, improved algorithms, integration with other systems, and evolving labour challenges may shift ROI over time.

1 Introduction

The rapid evolution of individual cow monitoring technologies has created new opportunities for dairy farmers to enhance labour efficiency, reproductive performance, pasture utilisation, and animal health management. While these systems are increasingly common in high-input, housed dairy production overseas, their value proposition within New Zealand's predominantly pasture-based, low-input systems remains less clear. New Zealand herds are managed under unique geographic, climatic, and operational conditions, characterised by rotational grazing, frequent visual contact with stock, and labour structures that differ markedly from housed systems. These unique differences raise important questions regarding whether technologies designed for housed systems can generate sufficient financial returns in grazing-based environments.

Despite growing adoption, (driven by heightened interest in labour-saving tools, the increasing complexity of modern dairy systems, and strong marketing claims from technology providers), there remains limited independent, New Zealand-specific analysis quantifying the actual financial impacts these technologies deliver at farm level. Existing studies tend to rely on international data, vendor-funded case studies, or modelling assumptions that may not reflect the performance benchmarks or management realities of commercial New Zealand dairy farms. As a result, farmers face uncertainty about whether investment in cow wearables is justified, what level of return might reasonably be expected, and under what conditions adoption is most likely to be profitable.

2 Aims and Objectives

The aim of this research is to assess the financial returns that New Zealand dairy farmers may achieve through the use of individual cow-monitoring technologies within pasture-based systems.

The objectives of this study are to:

1. Identify the scale and type of financial benefits that may be achieved through improved labour efficiency, reproductive performance, pasture utilisation, and animal health.
2. Determine the current costs associated with commercially available cow-wearable technologies in New Zealand.
3. Apply these benefits and costs to three large-scale case study farms to model the outcomes of adopting Halter and Sensehub technologies.
4. Develop investment principles that help farmers evaluate whether adoption is financially viable within their own farm systems.

3 Methodology

This research utilised a two-stage qualitative methodology. First, a structured literature review was undertaken to understand how cow wearable technologies have been developed worldwide and subsequently introduced into New Zealand dairy farming. Further research was undertaken to understand the financial offsets that could be achieved through application of the technology and what potential gaps in research there were in order to fully assess the financial returns. Peer-reviewed journal articles, industry reports, media articles and professional publications were sourced using electronic databases and search engines (e.g. Te Kete Wanaka (Lincoln University), Google Scholar, Google and ChatGPT).

In the second stage, three dairy farms were purposively selected for case study analysis based on the availability of high-quality performance data, herd scale (each exceeding 700 cows), and variation in dairy infrastructure (including both rotary and herringbone milking sheds). To minimise the influence of seasonal fluctuation, farm performance data was averaged across two production seasons for each case. This approach is consistent with recommendations for reducing temporal variation in farm benchmarking (DairyNZ, 2021).

Two hypothetical scenarios were then modelled for each farm. In the first scenario, it was assumed that the farm adopted Halter virtual fencing, behavioural and health monitoring collars; in the second, SenseHub (previously known as Allflex) behavioural and health monitoring collars. Expected changes in labour efficiency, pasture utilisation, animal health detection, and reproductive performance were inferred from the themes and quantified effects identified in the literature review, following the principle of applying theory to case context (Thomas, 2006). These projected operational improvements were applied to each farm's baseline dataset to estimate potential changes in physical and financial performance.

Finally, financial return calculations were conducted by applying the estimated benefits and cost offsets to the capital and operating costs associated with adopting each technology system. This enabled assessment of the potential economic viability and comparative financial returns of implementing Halter versus SenseHub monitoring systems across the three case study farms.

4 Literature Review

The purpose of this literature review was to investigate the origins and development of individual cow monitoring technologies, both internationally and subsequently, their introduction into the New Zealand market. It then sought to understand the financial benefits (or financial offsets) that can be achieved by dairy farms through the targeted use of the technology, with a view to separating the benefits of the technology from the features of the technology.

4.1 Historical development of cow monitoring technology

Internationally, individual cow monitoring technologies have been continually developed since the 1970s with one of the earliest innovations trialled being a custom-made pedometer in a waterproof case. Kiddy (1977) demonstrated consistent changes in activity when cows were in heat and concluded that activity monitoring could be used to help with heat detection.

Throughout the remainder of the 20th century, individual cow monitoring was predominantly achieved through the application of in-line monitoring sensors that captured milk yield and milk chemistry (mainly electrical conductivity and colour), used in conjunction with radio frequency identification (RFID). The use of RFID technology for individual cow monitoring transformed monitoring from periodic sampling to per-milking surveillance (Rutten et al, 2013) and allowed for individual monitoring of a cow without the need for a staff member looking at the animal's foremilk to identify issues.

Early in the 21st century, wearable accelerometers were found to be able to remotely and efficiently collect detailed data relating to measures of animal behaviour (Brown et al, 2013). Accelerometers are excellent at tracking movement, posture, and activity patterns in dairy cows. When combined with algorithms or complementary sensors, they provide a powerful means for oestrus detection, health monitoring, and welfare assessment. Their validated applications include measuring lying and standing behaviour, detecting lameness, identifying oestrus-related activity changes, and monitoring general well-being (Hendriks et al., 2020; Stygar et al., 2021; Lamanna et al., 2025).

A relatively modern development of dairy cow wearables involved the concept of “virtual fencing”. The first commercial virtual fencing system was patented in 1973 for controlling domestic dogs, with virtual fencing being used to control livestock for the first time in 1987 (Anderson, 2007). As a management tool, a virtual fence system uses invisible barriers, established by Global Positioning System (GPS) coordinates, that influence livestock movement with a combination of auditory and electrical cues (Ehlert et al. 2024; Antaya et al. 2024). Table 1 provides a summary of sensor types, measurements and information provided.

Table 1. Examples of sensors used in dairy cow monitoring technologies, the measurements taken and what information is given for herd management purposes, reproduced from Herlin et al (2021).

Type of Sensor	Measurement	Information
Activity	Activity, Rumination, Lying Time, step Count	Oestrus, Calving, Lameness, General Health
pH sensor	Rumen pH	Rumen Acidosis
Camera	Activity, Feed Intake, Body Shape	Ketosis, Body Condition, Lameness, Mastitis
Thermometer, Thermography	Body Temperature, Thermal Body Surface Radiation	Water Intake, Calving, Infection, Lameness, General Health
Microphone	Rumination Time	Rumen Function, General Health, Oestrus, Calving

4.2 Adoption of Cow Monitoring Technologies in New Zealand

Dooley et al. (2024) noted that “the majority of these technologies were developed for housed systems overseas”. This has created a challenge given New Zealand’s geographic location, including latitude and maritime influence, result in natural and climatic statistics (Roche et al, 2009). When these factors are combined with targeted research and farmer innovation, they have led to the New Zealand system of dairy production being regarded as the archetypal grazing system (Roche et al, 2017).

New Zealand’s pasture-based grazing systems have provided challenges for cow monitoring technologies due to behavioural differences in livestock between grazed and housed as well as practical issues such as transmission range and cellular service coverage. As a result of these challenges, pasture-based dairy systems had a lower adoption of precision livestock farming technologies (Shalloo et al., 2018).

As at 2023, uptake has been increasing at a large rate with approximately 18% of herds in the New Zealand dairy sector using wearable technology (which included collars, ear tags and rumen sensors), up from 3% in 2018 (DairyNZ, 2023). Information pertaining to subsequent adoption up to 2025 was unable to be found. Given recent milk price results and considering the rate of adoption between 2018 and 2023, one can assume adoption rates have increased.

4.3 Commercially Available Cow Monitoring Technologies in New Zealand.

Table 2 lists the cow wearable technologies that are commercially available in New Zealand, identified via a web search (September 2025). There are essentially three different types of products that make up this list: collars, ear tags and stomach boluses. Of the eight companies listed below, only one company, Halter, at this stage offers virtual fencing for dairy farming as part of its features. All companies offer heat detection and animal health alerts.

Table 2. Commercially available cow-monitoring technologies in New Zealand dairy industry.

		Outputs			
Company	**Brand**	**Heat Detection**	**Animal Health Alerts**	**Virtual Fencing**	**Website**
MSD Animal Health	Sensehub (Allflex)	☑	☑	☒	www.sensehub.co.nz
Halter	Halter	☑	☑	☑	www.halterhq.com
AGIS Harmelen Holding B.V.	CowManager	☑	☑	☒	www.cowmanager.com
smaXtec Animal Care GmbH	smaXtec	☑	☑	☒	www.smaxtec.com/en/new-zealand/
Afimilk	AfiCollar	☑	☑	☒	www.nz.afimilk.com
Datamars	Tru-Test	☑	☑	☒	www.nz.tru-test.com
GEA	CowScout	☑	☑	☒	www.gea.com/en/newzealand/
Waikato Milking systems	CowTRAQ	☑	☑	☒	www.waikatomilking.com

Assessing the New Zealand market share of each wearable offering in New Zealand is challenging due to the lack of detailed industry-wide adoption statistics. Halter is estimated to hold a material share of the New Zealand wearable market as the company deploying over 127,000 collars and declaring subscription revenues of $35.9m in the 2024/25 financial year (Uys, 2025). Sensehub is also estimated to hold a material share of the New Zealand wearable market with the company declaring in June 2023 that more than 750 farms were using Allflex collars (Rural News Group, 2023). Due to market presence and also being representative of behavioural monitoring products on the market, Halter and Sensehub will be explored as case studies in this report.

4.4 Value Proposition of Cow Wearable Technologies in New Zealand

According to Halter (n.d.), financial benefits to the farming operation through use of its product can be achieved through harvesting more pasture, reducing labour requirements, improving reproductive performance, and improving animal health outcomes. Sensehub claims its product can achieve the same financial benefits other than harvesting more pasture (Allflex Livestock Intelligence, 2021).

The following section looks at the potential financial offsets or benefits that the Halter or Sensehub collars could deliver when used on a commercial dairy farming New Zealand.

4.4.1 Potential financial returns from improved reproductive performance

The InCalf programme (a herd reproductive management programme) was introduced in New Zealand in 2007. Through whole farm modelling, it has been estimated that a 1% increase in 6-week in-calf rate and a 1% decline in non-pregnant rate at the end of the breeding programme is worth $4 and $10 per cow respectively (Burke, Tiddy, & Beukes, 2008). The modelling was undertaken in the 2007/08 season and payout used was $5.50. According to K. Roberts (personal communication, October 2025), The $4 and $10 per cow figures established pre-2010 remains unchanged despite the higher payouts that the industry has received recently. Were payout and cow prices to remain high for an extended period without costs necessarily in line with income, these figures would need to be updated.

4.4.2 Potential financial returns from reduced labour requirements

Federated Farmers of New Zealand and Rabobank (2024) reported the average salary for a farm employee was $70,923 with an average hourly rate reported as $29.80 per hour. These figures are averages of all dairy farm roles from dairy farm assistant through to dairy farm operations manager. This survey is undertaken on a biennial basis, with the next survey due in 2026.

4.4.3 Potential financial returns from harvesting more pasture

Neal, Roche, and Shalloo (2018) concluded that higher pasture and crop eaten per hectare was associated with higher profit per hectare of approximately $300/tDM consumed. Extrapolating this to profit per cow by rounding stocking rate to 3 cows per hectare, additional profit can be estimated to be approximately $100/cow. There are caveats associated with this potential return as there needs to be firstly an assessment of the pasture harvest yield gap (i.e. can an extra ton of feed per hectare physically be harvested) and what the specific costs of closing the gap are with the assumption that the full return is available if the gap is closed by changing pasture management practices (Neal et al, 2017).

4.4.4 Potential financial returns from improved animal health outcomes

Mastitis

DairyNZ (2021) notes that each case of mastitis costs approximately $150 in direct expenses. DairySmart NZ (n.d.) claims that the total economic cost (direct and indirect costs) of a case of mastitis is estimated to be approximately $500, suggesting that direct costs only account for approximately two-thirds of the cost of a mastitis case.

No New Zealand specific work has been undertaken on the exact cost savings of early detection, but McDougall et al (2007) acknowledged that early detection allows for higher cure rates and fewer chronic cases and reduced spread within a commercial operation (DairyNZ, 2012). International research has found earlier treatment of mastitis has led to cost reduction per case of between 20% (Pol & Ruegg, 2007) and 30% (Seegers et al., 2003).

Lameness

DairyNZ (2025) claims the incidence of cows treated in a single season in New Zealand dairy farming averages 14%, with top farmers achieving 8% or better. Similar to mastitis, there are direct costs associated with a case of treatable lameness as well as indirect costs such as lower fertility, reduced lifetime production and costs associated with low body condition score.

In New Zealand's pasture-based dairy systems, lameness is frequently underestimated but carries substantial economic consequences. According to Jarratt (2019), a single case of lameness may cost farmers between NZ$500 and NZ$1,000, contingent on factors such as cow value, milk payout, and stage of lactation. The cost is markedly higher - approximately five to tenfold - than the expense of simple treatment, because production declines immediately, conception may be delayed by up to three weeks, and the culling risk increases.

Metabolic Diseases

According to Dairy NZ (2012), the two most common metabolic disorders are parturient hypocalcaemia (commonly known as "milk fever") and ketosis, although conditions such as fatty liver syndrome and left-displaced abomasum could become more frequent as some farm systems intensify and increase milksolid production per cow.

Similar to other animal health issues, there are direct costs and indirect costs associated with metabolic diseases.

Dairy NZ (2023) quotes a New Zealand study in 2000 that estimates losses from milk fever to be $8,000 per 100 cows, accounting for both clinical and subclinical milk fever. Furthermore, NZ Farm Source (2024) quotes a figure of $2,600 per clinical case which also accounts for 10 to 15 cows estimated to be sub-clinical. These two figures broadly line up with reported milk fever incidence of 2% to 5% (Elanco, n.d.).

Dairy NZ (2012) states that there is no information on the prevalence of clinical ketosis in New Zealand, but it acknowledges that there is data to suggest that clinical and subclinical ketosis can be found in New Zealand farm systems with an estimated cost of $3,500 per 100 cows.

4.5 Review of Wearable Financial Returns – Globally and Within New Zealand

Globally, a number of studies have been conducted looking at financial returns from cow wearables focussed on improvements in reproductive and animal health outcomes. Rutten et al (2014) estimated an 11% internal rate of return (IRR) from adoption of activity-meter oestrus detection systems. Pfiffer et al (2020) undertook modelling on Holstein herds and found potential net returns of between €19 and €46 per cow per year in reproductive performance. Pfrombeck et al (2025) looked at a whole herd simulation and found potential returns of between -€33 to €119 per cow per year with the upper end of results being achievable in herds of poorer health.

Burton (2022) explored themes of financial returns and found that all farmers interviewed as part of the project advised a "positive return on investment or financially break-even at worst" although no rates of return were advised and were not broken down by cow technology type. Dooley et al. (2024) looked at three individual case studies of the financial returns of cow wearable technology with returns being expressed in increases in IRR. Results reported across the three case studies had improvement in IRR ranging from 2.13% to 4.00%. AgFirst & TransformAgri (2023) undertook case studies of ten farms using Halter and reported increases in EBIT over and above a baseline position of between -3.0% and +37.3%. These increases in EBIT were assessed across different seasons so likely included seasonality despite standardising milk payments received across the baseline years.

5 Case Study Context & Farm Descriptions

To evaluate the farm-level financial implications of adopting cow wearable technologies, three large-scale dairy businesses were selected as case studies. These farms, all located in the Central North Island and each milking more than 700 cows, represent commercially relevant examples of New Zealand's pasture-based production systems while offering variation in herd size, infrastructure, management structure, contour, and baseline performance. By profiling their physical characteristics, management structures, and historical reproductive and animal health outcomes, the analysis establishes a robust foundation against which the hypothetical Halter and Sensehub scenarios can be applied.

The following section outlines the key attributes of Farms A, B, and C, providing context for interpreting the modelled results that follow.

5.1 Farm A

5.1.1 Farm Attributes

Attribute	Value	Notes
Region	Central North Island	North of Taupo
Soil Type	Yellow-Brown Pumice	
Annual Rainfall	1,183mm/yr	Sourced from OVERSEER
Farm System Classification	System 2	<10% total feed supply as purchased supplement.
Land Area	246ha	Effective hectares only
Contour	Flat (85%), Rolling (15%)	Effective hectares only
Annual Production	277,837kgMS	2-year average

5.1.2 Herd and Production

Attribute	Value	Notes
Cows Wintered	748 cows	2-year average
Breed Composition	Kiwi-Cross	
Milk Production	385kgMS/cow	2-year average
Milk Production	1,129kgMS/ha	2-year average
Peak Cows Milked	721 cows	2-year average
Empty Rate (%)	12.3%	2-year average
6wk in-calf rate (%)	70.6%	2-year average
Heat Detection Efficiency	91.5%	2-year average – From MINDA Fertility Focus Report
Bulk Tank SCC (avg.)	144,500	2-year average
Mastitis (%)	14.2%	2-year average – treated animals
Lameness (%)	6.2%	2-year average – treated animals
Milk Fever (%)	3.1%	2-year average – treated animals

5.1.3 Infrastructure and Technology

Attribute	Value	Notes
Milking Infrastructure	Rapid-exit herringbone	~40 years old
Sets of Cups	50	Farm dairy is 72 but gated to reduce to 50.
In-shed Feeding	No	
Shed Drafting	Yes	Protrack
Irrigation	No	
Existing Automation	No	
Pasture Monitoring	Yes	Plate meter every 10 days.

5.1.4 Pasture and Feeding Systems

Attribute	Value	Notes

Pasture as % of total Diet	92%	2-year average
Grass silage made (on farm)	103tDM	2-year average – fed out as demand dictates
Supplement Types & Usage	380kgDM/cow	Imported supplements only (PKE and Grape Marc)
Wintering system	Swedes	100% wintered at home; 7% area in swedes then regrassed
Pasture & Crop Harvested	14.1tDM	2-year average

5.1.5 Labour and Management Structure

Attribute	**Value**	**Notes**
Total Staff (FTE)	4.5	4 permanent, 1 fixed term
Farm Roster	6 days on, 2 off	Limited casual labour
Management Structure	Owner Operator - Managed	Farm Manager, 2IC, Herd Manager, Assistant
Perceived Labour Constraints	Moderate	Low cows/FTE (187) and low kgMS/FTE (69,459kgMS)

Farm A is a medium-scale dairy business milking approximately 725 cows through a 50 bale, rapid-exit herringbone shed. The farm operates a predominantly pasture-based system with supplements provided as required to fill short term feed deficits. Labour is structured across 4 full-time staff with a 6:2 roster. Baseline performance indicates above-average levels of reproductive performance and 385kgMS per cow, providing a representative commercial baseline for the hypothetical technology modelling.

5.2 Farm B

5.2.1 Farm Attributes

Attribute	**Value**	**Notes**
Region	Central North Island	North of Taupo
Soil Type	Yellow-Brown Pumice	
Annual Rainfall	1,197mm	Sourced from OVERSEER
Farm System Classification	System 2	<10% total feed supply as purchased supplement.
Land Area	499ha	Effective hectares only
Contour	Flat to Gently Undulating	Effective hectares only
Annual Production	548,838kgMS	2-year average

5.2.2 Herd & Production

Attribute	**Value**	**Notes**
Cows Wintered	1,495 cows	2-year average
Breed Composition	Kiwi-Cross	
Milk Production	385kgMS/cow	2-year average
Milk Production	1,100kgMS/ha	2-year average
Peak Cows Milked	1,425	2-year average
Empty Rate (%)	13.4%	2-year average
6wk in-calf rate (%)	71.8%	2-year average

Heat Detection Efficiency	92.0%	2-year average – From MINDA Fertility Focus Report
Bulk Tank SCC (avg.)	149,500	2-year average
Mastitis (%)	28.5%	2-year average – treated animals
Lameness (%)	14.1%	2-year average – treated animals
Milk Fever (%)	2.8%	2-year average – treated animals

5.2.3 Infrastructure and Technology

Attribute	Value	Notes
Milking Infrastructure	Rotary Platform	~13 years old
Sets of Cups	60	
In-shed Feeding	Yes	On/off feeding at fixed volume only
Shed Drafting	Yes	Protrack
Irrigation	No	
Existing Automation	Yes	Automatic cup removers, automatic teat spray system
Pasture Monitoring	Yes	Satellite monitoring via Pasture.IO subscription (previously LIC SPACE)

5.2.4 Pasture and Feeding Systems

Attribute	Value	Notes
Pasture as % of total Diet	94%	2-year average
Grass silage made (on farm)	481tDM	2-year average – fed out as demand dictates
Supplement Types & Usage	260kgDM/cow	Imported supplements only (PKE)
Wintering system	Swedes	100% wintered at home; 8% area in swedes then regrassed
Pasture & Crop Harvested	13.9tDM	2-year average

5.2.5 Labour and Management Structure

Attribute	Value	Notes
Total Staff (FTE)	8.0	7 permanent, 2 fixed term
Farm Roster	6 days on, 2 off	No use of casual labour
Management Structure	Owner Operator - Managed	Farm Manager, 2IC, 2 Herd Managers, 3 Assistants
Perceived Labour Constraints	Moderate	Medium cows/FTE (213) and medium kgMS/FTE (78,405); retention challenges

Farm B is a large-scale dairy business milking approximately 1425 cows through a 60-bale rotary shed. The farm operates a predominantly pasture-based system with supplements provided as required to fill short term feed deficits. Labour is structured across 7 full-time staff with a 6:2 roster. Baseline performance indicates above-average levels of reproductive performance and 385kgMS per cow, providing a representative commercial baseline for the hypothetical technology modelling.

5.3 Farm C

5.3.1 Farm Attributes

Attribute	Value	Notes
Region	Central North Island	North of Taupo
Soil Type	Yellow-Brown Pumice	
Annual Rainfall	1,132mm	Sourced from OVERSEER
Farm System Classification	System 2	<10% total feed supply as purchased supplement.
Land Area	325ha	Effective hectares only
Contour	Flat (80%), Strongly Rolling (20%)	Effective hectares only
Annual Production	318,508kgMS	2-year average

5.3.2 Herd and Production

Attribute	Value	Notes
Cows Wintered	925 cows	2-year average
Breed Composition	Kiwi-Cross	
Milk Production	353kgMS/cow	2-year average
Milk Production	980kgMS/ha	2-year average
Peak Cows Milked	902 cows	2-year average
Empty Rate (%)	10.2%	2-year average
6wk in-calf rate (%)	74.4%	2-year average
Heat Detection Efficiency	92.0%	2-year average – From MINDA Fertility Focus Report
Bulk Tank SCC (avg.)	142,900	2-year average
Mastitis (%)	21.4%	2-year average – treated animals
Lameness (%)	13.5%	2-year average – treated animals
Milk Fever (%)	5.2%	2-year average – treated animals

5.3.3 Infrastructure and Technology

Attribute	Value	Notes
Milking Infrastructure	Rotary Platform	~35 years old
Sets of Cups	50	
In-shed Feeding	No	In shed feeding from 1 August 2025
Shed Drafting	Yes	Protrack
Irrigation	Yes	~50% effective area irrigated

Existing Automation	Yes	Automatic cup removers, automatic teat spray system
Pasture Monitoring	Yes	Plate meter every 10 days.

5.3.4 Pasture and Feeding Systems

Attribute	**Value**	**Notes**
Pasture as % of total Diet	93%	2-year average
Grass silage made (on farm)	86tDM	2-year average – fed out as demand dictates
Supplement Types & Usage	347kgDM/cow	Imported supplements only (PKE, Grape Marc, Triticale silage)
Wintering system	Swedes	100% wintered at home; 7.5% area in swedes then regrassed
Pasture & Crop Harvested	11.9tDM	2-year average

5.3.5 Labour and Management Structure

Attribute	**Value**	**Notes**
Total Staff (FTE)	4.5	4 permanent, 1 fixed-term
Farm Roster	6 days on, 2 off	Limited use of casual labour
Management Structure	Owner Operator - Managed	Farm Manager, 2IC, 2 Dairy Assistants
Perceived Labour Constraints	Low	High cows/FTE (232) and medium kgMS/FTE (79,625)

Farm C is a large-scale dairy business milking approximately 900 cows through a 50-bale rotary shed. The farm operates a predominantly pasture-based system with supplements provided as required to fill short term feed deficits. Labour is structured across 4 full-time staff with a 6:2 roster. Baseline performance indicates above-average levels of reproductive performance and 3353kgMS per cow, providing a representative commercial baseline for the hypothetical technology modelling.

6 Scenario Modelling and Results

6.1 Scenario Development and Assumptions

6.1.1 Scenario A: Adoption of Halter Collars

In Scenario A, it is assumed that each case study farm adopts Halter across the entire milking herd. Halter provides a combination of behavioural monitoring (e.g., rumination, activity, health alerts), automated heat detection, and virtual fencing capabilities that guide cow movement and replace (or substantially reduce) the need for putting up temporary fencing and manual herding. The modelling in this scenario focusses on four primary pathways of potential on-farm impact identified in the literature: **labour efficiency, pasture utilisation, reproductive performance and animal health monitoring**.

Assumptions

The following assumptions were applied consistently to all three farms:

1. **Labour Efficiency**
   Adoption of Halter is assumed to reduce time spent on stock movement, break fencing and routine herding tasks as well as reduction of key person requirements for heat identification during the five-week artificial mating period. For modelling purposes, **an assessment has been made on each case study farm as to how the business would restructure its permanent, fixed term and casual staffing requirements**. This assessment included ability to sustainably maintain current roster, provide internal cover for annual, alternate and sick leave whilst retaining sufficient capability within the farms.

2. **Pasture Utilisation**
   Virtual fencing allows for precision allocation of grazing area and potentially faster paddock shifts thereby reducing under and over grazing of pasture and crops. Pasture assessment under Halter uses satellite assessment of pre-grazing pasture covers with photographs of post-grazing residuals being taken, uploaded and assessed to confirm grazing residuals. There is nothing unique about using Halter for grazing management when compared to a farm that undertakes regular pasture monitoring. This regular pasture monitoring could be through use of a rising plate meter with information interpreted for each farm walk via a computer model (e.g. Land & Feed, PasturePlus) or through other satellite pasture monitoring services (e.g. Pasture.io, Aimer). As a result, an automatic increase in pasture utilisation has not been included in the model due to all three case study farms undertaking regular pasture monitoring.

   Peer-reviewed studies show Halter's virtual fencing is effective for containment, allocation and remote herding in pasture-based dairy systems – capabilities that could plausibly lift pasture utilisation where subdivision and terrain is limiting (Verdon et al, 2024). Quantifying this increase in pasture harvested is promising but currently supported mainly by industry analyses and vendor case studies. However, there is likely a scenario where pasture utilisation in land of steeper contour as well as poor subdivision is increased. For modelling purposes, **a 5% improvement in pasture utilisation on land that isn't classified as flat or gently undulating** has been applied.

3. **Reproductive Performance**
   Dairy NZ (2017) describe herd fertility as consisting of eight key management areas and go onto state that "*there is no simple recipe for achieving good reproductive performance*".

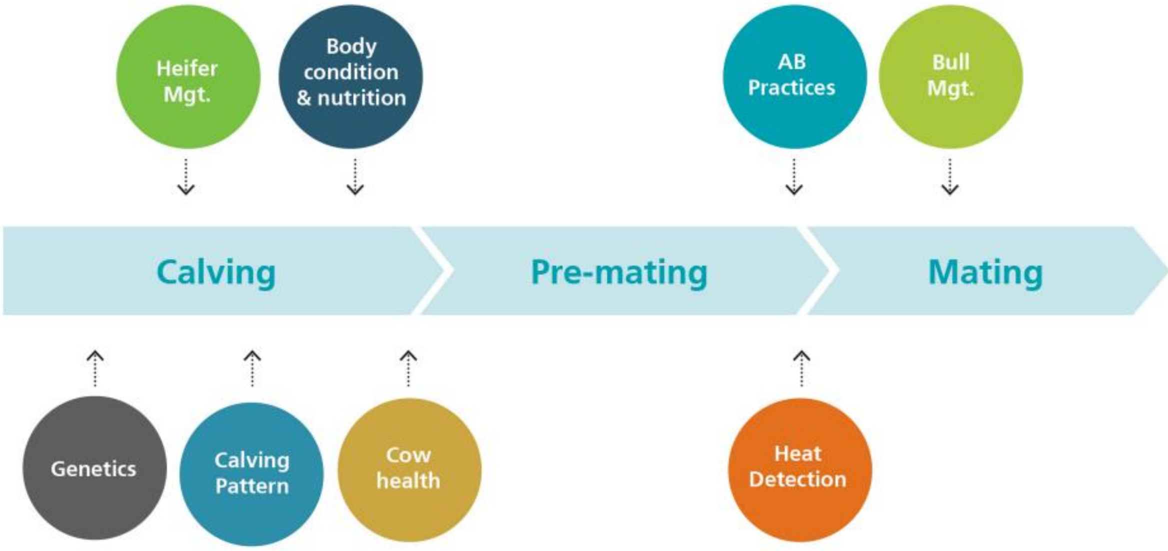

Figure 1. Key management areas to achieve high reproductive performance (DairyNZ, 2017)

Halter's oestrus detection capability is only directly applicable to the Heat Detection management area of the eight key management areas identified in Figure 1 although it is indirectly applicable to the Cow Health management area which is discussed in the next section. Dairy NZ (2024) concluded "*that if a farmer used wearables to automate their mating, then they had done so without compromising reproductive performance*".

For Modelling purposes, **each case study farm had its performance assessed against DairyNZ's Heat Detection Tool (Version NZ 3.0)** with results applied to baseline reproductive performance figures for those farms.

4. **Animal Health Monitoring**

Halter's behavioural monitoring system has the potential to influence animal health management, particularly in relation to lameness, mastitis, and metabolic conditions such as milk fever. The collar also continuously monitors rumination, activity, and behavioural deviation patterns, which are recognised indicators of emerging health issues in dairy cattle. Early identification of these conditions enables more timely intervention and may reduce both the severity and economic consequences, including reproductive performance, of clinical and sub-clinical disease events.

<u>Lameness</u>

Reductions in unnecessary movement and stress from herding are likely to influence lameness outcomes. Virtual fencing reduces instances of cows being moved at speeds inconsistent with their comfort, which can be particularly beneficial for cows in early lactation or with developing hoof lesions. Virtual fencing does however stop at the yard, so any lameness associated with yarding, such as white-line disease, is not prevented or minimised.

For modelling purposes, **a 25% reduction in lameness treatment incidence** was applied, reflecting conservative improvements attributable to early detection and lower herding-related stress.

Mastitis

Mastitis detection benefits arise primarily from rumination and activity deviations, which frequently precede clinical symptoms. Earlier identification shortens the time between infection onset and treatment, reducing severity, volume of discarded milk, and recurrence risk. New Zealand research indicates that earlier clinical intervention lowers the cost per mastitis case and reduces culling risk (McDougall, 2001; DairyNZ, 2021).

For modelling purposes, **a 10% reduction in clinical mastitis-related milk loss and treatment cost** was therefore applied across farms for scenario modelling.

Milk Fever

Changes in behaviour and rumination may also support earlier detection of metabolic disorders such as milk fever, particularly in the first week post-calving. While Halter does not directly measure blood calcium status, behaviour-based alerts can assist in identifying cows at risk before they go down. Improved mobility and reduced handling stress during transition are also supportive factors. Whilst it's acknowledged there is high variability in clinical presentation, earlier detection may reduce severity and increase chances of recovery to the milking herd.

For modelling purposes, **a 10% reduction in clinical milk fever cases and associated costs** was therefore applied across farms for scenario modelling.

6.1.2 Scenario B: Adoption of Sensehub Collars

In Scenario B, it is assumed that each case study farm adopts the Sensehub behavioural and health monitoring collar system across the entire milking herd. Sensehub provides a combination of behavioural monitoring (e.g., rumination, activity, health alerts) and automated heat detection. Unlike Halter, this system does not provide virtual fencing or remote stock movement capabilities therefore no pasture utilisation assumptions were considered. The modelling in this scenario focusses on three primary pathways of potential on-farm impact identified in the literature: **labour efficiency, reproductive performance and animal health monitoring**.

Assumptions

The following assumptions were applied consistently to all three farms:

1. **Labour Efficiency**
   Adoption of Sensehub is assumed to reduce key person requirements for heat identification during the artificial mating period only. For modelling purposes, **a 10% reduction in a single FTE was applied to each farm's labour allocation**. This assessment included ability to sustainably manage the artificial insemination period only (five weeks long on each of the case study farms).

2. **Reproductive Performance**
   Whilst there are undoubtedly some subtle differences in the mechanism by which heat identification is made by Sensehub collars when compared to Halter, the principle remains the same and no difference in heat detection accuracy between the two cow wearable technologies is documented.

For Modelling purposes, **each case study farm had its performance assessed against DairyNZ's Heat Detection Tool (Version NZ 3.0)** with results applied to baseline reproductive performance figures for those farms.

3. **Animal Health Monitoring**
   Sensehub's behavioural monitoring system has the potential to influence animal health management, particularly in relation to lameness, mastitis, and metabolic conditions such as milk fever. The collar also continuously monitors rumination, activity, and behavioural deviation patterns, which are recognised indicators of emerging health issues in dairy cattle. Early identification of these conditions enables more timely intervention and may reduce both the severity and economic consequences of clinical disease events.

   <u>Lameness</u>
   Sensehub collars do not have virtual fencing and remote herding capability. This therefore limits any potential benefit in lameness to that of early detection.

   For modelling purposes, **a 10% reduction in total lameness costs** was applied, reflecting improvements attributable to early detection only.

   <u>Mastitis</u>
   Sensehub's value in mastitis management is similar to that of Halter with benefits primarily achieved through early identification of cases.

   For modelling purposes, **a 10% reduction in clinical mastitis-related milk loss and treatment cost** was therefore applied across farms for scenario modelling.

   <u>Milk Fever</u>
   Sensehub's value in milk fever detection is similar to that of Halter with benefits primarily achieved through early identification of cases.

   For modelling purposes, **a 10% reduction in clinical milk fever cases and associated costs** was therefore applied across farms for scenario modelling.

6.1.3 Other Assumptions for Modelled Scenarios

The following assumptions were applied consistently to all three farms.

1. **Heat Detection Aids**
   A $5 per peak cow offset was applied to acknowledge that secondary heat detection aids (e.g. LIC Heat Patch, Kamar) are not required in automated systems.

2. **Technology Cost**
   Both Halter and Sensehub provided pricing for Farm C in August 2025.

   For Halter, their Pro Collar offering has been priced into the financial offset models at a cost of $155 per wintered cow plus $2 per cow (total $157/cow) to account for tower fees and sundry costs (internet and delivery fees).

   For Sensehub, their Premium Plan offering has been priced into the financial offset models at a cost of $54 per wintered cow plus $1.50 per cow (total $55.50/cow) to account for the required Protrack subscription and other sundry costs.

3. **Minimum Acceptable Rate of Return ("Investment Return")**
   10% was applied to the direct cost of collar investment as the hurdle rate to reflect the return required for the farm business to justify investment, accounting for the opportunity cost of capital, risk, and the long-term nature of technology adoption decisions.

7 Cross Case Analysis & Results

7.1 Overview of Modelling Approach

The purpose of scenario modelling in this section is to estimate the potential farm-level impacts of implementing either Halter or Sensehub (Allflex) cow monitoring systems across the case study farms. The modelling focuses on four primary outcome areas known to drive dairy business performance in New Zealand pasture-based systems:

- **Labour efficiency** (total FTE employed, time spent on heat detection, general stock work)
- **Pasture utilisation** (increased pasture and crop harvested)
- **Reproductive performance** (6 week in-calf rate, empty rate)
- **Animal health events** (mastitis, lameness, metabolic disorders and associated lost production and treatment costs)

The modelling approach integrates farm-specific baseline data with published biological response relationships and scenario-specific assumptions regarding the operational capabilities of Halter and Sensehub. Financial results are expressed on a per cow basis as well as a per farm basis to allow comparison across farms of differing scale and performance.

It is important to note that no peer-reviewed, head-to-head research currently compares Halter and Sensehub in New Zealand rotational grazing herds. As such, this analysis does not attempt to assert technical superiority of one system over the other. Instead, the modelling uses transparent and explicitly stated assumptions in the affected metrics.

As with all dynamic biological systems, there is a degree of uncertainty of the financial offsets which is why sensitivity testing has been used to determine how outcomes change under alternative assumptions.

The results therefore represent scenario-based projections, not empirical measurement. The intention is to illustrate how each system could influence outcomes under the operational conditions of each case study farm, rather than to generalise performance across the wider national dairy industry.

7.2 Baseline Performance (Before Technology Adoption)

The key metrics for each of the case study farms are summarised in Table 3.

Table 3. summary of key metrics of case study farms.

Parameter	Farm A	Farm B	Farm C
Wintered Cows*	748	1495	925
Peak Cows Milked*	721	1425	902
Farm Dairy	Herringbone	Rotary	Rotary
Milk Production/cow*	385kgMS	385kgMS	353kgMS
6-week in-calf Rate*	70.6%	71.8%	74.4%

Empty Rate*	12.3%	13.4%	10.2%
Heat Detection Efficiency*	91.5%	92%	92%
Pasture & Crop Harvested/ha*	14.1tDM	13.9tDM	11.9tDM
Contour – Flat or Gently Undulating	85%	100%	80%
Contour – Balance of effective area	15%	0%	20%
Staff Permanent FTE	4	7	4
Cows/Permanent FTE*	187	213	232
Fixed Term Staff (Jul – Dec)	1	2	1
Regular Pasture Monitoring	Yes	Yes	Yes
Perceived Labour Constraints	Moderate	Moderate	Low
Lameness Rate*	6.2%	14.1%	13.5%
Mastitis Rate*	14.2%	28.5%	21.4%
Milk Fever Rate*	3.1%	2.8%	5.2%

* *Two-year average (2023/24 & 2024/25)*

7.3 System-Assumption Parameters

The assumptions for modelled cost offsets are detailed in Table 4.

Table 4. Summary of modelled cost offsets by parameter.

Parameter	Halter Scenario Assumption	Sensehub Scenario Assumption	Rationale/Source
Labour Efficiency	See individual assessments below	10% offset of average FTE cost	Literature, vendor claims, farmer experience
Pasture Utilisation	5% improvement in pasture utilisation on land not classified as flat or gently undulating.	Not Applicable	vendor claims, farmer experience
Reproductive Performance	Individual application of Heat Detection Tool (NZ – V3.0) – see below	Individual application of Heat Detection Tool (NZ – V3.0) – see below	Literature
Lameness Rate	25% reduction in lameness treatment incidence.	10% reduction in lameness treatment incidence.	Literature, vendor claims, farmer experience
Mastitis Rate	10% reduction in total mastitis costs.	10% reduction in total mastitis costs.	Literature, vendor claims, farmer experience
Milk Fever Rate	10% reduction in total milk fever costs.	10% reduction in total milk fever costs.	Literature, vendor claims, farmer experience

7.3.1 Labour Efficiency Assumptions (Halter Scenario)

Farm A

- Removal of one permanent FTE due to fixed staff requirements for milking in 50 bale rapid-exit herringbone and herd movement reducing from three to two people.
- No change in casual staffing requirements to cover leave provisions.

Farm B

- Removal of one permanent FTE due to reduced herd movement requirements.

- Restructure one permanent FTE to one fixed term labour unit employed between July and December each year.
- No change in casual staffing requirements to cover leave provisions.

Farm C

- Restructure one permanent FTE to one fixed term labour unit employed between July and December each year.
- No change in casual staffing requirements to cover leave provisions.

7.3.2 Reproductive Performance Assumptions (Halter & Sensehub Scenarios)

Table 5. Heat detection efficiency summary table for modelling assumptions.

Parameter	Farm A	Farm B	Farm C
Act. Heat Detection Efficiency (HDE)	91.5%	92%	92%
Target HDE	95.0%	95.0%	95.0%
HDE Gap	3.5%	3.0%	3.0%

7.4 Individual Farm Scenario Results

The individual financial offset models for each of the case study farms are set out below in Tables 6 to 11. All 'per cow' metrics use peak cow numbers from the respective farm.

7.4.1 Farm A

Table 6. Financial offset model results – Farm A, Halter

Parameter	Criteria	Baseline	Halter Scenario	Difference (Halter vs. Baseline)	Halter Finacial Impact (Total)	Halter Finacial Impact (Per Cow)
Labour Efficiency	*Permanent FTE*	4	3	-1	$ 71,000	$ 98
Labour Efficiency	*Fixed Term FTE*	1	1	0	$ -	$ -
Pasture Utlisation	*Additional Feed Harvested*	14.1	14.21	0.11	$ 7,804	$ 11
Reproductive Performance	*6 Week in-calf Rate*	70.60%	72.46%	1.86%	$ 5,394	$ 7
Reproductive Performance	*Empty Rate*	12.30%	11.88%	-0.42%	$ 3,045	$ 4
Animal Health	*Lameness*	6.20%	4.65%	-1.55%	$ 8,428	$ 12
Animal Health	*Mastitis*	14.20%	12.78%	-1.42%	$ 5,148	$ 7
Animal Health	*Milk Fever*	3.10%	2.79%	-0.31%	$ 5,844	$ 8
Reproductive Performance	*Heat Detection Aid Offset*				$ 3,625	$ 5
Technology Cost	*Subscription & Sundry*				-$ 117,436	-$ 162
Technology Cost	*Investment Return*				-$ 11,744	-$ 16
Total	*Net Financial Return*				-$ 18,892	-$ 26

Table 7. Financial offset model results – Farm A, Sensehub

Parameter	Criteria	Baseline	Sensehub Scenario	Difference (Sensehub vs. Baseline)	Sensehub Finacial Impact (Total)	Sensehub Finacial Impact (Per Cow)
Labour Efficiency	*Permanent FTE*	4	4	0	$ -	$ -
Labour Efficiency	*Fixed Term FTE*	1	1	0	$ -	$ -
Labour Efficiency	*Sensehub Offset*	100%	90%	-10%	$ **7,100**	$ **10**
Pasture Utlisation	*Additional Feed Harvested*				$ -	$ -
Reproductive Performance	*6 Week in-calf Rate*	70.60%	72.46%	1.86%	$ **5,394**	$ **7**
Reproductive Performance	*Empty Rate*	12.30%	11.88%	-0.42%	$ **3,045**	$ **4**
Animal Health	*Lameness*	6.20%	5.58%	0.62%	$ **3,371**	$ **5**
Animal Health	*Mastitis*	14.20%	12.78%	1.42%	$ **5,148**	$ **7**
Animal Health	*Milk Fever*	3.10%	2.79%	0.31%	$ **5,844**	$ **8**
Reproductive Performance	*Heat Detection Aid Offset*				$ **3,625**	$ **5**
Technology Cost	*Subscription & Sundry*				-$ **41,514**	-$ **57**
Technology Cost	*Investment Return*				-$ **4,151**	-$ **6**
Total	*Net Financial Return*				-$ **12,139**	-$ **17**

7.4.2 Farm B

Table 8. Financial offset model results – Farm B, Halter

Parameter	Criteria	Baseline	Halter Scenario	Difference (Halter vs. Baseline)	Halter Finacial Impact (Total)	Halter Finacial Impact (Per Cow)
Labour Efficiency	*Permanent FTE*	7	5	-2	$ **142,000**	$ **100**
Labour Efficiency	*Fixed Term FTE*	2	3	1	-$ **35,500**	-$ **25**
Pasture Utlisation	*Additional Feed Harvested*	13.9	13.90	0.00	$ **3,500**	$ **2**
Reproductive Performance	*6 Week in-calf Rate*	71.80%	73.39%	1.59%	$ **9,063**	$ **6**
Reproductive Performance	*Empty Rate*	13.40%	13.04%	-0.36%	$ **5,130**	$ **4**
Animal Health	*Lameness*	14.10%	10.58%	-3.53%	$ **37,673**	$ **26**
Animal Health	*Mastitis*	28.50%	25.65%	-2.85%	$ **20,306**	$ **14**
Animal Health	*Milk Fever*	2.80%	2.52%	-0.28%	$ **10,374**	$ **7**
Reproductive Performance	*Heat Detection Aid Offset*				$ **7,125**	$ **5**
Technology Cost	*Subscription & Sundry*				-$ **234,715**	-$ **165**
Technology Cost	*Investment Return*				-$ **23,472**	-$ **16**
Total	*Net Financial Return*				-$ **58,515**	-$ **41**

- No additional feed harvested modelled on Farm B due to flat contour only however the annual cost of current satellite monitoring (Pasture.io) has been added as a cost offset in the model.

Table 9. Financial offset model results – Farm B, Sensehub

Parameter	Criteria	Baseline	Sensehub Scenario	Difference (Sensehub vs. Baseline)	Sensehub Finacial Impact (Total)	Sensehub Finacial Impact (Per Cow)
Labour Efficiency	*Permanent FTE*	7	7	0	$ -	$ -
Labour Efficiency	*Fixed Term FTE*	2	2	0	$ -	$ -
Labour Efficiency	*Sensehub Offset*	100%	90%	-10%	$ **7,100**	$ **5**
Pasture Utlisation	*Additional Feed Harvested*				$ -	$ -
Reproductive Performance	*6 Week in-calf Rate*	71.80%	73.39%	1.59%	$ **9,063**	$ **6**
Reproductive Performance	*Empty Rate*	13.40%	13.04%	-0.36%	$ **5,130**	$ **4**
Animal Health	*Lameness*	14.10%	12.69%	-1.41%	$ **15,069**	$ **11**
Animal Health	*Mastitis*	28.50%	25.65%	-2.85%	$ **20,306**	$ **14**
Animal Health	*Milk Fever*	2.80%	2.52%	-0.28%	$ **10,374**	$ **7**
Reproductive Performance	*Heat Detection Aid Offset*				$ **7,125**	$ **5**
Technology Cost	*Subscription & Sundry*				-$ **82,973**	-$ **58**
Technology Cost	*Investment Return*				-$ **8,297**	-$ **6**
Total	*Net Financial Return*				-$ **17,102**	-$ **12**

7.4.3 Farm C

Table 10. Financial offset model results – Farm C, Halter

Parameter	Criteria	Baseline	Halter Scenario	Difference (Halter vs. Baseline)	Halter Finacial Impact (Total)	Halter Finacial Impact (Per Cow)
Labour Efficiency	*Permanent FTE*	4	3	-1	$ 71,000	$ 79
Labour Efficiency	*Fixed Term FTE*	1	2	1	-$ 35,500	-$ 39
Pasture Utlisation	*Additional Feed Harvested*	11.9	12.02	0.12	$ 11,603	$ 13
Reproductive Performance	*6 Week in-calf Rate*	74.40%	75.99%	1.59%	$ 5,737	$ 6
Reproductive Performance	*Empty Rate*	10.20%	9.84%	-0.36%	$ 3,247	$ 4
Animal Health	*Lameness*	13.50%	10.13%	-3.38%	$ 22,832	$ 25
Animal Health	*Mastitis*	21.40%	19.26%	-2.14%	$ 9,651	$ 11
Animal Health	*Milk Fever*	5.20%	4.68%	-0.52%	$ 12,195	$ 14
Reproductive Performance	*Heat Detection Aid Offset*				$ 4,510	$ 5
Technology Cost	*Subscription & Sundry*				-$ 145,225	-$ 161
Technology Cost	*Investment Return*				-$ 14,523	-$ 16
Total	*Net Financial Return*				-$ 54,473	-$ 60

Table 11. Financial offset model results – Farm C, Sensehub

Parameter	Criteria	Baseline	Sensehub Scenario	Difference (Sensehub vs. Baseline)	Sensehub Finacial Impact (Total)	Sensehub Finacial Impact (Per Cow)
Labour Efficiency	*Permanent FTE*	4	4	0	$ -	$ -
Labour Efficiency	*Fixed Term FTE*	1	1	0	$ -	$ -
Labour Efficiency	*Sensehub Offset*	100%	90%	-10%	$ 7,100	$ 8
Pasture Utlisation	*Additional Feed Harvested*				$ -	$ -
Reproductive Performance	*6 Week in-calf Rate*	74.40%	75.99%	1.59%	$ 5,737	$ 6
Reproductive Performance	*Empty Rate*	10.20%	9.84%	-0.36%	$ 3,247	$ 4
Animal Health	*Lameness*	13.50%	12.15%	-1.35%	$ 9,133	$ 10
Animal Health	*Mastitis*	21.40%	19.26%	-2.14%	$ 9,651	$ 11
Animal Health	*Milk Fever*	5.20%	4.68%	-0.52%	$ 12,195	$ 14
Reproductive Performance	*Heat Detection Aid Offset*				$ 4,510	$ 5
Technology Cost	*Subscription & Sundry*				-$ 51,338	-$ 57
Technology Cost	*Investment Return*				-$ 5,134	-$ 6
Total	*Net Financial Return*				-$ 4,898	-$ 5

7.5 Economic Outcome of Modelled Scenarios

The following section reviews the scenario-modelled results from the three case study farms to identify consistent themes in physical performance and financial outcomes. Figure 2 presents the overall net position per cow for each technology (Halter and Sensehub), while Figure 3 displays the category-level offsets (labour, pasture utilisation, reproduction, animal health and heat detection cost offset) that contributed to the net benefit result.

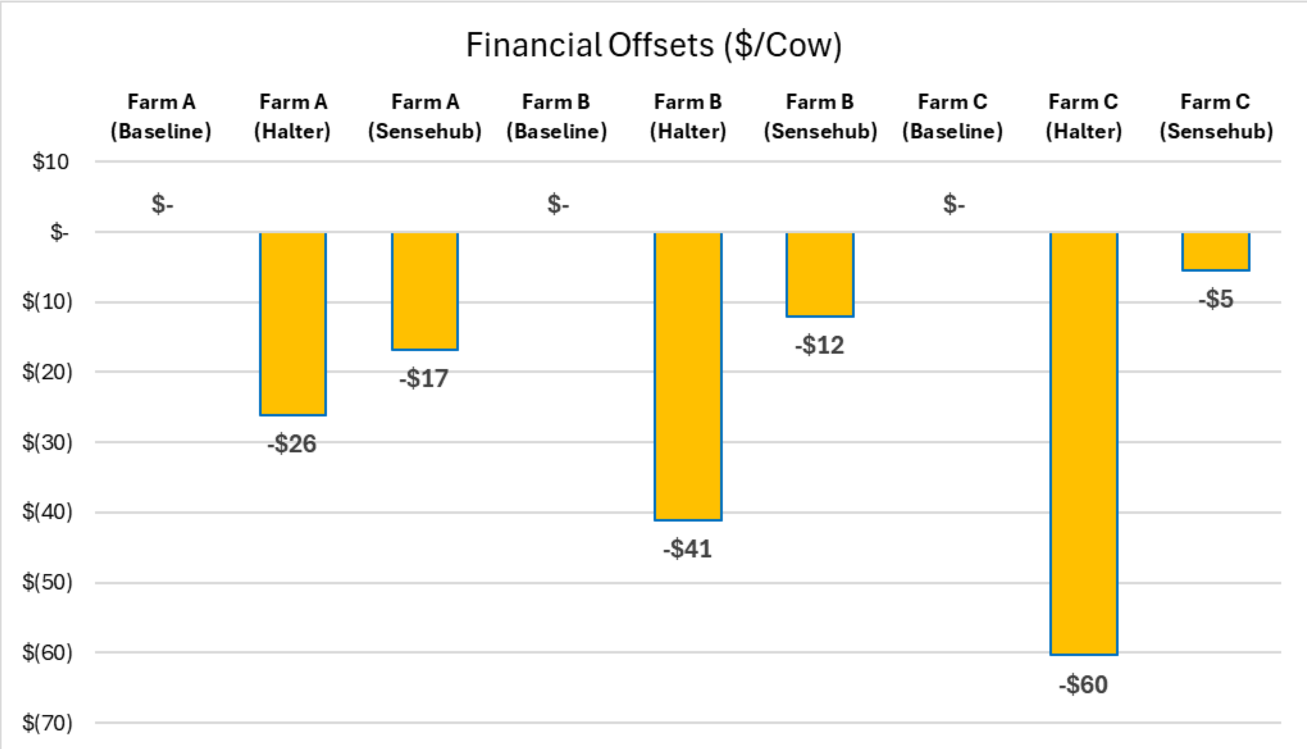

Figure 2. Financial offset results (per cow) for Halter and Sensehub across all case study farms

Across all farms, both technologies generated positive physical shifts, yet the net result, when compared to the baseline position, was negative for all scenarios. The magnitude and composition of benefits varied according to herd size, shed type and existing animal health performance.

The bar graph in in Figure 2 shows that Halter consistently showed the lowest cost offset per cow with modelled gains against the baseline position ranging from -$26 to -$60 per cow across the three farms. Sensehub delivered the highest cost offset, despite being below the baseline position in all three scenarios modelled, ranging -$5/cow to -$17/cow. The relative difference between the Halter scenario and the baseline scenario narrowed on farms with (a) higher labour offset, (b) reduced animal health issues and (c) reproductive performance. The relative difference between the Sensehub scenario and the baseline scenario narrowed on farms primarily with reduced animal health issues.

7.5.1 Category-Level Drivers of Change

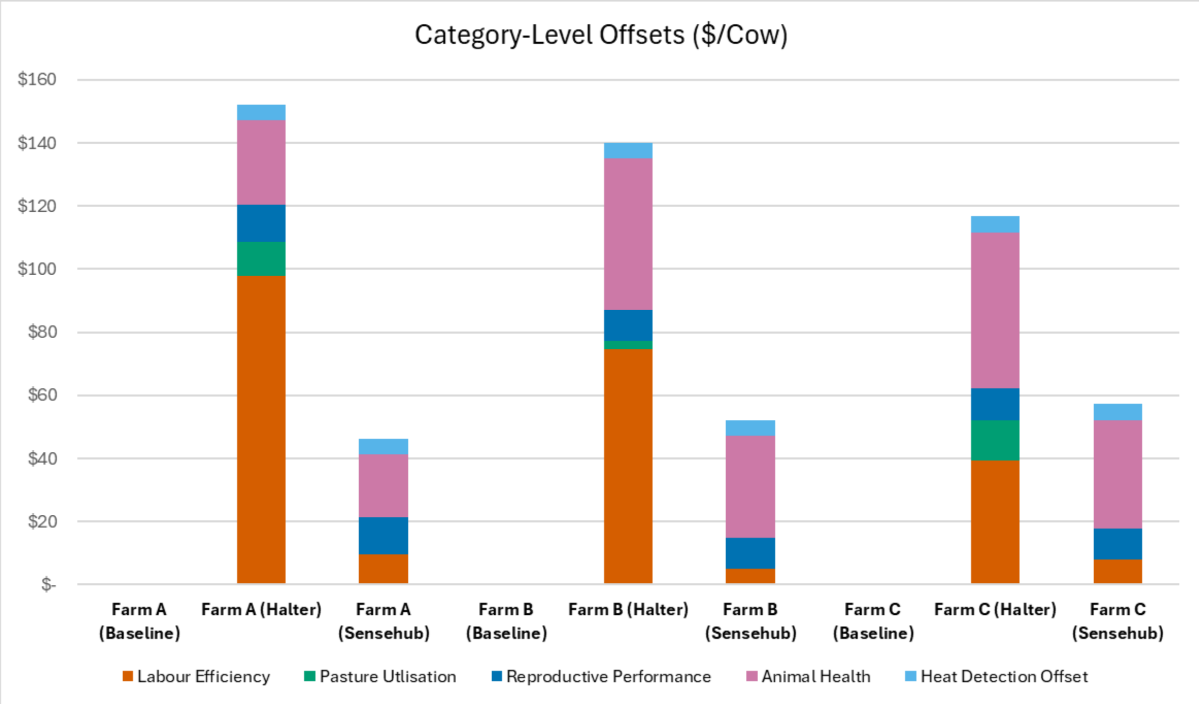

Figure 3. Category level cost offset results for Halter and Sensehub across all case study farms.

The stacked bar graph in Figure 3 highlights the source of these differences. A clear pattern emerged:

- Labour offsets were the largest contributor to Halter's modelled results in two of the three farms modelled. This result was driven by material labour reductions modelled across all three farms due to Halter's virtual fencing and remote herding capabilities as well as automated heat detection. These benefits translated from $39 to $98/cow of value, depending on the existing ratios of cows per labour unit.
- Animal health improvements contributed meaningfully to all three scenarios with scale differing depending on the baseline position. On farms where there was an existing lameness issue, Halter generated large reductions in cost arising from its better managed cow flow from its remote herding capability, with benefits ranging from $27 to $50/cow of value. Sensehub's alerts around generic animal health conditions generated the majority of cost offsets for its modelled outcomes in two of the three case study farms. Benefits ranged from $20 to $34/cow of value.
- Reproductive performance improvements were modest due to relatively high Heat Detection Efficiency (HDE) achieved by all three case study farms over the previous two dairy seasons, ranging 91.5 to 92% against a target of 95%. Modelled benefits ranged from $10 to $12/cow of value.

7.5.2 Patterns Across Farm Types

Despite structural and management differences across the three farms, three consistent themes emerged:

1. Labour offsets were greatest where cows per permanent FTE were under 200 (Farm A) and also where large numbers of cows were milked through a rotary shed (Farm B)

where minimum staff required to milk was three pre-Christmas and two post-Christmas.
2. Herds with underlying high levels of animal health issues showed the greater benefits from use of wearables.
3. All farms modelled, despite the above benefits, still could not show a break-even result compared to the baselines, let alone return at an acceptable hurdle rate.

The combined analysis reinforces that no single technology is universally superior; rather, each system provides a distinct array of benefits that aligns differently with historical individual farm performance. The overall cross-farm pattern suggests that Halter's virtual fencing and remote herding capability can reduce on-farm labour costs whilst all other facets of the technologies broadly deliver the same results across heat detection and animal health, and if used in conjunction with superior stockmanship, can deliver value.

7.6 Sensitivity Testing

Sensitivity testing was undertaken to understand how robust the modelled results were to changes in key biological and economic assumptions. Four one-way sensitivity scenarios were evaluated:

Scenario 1 - A 25% reduction in technology costs.

Scenario 2 – An additional 10% reduction in cost offsets across all animal health categories.

Scenario 3 - A doubling of reproductive performance improvements.

Scenario 4 - A uniform 5% increase in pasture and crops harvested across the whole effective farm area.

Pasture utilisation under Sensehub is not a feature of that technology therefore not tested, and no further labour reduction sensitivities were tested due to the assessment that staffing levels could not be reduced further without compromising the roster or putting undue pressure on remaining staff.

Tables 12 to 14 summarise the financial impact of each scenario on the net benefit per cow for both Halter and Sensehub. Results are presented as both absolute values and changes relative to baseline. Farms A and B demonstrated positive net results for Halter under scenarios 1 (hardware cost reduction) and 4 (improved utilisation) with all scenarios remining negative at Farm C. All three case study farms delivered a positive net result for Sensehub under scenarios 1 and 2 (improved animal health outcomes) with Farm C demonstrating a positive net result to all modelled scenarios.

Table 12. Summary of sensitivity testing scenario results for Halter and Sensehub – Farm A

Farm A	Description	Halter Net Result ($/cow)	Change from Baseline	Sensehub Net Result ($/cow)	Change from Baseline
Baseline	Original model	**-$26**	--	**-$17**	--
Scenario 1	Hardware cost reduced by 25%	**$18**	+$44	**-$1**	+$18
Scenario 2	-10% health event reduction	**-$6**	+$20	**$3**	+$20
Scenario 3	Doubled benefit for 6 wk IC rate & empty rate	**-$14**	+$12	**-$5**	+$12
Scenario 4	Whole-farm pasture & crop harvested +5%	**$35**	+$61	**--**	--

In Farm A, Halter's results are most sensitive to improvements in pasture utilisation and hardware cost reduction, whereas Sensehub's results shift most when animal health benefits improve as well as hardware cost reduction. Reproduction gains have the lowest marginal impact across this farm.

Table 13. Summary of sensitivity testing scenario results for Halter and Sensehub – Farm B

Farm B	Description	Halter Net Result ($/cow)	Change from Baseline	Sensehub Net Result ($/cow)	Change from Baseline
Baseline	Original model	**-$41**	--	**-$12**	--
Scenario 1	Hardware cost reduced by 25%	**$4**	+$45	**$4**	+$16
Scenario 2	-10% health event reduction	**-$9**	+$32	**$20**	+$32
Scenario 3	Doubled benefit for 6 wk IC rate & empty rate	**-$31**	+$10	**-$2**	+$10
Scenario 4	Whole-farm pasture & crop harvested +5%	**+$32**	+$73	--	--

In Farm B, Halter's results are most sensitive to improvements in pasture utilisation, animal health improvements and hardware cost reduction, whereas Sensehub's results shift most when animal health benefits improve as well as hardware cost reduction. Reproduction gains have the lowest marginal impact across this farm.

Table 14. Summary of sensitivity testing scenario results for Halter and Sensehub – Farm C

Farm C	Description	Halter Net Result ($/cow)	Change from Baseline	Sensehub Net Result ($/cow)	Change from Baseline
Baseline	Original model	**-$60**	--	**-$5**	--
Scenario 1	Hardware cost reduced by 25%	**-$16**	+$44	**$10**	+$15
Scenario 2	-10% health event reduction	**-$26**	+$34	**$29**	+$34
Scenario 3	Doubled benefit for 6 wk IC rate & empty rate	**-$50**	+$10	**$5**	+$10
Scenario 4	Whole-farm pasture & crop harvested +5%	**-$9**	+$54	--	--

In Farm C, Halter's results are most sensitive to improvements in pasture utilisation, animal health improvements and hardware cost reduction, whereas Sensehub's results shift most when animal health benefits improve as well as hardware cost reduction. Reproduction gains have the lowest marginal impact across this farm.

7.7 Discussion of Offsets and Assumptions

7.7.1 Realism of Operational Offsets

Labour Efficiency Offsets

Labour reduction represents the largest single source of financial improvement under Halter scenarios, particularly on the farms with lower cow numbers per FTE. These offsets were modelled based on actual staffing structures and the removal or restructuring of specific roles. While grounded in observed labour patterns, these assumptions depend heavily on the feasibility of consistently maintaining rosters, ensuring animal welfare, and retaining sufficient capability for leave cover.

In practice, labour savings may be eroded by:

- Staff turnover
- Technology adaption and adoption risks
- Reduced flexibility in unexpected events (e.g. adverse weather, disease outbreak)
- Inability to adapt to the new structure put in place

Conversely, it is possible that labour savings, specifically on Farm B, are understated with Halter able to provide even more labour offsets that can be imagined in a hypothetical scenario. Overall, the assumptions are reasonable but inherently sensitive to farm-specific management philosophy.

Pasture Utilisation Offsets

Pasture utilisation benefits were applied only under Halter and only to land classified as rolling or steep. This conservative framing reflects the uncertainty in quantifying pasture gains where regular plate metering and satellite monitoring are already well established on the case study farms.

The assumption that increased utilisation is limited to non-flat land reflects the literature and industry experience; however, it also means the modelling may understate potential gains where subdivision, cow flow, or paddock access constraints (independent of slope) currently limit utilisation.

Reproductive Performance

The modelling applied DairyNZ's Heat Detection Tool to quantify expected gains resulting from wearable-supported heat identification. These assumptions are modest because baseline heat detection efficiency (HDE) across all farms was already high (91.5 to 92%). Given the diminishing marginal returns when farms already perform strongly, reproductive benefits are conservative but appropriate.

One limitation is that the modelling excludes any improvement arising indirectly from better animal health or reduced lameness. This omission prevents double-counting but also means total reproductive improvement may be underestimated. Conversely, targeted investment into on-farm improvements may provide a better return than investment into cow wearable technology.

Animal Health Offsets

The assumed reductions in lameness (25% for Halter; 10% for Sensehub), mastitis (10% for both systems), and milk fever (10% for both) reflect conservative interpretations of available research and industry experience. They also account for the lack of peer-reviewed evidence comparing the two systems' detection accuracy. There is also a lack of peer-reviewed evidence for the quantum of early detection benefits.

However, several factors influence the reliability of these assumptions:

- Lameness outcomes depend heavily on farm dairy design, yard surfaces, track quality, and stockmanship - factors not influenced by collars alone.
- Mastitis and milk fever improvements vary markedly by herd history and transition management practices and inherently, prevention is always going to have a greater benefit than cure. No feature of cow wearables operates as a genuine preventative measure for mastitis or milk fever.

- Health savings are sensitive to disease prevalence; farms with low baseline incidence may see little benefit, while high-incidence farms may experience larger-than-modelled gains.

Overall, these assumptions represent plausible but central-case values that should not be interpreted as universal outcomes.

7.7.2 Economic Assumptions Driving the Model

Technology Costs

Capital and subscription costs for Halter and Sensehub significantly influence net results. Costs were modelled using current commercial pricing for the mid-rage offering of the two companies researched, but these prices are dynamic and subject to:

- Alternate offerings from Halter and Sensehub being explored
- economies of scale and purchaser negotiation of product pricing
- future pricing strategies
- hardware lifespan
- potential bundling of services

The sensitivity analysis shows that even the modest reductions in technology cost dramatically improve net outcomes, especially for Halter. This indicates that technology pricing is a critical determinant of ROI rather than biological response alone.

Labour Rates and Replacement Values

The modelling uses national average labour costs which was undertaken to ensure a fair approach to pricing labour, acknowledging that farms will price labour for a variety of reasons. Labour shortage pressure, particularly in regions with constrained labour supply, could also strengthen the true economic value of reducing reliance on skilled staff.

Disease Cost Assumptions

The cost of mastitis, lameness, and metabolic diseases varies considerably between farms depending on:

- treatment protocol and associated costs
- discarded milk volumes and milk price
- production level at time of disease
- culling risk and farm culling policy

While the values used in modelling are supported by New Zealand literature and broadly incorporate the above variables, they reflect approximate industry averages rather than calculated costs from the case study farms in question. This may over or under-estimate true savings.

7.7.3 Interactions and Overlaps Between Offsets

The modelling treats labour, reproduction, health, and pasture utilisation as separate categories, but real-world interactions exist. Examples include:

- Early lameness detection improves milk production, fertility, and cull rate simultaneously.

- Reduced herding stress (Halter) can lower lameness risk and improve cow flow, indirectly affecting milking efficiency and labour.
- Increased pasture utilisation also lowers bought-in feed costs, which were not modelled.
- Fewer animal health events can materially reduce staff workload, indirectly affecting labour.

Treating these areas separately reduces the risk of double-counting benefits but also means that the modelling likely understates the true cumulative influence of multiple small improvements.

7.7.4 Limitations of the Assumptions

The modelling approach is deliberately conservative and transparent, but key limitations remain:

- Technology performance was not validated with case-farm data (i.e. scenarios are purely hypothetical).
- No peer-reviewed evidence exists comparing Halter and Sensehub directly.
- Biological responses can vary widely between years; a two-year baseline reduces but does not eliminate this.
- The model does not incorporate intangible benefits (e.g., health and safety, staff satisfaction, reduced bull use).

These limitations do not undermine the scenario analysis, but they reinforce that results should be interpreted as plausible projections rather than predictions.

7.7.5 Implications for Interpretation of Results

Because all assumptions are made explicit and sensitivity testing demonstrates how outcomes shift under alternative values, readers can interpret the results with confidence in their transparency. Importantly:

- The relative differences between Halter and Sensehub provide insight into where each system generates value.
- The absolute results (i.e., negative or positive net outcome) are highly dependent on cost structure and baseline farm performance.
- The modelled offsets strongly suggest that technology ROI is context-specific; the same system can generate positive, neutral, or negative outcomes depending on the baseline performance of a farm. From a purely financial perspective, there is a principle that higher levels of ROI will be achieved on poorer performing farms that their higher performing counterparts.
- Alternate strategies for alleviating issues such as animal health, reproduction and pasture utilisation have not been explored in the case studies.
- Other labour-saving initiatives (e.g. automatic cup removers in Farm A) have not been explored.

This reinforces a central finding of the study: **no technology is universally superior**; each system's financial viability is farm-dependent and assumption-sensitive.

8 Discussion

This study set out to evaluate the financial returns associated with adopting two commercially available cow wearable technologies (Halter and Sensehub) across three large-scale New Zealand dairy farms. Halter chosen as (currently) the only virtual fencing and remote herding option on the market. Sensehub was chosen as being widely used as well as being a proxy for the other wearables on the market, as identified in the literature review.

Although each technology was modelled to have meaningful improvements in labour efficiency, reproductive performance, animal health detection, and pasture utilisation (for Halter), the modelled financial outcomes were negative in all baseline scenarios.

To interpret these findings, this discussion looks at biological, economic, and operational considerations, explores alternative investments farmers may pursue, and evaluates the broader concept of value from wearable technologies in New Zealand's predominantly pasture-based dairy systems. This section concludes by outlining strategic conditions under which wearable technologies may generate a positive return on investment and by considering the future direction of sensor-based monitoring in New Zealand agriculture.

8.1 Interpreting Technology ROI in the Context of NZ Pasture-Based Systems

A defining feature of the New Zealand dairy industry is its low-input, pasture-based production model. This context significantly influences the value proposition of cow wearable technologies. Much of the international research demonstrating strong economic returns has been undertaken in housed systems, where labour models are highly segmented, heat detection is more difficult, and cows are observed less frequently (Rutten et al, 2013 and Herlin et al, 2021). In contrast, many New Zealand farms already achieve high levels of reproductive performance and animal health outcomes, aided by regular in-person observation of grazing herds, excellent industry benchmarking and resources (e.g. DairyNZ) leading to easier gap analysis and close alignment between labour and herd structure.

The modelling in this study reflects these characteristics. All three case study farms had high baseline heat detection efficiency (91.5–92%), experienced and committed farm managers who are close to the animals, well-developed transition management practices, but with above-average incidence of lameness and mastitis. Against this backdrop, the incremental gains from wearable technologies were naturally smaller than those reported internationally. Furthermore, the capital and subscription cost structures associated with both Halter and Sensehub were found to be largely relative to the modest incremental performance improvements achievable in well-managed, pasture-based systems. **These structural realities explain why the modelled financial outcomes were negative, despite the technologies demonstrating substantial biological and operational benefits**.

8.2 Farm-Specific Value: Why Performance Baselines Matter More Than Technology Choice

A central finding of this study is that the relative financial viability of wearable technologies depends less on the technology chosen and more on the baseline performance of the farm. Farms with poorer reproductive performance, poor pasture and crops harvested (Halter only), higher animal health incidence, or less efficient labour structures will logically reap larger benefits from the introduction of sensor-based monitoring.

The three case study farms all performed in the upper half of the industry for key metrics such as heat detection, 6-week in-calf rate, and transition cow outcomes. In recent benchmarking, two of the three farms were in the 90th percentile of DairyNZ's North Island Corporate Benchmarking for pasture and crop harvested in the 2024/2025 season. Accordingly, there was less of a gap in performance for wearable technologies to close. Reproductive improvements contributed only $10 to 12 per cow across all farms, an amount insufficient to materially shift ROI. Similarly, although lameness reductions were meaningful biologically, one of the farms already had moderate lameness prevalence, limiting the absolute cost savings.

Thus, the modelling reinforces an important principle: **the lower the baseline performance, the higher the marginal return from technological intervention**. For farms with suboptimal reproductive or animal health results, or with labour inefficiencies arising from herd size, location, or infrastructure, wearable technologies may provide substantially higher financial returns than those modelled in this study. The results should therefore not be generalised across the entire sector but rather interpreted as case-specific projections for farms already performing to a high industry standard.

The Role of Labour Economics in Wearable Profitability

Labour efficiency was the largest contributor to Halter's modelled benefits, particularly on Farms A and B. Virtual fencing and remote herding significantly reduce the time spent on break shifting, stock movement, and heat detection supervision. However, real-world labour restructuring is complex. Milking sheds require minimum staffing levels for animal welfare and stockmanship in general, and rosters must maintain sustainability, resignation risk and leave cover. Even when time savings exist, they do not always translate into the removal of material labour offsets. Some farms in New Zealand may enjoy the ability to attract labour resources that expect less than full time hours. That would be the exception and not the norm.

The case studies reflected this challenge. On Farm A, only one permanent FTE could be removed, despite significant reductions in stock movement labour. On Farm C, a permanent role could only be converted into a fixed-term role due to milking shed constraints. If operational contingencies (e.g. adverse weather, staff turnover, atypical disease events) require additional labour flexibility, reductions in staffing can impose risks.

At the same time, the modelling potentially understates the labour value in highly labour-constrained environments. Many New Zealand farms report difficulty attracting and retaining skilled staff. In such environments, technologies that reduce dependence on skilled labour may hold greater value than the direct wage savings calculated in this study. Therefore, **while labour was the largest contributor to potential wearable ROI, its true economic value likely varies significantly** depending on labour market context, staff capability, and the structure of the farming system i.e. on a farm-by-farm basis.

8.3 Alternatives to Wearables: System, Infrastructure, and Training Investments

A critical consideration emerging from this study is how wearable technologies compare to alternate capital or operational investments. Many of the issues that wearable technologies aim to address—lameness, mastitis, reproductive performance, and grazing efficiency—are fundamentally influenced by farm infrastructure and management capability. Or put another way, targeted investment could well be better directed at alternate solutions to identified problems.

For example, lameness reductions modelled in this study were attributable partly to early detection (Halter had additional reductions modelled due to its remote herding features rather than a herd potentially being rushed along a farm race by a staff member on a motorbike). However, white-line disease and sole bruising are strongly influenced by farm races, track drainage, yard surfaces, backing gate use, and cow flow at the farm dairy. Investment in resurfacing races or improving yard design may produce larger and more durable reductions in lameness incidence than technology-based detection alone.

Similarly, mastitis is strongly influenced by milking routine, shed hygiene, milking equipment function, and transition cow management—areas more responsive to staff training than to wearable detection signals. Reproductive performance is influenced by body condition score management, non-cycler identification, transition health, and nutrition, all of which can be improved through management systems rather than sensors.

These observations suggest that ultimately, **prevention is better than cure** and**,** in many cases, yield higher or more reliable returns than wearable technology, and that wearables, under current technological constraints, may not be the best options for farm businesses looking to achieve ROI for targeted investment on farm.

8.4 Potential Value Beyond Direct Financial Offsets

Although this study measured ROI using direct and quantifiable cost offsets, wearable technologies provide a range of intangible or strategic benefits that are more difficult to monetise. These include:

- Improved staff safety, particularly through reduced motorbike use, reduced potential for bull interaction and fewer manual stock movements.
- Lower cognitive load during mating, which may improve accuracy and reduce fatigue.
- Improved job attractiveness, potentially enhancing recruitment and retention in a challenging labour market.
- Welfare improvements from calmer stock movement, reduced pressure on lame cows, and earlier detection of health issues.
- Compliance and reporting benefits, including traceability and digital recording of health events.
- Reduced direct motorbike costs for example, fuel and repairs and maintenance.
- Aged pregnancy diagnosis for the entire mating period becomes more accurate, thereby giving increased certainty of calving spread.
- Potential for reduced bull power, offering long-term economic advantages through removal of volatility of bull prices and opening up genuine options around dairy-beef or other specialised breeding options.

Some farmers may choose to invest in wearable technologies for these non-financial or difficult to directly quantify reasons, particularly where labour availability is uncertain or animal welfare improvements align with personal or corporate values. Ultimately, **the concept of value needs to include not just the financial but the non-financial as well**.

8.5 Sensitivity to Physical and Economic Assumptions

The sensitivity analysis demonstrated that small changes to key assumptions could shift wearable ROI from negative to positive. For Halter, ROI became positive on Farms A and B when hardware costs decreased by 25% or when pasture utilisation increased by 5% across the whole farm. For Sensehub, ROI became positive on all farms under a 10% additional improvement in animal health outcomes or a 25% reduction in technology costs. The surety of financial returns of early intervention on animal health issues is an area that needs to be scientifically explored with New Zealand farming systems.

These findings highlight that the economics of wearable technologies are highly elastic. As costs decline either through scale, technological maturation, or competitive pressure, the likelihood of positive ROI will increase. Similarly, in years or farms where animal health events are more prevalent, the value of early detection will rise.

The results underline that **wearable technology ROI is dependent on an individual farm business's circumstance**. Cost changes, payout cycles, seasonal variation, and technology evolution will all influence ROI in ways that static modelling cannot fully capture.

8.6 Limits of Early Detection: Prevention vs. Cure

A further insight from the modelling is that early detection does not replace the need for robust prevention strategies. Wearable technologies can alert farmers to early deviations in behaviour, rumination, or activity, but they do not prevent the underlying causes of lameness, mastitis, or metabolic disease. The greatest returns in animal health come from preventing disease in the first place, not detecting it early.

Examples include:

- Lameness prevention requires infrastructure and cow flow improvements.
- Mastitis prevention is driven by milking routine and staff actions, milking machine calibration, hygiene, and teat condition.
- Milk fever and ketosis prevention are influenced by transition cow nutrition and management.

Thus, while early detection undoubtedly reduces disease severity and cost, its financial impact is capped by factors that technologies cannot influence. The modelling in this study intentionally avoided double-counting these benefits and therefore may understate the combined impact of small improvements across health, reproduction, and labour. Nonetheless, the results highlight an important principle: **wearables enhance, but cannot replace, good stockmanship**.

8.7 The Evolving Future of Cow Wearables in New Zealand

Based on these case study results, wearable technologies are not yet consistently profitable under current pricing and performance assumptions, the trajectory of technological development strongly suggests that ROI may improve substantially over time. Anticipated developments include:

- Reduced hardware costs as devices become smaller and cheaper to produce.
- Integration of multiple sensors (locomotion, body temperature, rumination, metabolic markers) into single devices.
- Integration of grazing, number of bites and cow location data into grazing planning models.
- Machine-learning-based alerts with greater predictive capability for lameness, mastitis, and metabolic disease.

- Integration with pasture modelling to optimise grazing decisions in real time.
- Bundled solutions, where collars integrate directly with drafting, feed management, soil sensing, feed quality and compliance reporting.

Given these trends, it is likely that **wearable technologies will become more accessible and more valuable over time**. Early adopters may be in a strategic position to capture these future benefits earlier than subsequent adopters.

8.8 Risks, Uncertainties, and Implementation Challenges

Despite the promising potential of wearable technologies, risks remain. Technology adaptation requires training, organisational change, and staff buy-in. Issues such as battery failure, signal dropout, device malfunction, and system downtime can affect performance. Over-reliance on technology may reduce stockmanship skills, and critical capability risk cannot be ignored. Cyber security and data privacy concerns add further complexity.

These risks do not invalidate the technology's potential but underscore **the importance of robust implementation, contingency planning, and staff capability development**.

8.9 When Should a Farm Invest?

Drawing together the themes above, this study reinforces that wearable technology adoption should be contingent upon clear alignment between farm challenges and technology capabilities. The following framework emerges:

1. Address fundamental infrastructure issues first (races, yard surfaces, drainage, backing gate function).
2. Ensure strong staff capability and milking routine management to optimise mastitis, lameness, and reproduction outcomes.
3. Evaluate labour structure realistically, including minimum staffing for milking, leave cover, and skill distribution.
4. Ensure data systems enable objective assessment of baseline performance to determine where the greatest gains can be made.
5. Quantify disease incidence and its cost structure before relying on modelled averages.
6. Use sensitivity testing, as shown in this study, to evaluate financial risk and opportunity.
7. Make technology decisions based on farm-specific problems, not general expectations.

Wearables can be transformative under the right conditions, particularly in high-labour-intensity systems, in herds with significant health issues, or on farms where physical infrastructure constrains pasture utilisation. However, **farms that already perform at above-average levels, like the case study farms, are less likely to achieve positive financial returns** under the current cost of cow wearables.

9 Conclusion

This research set out to quantify the financial returns associated with adopting individual cow monitoring technologies—specifically Halter and Sensehub—across three large-scale, pasture-based New Zealand dairy farms. Through a structured literature review, detailed farm profiling, scenario modelling, and sensitivity analysis, the study evaluated how these technologies influence labour efficiency, pasture utilisation, reproductive performance, and animal health outcomes. The central finding is that, although wearable technologies deliver meaningful biological and operational improvements, they did not achieve a positive financial return under baseline assumptions for any of the three case study farms.

Several consistent insights emerged. First, the value proposition of wearable technologies in New Zealand is fundamentally shaped by the features of the pasture-based production model. Frequent visual contact with cows, high baseline reproductive performance, effective transition management, and moderate animal health incidence reduce the incremental gains available from automated monitoring or early detection. The technologies were not ineffective; rather, the case study farms already captured much of the "performance gap" that wearables aim to address.

Second, the results demonstrate that technology value is highly farm-specific. Wearables generated larger relative benefits where herd size, contour, or labour structure created inefficiencies, or where animal health issues were more pronounced. Farms with high existing performance, such as those modelled, naturally gained less. This reinforces the principle that wearable technologies should not be considered universal solutions, but targeted tools suited to specific farm contexts and pain points.

Third, labour efficiency emerged as the most significant driver of economic benefit, particularly for Halter. However, labour restructuring is constrained by the minimum staffing levels required for milking, roster sustainability, and the need for skilled cover during peak periods. As a result, not all theoretical time savings converted into realised wage savings. Conversely, in labour-scarce regions or on farms with chronic staff shortages, the true value of labour reduction may exceed the conservative assumptions used in this study.

Fourth, while wearables demonstrated clear potential to reduce the severity and cost of animal health events, early detection does not replace prevention. Lameness, mastitis, and metabolic diseases are strongly influenced by infrastructure quality, cow flow, staff capability, and transition nutrition; factors that are mostly outside the scope of sensor-based technologies. In many cases, system and infrastructure improvements may generate higher returns than investment in detection tools.

The sensitivity testing underscored that the financial viability of wearables is elastic rather than fixed. Modest changes—such as a 25% reduction in hardware cost, a 5% increase in pasture utilisation, or slightly greater improvements in animal health—shifted several scenarios into positive territory. This suggests that ROI is likely to improve as hardware costs fall, algorithms advance, integration deepens, and farmer innovation and market competition increases.

Finally, the analysis highlights the broader concept of value beyond direct financial offsets. Improved staff safety, reduced cognitive load during mating, enhanced animal welfare, more consistent monitoring, digital traceability, and strategic positioning for future regulatory or technological shifts all represent real, albeit non-monetised, benefits that many farmers have and will consider in adoption decisions.

In summary, wearable technologies offer clear operational advantages but did not meet financial breakeven under the assumptions applied to the three high-performing case study farms. Their financial viability depends on the alignment between technology capabilities and the specific challenges, limitations, and performance levels of the individual farm. As the technology matures and prices decline, the likelihood of positive financial returns will increase. Until then, adoption should be guided by a careful evaluation of baseline performance, labour constraints, infrastructure, health issues, management philosophy, and the broader strategic goals of the business.

This study contributes a transparent, scenario-based framework for assessing wearable technology ROI and highlights the importance of context in technology adoption decisions within New Zealand's pasture-based dairy sector.

10 Recommendations

Based on the findings of this research and recognising the performance characteristics and operational realities of New Zealand's pasture-based dairy systems, several recommendations can be made to guide future investment decisions relating to cow wearable technologies.

First, **wearable technologies should only be considered where clear and quantifiable performance gaps exist**. The modelling demonstrated that farms already performing at a high standard in reproduction, animal health, labour efficiency, and pasture utilisation are unlikely to achieve a positive return on investment under current cost structures. Before committing capital, farms should undertake a robust assessment of baseline metrics—particularly lameness incidence, mastitis and metabolic disease costs, 6-week in-calf rate, empty rate, pasture and crops harvested, and labour structure to establish whether a material opportunity for improvement genuinely exists.

Second, **farm businesses should prioritise system and infrastructure improvements before adopting wearable technologies**. Many of the issues that wearables aim to detect or mitigate, such as lameness, mastitis, and metabolic disease, are influenced more by the quality of races, yard safety, cow flow, transition nutrition, milking routine, and staff capability than by monitoring tools. Reproductive performance is unlikely to be improved if heat detection is assessed as not to be limiting. Investments that directly address these underlying drivers often yield higher and more durable returns than early-detection technologies alone. Wearables should therefore be viewed as complementary tools that support, rather than replace, prevention-focused management.

Third, **labour efficiency gains must be evaluated realistically and in the context of roster sustainability and minimum staffing requirements**. Although virtual fencing and activity-based health alerts reduce time spent on stock movement and heat detection, they do not automatically enable a reduction in required labour. Milking shed configurations, calving pressure, leave cover, weather events, and individual staff capability all influence whether theoretical labour savings can be practically realised. Any labour-related return on investment calculation should therefore be grounded in a realistic restructuring plan.

Fourth, **wearable technologies should be assessed alongside alternative investments that may deliver greater or more reliable financial returns**. Improvements such as automatic cup removers, enhanced drafting systems, additional subdivision, better track surfaces, or targeted staff training can, in many situations, address the same underlying constraints at a lower cost and with less system disruption. Farmers should therefore consider wearables as one option within a broader suite of potential farm improvements, not the default pathway to performance gain.

Fifth, **farmers should expect transparent, evidence-based sales practices from technology providers**, with a clear distinction between product features and proven financial benefits. Providers should be encouraged to present scenario-based projections grounded in each farm's baseline data, to disclose where peer-reviewed evidence is limited, and to avoid overstating financial returns by presenting capabilities as guaranteed outcomes. Given the investment magnitude, farmers should require clarity on expected ranges of benefit rather than generalised claims or anecdotal case studies that have no scientific basis.

Finally, **farms should revisit wearable technology viability periodically as hardware costs decrease, algorithms advance, and system integration deepens**. Sensitivity testing in this study showed that modest reductions in cost or improvements in biological response can shift several scenarios into positive financial territory. As the technology matures and the market evolves, the economic case may strengthen. A regular reassessment—particularly during periods of labour constraint, high disease pressure, or favourable pricing—will ensure that adoption decisions remain aligned with both the financial and strategic goals of the business.

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