Beef on the Brink of a Tech Revolution: Wearables on NZ Hill Country

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EXECUTIVE SUMMARY

This report investigates the potential for wearable technology—specifically virtual fencing—on beef cattle to drive a step change in the performance and sustainability of New Zealand hill country farming. Hill country farms, which make up half of New Zealand's sheep and beef sector, have faced significant challenges in recent years, including declining profitability, competition from carbon forestry, and environmental pressures. These pressures have resulted in many hill country farmers questioning their long-term financial sustainability. While hill country farm systems typically run at much lower stocking rates than their counterparts on rolling and flat country, the high cost and impracticality of physical subdivision have long been considered limiting factors to the adoption of intensive grazing systems that could improve productivity and environmental outcomes.

Through a combination of literature review, digital surveys, interviews, and detailed farm case studies, this report finds that wearable technology offers a promising solution to these challenges. Early adopters of virtual fencing have been enabled to change their farm system, implementing an intensive rotational grazing system. They have reported significant benefits, including substantial increases in pasture production and utilisation, substantially higher stocking rates, reduced labour and supplementary feed costs, and improved environmental protection of waterways and sensitive areas. Case studies demonstrate that these gains can be achieved without increasing labour requirements and can lead to improved farmer wellbeing and outlook.

However, the report also identifies key risks and constraints. The success of wearable technology depends on effective pasture management, upskilling of farmers, and robust support and training—areas where consultants and industry organisations, with the support of wearable technology providers, have a critical role. There are also knowledge gaps regarding the long-term impacts of intensive grazing on soil fertility, water retention, nutrient cycling, and greenhouse gas emissions in hill country environments.

The report recommends

- Prioritising new, unconstrained research for hill country.
- Farmer upskilling in pasture management and farm system change.
- Clear protocols and best practice guidelines for using wearables that safeguards animal welfare and environmental outcomes.
- Training and extension to support farmer upskilling and system change using wearables
- Research into the cost benefit of wearables on beef production in varying systems.
- Investment into on farm water infrastructure and innovation into high-tech low-cost water solutions.

While the outlook for wearables on beef is optimistic, this is recent innovation, and ongoing evaluation is required to determine their sustained benefits and limitations.

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TABLE OF CONTENTS

TABLE OF FIGURES

FIGURES

1 INTRODUCTION

Hill country farming in New Zealand represents 50% of sheep and beef farms and is an important component of the sheep and beef sector. Hill country fits within 3 farm class categories at Beef and Lamb New Zealand (2025), that of North Island hard hill, North Island hill and South Island hill country, with these dominated by sheep and beef breeding and store operations, with some finishing of stock on easier parts of these farms. Hill country farms are complex. Their challenging landscapes make efforts to improve production both physically challenging and financially prohibitive.

In recent years New Zealand hill country farming has come under pressure. With 2022-2024 hill country results showing declined farm profitability with 2024's financial year ending with a negative economic farm surplus according to the (Beef + Lamb (n.d.) farm survey results. The current outlook for New Zealand's sheep and beef sector is positive in coming years from a market perspective, due to strong global demand and supply remaining tight (Apparao et al., n.d.). However globally the world is a volatile and complex place, particularly as a nation and industry that relies on global export, as has been seen playing out with the tariff wars in America (KPMG, n.d.).

In recent years, hill country farming in New Zealand has also come under immense pressure from a new competitor for the land, carbon farming. Between 2017 and June 2024, over 261,000 ha of sheep and beef farmland was sold and converted into production and carbon forestry. Of these 261,000 hectares converted, 88% was Land Use Class (LUC) 6, 7, 8 land (Orme, 2024). Poor profitability has made it difficult for hill country farming to compete with carbon forestry, leading to this immense scale of land use change that has been seen (Orme & Orme, 2021).
Now more than ever, there is a need for our hill country farming to find their step change moment, that allows them to move from an industry on the brink to one with a positive and sustainable future ahead,

Hill country farming has not seen a technological advancement that was able to create a step change in production since 1949 when the introduction of the top-dressing plane enabled hill country farmers to apply fertiliser to their properties (Caradus et al., 2023). Once again, the industry has found itself in need of an advancement that can create the step change that is needed for our hill country sheep and beef farmers to survive into the future.

We are now seeing technology change at a pace and scale that we have never seen before. Wearables for cattle have seen rapid uptake and application in the dairy industry, will the same be true for beef? It must be noted that the wearable for beef is currently limited to virtual fencing and geolocating, while dairy includes a multitude of animal health data outputs. Whilst virtual fencing as a means of controlling animals has been around in varying forms for many years, having first been used in 1987 (Anderson, 2007), it has only recently become an option for New Zealand's beef farmers with the introduction of Halter on Beef and Gallagher eShepherd commercially in 2023. Will this new and exciting technology create the step change that hill country farming in New Zealand so desperately needs?

2 AIMS AND OBJECTIVES

The overarching aim of this report is to assess the potential for wearable technology on beef cattle production systems to create a step change in on-farm performance. The report focuses on the applications of the wearables and the implications of this technology specifically for New Zealand hill country farming. In recent years, hill country farming has come under increased pressure, with diminished financial returns and pressure from carbon forestry as a competing land use.

The objectives of this report are to:

- Identify the areas within hill country farm systems where virtual fencing through wearables on beef can provide benefits.
- Identify the potential system change and production gains that can be achieved.
- Identify barriers and risks to successful adoption.
- Explore factors that could support the successful implementation of wearables on beef in hill country.

For this report, financial impacts have not been investigated, with the report focussing on production benefits and limitations. This is due to the vast variance in hill country farming systems in New Zealand, attributed to climate, soil, infrastructure and stocking policy differences between farms. This variance of farm situations will impact the potential financial outcomes for individual farm businesses.

Given that wearables on beef currently only offer virtual fencing and geolocating, this report will focus on that area of application for hill country farming. It will touch on potential additions to the technology that farmers considered to be of benefit to beef farmers.

3 METHOD

3.1 LITERATURE REVIEW

A literature review was undertaken focusing on two main areas: the limitations and challenges of hill country farming in New Zealand and around the considerations involved in implementing wearables on beef in this context. Due to the recent development of wearables on beef in New Zealand, there was a gap in the literature on the impacts of system change for hill country farms using wearables. This highlights a need for further research in this area.
As the surveys, interviews and case studies have been carried out, the literature review has been revisited to cover new topics that emerged.

3.2 DIGITAL SURVEY

An online digital survey was carried out using Survey Monkey to gather data on the current use and understanding of wearables on beef in New Zealand. This survey was targeted at New Zealand beef farmers, both those using and those not using wearables on beef.
Key topics included in this survey were

1 and 2 – Farm details
3 – Users of wearables
4 – Non-Users of wearables
5 – Wearables in the future

Sections 1and 2 consisted of multi-choice answers designed to collect farm and demographic data as well as the farm's current use or non-use of wearables.
Section 3 was for users of wearables on beef only, with non-users skipping this section and moving straight to the next section for non-users. Section 3 began by asking multichoice questions about the brand of wearable used, as well as the benefits. These were followed by open-ended qualitative questions enquiring about further benefits, challenges and farm system changes that had been implemented with the use of wearables on beef.
Section 4 consisted of a mixture of multichoice and open-ended questions for non-users of wearables on beef. This section enquired about the barriers for farmers to invest in wearable technology, perceived benefits and the potential to change their farm system using wearables.
Section 5 looked to the future with an open-ended question looking at all respondents' ideas for additional output from wearables, beyond virtual fencing, that could further add value to the New Zealand beef farming sector.
All multi-choice questions and the consent were required to be completed, open ended questions were optional.
Sharing of the survey occurred across various online channels, including LinkedIn, and was also sent out to farmers in the Beef + Lamb New Zealand e-dairy. A copy of the survey questions can be found in Appendix B of this report.

Open ended questions were analysed, and key themes were extracted from the information.

3.3 INTERVIEWS

6 semi-structured interviews were carried out with farmers using wearable technology on beef and farm consultants with experience with intensive cell grazing systems and/or wearable technology. These interviews helped build on the key ideas from the initial literature review and helped fill the gap within the literature review around the use of wearables on beef in hill country farm systems and the implementation of intensive grazing systems on hill country farms.

Interviews were conducted over the phone or on teams, taking around 30 minutes to complete. All interviewees signed a Kellogg consent form, acknowledging that they gave consent to be interviewed and that all information would be anonymous.

These semi-structured interviews drew on the participants' experience and knowledge of how wearables on beef are used and the impact of intensive grazing systems on factors such as pasture productivity, pasture utilization and environmental impact.

Core questions revolved around

1 – The core benefits seen from the use of wearables or an intensive grazing system such as a cell system.
2 – The environmental impact, positive or negative, of intensified cattle grazing systems.
3 – The potential knowledge gap for traditional sheep and beef farmers, regarding their understanding of how to gain the optimum benefit from wearables on beef, through system change.
4 – How the future could look with wearables.

During the interview further prompting questions were asked to delve deeper into certain areas when necessary.

Thematic analysis was carried out to find the key themes from the interviews. Key themes were mapped using Miro and three key themes were extracted along with relevant quotes for each theme.

3.4 CASE STUDIES

Case studies were carried out on two hill country farms that have been using wearables for over 1 year. These farms were two vastly different farm systems with wearables being implemented in different ways. One case study was conducted on a farmlet within the entire farm for ease of reporting. The other looked at the whole farm.
These case studies primarily looked at the pain points and motivators behind the implementation of wearables, an overview of the farm prior to wearables and now, along with their key learnings.

These were carried out to help address the gap in the literature review around research into the implementation of wearables on hill country farms in New Zealand.

3.5 USE OF ARTIFICIAL INTELLIGENCE

I would like to note the use of Artificial intelligence in writing this report. Microsoft Co-pilot was used to support editing and structure of this report.

4 LITERATURE REVIEW

Due to the recent introduction of wearables for beef cattle in New Zealand, the available literature is limited. As a result, this review focuses primarily on the key themes and considerations that are relevant to the potential changes in a hill country farm system, rather than the technology itself.

4.1 THE KEY CHALLENGES LIMITING HILL COUNTRY FARMING

Traditionally the key drivers of improved performance on hill country farms in New Zealand has been the increased application of fertiliser such as phosphates and the strategic use of nitrogen to increase pasture production at key times of the year. This has led to an increase in pasture consumed and increasing carrying capacity and animal performance (White et al., 2010). Whilst improved subdivision has also been recognised as a key tool to help improve farm performance through better pasture utilisation and management, implementation has been limited due to the high cost and physical practicality of this in hill country farm businesses (Beef + Lamb New Zealand, 2017). These limitations make it difficult to further increase production in a manner that is financially and physically feasible.

The incorporation of cattle into New Zealand hill country systems has traditionally been based around a beef cow breeding herd, in a complementary role to sheep. Profit has often not been the core focus for cattle in these systems, rather the cattle have played an important role in managing pasture quality to enhance the profitability of the sheep operation. As well as assisting in weed control and parasite management (Morris et al., n.d.).

Environmentally, hill country farming continues to come under the spotlight due to the erosion risk it poses, and the impact this has on sedimentation of our waterways, however in recent years stock access to waterways has had the spotlight on it via the low slope stock exclusion regulations (*Environment New Zealand 2007*, 2007). Whilst these regulations have been halted the sentiment to see better protection of our waterways remains (Stock Exclusion Essential Freshwater, n.d.).

The cost of conventionally fencing waterways if regulated has a severe impact on the already fragile profitability of NZ Hill Country farming, research suggests reduced profitability by up to 93% for hill country farms in comparison to waterways remaining unfenced. In comparison virtual fencing offered a much lower reduction, up to 17% reduction in profitability (Box et al., 2023). While still a large reduction in profitability there are many other benefits that virtual fencing provides that conventional fencing of waterways doesn't, including potential production benefits.

4.2 THE TECHNOLOGY - WEARABLES ON BEEF

While wearable technology has been growing in use in the dairy industry since 2018, its launch into the beef industry has only happened in the last 2 years (DairyNZ, 2025) (Rangitonga, 2023). Currently wearable technology for beef is only offered by two companies in New Zealand, and its application is limited to virtual fencing and geolocating technology for beef cattle. In comparison, there are a wide range of providers and applications for wearables in the dairy industry. A wide range of data is provided on animal health, reproduction and performance in the dairy industry, allowing them to achieve precision management of their cattle, with some wearables in the dairy industry solely providing animal health and performance data (Lamanna et al., 2025).

The effectiveness of virtual fencing on beef cattle is also often questioned, with a notion that the more temperamental beef cattle will not be able to be held behind a virtual fence as successfully as dairy cattle are. Studies done on beef heifers, then as cow calf pairs overseas using Nofence collars, showed that virtual fencing collars could effectively contain cattle, including cows with calves at foot behind a virtual fence line to implement rotational grazing systems (Harland et al., 2025).

4.3 ANIMAL WELFARE CONSIDERATIONS OF WEARABLES

Animal welfare around virtual fencing is a concern of both farmers, our markets and the general public (SPCA, 2025) Currently New Zealand have no regulations around the use of virtual fencing of cattle, however the recent review of the Animal Welfare Code has moved to help address the use of this technology (Veterinarians for Animal Welfare Aotearoa, 22024).

Trials were undertaken with beef heifers in the UK, using No fence, a virtual fencing system similar to the wearables for beef available in New Zealand, following the advised training period. This research showed no impact on faecal cortisol metabolite levels from cattle subjected to virtual fencing compared to those grazing using standard electric fencing. Faecal cortisol metabolites are used to study the stress response in cattle. These findings were in line with multiple other studies looking at the stress response of cattle to virtual fencing (Anderson, 2007; Grinnell et al., 2025). Both Halter and Gallagher eShepherd have strict ethical oversight regarding the welfare of animals fitted with their wearable technology. Gallagher eShepherd have an Animal ethics committee (Gallagher, n.d.) and Halter an Animal Welfare Charter that sets out animal welfare expectations of both Halter and the farmer. (Halter, n.d.)

To help ensure cattle fitted with virtual fencing enabled wearables to learn and adapt with minimal stress on the animal, it is essential that a suitable training period is undertaken. Cattle need to learn the audible warnings that are received prior to crossing the virtual fence line and the resulting electrical pulse if they do cross this line, through avoidance learning (Musinska et al., 2025).

4.4 PASTURE MANAGEMENT OF NEW ZEALAND HILL COUNTRY

An inability to effectively manage pastures due to financial and physical restrictions around subdivision on hill country has long been considered one of the main limiting factors affecting hill country production. As a pasture-based livestock system the amount of pasture grown and consumed has a direct impact on livestock performance and profitability (Chapman & Macfarlane, 1985). Pasture utilisation and therefore pasture quality are not currently reaching their potential on New Zealand hill country, due to the impracticalities of intensive subdivision on this class of country. Due to lower soil fertility levels on much of this land, the resulting pasture species dominating the sward tend to have poorer feed value and lower growth potential than predominantly ryegrass and clover sward (Beef + Lamb New Zealand, 2017). Brown top grass species has been shown to make up almost 20 % of the pasture sward, compared with 10 % of the sward being perennial ryegrass in hill country pastures according to (Kemp & López, 2016). Other limitations to hill country pasture production include soil moisture and temperature, however both are out of the farmers control (Chapman & Macfarlane, n.d.).

Pasture management in New Zealand hill country often sits at the two extremes with pasture either over or under grazed at certain times of the year (Chapman & Macfarlane, n.d.). Within paddocks there are also variances in contour, aspect, fertility and slope. Animal grazing behaviour also leads to animals inconsistently grazing across hill country paddocks. Areas of a gentler slope within a paddock are often grazed more intensively by stock than those of a steeper slope. This leads to pasture residuals throughout the paddock that are either above or below the optimum pasture residual of 40-50mm. Pasture production in these overgrazed areas is then reduced while the under grazed areas experience a reduction in pasture quality and metabolisable energy, becoming less palatable to stock, further exacerbating the over and under grazing of areas within a paddock. In the ideal farm system these differing areas would be fenced separately to enable more precise management (Chapman & Macfarlane, n.d.) (Kemp & López, 2016). Additional to this, pasture growth rates also vary greatly across different aspects of a paddock, with Chapman & Macfarlane (n.d.) referencing growth rates on steep dry faces growing 5 tonnes DM/ha annually, in comparison to stock camps growing up to 25 tonnes of DM/ha annually.

Pasture utilisation data for New Zealand hill country farms is limited however several pieces of literature reference varying levels of pasture utilisation. In their 2011 Journal article, Hoogendoorn et al. (2011) references pasture utilisation rates of 50% on steep land compared to 70% for easy land. However, Gillingham & During, (1973) reference higher annual pasture utilisation rates of 76-80% on steep slopes. It must be considered that this trial was undertaken using Romney whether hogget's, a much different class of stock than would be seen today. Today as sheep systems have a far greater focus on breeding and growth performance, with whethers no longer kept for wool. Therefore, it can be assumed that utilisation rates achieved now would not be as high as this study suggests. These variances in pasture utilisation likely reflect variances between farm systems, such as stocking rate, extent of subdivision, water and grazing management applied. As pasture that is not utilised is left in the paddock to rot down, this creates a missed opportunity to consume and turn pasture into kgs of meat production.

During the winter and early spring period, optimum pasture covers are difficult to maintain on hill country farms without limiting animal performance. Due to the practicalities of rotationally grazing lambing ewes, many hill country farmers also move from rotational grazing into a set stocked situation, with a set number of ewes entering a paddock prior to lambing and being left in that paddock until beginning to rotationally graze again after docking or weaning. Whilst the stocking rate of set stocked ewes is as closely matched to pasture growth rates as can be, it often is occurring at the time of low pasture growth rates leading to overgrazing until pasture growth rates increase. This then makes it challenging to maintain the required pasture covers needed to achieve optimal pasture growth rates in spring and early summer (Wall et al., 2012.). Average pasture covers of 2000kg DM/ha in set stocked situations and grazing residuals of 1200 kg DM/ha have been recommended by Wall et al., (n.d.) to achieve optimal pasture production. This difficulty in maintaining optimum winter pasture covers then limits the ability to support a higher winter stocking rate over the winter/early spring period (Donaghy et al., 2021). Beef + Lamb New Zealand, (2020) states that hill country stocking rates are low, at between 6–10 stock units/effective ha, 55% sheep to 45% cattle, in comparison to stocking rates of 7–13 stock units/effective ha on easy hill country (Journeaux & Van Reenen, 2016a). This variance in stocking rates between hill country and easy hill country is in part due to easy hill country traditionally being easier to subdivide, allowing for better management of pastures particularly over the winter and early spring period. This enables these farms to carry a higher winter stocking rate. Virtual fencing of cattle enables hill country farms to manage their pastures more effectively during the winter and early spring period, allowing them to carry a higher stocking rate as their counterparts on easy hill country do.

Autumn and winter pasture management plays an important role in setting pasture up for spring growth. There is a fine balance between leaving too much pasture or leaf behind and not leaving enough leaf behind. As a plant requires photosynthesis to grow, enough leaf area must be left behind after grazing for the plant to achieve a photosynthesis rate that supports optimum regrowth. Wall et al., (n.d.) suggest 3-4cm pasture height minimum, slightly less than the optimum of 4-5cm described by (Chapman & Macfarlane, n.d.). Conversely, young tillers of a ryegrass plant photosynthesise more efficiently than older leaves. Parsons et al. (1988) found that within 4 days of grazing, these young growing leaves with a higher photosynthesis rate made up to 40-50% of the total leaf area. To photosynthesise, leaves need to be able to intercept high light intensities, particularly as they emerge, therefore conversely if too much old pasture is left behind this can hinder light inception by the new leaves. These factors make the balance of leaving pasture residuals too high or too low complex (Wall et al., n.d.).

This limitation of the winter stocking rate then leads to limitations of pasture utilisation in Hill Country farming in New Zealand. The ability to effectively consume enough pasture to meet peak pasture growth rates in spring is limited by the stocking rate carried through the winter (Donaghy et al., 2021). During spring, pasture growth rates peak, and often pasture growth exceeds animal demand on hill country. Adding to this, many hill country farms do not have adequate subdivision to provide optimal grazing pressure across the paddock once late spring/early summer peak pasture growth arrives. Therefore, excess pasture grown cannot be effectively utilised by stock. This results in the optimum pasture residuals not being reached and a buildup of dying and decaying plant matter being left behind for future grazing. This in turn reduces the quality of remaining pasture for future animal consumption. (White et al., 2010) (Beef + Lamb New Zealand, 2017) (Chapman & Macfarlane, n.d.)

In a trial, Fajardo et al. (2025) compared traditional set stocking or continuous grazing systems like those seen on hill country, particularly over the winter/early spring period, to an intensive cell grazing system. The results showed a significant difference in pasture growth and quality, leading to a substantially increased stocking rate. Over a 4-year period the pasture production (kgs DM/ha) in the cell grazing system was measured at 38% more than pasture production in the set stocked system. Within this 4-year period was seasonal variance due to climatic conditions, however the cell grazing system consistently produced more pasture. A similar trial was carried out by Bertelsen et al. (1993) with similar findings. The annual average pasture cover for the compared systems did not vary however there were monthly variances seen in average pasture covers between the 2 systems. Fajardo et al. (2025) linked his monthly variance in average pasture cover between the 2 systems to the ability for the cell grazing system to more closely match the seasonal variances in pasture growth rates. The benefit of the impact of cell grazing over winter was also evident with higher growth rates and pasture covers seen during this period in the cell grazing system vs the set stocked system. This ability for additional pasture growth from cell grazing systems is also supported by Parsons et al., (1988) who found that long term photosynthesis rates were higher in rotationally managed pastures, supporting increased grass growth in these systems. As a result of the increased pasture production found in Fajardo et al., (2025) trial, there was a correlating increase in animal liveweight production per hectare of 44%. This finding is in line with a similar trial by Bertelsen et al. (1993) where an increase in the stocking rate per hectare of 52% was seen between the set stocked and rotationally grazed systems.
Another interesting change that was noted in the Fajardo et al. (2025) trial was the change in the composition of the pasture sward. Under the cell grazing system the percentage of perennial ryegrass within the pasture sward increased significantly, whilst decreasing significantly in the sward grazed by set stocking. White clover in the sward remained the same under a rotational system whereas it decreased dramatically, almost disappearing under the set stocked system (Fajardo et al., 2025). Clover is an important species within a pasture sward that aids the growth of other forage species in the sward, via nitrogen fixing and also animal production due to the high-quality feed it produces for stock to consume (Nichols et al., n.d.).
It needs to be noted that the set stocked system in the Fajardo et al., (2025) trial was managed to keep the pasture cover at a minimum of 2000kgs DM/ha. In contrast many pastures on hill country set stocked with ewes for lambing would fail to maintain pasture covers at this level. Therefore, the benefits of cell grazing for hill country pasture production could be greater than this study suggests.

4.5 CREEP GRAZING OF CALVES

Creep grazing of calves is only a consideration for operations running beef breeding cow operations.
Creep grazing of calves is a practise not seen in New Zealand, although some New Zealand relevant research has been carried out with ewes and lambs. The use of wearables on beef breeding cows now enables this practise in New Zealand. Creep grazing is a practise where calves can move away from the cows into their own area where they are not in direct competition

with their dams, typically through a creep gate, allowing them access to a higher quantity and/or quality of feed. With cows held behind a virtual fence, calves can creep graze ahead of their dams on the better feed and are not competing with the cows for this premium feed.

Calves creep grazed have access to extra nutrition without competing with their dams (Pent et al., 2025). However, in these trials, calves were offered access a feed of high protein content and nutritional value, such as meal and high-quality forages rather than pasture only. These overseas creep grazing trials on beef calves have shown positive results in calf liveweight gains, and liveweight through to slaughter or maturity. An increase in calf average daily weight gains of 30% and a 5% increase in carcass weight for calves that were creep feed vs not (Stewart, n.d.) (Sexten et al., 2004).

Research also suggests that whilst creep grazing positively influences calves liveweight gain, it has no effect on the dam's body weight as the calves continue to suckle the same amount of milk from their mothers despite having access to additional forage (Pent et al., 2025).

Whilst some research has been carried out on creep grazing of lambs on ewes in New Zealand showing positive impacts on lamb growth rates (Allan et al., 2014). Lamb creep grazing trials by Moss et al. (2009) were carried out in New Zealand, with lamb's creep grazed on pasture showing a 25% increase in average growth rate to those that were not creep grazed. It was also noted that there appeared to be more benefit when there was lower pasture availability.

4.6 FERTILITY TRANSFER IN HILL COUNTRY

Reduction or reversal of fertility transfer occurring under current grazing systems is an additional consideration for hill country farmers moving to a cell grazing type system. Under current extensive grazing systems on hill country, due to the nature of the varying slope found within paddocks and animals grazing and camping behaviour, it has been long recognised that there is a transfer of fertility between steeper slopes and more gentle slopes within a paddock. With stock grazing on steeper slopes then moving to the gentle slopes to camp and ruminate, transferring fertility through the deposition of urine and dung in these concentrated areas (Kemp & López, 2016). Gillingham, (1978) found the extent of this transfer of dung to flat, easy and steep areas of a paddock to be 67%, 27% and 4%, respectively. Gillingham & During (1973) found that net losses of K, N and P by transfer were 12%, 21% and 26% respectively. Pasture production in turn is then impacted, not entirely by nutrient transfer as slope has some part to play in the variances in pasture production. In the same study (Gillingham & During, 1973) found annual pasture production varied from 15 tonne of DM/ha in camping areas compared to 9.5 tonne on hill side slopes, in line with the findings of Gillingham, (1978).

Under a more intensive rotational or cell grazing system using virtual fencing, with animals grazing, ruminating and defecating within their break rather than moving back to preferred camping areas it is expected this fertility transfer would be reduced or reversed, positively effecting the fertility of hill slopes and therefore pasture production on these slopes.

4.7 SUMMARY OF LITERATURE REVIEW

In conclusion, the literature reviewed here underscores a missed opportunity to enhance pasture management on hill country due to the current impracticalities of traditional subdivision methods using physical fencing. Adding to the challenge of pasture utilisation on hill country is the effect fertility transfer from stock has, causing variability of pasture growth and utilisation within various slope aspects and animal preferences of a paddock. There is opportunity for substantial gains to pasture utilisation and production and subsequential stocking rates if further subdivision is possible, allowing improved pasture and stock management.

The financial and physical barriers to further subdivision on hill country also make it challenging to address environmental issues such as stock access to waterways. Government regulation, whilst currently paused, will likely return adding further financial burden to hill country farms already battling to remain financially sustainable.

Creep grazing of calves is a practice currently not used by beef breeding systems in New Zealand given many of these systems are run extensively on hill country making it impractical. Overseas calf creep grazing and comparative studies of lamb creep grazing show this practise provides positive benefits to young stock growth rates prior to weaning. This in turn leads to heavier weaning liveweights, whilst not negatively impacting the lactating dam.

Wearables on beef, using virtual fencing, now offer an opportunity to enable further subdivision of hill country farms, unlocking this currently untapped potential, while adding additional benefits of creep grazing and environment management at the same time.

5 ONLINE SURVEY RESULTS AND ANALYSIS

The summary of the online survey results from 77 respondents is detailed below.

5.1 FARM DETAILS

Survey participants were asked questions in relation to the farm they are involved with. Details included farm size in hectares, regional location, farm class using the Beef and Lamb NZ farm class definitions, and the classes of livestock being run. Age demographics were also collected in this section.

Respondents were spread throughout the country; however, Ruapehu-Whanganui and Waikato regions made up the majority with 51% of respondents farming in these two neighbouring regions (Figure 1). This may be due to several reasons. This result was also reflected to the same extent in the regions where farmers using wearables were located. This suggests that farmers in these regions may have a higher awareness of wearable technology on beef, although this is not proven.

The majority - 57%, of the respondents had a North Island Hard Hill or Hill Country farm class. This was to be expected given the topic focus was wearables use on hill country as well as many New Zealand hill country farms being in the North Island (Figure 2).

The various stock classes highlighted the complexities of hill country dry stock farming in New Zealand, with over 60% of respondents farming breeding cows and ewes as well as trade cattle (Figure 3).

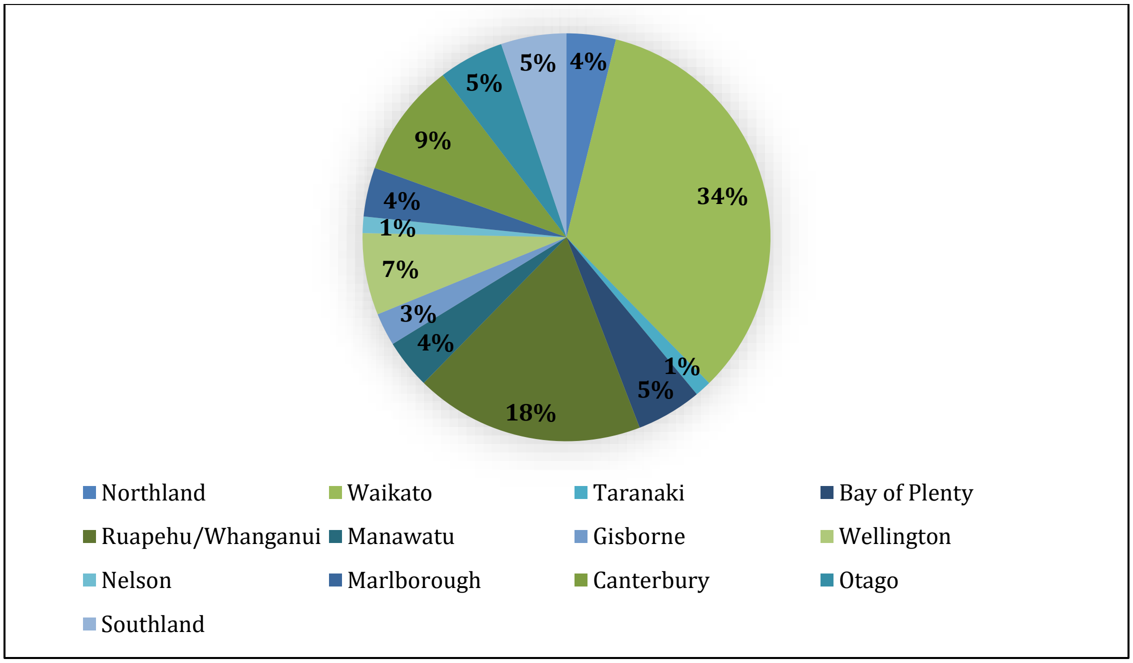

Figure 1: ***Regional locations of survey respondents***

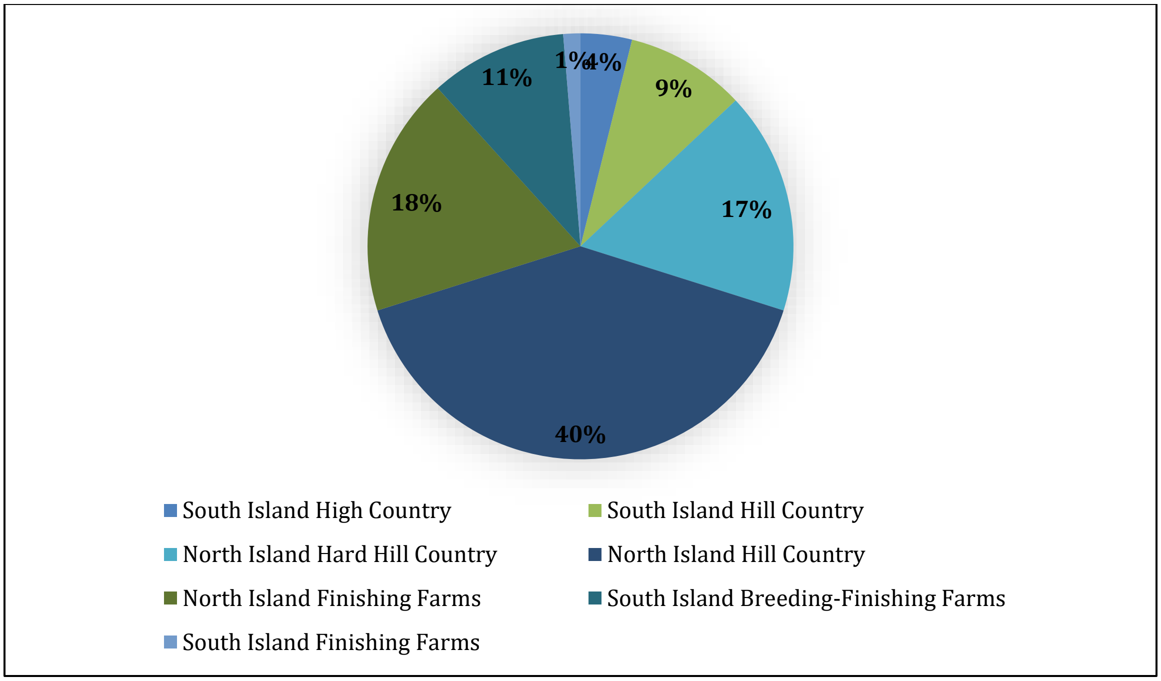

*Figure 2: **Farm Class of Survey Participants***

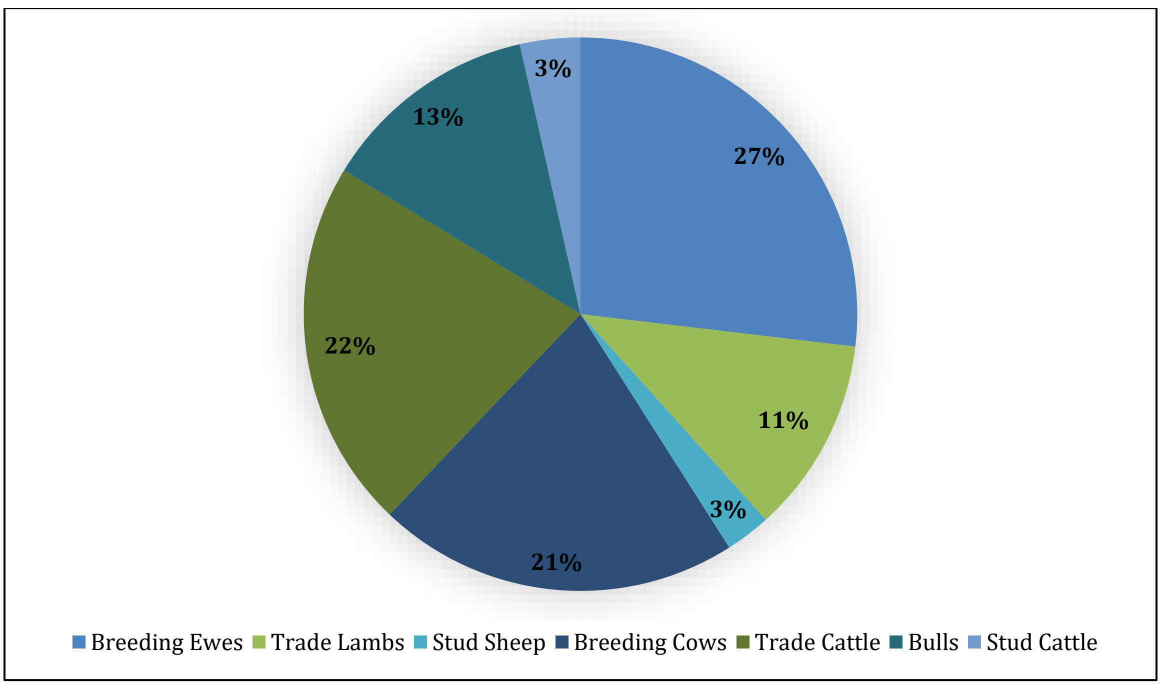

*Figure 3: **Stock Classes Run by Participants***

5.2 CURRENT USE OF WEARABLE TECHNOLOGY

This question was used to split users and non-users of wearables on beef into two groups, to then ask different questions of each group.
Due to the technology being relatively new to the beef industry in New Zealand, having only been launched on the commercial market less than 2 years ago, the number of respondents that were using the technology was a smaller number of 12, 16% of total respondents, with 65 respondents not yet using wearables on beef (Figure 4).

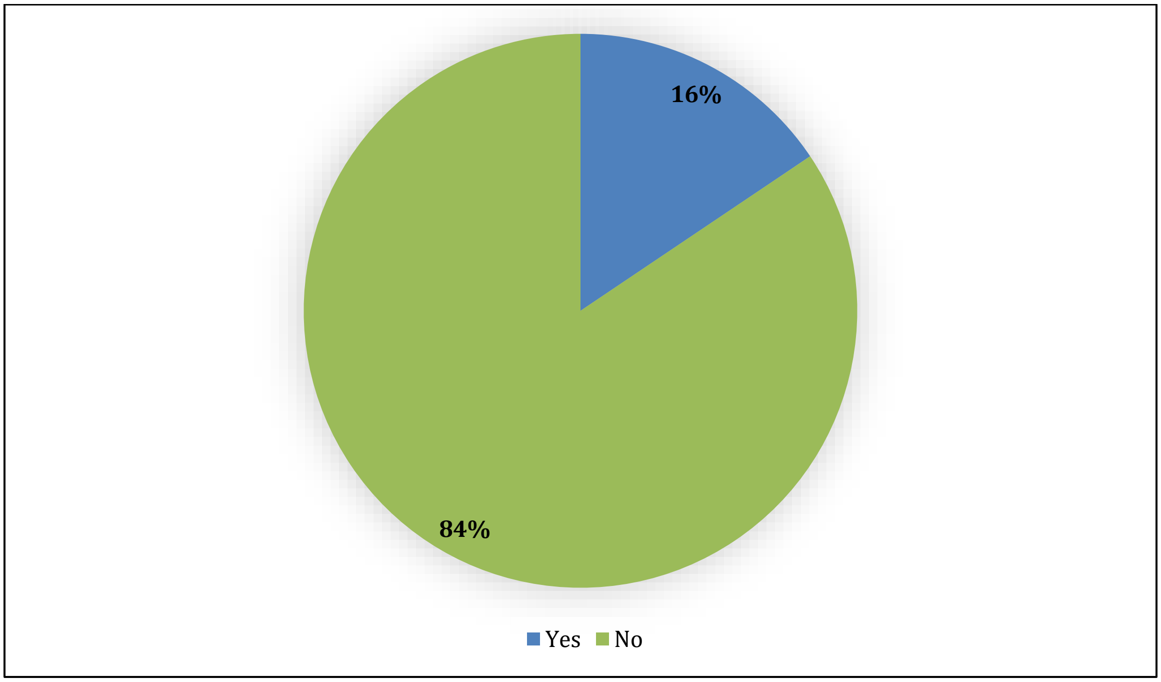

Figure 4: ***Respondents Using Wearables on Beef***

5.3 FARMS CURRENTLY USING WEARABLES ON BEEF

Respondents that answered yes to the screening question prior, were moved to a set of questions to further understand their experience with wearables on beef and how it has impacted their farm business. Halter and Gallagher E Sheperd were the only two types of wearables identified as being used on beef by the respondents.

5.3.1 BENEFITS OF WEARABLES ON BEEF

Respondents gave a range of benefits seen within their farm business from using wearables on beef, as can be seen in Figure 5. The key benefits that were seen across all respondents using wearables was based around pasture, with 100% of respondents seeing an increase in pasture production and 92% seeing an increase in pasture utilization. Additionally, 75% of respondents have also seen an increase in their farm carrying capacity and animal performance.

When comparing farm class to benefits seen from the use of wearables on beef, the results show that there may be a wider range of benefits for farmers on steeper classes of country. Given the small number of respondents using wearables and that many acknowledge they have not been using wearables long, it is likely too soon to see the full extent of potential benefits that wearables may provide.

Labor savings were also a benefiting factor for 92 % of respondents, although some noted that replacing broken collars and technical issues had negated the labour savings for their business.

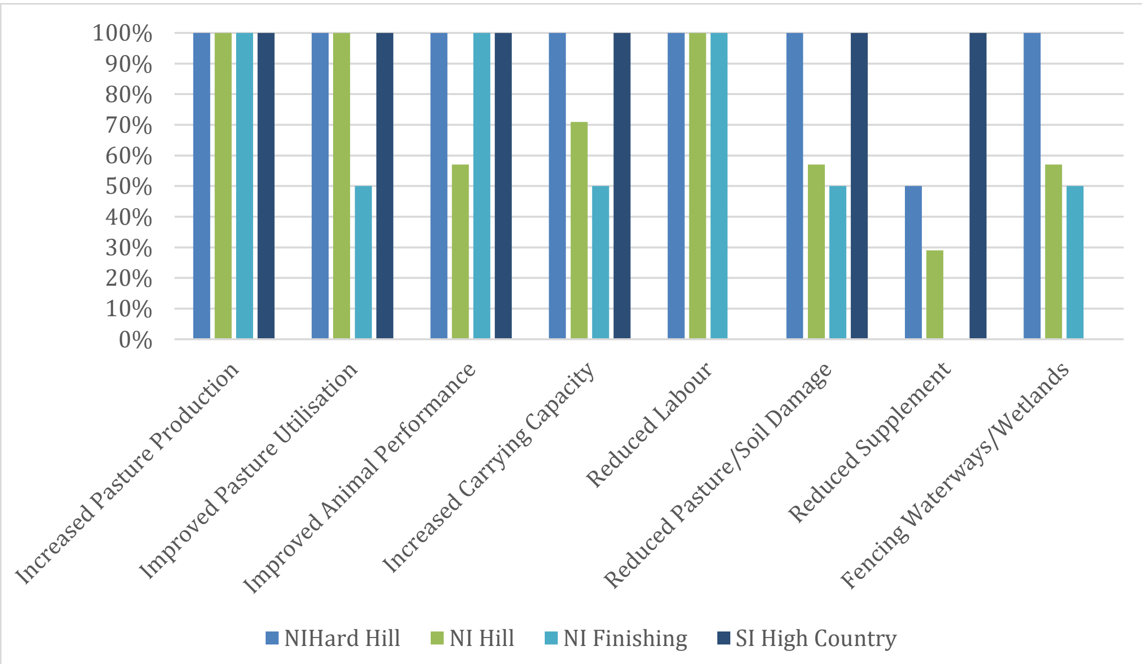

Figure 5: ***Benefits seen by different farm classes using wearables on beef***

5.3.2 COST SAVINGS FROM WEARABLES ON BEEF

Cost savings seen from the use of wearables by respondents were also enquired about with 50% reporting cost savings and 50% not (Figure 6). Area's respondents reported savings being attributed to were primarily around labour savings, either reduced or have not had to increase with a move to a more intensive farming system. Other cost savings were from reduced fencing, vehicle costs and supplementary feed made or purchased.

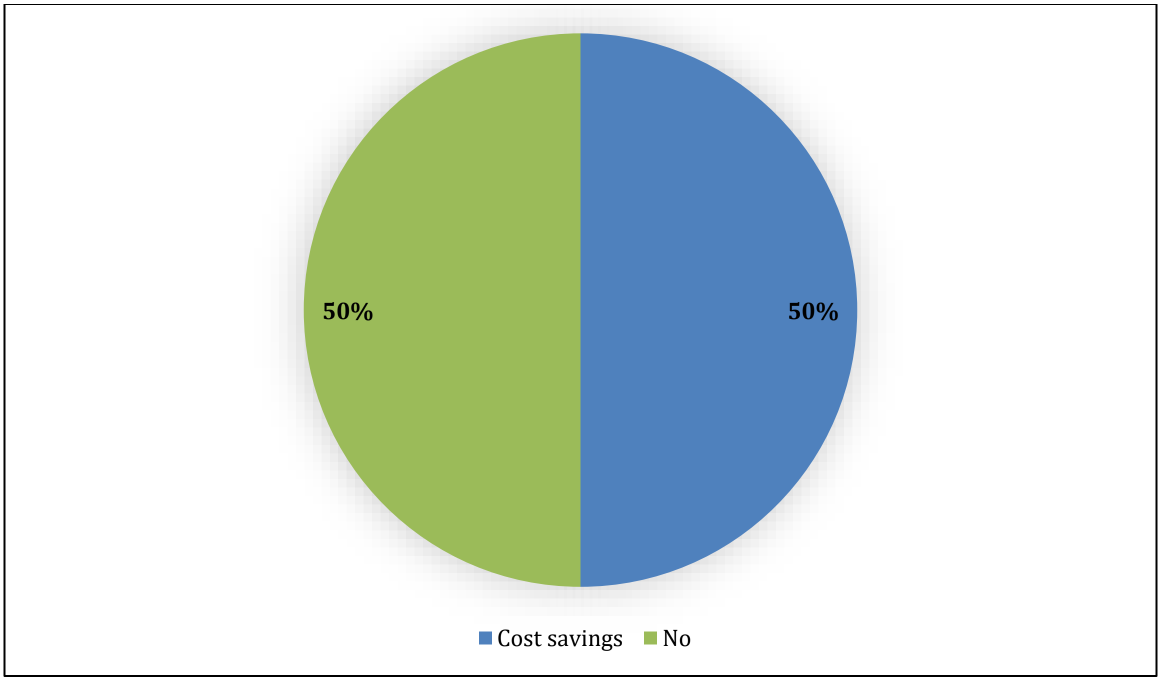

*Figure 6: **Survey Participants That Had Seen Cost Savings from Using Wearables***

5.3.3 UNEXPECTED BENEFITS OR WEARABLES ON BEEF

This question was to identify any benefits that had not been expected by the respondent when they first implemented the use of wearables in their business and some benefits that may have been missed in the other questions. One benefit that came up consistently was the ability to have a real time stock count on the wearable app and know where stock are at all times.

5.3.4 THE CHALLENGES OF IMPLEMENTING WEARABLES ON BEEF

Many of the challenges outlined by respondents were those that you would expect when implementing a new technology on farm. However, there were key issues that came up around learning to incorporate the technology and a new management tool into their system. The varied contour of hill country posed challenges with feed allocation, due to varying pasture covers across the varied contour of a paddock. Paddock contour also posed challenges around stock movement, with care needing to be taken with virtual fence line placement, particularly in steeper paddocks, to allow for safe movement of stock.

5.3.5 HARDWARE OR TECHNOLOGY ISSUES

Varying levels of hardware and technology issues were identified by respondents from no issues to multiple collar failures. Collar failure was the main issue, with collars breaking or failing.

5.3.6 FARM SYSTEM CHANGES AFTER IMPLEMENTING WEARABLES

All respondents had already made farm system changes or were about to make changes. Sheep numbers were being reduced and cattle numbers increased by 3 out of 12 respondents, while also increasing the stocking rate at the same time. More intensive rotational grazing systems had been implemented by 8 out of 12 respondents.

5.4 FARMS CURRENTLY NOT USING WEARABLES ON BEEF

5.4.1 BARRIERS TO THE UPTAKE OF WEARABLES ON BEEF

The upfront and ongoing cost of wearables and the lack of confidence around the cost benefit that wearables on beef could provide the farm business, was the most important factor that respondents were concerned about when considering investing in wearables on beef in their farm business.

The other main factors that were hindering the respondents desire to invest in wearables were also a lack of water infrastructure and concerns around cell coverage – either a lack of causing issues or the potential to have full cell coverage lowering the cost of wearables for that farm business in the future.

5.4.2 PERCEIVED BENEFITS OF WEARABLES ON BEEF

When respondents that were non-users of wearable technology were asked if they believed that wearables on beef could provide benefits to their farm system, 83% of respondents answered yes, with 14% unsure and 3% answering that they didn't see any potential benefits for their farm business (Figure 7).

Using wearables to improve pasture management, leading to better pasture utilization and more pasture production, was mentioned in various ways as a benefit by all but 15 of the 56 respondents to this question, 9 respondents skipped the question.

Protecting the environment, waterways, trees and soil also feature throughout the responses, along with better utilization of labour resources or reduced labour requirements.

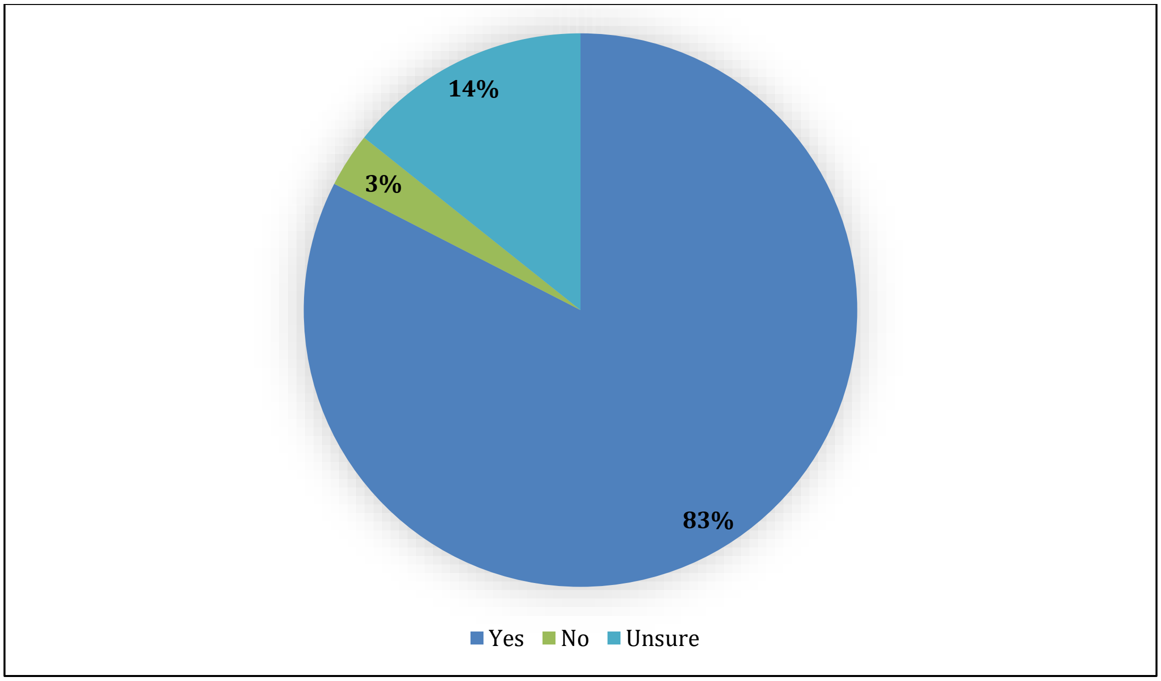

Figure 7: ***Perceived Benefits of Wearables from Non-Users.***

5.4.3 POTENTIAL IMPLEMENTATION OF WEARABLES

If respondents were to implement wearables on beef in their farm system, only 56% of respondents would use the virtual fencing function that wearables provide the entirety of the year. Following on from this, only 44% of respondents not yet using wearables would implement a farm system change using wearables, with 34% unsure if they would and 20% saying they wouldn't. There was no correlation seen between using wearables all year round or not and the intention to implement a system change (Figure 8).

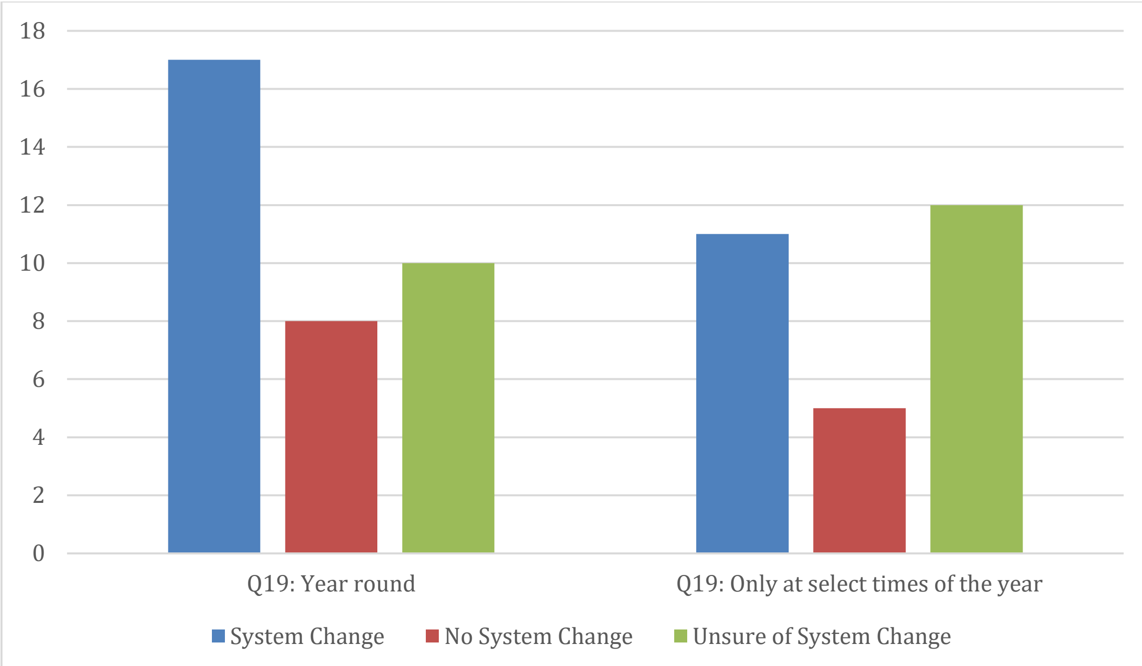

Figure 8: ***Graph showing the percentage of respondent's intention to use wearables all year round or not against the intent to implement a farm system change.***

5.5 LOOKING AHEAD

Looking ahead to other potential technology that wearables on beef could add that all respondents believed would benefit hill farms, animal health monitoring came up in most of the answers given. Rumination data, heat detection and pasture covers were also mentioned numerous times.

6 INTERVIEW RESULTS AND ANALYSIS

Both farmers using wearable technology and consultants experienced in sheep and beef or cell grazing systems were interviewed. A thematic analysis was conducted to pull the key themes from these interviews. 3 key themes were extracted from the interviews Figure 9), these are discussed below.

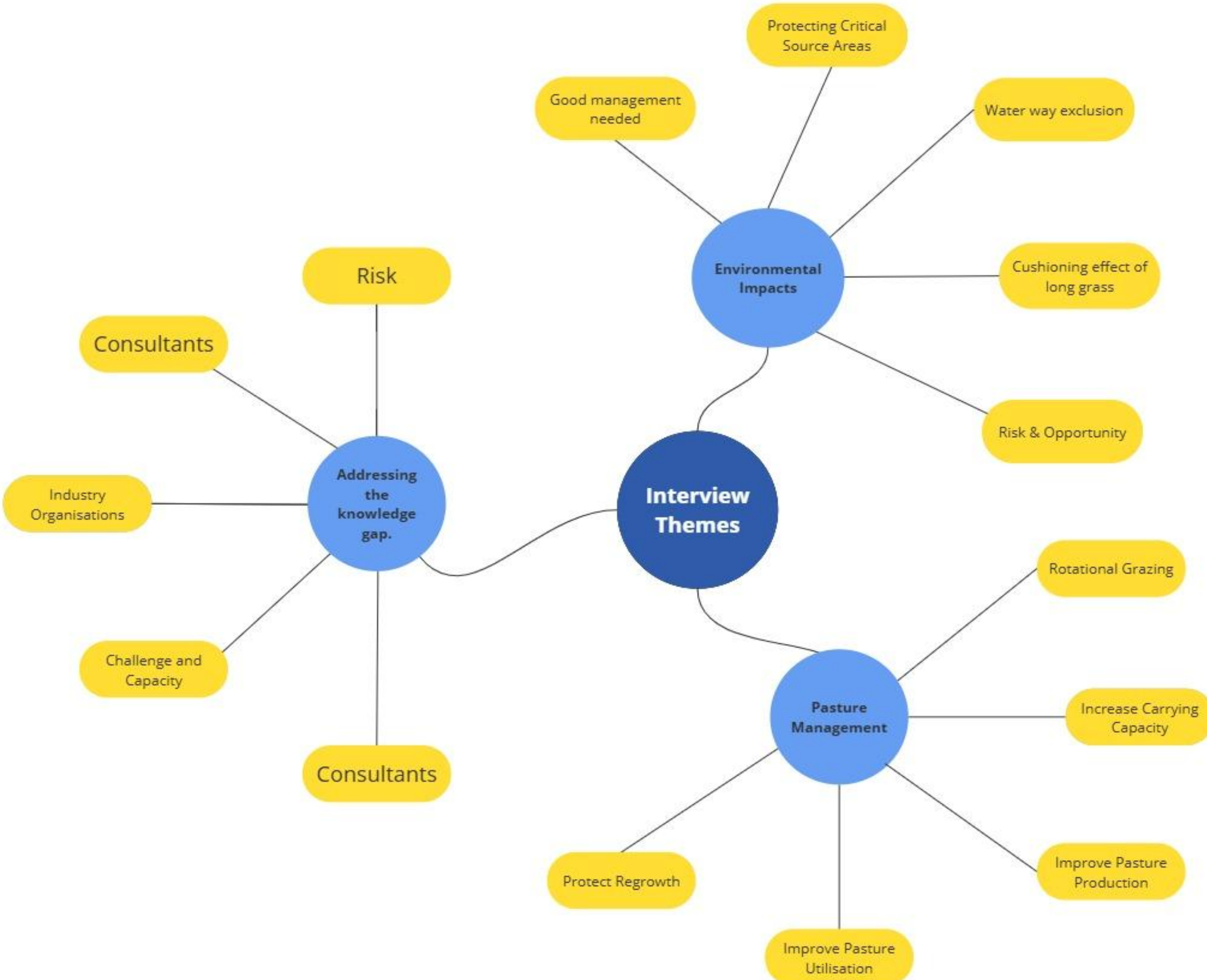

*Figure 9**: Key theme and sub theme extraction from interviews**.*

6.1 PASTURE MANAGEMENT

During the interviews, pasture management and the key components of pasture management came up and were intertwined throughout the conversation. Participants view wearables as a tool that enable hill country farmers to implement a rotational grazing system with a high level of subdivision that has typically been deemed not possible due to the physical and financial restraints of fencing hill country in the traditional manner.

"How do we actually utilise that pasture a whole lot better? That was my great frustration."

The ability for farmers to implement an intensive rotational grazing system, such as cell grazing, on hill country was discussed by both farmers and consultants. The benefits of a well-managed intensive grazing system were highlighted. The control these grazing systems give farmers was pointed out as being key, enabling farmers to better utilise the pasture they are growing as well as protecting pastures and adjusting the rotation length to match the growth and needs of both grass and stock throughout the season, leading to an increase in annual pasture production, with both of these factors combining to enable more pasture to be eaten.

"Grazing that regrowth is really compromising pasture production"

During interviews, consultants predicted, and farmers had witnessed significant gains in pasture utilisation and production. To fully realise these gains and turn them into improved farm performance, it was advised that farmers would need to increase the stocking rate on many hill country farms when implementing a more intensive grazing system to consume the increased feed available and turn it into animal production.

"*We grew 1.45 t more dry matter, on the daily shift versus the shuffle graze of 10 to 12 days per break over seven months. We didn't have our stocking rate up, so we didn't make any more money. That's an example of where you need to increase stocking rate as well so we need increase stocking rate another 50%"*

Another potential factor mentioned that could limit the gains from more precision pasture management was stock water and the need for farmers to consider their current water systems and what level of investment would be required to get stock water to a suitable standard to achieve potential gains.

"You do need to get the right water in place to enable that grazing"

All participants emphasised the opportunity to use wearables on beef to create a step change in pasture management on hill country farms and a resulting substantial gain in farm performance.

"Could be double" – one participant when asked how substantial the production gains could be under a cell grazing system

"You could double your winter carrying capacity"

To achieve these gains, participants also noted some considerations around executing a system change and additional investment around water.

"It will be significant provided they really change the management"

6.2 ENVIRONMENTAL IMPACTS

When questioned about the perceived environmental impact of intensive rotational cattle grazing systems such as cell grazing, participants all felt that these systems were potentially less impactful on the environment than some more extensive or set stocking systems. However, this belief was under the caveat that the pasture management was well executed. If pasture management was poorly executed, participants felt that the opposite would be true, and the intensive system would potentially have a negative impact on environmental outcomes. If well managed, an intensive grazing system can be less damaging to the environment.

"So, the key is when it's done well, yes, it can be less damaging to the environment."

With higher pasture covers and long grass in a longer winter round, participants mentioned they had observed that the grass sward acted as buffer and almost had a cushioning effect between the cattle and the soil, leading to reduced pugging. It was described how in a cell grazing system on hill country, ungrazed cells with long grass can also act as a buffer zone between grazed breaks and waterways, reducing the potential and amount of sediment entering the waterways.

"My observation is that when you're in that sort of long grass farming, long rotation, you create less mud because you've got that that pasture as a natural buffer to reduce the level of pugging"

"You'll never graze in those five cells together, you might be working from the bottom, or you might be working from the top, or you might be going across and coming up and then come back again so there's always the buffer zone."

Participants also acknowledged the benefit that virtual fencing offered around fencing of waterways, wetlands, critical source areas and trees. There were examples given of situations where a physical fence was not possible due to challenging contour or flooding issues, and virtual fencing enabled easy fencing of these waterways with an adequate buffer zone.

"We can't fence our rivers down here because the first flood can take it all the way, whereas now we can actually keep them where we want them to be and demonstrate we're doing that"

6.3 ADDRESSING THE KNOWLEDGE GAP

Participants reflected on a potential knowledge gap, not only with farmers but also consultants and industry organisations that would need addressing. In the consultant space, it was also noted that there was potentially a lack of capacity to support farmers, particularly given the current rate of uptake of wearables in beef that is being seen.

"We haven't had the laser focus on that sort of thing where of the tools have not been available to actually achieve that, unless you go to like a techno system or a cell system, but you know that's generally not steep hill country is it?"

"I think there would not be enough capacity if we said we really need a good solid education piece to sit behind to support farmers"

This knowledge gap was also acknowledged as being a risk that if not addressed could lead to variable outcomes for farm businesses that implement wearable technology.

7 FARM CASE STUDIES – A BEFORE AND AFTER LOOK AT VIRTUAL FENCING FOR BEEF CATTLE

Two case studies were conducted on farms that have been using wearables on beef for a year or more. They are summarised below; full case study notes can be found in Appendix C.

7.1 CASE STUDY – FARM A

Farm Profile:

- North Island Hill Country Farm Class (Beef and Lamb New Zealand, 2025).
- Mixed sheep and beef breeding and finishing system.
- 60% LUC 6 and 7, 30% LUC 3.

The Problem:

- Financial challenges of farming hill country – Financial sustainability.
- Looking for step change in farm performance.
- Mental health and enjoyment of farming at an all-time low.
- Potentially selling the property.
- Regulations around freshwater – futureproofing.
- High workload.

- High operational costs with supplement feed and fencing maintenance.

The Solution – Virtual Fencing

- Entire property enabled for virtual fencing.
- 150 collars on breeding cows initially.
- A further 80 heifers promptly collared after seeing benefits to pasture management.
- All cattle except yearling bulls and calves on dams are now collared.

Outcomes After 1.5 Years:

- Labour - Daily workload for fence shifting and feeding was reduced from 5–9 hours to just 30 minutes using virtual fencing, freeing up time for off-farm work.
- Stocking Rate: Breeding cow numbers increased by 21.5%, R1 heifers by 125%, and R1 bulls by 16%, with no change in sheep numbers and less supplement fed. No reduction in performance seen.
- Supplement Use**:** Hay and silage requirements dropped, saving approximately $8,250 annually.
- Pasture Management: Daily breaks and back fencing improved pasture quality and protecting pasture regrowth, enabling longer winter rotations and more precise grazing.
- Environmental Protection: Major waterways and critical source areas are now excluded from collared cattle, improving vegetation cover and waterway protection. Protection of poplar pole plantings is now simple.
- Soil Health**:** Minimal pugging and soil damage were observed, even in wet winters, due to higher pasture covers, back fencing, protecting high risk areas and cattle not pacing breaks and paddocks.
- Fencing Costs: Reduced need for conventional fencing replacement, saving $6,000 in the first year and enabling rapid subdivision of the farm.
- Farm Management: Real-time stock monitoring and flexible drafting improved efficiency and animal welfare, including the ability to pause individual animals as needed to allow them access to additional feed and the ability to move away from bullying behaviour in the herd yet maintain social structure of the herd.

Lessons Learned:

- Required a shift in mindset and upskilling.
- Integrating additional technology (e.g., pasture measurement tools)
- Need to throw the rule book away and use fresh thinking
- Plans to further increase stocking rates and optimise performance.
- Plan to extend the current water system.

7.2 CASE STUDY – FARM B

This case study was based on a 130 ha farmlet within the property, where a cell system was trialled by the farmer using virtual fencing.

Farm Profile

- North Island Hard Hill country Class (Beef and Lamb New Zealand, 2025)
- Traditional ewe breeding and store lamb system, with some trade cattle.
- Summer Dry

The Problem:

- Financial sustainability
- Labour requirements and challenges to implement system change
- Seeking step change in performance.

The Solution:

- 100 ha trialled – 3 towers cover this area
- Farm system changes to a cell grazing bull system
- No increase in labour.
- After 12 months, the farm achieved significant improvements:

Outcomes:

- Labour: No increase in labour requirements despite system change, and reduced sheep-related work.
- Stocking Rate: Winter stocking rate doubled from 9–9.5 to 18 stock units per hectare.
- Production: Carcase weight production increased to 380 kg/ha, 60% above the Beef + Lamb NZ benchmark for hard hill country, with pasture eaten rising from 4 to 8 tonnes DM/ha.
- Environmental Protection: All critical source areas and waterways (10% of the farm) were excluded from grazing, with water supplied to all paddocks via micro troughs. Early signs of natural reversion and improved stream bank protection were observed. 30 ha of the 130 ha is now retired.
- Soil and Pasture Management: Pugging damage became more manageable and localised, with the ability to quickly move cattle and rest at-risk areas. The system provided high flexibility in grazing management, allowing precise adjustment of break sizes and rotation lengths.
- Other Benefits: Real-time stock monitoring improved management, and the ability to pause individual animals supported animal welfare and social structure.

Key lessons:

- Trialling a system on a small scale before expanding
- Farmer mindset key in adopting new technology
- The farm plans to expand the system further and integrate additional precision technologies to optimise land use and production.
- Water system is necessary.

8 KEY FINDINGS AND DISCUSSION

One of the biggest untapped opportunities for New Zealand hill country farming, from a pastoral farming perspective, is the potential ability to move the current extensive system into an intensive system, utilising the pasture they are already growing more effectively, as well as growing more pasture. Prior to the invention of virtual fencing via wearables, increased subdivision had been deemed financially prohibitive and physically unfeasible for most hill country farmers. With this technology, these existing barriers are potentially removed, without an increase to workload and at the same time if managed well providing environmental benefits. Whilst it is still early days, with the earliest adopters not yet 2 years in, the long-term value of this technology is still to be seen. However, these early adopters are beginning to witness change. It is noteworthy that the two case study farmers did not fit the profile of typical early adopters. Unlike early adopters, who are usually in a more secure financial position, these farmers described facing significant financial pressures and saw the adoption of new technology as a necessary step to secure the long-term viability of their farm businesses (Lissaman et al., 2013).

8.1 BENEFITS

8.1.1 PASTURE PRODUCTION AND UTILISATION

Throughout the surveys, interviews and case studies, every farmer that has invested in wearable technology on their farm had witnessed an increase in their pasture production and 92% of those surveyed had witnessed an increase in pasture utilisation. The increases in carrying capacity of 35% and 50% of collared cattle for the case study farms were in line with studies comparing rotational or cell grazing with set stock systems. While these increases are already substantial, both case study farms felt there were still more gains to be had. This is encouraging that the literature looks to be lining up with the results beginning to be seen on the ground, despite most research in this area being carried out on flat to easy country. However as was pointed out by one interviewee, the important key to improving pasture growth and utilisation is to increase the stocking rate to match the grass growth.

Virtual fencing on hill country allows the farmer to manage pasture and rotation length to best match the growing conditions, conserve feed at key times of the year, such as winter to maintain pasture covers at a level that supports optimal pasture growth in the spring. The ability to back fence, protect pasture regrowth and the emerging tillers allows the pasture to photosynthesise to its full potential, in turn improving pasture production.

The benefit that will be realised by individual farmers from pasture production and utilisation increases will likely vary greatly, being limited by a variety of factors, such as the degree of subdivision they had pre wearables, their stocking policy pre wearables and their openness to changing their farm system. The percentage of animals on farm that are collared will also affect the result as they are the only stock that will create these pasture benefits, i.e. sheep and uncollared cattle will not be able to be managed in this manner.

8.1.2 CREEP GRAZING

This benefit will only be seen by those that are using wearables on beef breeding cows.

Creep grazing appears that it could add a production gain for calf weight gain whilst they are still nursing on cows. Only one of the case study farms had breeding cows; they had witnessed only small gains in the calves' average daily weight gains in their first year with calves at foot. However, the year was a drought year in comparison to the two exceptional summers prior that the results were being compared to. This result achieved may have been far better than typically would have been achieved in a severe drought year without wearables, due to the ability to limit the cows dry matter intake and allow the calves to graze ahead on the better feed available.

Creep grazing may also give the ability to manipulate weaning dates of calves to match the pasture growing conditions.

Research in this area also has its limitations as it has mostly been carried out in trials where calves were creep fed supplements or forage of a higher nutritive value than pasture.

8.1.3 FERTILITY TRANSFER

This topic was investigated further in the literature review after being discussed by one of the interview participants. The participant brought up the topic after describing his experience with fertility transfer in a techno farming system with bulls, which after becoming overwhelmingly obvious, the system was changed to reduce the bulls congregating in the same area at each grazing. 5 years later and the transfer was reversed.

Research into the topic shows that fertility transfer for hill country is a very real challenge, that also adds to the pasture management challenge on hill country, with stock camps growing substantially more grass than steeper sidling's within a paddock, due to the transfer of nutrients by stock.

By using a cell grazing system with back fencing, stock have less ability to congregate in the same small area of a paddock, therefore fertility transfer should begin to reverse, moving nutrients back to the hill slopes, or at very least halting the transfer of nutrients happening under the current grazing systems.

This combination of the nutrient transfer back onto the hill and better grazing management is also expected to change the pasture sward composition, with an increase in high quality and better performing pasture species within the sward.

8.1.4 ENVIRONMENT

This area is potentially a benefit but also a risk with the use of virtual fencing on hill country. Interviewees believed that a well-managed intensive grazing system had the ability to protect soils during wet periods, the ability of high pasture covers to act as a cushion for soils, the short period cattle were on one break and protecting at risk and damaged areas from further damage were tools that enable pugging damage to be reduced. However, they all noted this was under the caveat of being "well managed". If poor management practices took place, they believed the opposite was true, that an intensive grazing system would in fact be more damaging.

There are other environmental benefits that virtual fencing can provide hill country farms. The ability to fence collared stock out of all waterways, critical source areas, trees and other sensitive areas. This enables hill country farmers to potentially future proof themselves to further stock exclusion regulations. It also aids in the process of planting poplar poles and planting or reversion of steeper areas without the need to protect from cattle browsing as noted by both case study farmers.

8.1.4 COST REDUCTION

Labour: The reduction in labour that wearables provide individual farmers will vary. A reduction in labour was seen across all farmers surveyed and the case study farms. Although this is challenging to quantify as in some instances the additional labour never occurred, such as for Farm B in the case study. However, additional labour would have been required to make the system change. Whereas for Farm A, it had enabled more off farm income through reduced workload at busy times. Whilst it is a key consideration, it would not be the key factor to support investing in wearables.
Another component of the labour factor is from a health and safety and job satisfaction perspective as pointed out by Farm B in the case studies. Particularly if there is a system change from extensive sheep to intensive beef finishing. A health and safety risk is posed to staff doing stock shifts on steep hill country if single wire electrics are used, along with job satisfaction being challenging in these systems. Wearables enable a system change, removing these staffing constraints.

Supplementary feed: Through the enhanced ability to better manage pasture using virtual fencing, there is opportunity to remove the peaks and troughs seen in a farms pasture growth-feed demand curve and better match feed demand to supply. Therefore, supplementary feed such as hay and silage may be able to be removed from the system, with a significant reduction in cost and labour. As seen in the survey results this may differ from farm to farm and their current supplement use policies.

8.1.5 BREEDING COW PERFORMANCE

Breeding cow performance was not covered in any of the analysis; however, this provides a potential area that wearables could provide benefit. (Beef + Lamb New Zealand, 2017) have identified beef cow reproductive performance as an area where improvements could be made in beef breeding systems. New Zealand's beef cow reproduction performance has remained stagnant over the past 30 years, fluctuating around 89% calving rate for cows wintered (Beef + Lamb New Zealand, 2017). With the use of virtual fencing and the resulting system change, there is potential to improve the reproductive performance of beef cows through the ability to better manage and monitor animals at calving. A change in pasture management may enable cows to be calved in a group rather than set stocked through sheep as currently occurs on many farms, as well as being appropriately fed at key times to support optimum reproductive performance.

8.1.6 DAIRY BEEF OPPORTUNITY

There is also an opportunity for the replacement of beef breeding cow herds and ewe flocks with dairy beef using wearables to implement intensive cattle grazing systems on hill country. As shown by Case study B, there is an opportunity to take advantage of surplus dairy beef calves coming out of the dairy industry. Virtual fencing allows for hill country farms to transition from sheep. Such as store lamb breeding systems often found on hard hill country into an intensive cattle system, taking full advantage of the improvements in pasture utilisation and production. This substantial increase in pasture eaten through an increase in pasture utilisation and production allows for a significant increase on stocking rate on hill country. These gains were seen in case study B with an increase of pasture eaten from 4 tonne of dry matter to 8 tonne and a consecutive doubling of stocking rate from 9 – 18 stock units per hectare. It is important however that these systems are well managed to achieve this increase and not create negative impacts on the environment.

8.2 RISKS AND CONSTRAINTS

8.2.1 KNOWLEDGE/CAPACITY GAP

A knowledge gap was identified during the project. It was first noticed during the survey, when 46% of respondents that were not yet using wearable technology stated that if they were to invest in wearables, they would not use virtual fencing all year round. Only 44% of respondents said they would change their farm system. This was backed up when interviewees were questioned around this, along with case study farmers highlighting the fact that upskilling and an open mindset to change were a necessity.

This knowledge gap is expected, given the potential change in pasture management that could be realised using virtual fencing. When we look at the dairy industry and their intensive pasture management systems, they refined these slowly over time to get to the systems they are now running. This change can move hill country farmers from an extensive to an intensive system overnight, without the learning journey that occurs over time. Additional to this are the complexities of hill country farming and the removal of what had been long standing limitations around subdivision, that have become engrained in farmers mindsets.

This knowledge gap is not limited to farmers, but also consultants and industry organisations that provide support and extension to sheep and beef farmers. In the same manner as the farmers, they have been advising within the current restraints of hill country systems and will need to learn and adapt. Alongside this knowledge gap in consultants also sits a capacity issue, with a limited number of consultants currently practicing in the sheep and beef space. Quality sheep and beef consultants are already in short supply, and with the current speed of uptake of wearables on beef this is likely to be stretched further.

8.2.2 ANIMAL WELFARE

There is a significant need for animal welfare of cattle with wearables to be at the forefront of farmers and the wearable provider's minds. As farmers come under ever increasing scrutiny around animal welfare from the public and consumers, care needs to be taken that animal welfare is not impacted using wearables. It needs to be remembered that virtual fencing collars are banned or heavily regulated in some overseas countries. As an export country we need to give thought to consumer perceptions in our markets, particularly if virtual fencing is banned there. Interviewees felt that animal welfare wasn't impacted, in fact animals appeared to be calmer. However, due to the complexities of hill country, care is needed to ensure animal movement on steep areas and access to water, or shade are not impeded.

8.2.3 WATER AND FERTILISER

These are two factors that need to be considered alongside the use of a system change using wearables. Currently water on hill country farms is predominantly limited to a level suitable for the current farm systems. Both the case study farms and interviewees brought this up as an important addition to virtual fencing to realise the maximum gains. Water does provide its own benefits. As outlined by (Journeaux & Van Reenen, 2016b) water reticulation in combination with some traditional subdivision has a payback period of between 1.5-7.5 years.

8.2.4 ENVIRONMENT

While there is potentially a positive impact on the environment from a soils and waterway sedimentation perspective, there is potential for the opposite to happen. All interviewees noted the importance of the system and pastures being "well managed". If poor management practices took place, they believed the opposite was true, that an intensive grazing system would in fact be more damaging to soils. While virtual fencing is a powerful tool to create positive outcomes, it is equally as powerful at creating negative ones.

Two other areas that need to be considered is the impact of intensification on nitrate leaching through an increase in urine and dung patches due to the higher stocking rate, as well as an increase in greenhouse gas emissions.

9 CONCLUSIONS

This report has touched the surface of the potential benefits that wearables, in particular their application of virtual fencing can provide the New Zealand hill country farmers. This technology is new and evolving, with the early adopters not yet 2 years into farming with wearables, we are yet to fully realise and quantify the benefits this technology can provide. However, the findings of this report show there is potential to create a step change for hill country farming in New Zealand.

The removal of what had long been seen as limitations on hill country farming around subdivision have now been lifted with invention and commercialisation of virtual fencing technology. Enabling hill country farmers to move to an intensive rotational grazing system, improving farm performance, while at the same time enhancing environmental stewardship of their land. There are multiple other beneficial aspects such as reduced supplementary feed, that sit behind this and will add to the value proposition; however, improved pasture management is the key factor to success and will drive many of the other outcomes.

Results from the survey show that the early adopters of wearables on beef have seen a benefit to pasture production and utilisation in their farm systems. Further to that, the case study farmers have demonstrated the ability to turn that into substantially increased carrying capacity on their farms, whilst maintaining animal performance. Alongside the improved performance they have also achieved enhanced environmental outcomes as the interview participants suggested were possible under good management.

Whilst these early signs are promising there are some critical success factors that need to be considered. Whilst the topic of this report is wearables, the true gold that sits within this technology is the ability for it to remove longstanding hill country limitations to subdivision and allow farmers to implement a step change in farm systems. For individual farmers to fully realise the potential of this, upskilling will be necessary to enable them to effectively implement a system change in their farm business. As well as a need for further investment into water infrastructure.

With anything new there also sits risk. Whilst the potential gains for hill country farmers are promising, there is a risk from poor management of a farm system change. The powerful and precise nature of wearables as a tool, can easily create negative outcomes around animal welfare and environmental outcomes if not well managed. Poor management also does not allow farmers to achieve the full performance and financial benefit that wearables can give. With the additional expense of wearable technology to the business, this may in fact create a poorer financial result than pre-wearables.

Something that has come as a surprise during this project and is not a benefit that would not be expected to be associated with wearables, is the improvement in farmer mental health and mindset. Throughout the interviews and case studies it was clear to see that the introduction of wearables and the resulting system change, had greatly improved farmer wellbeing. Many of the farmers using wearables that were talked to, had major concerns about the future viability of their farm businesses prior to investing in wearable technology. They were now excited about the future and farming again. Unlike typical early adopters, the two case study farmers—who previously faced financial challenges—are now optimistic about the future and see wearable technology as a crucial step toward achieving financial sustainability.

One of the biggest challenges to the success of wearables on beef is going to be farmer mindset and their ability to have an open mind, remove the current constraints of their farming management, take the blinkers off and embrace change. To quote one farmer "*Farmer mindset is the biggest limiter*".

10 RECOMMENDATIONS AND NEXT STEPS

Key recommendations for farmers and industry to fully understand and realise the potential benefits that wearables, particularly virtual fencing could provide hill country farming.

- *Upskill in Pasture Management:*
  Farmers adopting wearable technology should invest both time and money into training and support focused on intensive pasture management, rotational grazing, and cell grazing systems to maximise production and ensure positive environmental outcomes.

- *Investment and Innovation in Water Infrastructure*:
  To fully realise the gains from virtual fencing and more intensive grazing, farms need reliable and flexible water systems. Innovation around cost-effective water systems for hill country would also help support this.

- *Industry support to address knowledge gaps*:
  Industry organisations, such as Beef and Lamb NZ, need to look to provide extension and support to farmers to address the knowledge gap and support effective uptake of wearable technology. This may also require upskilling of facilitators and updating learning resources to reflect changes that the new technology provides. Collaboration with the technology providers would also be beneficial. There is some urgency for this as

the rate of uptake of wearables in beef is growing in speed, yet there are very few resources available for farmers to help them support their decision making.

- *Manage Animal Welfare and Environmental Risks:*
  Wearable providers need to establish clear protocols and training for farmers, to minimise animal welfare and environmental risk when using wearables.

- *Further Hill Country Research*:
  Support new research into the long-term impacts of wearables on hill country farming, including effects on pasture sward composition, soil fertility, emissions, water quality, and greenhouse gas emissions. Current research is limited to the realms of the current extensive hill country farming systems in practice or undertaken on flat to easy country that has been managed in a different manner historically. Given MPIs goal of doubling agriculture exports by 2034 perhaps they have a role to play here in supporting research in this area.

- *Financial Analysis on Use of Wearables:*
  In depth financial analysis needs to be undertaken to accurately assess the cost benefit of wearables on beef that is accessible to farmers and consultants.

- *Promote Technology Layering and Integration:*
  Encourage farmers and wearable providers to integrate other precision agriculture technologies (e.g., pasture measurement apps, animal health monitoring) to further enhance farm performance and decision-making.

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11 LIMITATIONS OF THIS STUDY

11.1 FINANCIAL ANALYSIS

An investigation into the cost benefit analysis of wearables on beef was not carried out as part of this project for several reasons.

New technology - Due to the lack of accurate understanding of the performance gains and cost savings to be realised as the technology is very new, with few hill country farmers using it for more than a year.

Vast variance in hill country farm systems – Due to the vastly different aspects of individual hill country farms, such as degree of subdivision pre-wearables, stocking policy, water, climate etc, these will all affect the cost benefit analysis for each farm.

System change – The cost benefit results achieved by individual farmers will vary depending on the willingness to upskill, think in new ways and change their farm system.

11.2 RESTRICTED HILL COUNTRY RESEARCH

Literature on improving hill country farm performance is currently undertaken within the current restrictions of subdivision, with most of the research into intensive rotational grazing undertaken on flat to easy country.

11.3 INTERVIEWS

Due to a lack of farmers using wearables that were willing to be interviewed, the number of people interviewed was only 6 with 3 being consultants that had worked with cell grazing systems.

12 REFERENCES

Allan, W., Geenty, K., & Beetham, R. (2014). *GROWING GREAT LAMBS WORKSHOP RESOURCE BOOK*.

Anderson, D. M. (2007). Virtual fencing past, present and future. *Rangeland Journal*, *29*(1), 65–78. https://doi.org/10.1071/RJ06036

Apparao, D., Berentson, P., Brown, K., Carey, A., Duranovich, F., Giles, N., Grimwade, L., Kelman, L., Kusuma, A., Laubscher, J., Leroy de Morel, L., Joy Mandap, L., Martin, R., McCrossin, N., Patrick, T., Riley, C., van Lijf, W., Wever, M., Williams, J., … Young, B. (n.d.). *Situation and outlook for primary industries June 2025.* www.mpi.govt.nz

Beef + Lamb. (n.d.). *Sheep and beef farm survey*. Https://Beeflambnz.Com/Industry-Data/Farm-Data-and-Industry-Production/Sheep-Beef-Farm-Survey. Retrieved October 25, 2025, from https://beeflambnz.com/industry-data/farm-data-and-industry-production/sheep-beef-farm-survey

Beef + Lamb New Zealand. (2017). *Beef + Lamb guide to cattle farming*.

Beef + Lamb New Zealand. (2020). *Fact sheet - hill country sheep and beef farms*.

Beef + Lamb NZ. (2025). *Beef + Lamb insights sheep & beef farm survey*. https://beeflambnz.com/knowledge-hub/PDF/northland-waikato-bop-quintile-analysis-and-forecast.pdf

Beef and Lamb New Zealand. (2025, October 1). *Farm Classes - Beef & Lamb*. Https://Beeflambnz.Com/Industry-Data/Farm-Data-and-Industry-Production/Farm-Classes.

Bertelsen, B. S., Faulkner, D. B., Buskirk, D. D., & Castree, J. W. (1993). Beef cattle performance and forage characteristics of continuous, 6-paddock and 11-paddock grazing systems. *Journal of Animal Science*, *71*, 1381–1389.

Box, L., Ward, J., Obadovic, I., Tozer, K., & Stevens, D. (2023). Developing a multiagent framework to explore the implications of fencing waterways using virtual fencing on New Zealand hill country farms. *Journal of New Zealand Grasslands*, *85*, 101–108.https://doi.org/10.33584/jnzg.2023.85.3657

Caradus, J. R., Goldson, S. L., Moot, D. J., Rowarth, J. S., & Stewart, A. V. (2023). Pastoral agriculture, a significant driver of New Zealand's economy, based on an introduced grassland ecology and technological advances. *Journal of the Royal Society of New Zealand* (Vol. 53, Issue 3, pp. 259–303). Taylor and Francis Asia Pacific. https://doi.org/10.1080/03036758.2021.2008985

Chapman, D. F., & Macfarlane, M. J. (1985). Pasture growth limitations on hill country and choice of species. *Grassland Research and Practice Series No. 3*, 25–29. Retrieved October 23, 2025, from https://www.researchgate.net/profile/Malcolm-Macfarlane/publication/266568377_Chapter_3_Pasture_growth_limitations_in_hill_country_and_choice_of_species/links/55492a360cf25a87816ab223/Chapter-3-Pasture-growth-limitations-in-hill-country-and-choice-of-species.pdf

DairyNZ. (2025, October 22). *A closer look at wearable technology*. Https://Www.Dairynz.Co.Nz/News/a-Closer-Look-at-Wearable-Technology/.

Donaghy, D., Bryant, R., Cranston, L., Egan, M., Griffiths, W., Kay, J., Pembleton, K., & Tozer, K. (2021). Will current rotational grazing management recommendations suit future intensive pastoral systems? *NZGA: Research and Practice Series*, *17*. https://doi.org/10.33584/rps.17.2021.3464

Environment New Zealand 2007. (2007). Ministry for the Environment.

Fajardo, M., Morgan, S. A., Chilibroste, P., Lee, M. R. F., & Rivero, M. J. (2025). Animal and pasture responses in contrasting temperate pasture-based cattle management systems: set-stocking versus cell grazing. *Animal*, *19*(10). https://doi.org/10.1016/j.animal.2025.101635

Gallagher. (n.d.). *GGL eShepherd Terms of Reference 03032023original*.

Gillingham, A. G. (1978). *Phosphorus cycling in grazed, steep hill country: a thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Soil Science at Massey University*.

Gillingham, A. G., & During, C. (1973). Pasture production and transfer of fertility within a long-established hill pasture. *New Zealand Journal of Experimental Agriculture*, *1*(3), 227–232. https://doi.org/10.1080/03015521.1973.10427647

Grinnell, N. A., Hamidi, D., Komainda, M., Riesch, F., Horn, J., Traulsen, I., Palme, R., & Isselstein, J. (2025). Supporting rotational grazing systems with virtual fencing: paddock transitions, beef heifer performance, and stress response. *Animal*, *19*(2). https://doi.org/10.1016/j.animal.2024.101416

Halter. (n.d.). *Halter Animal Welfare Charter*. Vhttps://Www.Halterhq.Com/Animal-Welfare-Charter/Animal-Welfare-Charter.

Harland, A. J., Novais, F. J., Fitzsimmons, C. J., Church, J. S., da Silva, G. M., Londono-Mendez, M. C., & Bork, E. W. (2025). Evaluating virtual fencing as a tool to manage beef cattle for rotational grazing across multiple years. *Journal of Environmental Management*, *381*, 125166. https://doi.org/10.1016/J.JENVMAN.2025.125166

Hoogendoorn, C. J., Bowatte, S., & Tillman, R. W. (2011). Simple models of carbon and nitrogen cycling in New Zealand hill country pastures: Exploring impacts of intensification on soil C and N pools. *New Zealand Journal of Agricultural Research*, *54*(4), 221–249. https://doi.org/10.1080/00288233.2011.599395

Journeaux, P., & Van Reenen, E. (2016a). *Economic Evaluation of Stock Water Reticulation on Hill Country A report prepared for the Ministry for Primary Industries and Beef + Lamb New Zealand*.

Journeaux, P., & Van Reenen, E. (2016b). *Economic Evaluation of Stock Water Reticulation on Hill Country A report prepared for the Ministry for Primary Industries and Beef + Lamb New Zealand*.

Kemp, P. D., & López, I. F. (2016). Hill country pastures in the southern North Island of New Zealand: an overview. *Hill Country - Grassland Research and Practice*, *Series 16*, 289–298.

KPMG. (n.d.). *Agribusiness agenda 2025*.

Lamanna, M., Bovo, M., & Cavallini, D. (2025). Wearable Collar Technologies for Dairy Cows: A Systematized Review of the Current Applications and Future Innovations in Precision Livestock Farming. In *Animals* (Vol. 15, Issue 3). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/ani15030458

Lissaman, W. A., Casey, M., & Rowarth, J. S. (2013). Innovation and technology uptake on farm. *Proceedings of the New Zealand Grassland Association*, *75*, 27–32.

Nichols, S. N., Crush, J. R., Eady, C. C., Faville, M. J., Ghamkhar, K., & Woodfield, D. R. (2016). Future forage plants for hill country systems. *Hill Country - Grassland Research and Practice*, *Series 16, 233-242*.

Morris, S. T., Charteris, P. L., & Matthews, P. N. P. (n.d.). *PASTURE-BASED BEEF PRODUCTION IN NEW ZEALAND*. https://www.researchgate.net/publication/237699940

Moss, R. A., Dynes, R. A., Goulter, C. L., & Saville, D. J. (2009). Forward creep grazing of lambs to increase liveweight gain and post-weaning resistance to endoparasites. *New Zealand Journal of Agricultural Research*, *52*(4), 399–406. https://doi.org/10.1080/00288230909510522

Musinska, J., Skalickova, S., Nevrkla, P., Kopec, T., & Horky, P. (2025). Unlocking potential, facing challenges: A review evaluating virtual fencing for sustainable cattle management. *Livestock Science*, *295*. https://doi.org/10.1016/j.livsci.2025.105693

Orme, P. (2024). *Land-use change from pastoral farming to large-scale forestry Update*.

Orme, P., & Orme, S. (2021). *Independent validation of land-use change from pastoral farming to large-scale forestry*.

Parsons, A. J., Johnson, I. R., & Williams, J. H. H. (1988). Leaf age structure and canopy photosynthesis in rotationally and continuously grazed swards. *Grass and Forage Science*, *43*(1), 1–14. https://doi.org/10.1111/j.1365-2494.1988.tb02136.x

Pent, G. J., Swecker, W. S., & Tracy, B. F. (2025). Creep-grazing fall-born calves on winter annual forages. *Translational Animal Science*, *9*. https://doi.org/10.1093/tas/txaf075

Rangitonga, Stacey. (2023, December 12). Wearable technology enters the beef sector. *Waikato Times*.

Sexten, W. J., Faulkner, D. B., & Ireland, F. A. (2004). Influence of creep feeding and protein level on growth and maternal performance of replacement heifers. *The Professional Animal Scientist*, *20*, 211–217.

SPCA. (2025, October 11). *Virtual fencing and herding technologies*. Https://Www.Spca.Nz/Advocacy/Position-Statements/Article/Virtual-Fencing-and-Herding-Technologies. https://www.spca.nz/advocacy/position-statements/article/virtual-fencing-and-herding-technologies

Stewart, L. (n.d.). *Creep Feeding Beef Calves*.

Stock exclusion Essential Freshwater. (n.d.).

Veterinarians for Animal Welfare Aotearoa. (22024, December 11). *Veterinarians for animal welfare Aotearoa to develop code of ethical conduct for the virtual fencing technology*. https://www.infonews.co.nz/news.cfm?id=126554

Wall, A. J., Stevens, D. R., Thompson, B. R., & Goulter, C. L. (2012). *Winter management practices to optimise early spring pasture production: a review*.

White, T. A., Snow, V. O., & King, W. M. G. (2010). Intensification of New Zealand beef farming systems. *Agricultural Systems*, *103*(1), 21–35. https://doi.org/10.1016/j.agsy.2009.08.003

APPENDIX A: SURVEY QUESTIONS

All questions asked in the survey are detailed below.

FARM DETAILS
Farm Size
0-100 ha, 100-400 ha, 400-1000 ha, 1000+ ha

What region do you farm in?
Northland, Waikato, Taranaki, Bay of Plenty, Ruapehu/Whanganui, Manawatu, Gisborne, Hawkes Bay, Wellington, Tasman, Nelson, Marlborough, Canterbury, West Coast, Otago, Southland

Farm Class – Beef and Lamb NZ Farm Classes (Description given in the survey using Beef and Lamb farm class descriptions)
South Island High Country, South Island Hill Country, North Island Hard Hill Country, North Island Hill Country, North Island Finishing Farm, South Island Breeding-Finishing Farm, South Island Finishing Farm, South Island Mixed Cropping and Finishing Farm

Stock Classes run on the farm currently? (Tick all that apply)
Breeding ewes, Trade lambs, Stud sheep, Breeding cows, Trade cattle, Bulls, Stud cattle

Please indicate your age below.
Under 18, 18-24, 25-34, 35-44, 45-54, 55-64, 65+

CURRENT USE OF WEARABLE TECHNOLOGY
Do you currently use any wearable technology on beef?
Yes/No
Answer yes continued to next section
Answer no skipped to section Farms currently not using wearable technology on beef

FOR FARMS CURRENTLY USING WEARABLE TECHNOLOGY ON BEEF
Which system do you use?
Halter
Gallagher E Sheperd
Other – Please specify

What areas of your business have benefited? (Tick all that apply)
Increased pasture production, Improved pasture utilisation, Improved animal performance, Increased carrying capacity, reduced workload/staffing, fencing waterways/wetlands, reduced supplementary feed requirements, Other (Please specify)

Has your business seen any cost savings from using this technology?
Yes/No

If yes, in which areas were there savings made? (Open Question)

Are you willing to provide figures for these benefits?
Yes/No

Were there any unexpected benefits? If so, what were they? (Open end question)

What challenges did you face when adopting wearable technology? (Open end question)

Have you experienced any hardware or technology issues? If so, what were they? (Open end question)

Have you made any farm system changes since adopting wearables? (Open end question)

FARMS NOT CURRENTLY USING WEARABLE TECHNOLOGY

If you have considered wearables, what factors have stopped you from investing? (Open end question)

Do you think wearables could offer benefits to your farm system?
Yes, No, Unsure

If yes, what benefits do you think wearables would offer? (Open end question)

Would you use virtual fencing year-round or only at certain times of the year?
Year round, only at select times of the year

If you invested in wearables, do you think you would change your farm system?
Yes, No, Unsure

LOOKING AHEAD

Are there other benefits (beyond virtual fencing) that you think wearables could provide to beef farming in New Zealand – ie Heat detection, animal health monitoring, rumination tracking (Open end question)

INTERVIEWS

Would you be interested in taking part in a formal interview to gain more insights from you for my project?
Yes/No

If yes, please provide your name and email.

APPENDIX B: CASE STUDIES

CASE STUDY – FARM A

THE FARM OVERVIEW PRE WEARABLES

Farm Profile – pre wearables

Farm Class: NI Hill Country ((Beef and Lamb New Zealand, 2025)

System Type: Sheep and Beef breeding and finishing system.

Cattle – Breeding cows with replacement heifers retained. A stud operation is also integrated into the commercial cattle system with yearling sire bulls sold from September to October. Any bulls that are not sold as yearlings are sent to slaughter prime with a target LW of 600 kgs in March. A line of steers is finished to a LW target of 600+ kgs LW before 20 months of age. A small line of cull bulls and all cull heifers are sold as weaners.

Sheep – Breeding ewes with replacement hoggets retained. Most lambs are finished, with a portion sold store at weaning. Flexibility allowed around the number of lambs sold store or prime depending on seasonal conditions.

Farm size and Scale: 390 ha total, 350 ha eff

Land and Climate Characteristics:

70 % LUC 6&7, 30 % - LUC 3

Hill country with abundant ephemeral watercourses, seeps, and streams

Traditionally summer safe area but droughts are becoming more frequent

Winters can vary, often wet and cold but can be dry also, slow grass growth with wet soils decreasing utilisation

Pockets of easy rolling country broken up with steeper hill country that hasn't been developed due to its location on the farm and being set amongst steeper hill country.

Subdivision and Grazing Management:

Easier country subdivided into paddocks between 2 and 10 ha in size.

Hill country subdivided into paddocks between 5 and 25 ha in size, pockets of easy country set within these.

Ewes - 1250 Ewes set stocked in Mid-July for lambing on hill country
Begin rotations on same hill country once lambs were weaned in December.

Cows - 140 Cows set stocked over Autumn/Winter from March till middle of July with hay supplementation June-July.
Grazed on 2 ha of winter oats from end of July over the lead up to calving in August with further hay inputs.
Cows are calved being break fed daily behind a hot wire and continue behind a hot wire until mid-October, then begin rotating through paddocks. Once lambs are weaned cow and calf mobs are following lambs and ewes to groom pasture.

Finishing cattle - replacement cattle and finishing lambs are rotated around paddocks on easier country, higher residuals left for cows to follow on and clean up. Finishing cattle supplemented with silage late autumn and winter to maintain LW gain for fast finishing aiming for 300+ kg CW

The challenge

Labour: High winter workload and taxing on mental health.

Farm Performance/profitability: A major step change in the farm system was needed to survive. With the current farm system and limitations of the land it felt as though there were few viable options left to significantly increase production.

Environmental issues: With waterway stock access regulation (Low Slope) and the PC1 changes within Waikato coming and foreseeing that they would only get stricter, looking to future proof the farm in a financially sustainable manner. Also uncomfortable with the soil and pasture damage caused over the winter period.

Operational costs: The farm and system had high costs due to a high level of supplement making (hay/silage/crop), fence maintenance and replacement. Many of the fences were reaching the age of replacement, priority was on replacing those before further subdivision could be undertaken.

Mental Health: All the above were having a large negative impact on mental health, resulting in a loss of passion for farming. Stuck in the weeds trying to survive the day to day, not focusing on the business itself enough.

THE SOLUTION – VIRTUAL FENCING

Adoption goals:

To make wearables work for the business as soon as possible, pay back the investment, annual cost and improve the performance and profitability of the farm business. During suppressed product prices and high costs, the risk from adding the cost of wearables into the business was high but the feeling was the returns would outweigh this through improved pasture utilisation and production.

Implementation process:

Training protocol: Training done as per companies training programme, with uncollared calves still at foot on initial cows. Cattle understood the virtual fence line within 24hrs and could be seen turning purely on the audio cue first 24hrs. Reactions to interactions with the virtual fence were calm. It took longer for cattle to learn to trust the collar cues to shift into a new break. Important to time training shifts to the cows natural grazing times to speed up the process.

Hardware and setup: 8 towers installed to give full coverage over the entirety of the farm. Installation of the towers was simple, in comparison to putting in permanent conventional fence lines.

Results and outcomes

The table below aims to capture the changes that have occurred within the farm business after the implementation of wearables on beef on the case study farm.

Metric	Before Virtual Fencing	After Virtual Fencing 1 ½ years in	Change / Improvement
Labour	- 5 hours/day shifting electric fences over calving - 4 hours/day feeding out hay to set stocked cows	- 30 minutes a day creating virtual breaks. - 1 day a month adjusting collars	- Reduction in hours worked on farm has allowed for more hours able to be worked off farm. - 1 business partner worked off farm for an additional 150 hours over winter period.
Stocking rate (Wintered)	1250 ewes 370 ewe hoggets' 140 breeding cows 40 R1 heifers 24 R1 steers 30 R1 bulls	1250 ewes 370 ewe hoggets' 170 breeding cows 90 R1 heifers 24 R1 steers 35 R1 bulls	Ewes no change Hoggets' no change Cows 21.5% ↑ R1 Heifers 125 %↑ R1 Steers no change R1 Bulls 16% ↑
Supplement made/fed			- Reduced 12 tonne DM hay feed – value $5000 - Reduced 9 tonne DM silage fed – Value $3250
Pasture utilization and production	- Large hill country paddocks hard to maintain pasture quality without limiting pasture growth. - Plenty of rough feed left on hills and grazed off by cows in autumn. - Cattle would go in behind ewes over late spring/summer and could be in there for up to 2 weeks.	- Cows on daily breaks in paddock with ewes. - Appropriate pasture residuals able to be achieved without grazing regrowth. - Cows back fenced off grazed areas as much as possible depending on water access. - Cattle locked onto less favourable areas to graze effectively.	- Pasture quality appears to be improving. - Regrowth allowed to come away with back fencing without being constantly grazed off by cattle. - Longer winter rotations achieved.

Environmental protection	- Main waterways in easy country fenced when time and money allowed	- Major waterways, seeps, critical source areas have collared cattle excluded – not calves.	- Waterways are now covered with overhanging grass and vegetation keeping them cool in summer.
Soil damage/pugging	- Winter damage from cattle set stocked on low covers - Winter cropping damage - Winter break feeding behind hot wires causing pugging in wet soils along temporary fence lines - Damage from feeding out during wet	- Cattle on daily breaks on high covers in winter - Higher covers protect soil - Ability to move cattle on during heavy rain events - Cattle no longer pace hotwires, dissociate people and vehicles with feed - No winter cropping - Reduce winter feeding of supplement and resulting damage – avoid feeding out on wet days and give extra grass instead	- Minimal winter pugging even in an exceptionally wet winter - No winter crop damage damage - Exceptionally better soil protection -Reduced soil lose to waterways through pugging damage
Paddock flexibility	- Little flexibility - Grazing rotations on a paddock basis - Not easy task to give extra break in weather - Back fencing was not an easy or daily task	- Exceptionally flexible - Easy to adjust break size and fence lines as needed - Look at area grazed now rather than the paddock - can be as creative as you like to back fence daily	- Adjustments easily made meaning break sizes are adjusted regularly to precisely match stock numbers, requirements and growing conditions - If fence was in wrong place last round easy to change the following grazing
Animal performance		- Calves now able to creep graze and cows held up	- In a drought year calves Av daily weight gain in MA cows the same as previous 2 good summers despite stripping weight off cows, 50 gms per day ADG in calves on young cows

Fencing	- Combination of 7 wire conventional, 5 wire electric and reels/standards. – High replacement and maintenance costs of existing aged fences - Further subdivision required in easy country to improve pasture management - Reels and standards used over calving	- No reels and standards used. - Able to use virtual fencing to protect existing fences from cattle damage. - Now question when fences at end of life – Do you replace them?	- Reduced fencing replacement cost of $6000 in first year with virtual fencing. - Subdivided entire farm in a couple of days
Farm management	- Manual stock count - Cows mob/location manually recorded every time it changed. - Visual tags and EIDs. - Bring into yards to draft.	- Real time stock count - Can locate any individual cow in real time. - Can use LED light to identify cows. -Pause individual cows required and let out of break.	- Finding cows mob location and paddock when needed is simplified - Can check all cows are out of paddock when shifting - Ability to pause cows and draft in paddock - Can pause sick/picked on cattle or when introducing to a new mob, allowing them the freedom to get away from others and have extra feed

Lessons learned and recommendations

Biggest challenges: Throwing the old way of doing things away, thinking in a different way. Adjusting collars on fast growing stock.

Key learnings: Need to upskill and bring in additional support during the learning process as adjusting the system. Throw the rule book away, what you thought you knew is no longer. Add in additional technology to help, have added PastureIO to help with measuring pasture.

Future Plans: Continue to increase stocking rate, intend to see how high we can push this without reducing performance. Carry all young stock through the winter, to finish or sell in Nov/Oct

CASE STUDY – FARM B

FARM PROFILE – PRE WEARABLES

This case study is done on a 130-ha block that is part of a class 3 NI hard hill country farm running a predominantly breeding and store system. Wearables on beef have been a part of the farm business for 12 months.

Farm profile – pre wearables

Farm Class: NI Hard Hill Country ((Beef and Lamb New Zealand, 2025)

System Type: Ewe breeding and store lamb system with 0.5 head of trade cattle per hectare

Farm Size and Scale: Eff ha 100 - Total 130 ha

Land & Climate Characteristics:
Climate 1200-1300 ml
Summer dry tendency
LUC 6

Subdivision and Grazing Management:
Ewes rotationally grazed around paddocks until set stocking
Set stock late July early August in preparation for lambing
Start rotationally grazing again late November/early December
12 ha – 20 ha paddock size

The challenge

Financial sustainability – needed to go forwards rather than backwards
Mental Health – not helped by farm profits
Already looking at system change to cell grazing, wearable technology was simply an enabler

THE SOLUTION – VIRTUAL FENCING

Adoption Goals

To shift the farm system from a sheep breeding and store property to a cell grazing bull system without needing to increase labour requirements and create a step change in farm production. Began by trialling a cell grazing systems with single wire electrics on a small section of hill country. The wearables had to pay for themselves through labour saving – after estimated labour savings, production needed to increase 6-7% to cover the annual cost, assuming a 0.5 FTE labour unit would be required and housing etc.

Implementation process:

Training Protocol: Training done as per companies training programme. Training was able to be achieved in 3 days using double shifts during the training process.

Hardware and Setup: 3 towers to cover 100 ha. Installation of towers was simple, moving the equipment to challenging spots proved the most difficult aspect.

Results and outcomes

The table below aims to capture the changes that have occurred within the farm business after the implementation of wearables on beef on the case study farm.

Metric	Before Virtual Fencing	After Virtual Fencing	Change / Improvement
Labour	- Husband and wife operation - Dagging, docking, drenching, shearing and stock work. If implemented system change using electrics - additional labour - not attractive job managing and maintaining a cell system on hill country - health and safety challenges on hill country with this system	- Reduced sheep work	- Potentially a slight decrease due to the removal of sheep and associated labour - changed to a more intensive system without increasing the labour requirement.
Stocking rate (wintered)	- 9-9.5 SU	- 18 SU/ha	- Doubling of winter stocking rate.
Carcase weight production	- Not measured in the sheep system - Beef + Lamb benchmark data – 150kg/ha top 20% hard hill (Beef + Lamb NZ, 2025)	- 380 kg CW/ha after trial period at 16 SU/ha	- 60% above the kg CW/ha production data from Beef + Lamb benchmark data for hard hill. - Have added an additional ½ a SU per ha with wearables from the initial trial with single wires
Pasture utilization and production	- 4 tonne DM eaten (Farmax modelling)	- 8 tonne DM eaten (Farmax modelling)	- Doubling of pasture eaten - A combination of increased pasture

			utilisation and production
Environmental protection	- Natural water only with no troughs. - Stock access to waterways.	- Water in all paddocks via micro troughs - All CSAs and waterways excluded – 10% of total area	- Stream banks now protected from stock damage. - Natural reversion being seen. - Too soon to see change in water quality, baseline measurement has been taken.
Soil damage/pugging	- Standard amount from sheep, spread lightly over entirety of a paddock	- Pugging damage is now in more focussed areas if it happens.	- Management is important making the decision to move cattle on if needed. - Cattle can be moved off damaged area quickly - ability to rest and protect at risk areas
Paddock flexibility	- Minimal flexibility, - Conventional - 3 wire electrics dividing some. - Terrain made further subdivision difficult and labour intensive.	- Easily adjust break size to create a rotation length between a 90 day and 30 day round - Accurately meet pasture growth, pasture conservation requirements, varying mob sizes or environmental conditions.	- Extremely flexible. - Individual grazing areas or breaks rather than paddocks - Easily adjust if needed.
Other benefits			- Real time stock count. - Can see where cattle are always, i.e. if they have gotten into neighbours - Ability to pause bulls that being picked on, allowing animal to maintain social structure with the ability to remove themselves away from mob.

Lessons learned and recommendations

Biggest Challenges: Learning an entirely new system to shift from sheep to intensive bulls. Has changed outlook on farming, increased production and profitability substantially and had positive environmental outcome.

Key Learnings: The key enabler for the farmers was trialling one smaller system, before scaling up. You will learn a lot but in a small manageable scale.

Looking Forward: Transitioning an additional 100ha into the cell system with wearables. Having managed an exceptionally wet winter on the initial 100 ha, there is now confidence in how the system handles a wet winter.

Looking at layering more technology and farm in a more granular precise manner. Investigating using wearables to enable precision grazing of hill country, and enabling planting of specific forages, using drones, best suited for that area to increase production, ie hillsides that are more prone to drying out.

Mosaic land use. Retiring steeper sidling's and riparian areas that could potentially be entered into the ETS for additional income

Farmer Quotes: "Farmer mindset is the biggest limiter"