Innovations behind the farm gate that will influence performance of hill farming

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The challenges on farm

What are the big issues that will face us in the hill country over the next 3 decades? It is these issues and the resulting pressures that are likely to shape the innovations required to support a robust future for hill country farming. If necessity is the mother of invention, then what are the pressures and hence what will shape the likely innovations that will be necessary for this important sector in the time ahead?

Profitability is at the heart, but the pathway to adoption of innovation begins with farmers understanding and being confident to make system changes as well as having the desire to do it. By looking back over the past few decades at the major lift in productivity, especially in sheep, and at some of the innovations that have contributed, we may be better able to look ahead.

There are some broad principles that are likely to be important over the next 30 years:

- a robust hill country community must have a working environment and lifestyle that is rewarding both mentally and financially
- the hill country farming sector will require improvements in productivity – more output for the same physical inputs, underpinned by the need to grow more feed of higher quality on the same area, and to sustain feed of higher nutritive value for longer during the year
- there will be external pressures especially with the environment (e.g. riparian management and water quality) which will increase compliance costs, and farmers will need to farm within various limitations;
- a spread in product supply off farms is better for the market than a concentrated supply; it is likely that a greater spread of supply than the current situation will be necessary to satisfy new markets, especially those without a seasonally complementary local industry – this will require different ways of thinking about the feed platform.

The vision for 30 years on is that the sector will have made some appropriate collective decisions and the wider geo-political scene will have been favourable, meaning hill country is effectively and profitably farmed.

Effective innovations

There are many innovative approaches and technological developments that would help support a highly productive hill farming sector. For a producer to consider seriously an innovation within their farming system, they must be able to see themselves actually doing it. For effective integration into the farming system, an innovation or new technology must improve profitability, and be simple to understand and be simple to implement at the farm level. To be effective at a sector level, an innovation must be readily scalable and readily transferrable (Figure 1).

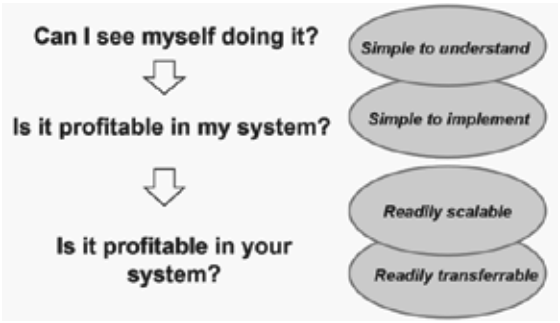

Figure 1 A conceptual basis for considering the successful integration of an innovation into a system.

Impact of innovation on farm – looking back

Thirty years ago, a paper by Parker & McCall (1986) discussed some aspects of hill country productivity through a survey of 30 Wairarapa hill farms (70% steep country). Ewe liveweights averaged 51 kg, with lambing of 99% and a 30 kg ewe hogget in the autumn at an average winter stocking rate of 11.3 stock units per effective hectare. While no data are available for these farms, the performance was similar to the overall average for New Zealand in the mid-1980s.

In the 3 decades since then, the overall improvement in sheep productivity over the whole industry has been impressive with about an 85% increase in productivity per ewe (expressed as the weight of carcase sold per adult ewe mated, Table 1) for an estimated 40% increase in total feed used per ewe. More than half of this is due to genetic improvement in the sheep and the rest to other factors such as improvements in pasture management and pasture genetics.

The increase in efficiency has meant that a higher proportion of feed harvested was for production of saleable product rather than for maintaining the breeding female. Hence, it is helpful to look at what

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innovations have been effective over the last 30 years, and what were the pressures and opportunities that stimulated adoption of innovations?

A key influence has been the improved utilisation of spring feed surplus and that this has come from incorporating a combination of innovations from scanning, nutrition, health treatment, genetics and knowledge of the impact of cattle to sheep ratios. Well-fed ewes are rearing two lambs and weaning both to far heavier weights in about 3 months than their counterparts 30 years ago. High quality spring feed converts much more effectively into saleable product, and the quality of the subsequent feed is improved greatly, allowing better summer production. The feed demand has increased through this period and better matches the natural feed supply pattern. This closer match between demand and supply has a positive and additive effect allowing higher performance from subsequent grazings.

Looking forward

The key to a robust future for the hill country is profitability. This necessitates a robust return on investment; putting aside the issue of whether the land resource is inherently over-valued there is the need is for increased returns and reduced costs. There are three key aspects to this – the *enviro-political factors, profitability/productivity* and the *farmer/farm aspects*.

Enviro-political factors

In the wider New Zealand context, hill country farming is not seen as important – the urban electorate sets the agenda and the farming view of issues in the hill country do not win votes at elections. In fact, hill country farming is considered part of the problem – farming adversely affects water quality, and there is no reason why farming should not pay its fair share of greenhouse gas costs. The expectation in the longer term is for greater challenges and possibly even a need to seek a licence to farm. In other words, what activities will be acceptable in farming the hill country? There is a spotlight on nutrient loss from agricultural systems – particularly at the more intensive end. How can the hill country sector show that it is a genuine low impact option and what role will innovative approaches play in developing the story? Whatever the future of the hill country, the need to consider environmental perspectives will be critical.

To ensure that farmers keep a reasonable level of control of the future of hill country, there is the need for a story with evidence that illustrates the powerful empathy of farmers with the land they farm. Consumer relationships must improve as successful ongoing business assumes that customers who want to buy our products are prepared to pay prices that mean farming is profitable.

In 30 years' time, these customers will also have the choice of low cost plant-based or even laboratory-grown synthetic meat, produced with minimal environmental impacts and no animal welfare issues. Consumers with these options will need good reasons to pay more for 'naturally grown real meat'.

Profitability and productivity – looking ahead

The improvement in productivity over the last 30 years, especially in sheep, has been an impressive -10 kg of carcass sold per ewe mated. Looking at the next 15 to 30 years, where per animal production may reach some practical ceilings; there will probably be a need for more attention on market factors alongside production factors. Therefore, it is valuable to consider what needs doing to match the achievements of the past 30 years? Table 2 data shows what would be required to match this 10 kg change in per ewe productivity over the next 15 years.

Table 2 indicates that an increase of 10 kg per ewe in productivity over the next 15 years is definitely achievable through ongoing refinement of all the things that farmers are already doing much better than they did 30 years ago.

The productivity of the land-base is what underpins profitability. In livestock farming, this is a function of soil fertility, water supply, the quality of feed grown and managerial ability to utilise this feed. Managing

Table 1 Components of the change in overall ewe productivity (kg carcase sold per adult ewe mated) over the last 30 years.

	Annual rate of change	Overall gain	Performance	
			1984/85	2013/14
Lambs tailed per adult ewe	1.1%	33%	100%	132%
Lamb carcase weight (kg)	0.19	44%	13.0	18.7
Carcase weight (kg) of cull ewes	0.21	47%	19.8	25.7
Overall ewe productivity (kg carcase sold per ewe mated per year)	0.43	85%	12.4	22.9
Feed used per kg carcase sold in MJ ME or (kg DM) per kg carcase sold			639 (59)	447 (41)

the pattern of feed supply and feed demand are critical factors to meet changing market requirements and farming targets. Those production systems that manage to maximise economically and environmentally sustainable pasture production, and then closely match this to animal demand will produce lower cost, higher quality feed and highly efficient outputs of saleable product. The benefit will be realised through improved profitability.

A more variable climate is expected in the future – heavier rain events and extremes of heat, so how do farmers accommodate this variability? A changing climate will influence how feed is grown and the pattern of feed supply, and along with the enviro-political considerations, will influence water usage and management. However, a highly seasonal pattern of growth is not likely to change.

Can resource management improve? Are sheep that can perform well with limited water a much better long-term proposition for drier areas than cattle? Growing more feed in the hill country is unlikely without more nutrients – therefore, development of new ways to minimise water quality impacts are essential. Management of animals and nutrient applications must minimise leaching hotspots.

What about some more stretch in our thinking? Are there livestock other than sheep and cattle – what about breeding sports horses where New Zealand already has an international market? What about products in addition to meat – for example, seasonal sheep milking in the hill country?

There are also alternatives to livestock to consider – in some areas or parts of farms, trees for timber may be more valuable (but trees are a long-term bet on the future). Re-planting native vegetation may be more valuable whether this is to help secure water catchments or for honey supply or for conservation.

Extracting nutrients from water before it reaches the streams, rivers and lakes by growing harvestable algae may offer possibilities; the algae could be a feedstock or a source of nutrients to re-use.

People

People are the heart of the hill country and those who have responded to the challenges of the last 30 years are the ones still farming the hill country. The qualities that have enabled the integration of innovations that have improved productivity are the same qualities that will underpin the future.

The enablers for the next decades

The central proposition is that innovations need to be both *simple to understand* and *simple to implement* so that farmers can incorporate them with confidence into their systems. Given the critical importance of the people factor, it is included alongside the four core contributors to profitability. These are productivity, the capacity to improve productivity through genetics and management, the prices received for products and costs of production. How innovation could contribute to a long-term sustainable future for farming in the hill country also included.

People

The hill country needs farmers/people who want to be there – with access to technologies that enable them to operate sound long-term businesses. That is, the farmers need profitable animals and the technology to support

Table 2 Meeting the challenge to increase overall ewe productivity by 10 kg over the next 15 years.

	Productivity		Approaches
	Now (year)	15 years	
Lambs tailed per adult ewe mated (%)	132	154	More from hoggets, genetics, survivability
Lambs tailed from adult ewes (%)	127	138	Increased ewe liveweight
Percentage of ewe hoggets retained (%)	31	30	Improved survival – better nutrition
Percentage of hoggets mated (%)	32	72	] Increased hogget liveweight and higher fertility hoggets
Tailing percentage for mated hoggets (%)	50	72	
Lamb carcase weight (kg)	18.7	22.7	Increased ewe liveweight and higher proportion of ewes mated to high-performing terminal sires, with no change in age at slaughter; higher ME feed base,
Ewe disappearance rate (%)	10	7.5	Healthier ewes, better match of feed
Ewe (cull) carcase weight (kg)	25.7	27.7	
Estimated ewe liveweight at mating (kg)	64.8	68.3	Better genetics and feed management
Overall ewe productivity (kg)	22.9	32.9	The consequence of better genetics and better management
Feed used per kg carcase weight sold: MJ ME (and kg DM)	447 (41)	358 (33)	

their businesses and improve productivity per dollar invested. Improvements in the effectiveness of the use of labour may well reduce the number of people needed for regional farm work, which may not be a desirable outcome. Are there other ways to use the hill country for farming associated businesses to keep people local? Planning a vibrant future means thinking trans-generationally and shifting away from a situation where most planning is around survival with short-term thinking the result. Other factors that reinforce short-term thinking include market and price volatility and the seasonal pressure of increasingly variable climatic conditions.

Attracting talented people into the hill country sector or even retaining those that are there will not be easy, so ensuring that the sector is sufficiently robust and underpinned by long-term thinking and long-term initiatives is vital. Relentless short-term pressure will undermine the sector, and while agriculturalists are inherently aware of supply/demand dynamics, the impact of new technologies and innovations, will be more quickly realised through policies that support R&D for the sector over longer periods.

Beyond the farm gate, the need is for innovation that enables long-term businesses to produce products that customers want to buy in international markets – this means building strong relationships all the way from the farm to the consumer. People must be at the heart of these relationships. Wanting high prices means not selling commodities.

Core contributors to profitability

Productivity – feeding animals to produce saleable product

This relates to managing the core resources for livestock farming – the animal and the feed-base. Given the loss of easier country to other uses, the future for the hill farming sector is the whole breeding to finishing chain, in which case, feed quality and the pattern of feed supply become critical.

There are two aspects to consider – productivity per animal and productivity per hectare. This means ensuring the quality and quantity of feed required to realise the improved performance are available at the right time.

Plant breeding has brought changes to the species mix used in hill country including the use of plantain and chicory along with ongoing improvement to ryegrass, including novel endophytes, and multiple new clover cultivars. Hill country farmers have much better choices, although on many farms, pasture renewal has been a low priority. Differential application of fertiliser and greater targeted nitrogen (N) application will play a part in the future of profitable hill country management. The requirement for more feed used per hectare or more importantly higher intakes per head, feed quality will need to be better to support the higher voluntary intakes.

With limits on water and nutrients, there is a possibility of manipulating the sward using advances in herbicide technology to favour species that offer better use of these resources. A desirable outcome would be to generate swards with a higher metabolisable energy (ME) content that are fixing N and ensuring that the available nutrients are well utilised.

The productivity or performance of the animal underpins profitability. The meat animal sector (sheep, cattle, deer, and goats) needs animals that are themselves robust – where performance is unaffected by changing conditions (or even anti-fragile, where performance actually improves – for example, they mobilise the fat that would be a problem if they kept it). In thinking about the animal, what are the issues for farming ruminants on hill country – flies, internal parasites, facial eczema, viruses, ticks, ryegrass staggers (old ryegrass-based pastures in the hill country). Both genetic improvement and improvements in management have much to offer.

The capacity to improve productivity through genetics and management

In genetic improvement, three basic tools work best in combination: differences between breeds, selection within breeds, and crossing between breeds. In practical cross-breeding, complementary differences between breeds are utilised by taking valuable traits from the chosen breeds, while selection within breeds enables the choice of individuals that are superior for additional valuable improved traits; hybrid vigour then yields a bonus.

Genetics and management are complementary; genetics enables in that it sets the limits, but management delivers in terms of how much you get. We need to look at where genetics can make an impact – the dramatic improvements in sheep productivity have come through improvements in lambing performance and growth both within breeds and through cross-breeding and composites. In beef cattle, the potential for improvement in reproduction is limited, and although the impacts of within breed selection and cross-breeding are worthwhile, the potential is much less than that for sheep.

Technology

Typically, where innovations help make better decisions and help make life easier or more enjoyable, farmers will generally find a way to incorporate them easily. A vast range of new technologies have been incorporated by managers of hill farms but the impact of the IT revolution is not yet being realised. The lower prices and portability/connectivity will have real impact in enabling more data collection and useful monitoring. A

good example is the better monitoring of environmental changes such as moisture levels and soil temperatures that will enable better decisions about the likely pattern of feed production. Integrating such data into a management system is the real innovation.

Prices for animals sold

Product prices vary for many reasons, some of which relate to the market. Due to the seasonal supply of feed, there has been a seasonal pattern to the schedules and farmers with systems that enable supply outside of peak times reap rewards. More recently, meat processor behaviour has been a reflection of processing capacity rather than response to market demands. Looking ahead to a scenario where there is a vibrant red meat sector in 30 years, some re-alignment of capacity will have taken place. Process innovation that provides full product tracking from the farm to the market with feedback loops will provide farmers with valuable data about their products in the market. It will enable greater understanding of on-farm and processing factors that influence quality traits relevant to the consumer experience such as taste and tenderness and will enable further advances in genetics and management.

Costs of production

Across the spectrum of inputs, compliance costs meted out through levies, local body rates and increased time demands are likely to continue to erode margins. There will be normal inflation of pricing with the exception of some technology-based inputs where technical advances allow a lower cost. An increase in pest and disease pressure will come at a cost to farmers and unwelcome invaders such as the clover root weevil pose ongoing threats. The question of genetic modification especially with the likely developments in technology will need serious reflection and thought set against consumer acceptance and industry risk.

What are the major opportunities for innovative approaches on-farm?

Converting compliance costs into profits

There will be more compliance costs with farming. Three examples of compliance are compulsory identification systems for animals, the potential for charges or a tax on greenhouse gas emissions, and restrictions on nutrient flow into waterways.

Despite some well-publicised perspectives from farmers, traceability that requires individual animal ID is becoming an increasingly important issue in international markets. However, ID systems provide opportunities to collect data, but data are not much good on their own. The DIK principle (data – information – knowledge) sums it up: data converted to information then useful knowledge for application.

Greater use of automated weighing and drafting systems, especially easily portable automated systems that can be used around properties rather than just at the yards, will allow greater frequency of weighing events and early identification of individual or mob issues that require action. This will enable the higher degree of animal management needed to move animal performance up another level on a farm scale.

The pressure to deal with greenhouse gas emissions will increase. A vaccine may well provide a way to reduce methane emissions from ruminants and potentially a proportion of the energy saved may well find its way into productive use by the animal.

There are many pressures around water. How do we keep animals out of waterways, how do we capture nutrients from water, how do we prevent leaching of nutrients?

The feed base

Management can make a major contribution especially in pasture but this will require advances in the establishment and maintenance of improved cultivars and species. Over time, the need is for animals that are able to channel a higher proportion of their energy intake into production rather than maintenance. Feed quality needs to improve to allow higher voluntary feed intakes, a factor that requires innovations in the establishment and maintenance of superior swards as well as genetic gain in the animal. Innovation in pasture management will include practices that optimise returns from new species, balancing needs of the animal with requirements of the improved pasture for nutrients, resistance to pests and persistence.

The animal

Where do beef cattle fit? Could surplus male dairy cattle fill this niche? The widespread adoption of (cheap) sexed semen in the dairy industry would mean that cows no longer required for replacements could produce something that may be even more suitable for beef production. The high usage for percentage of artificial insemination in the dairy sector allows identification of superior male genetics for spreading over a larger female pool. The Wagyu option is a developing example. However, this requires a change to the dairy sector to treat the calf as a potential product rather than as "a necessary evil" required to generate milk. Welfare and social media may well work in favour of the red meat sector to stimulate change in practices and attitudes.

Expected innovations in the development and application of genetic technologies will enable more of a focus on traits with lower heritability such as taste and tenderness. However, this will require payment for the farmer contribution to improvements in these traits.

At present, the reality is that it pays farmers to focus genetic improvement on productivity traits rather than on product quality traits. This could change with the implementation of full product tracking systems from the consumer back to the farmer. As limits of production are reached (some would argue three lambs is one too many) can a change in the focus of genetic improvement towards less heritable traits keep pace with the increase in productivity that has accrued and that has enabled maintenance of at least some profitability?

Practical innovations

Further developments will occur in some of these areas.

- Developments in IT will be important at the whole farm level. Satellites and associated connected devices will likely offer the connectivity that is lacking now; for example, imagine a phone app utilising NIWA data, data on soil moisture from sensors, animal intake and performance data along with satellite imagery to support sale/purchase decisions specific to each farm.
- Drones have a particular place in management such as for detecting changes in pasture production and crop health, water and riparian management and monitoring of animals – all of these will reduce the need for people to be travelling around farms – this will have safety benefits.
- Virtual fencing is a possibility so that animals are constrained from moving outside defined areas by signals picked up by their ear tags.
- Smart, low cost ways of seeding beneficial species in hill environments are essential. Can suitable areas of easy country be used to multiply seed for oversowing and what about establishing small patches of improved legume species (with very high nectar and pollen production) and relying on bees to transfer pollen to the established plants? Can grazing animals be used to harvest and distribute seeds such as annual clovers strategically? What about ways to introduce improved grasses or long-lived herbs such as those with much deeper root systems?
- Further innovations in water storage and irrigation systems may allow for more widespread and effective use of partial irrigation systems in both easy and steep country and facilitate more robust and productive systems
- Re-thinking the options around alternatives to pasture with more focus on standing fodder such as high nutritive value shrubs and trees?
- Where do multi-use crops fit? What about crops that provide feed for honey producing bees along with feed for livestock?
- Are there opportunities for genetically modified pasture species with deeper roots, greater productivity and higher feed quality that may also be able to fix their own N? Will markets and market segments be lost through use of GM products? Will the gain in productivity be worth more? Could the use of GM plants actually be better for the environment and provide a healthier eating experience?

An important question is do these represent gaps that can best be served by more R&D or are they more practical applications? Who is responsible for promoting and alerting us to the opportunities?

Bringing this all together

Can we bring this altogether by looking at the FACE of farming – the Farmer, the Animal, the Customer/ Consumer and the Environment?

- Farmers – profitable and happy
- Animals – healthy, robust and efficient
- Consumers – happy to pay
- Environment – sustainable

There are many sources of innovation and innovation often comes out of other industries and is then adapted for farming purposes. Often, it is the adaptation of the technology to farming and the integration of the technology into farming practice that provides the real innovation. Arguably, ultrasound scanning was the innovation, but the innovation did not generate profit for sheep farmers without them utilising the information to feed ewes differentially in appropriate areas to capture the benefit through weight of lamb sold.

If necessity truly is the mother of invention, then some pressure on farm profitability is very likely to stimulate innovation behind the farm gate. The incentive to change when things are going well is not strong but these are actually often the best occasions to do so, as the time and resources to review and consider alternatives are most plentiful. An on-farm gain of 10 kg in productivity per ewe over the next 15 years looks to be achievable through adoption and refinement of existing knowledge. To achieve gains over and above this will require a greater degree of innovation.

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