

IS DAIRYING SUSTAINABLE? A CASE STUDY

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Introduction

It is axiomatic that in 20 years' time we all wish for a NZ dairy industry that is sustainable. But what does this mean and how can it be measured?

The RMA describes sustainable management as managing the use, development and protection of resources for social, economic and cultural well being while sustaining these resources for the use of future generations and protecting the life supporting capacity of air, water and soil. However, this legal definition does not provide a framework against which to determine sustainability. In contrast, the FESLM (Framework for the Evaluation of Sustainable Land Management)¹ definition incorporates these same basic principles and the framework it offers has been designed so that sustainability can be assessed or compared at least in a qualitative sense. The FESLM framework incorporates at its broadest level, five pillars or objectives: *Productivity, Security, Protection, Viability and Acceptability*. If, for any land management use or practice, the objectives set for each pillar are achieved then that land use or practice is deemed to be sustainable. Thus it can be used to assess any type of land use (e.g. dairying versus sheep and beef farming) over a given time frame or any within-farm practices such as a given fertilizer-use policy.

In this paper we are going to apply the FESLM definition to two contrasting dairy farming systems: a conventional in situ grazing system and a nil grazing system.

Methodology

The FESLM definition of sustainability states that:

"Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:

- *Pillar 1: Maintain or enhance production/services (Productivity)*
- *Pillar 2: Reduce the level of production risk (Security)*
- *Pillar 3: Protect the potential of natural resources and prevent degradation of soil and water quality (Protection)*
- *Pillar 4: Be economically viable (Viability)*
- *Pillar 5: Be socially acceptable (Acceptability)."*

The FESLM framework allows for many parameters for each pillar and layers within each parameter, making any final assessment both detailed and comprehensive. For the purposes of this paper we have taken a much simplified approach using a single parameter representative of each of the five pillars to make the comparison between the systems, accepting that others may choose different parameters or sets of parameters to represent each pillar. The parameters for this exercise are:

- Pillar 1: Production – pasture yield
- Pillar 2: Protection - nutrient leaching, runoff and gaseous emissions
- Pillar 3: Security - risks of incurring future regulation that impacts on farming system

¹ International Framework for Evaluating Sustainable Land Management (Smyth and Dumanski, 1993)

- Pillar 4: Acceptability - public opinion
- Pillar 5: Viability - economic return

Two dairying systems are compared: 1) a nil grazed, or cut and carry system; and 2) a fully grazed, or conventional system, designed to represent current typical dairy practice in New Zealand. For this exercise, the nil grazing system incorporates robotically milked stock in sheds designed to maximize light and air movement with automated feeders and slurry scrapers and wash down. The effluent is separated, storage ponds are covered and the effluent is regularly recycled to land as a liquid fertiliser during the growing season. Solids are also stored under cover and returned to the land annually as a soil conditioner. Pasture is harvested regularly and ensiled on site. Pasture renewal is on a pasture-to-pasture basis. The conventional or in-situ grazing dairy farm is pasture based grazed system with cows outside and milked twice a day and wintered on the property. Effluent from the uncovered yard is scraped daily and there is a two-pond system. Effluent from the second pond is spread on a daily basis using a traveling irrigator. The farm achieves average pasture yields and milksolids production for the area. An area of forage crop is grown as a break during pasture renewal and is break-fed in situ. Some silage is made and stored on the farm and is fed out on the paddocks.

Each production system is assessed for each FESLM Pillar using the subset of parameters described above. For each Pillar the in-situ grazing system is used as the baseline against which the nil-grazing system is compared. The exception is the economic comparison where due to lack of data a restricted grazing rather than nil-grazing was used in the comparison.

Pillar 1: Production

“The return from SLM may extend beyond material yields from agricultural and non-agricultural uses to include benefits from protective and aesthetic aims of land use.”²

New Zealand is a good place to grow grass. Annual pasture production typically ranges up to 17 t DM/ha (NZFMRA, 2004), and dairy farming is generally carried out in these areas that are favourable to growth and grazing – not too cold or wet in the winter, not too hot and dry in the summer (or with irrigation) and on land which is not too hilly and steep³. Productivity of well-managed pastures depends mainly on sunshine, temperature, water, and nutrients however, pasture performance, even under well-managed grazed systems, is not optimal for two principal reasons: sward damage and soil compaction from animal treading; and uneven return of nutrients. Neither is all of the pasture grown is converted into product.

Uneven return of nutrients

The return of nutrients through the grazing cow leads to a very uneven reapplication. The quantities of N that are randomly deposited greatly exceed the immediate plant requirements in the area of the urine patch and up to 70% of pasture gets no excretal N⁴. In addition excretal returns are deposited on nonproductive land, such as tracks, around feed and water troughs and in gateways.

In her assessment of grazed, restricted grazed and nil grazed systems, de Klein⁵ concluded that nil grazing systems could increase the dry matter production of dairy pastures by approximately 20 % compared with conventional grazing systems solely based on the even redistribution of effluent and consequent increased utilization of excreta N in the system.

Animal treading

Animal treading can cause both sward and soil damage. Although in the medium term a soil can recover if damage is not too great, short-term damage can severely restrict pasture

² Smyth and Dumanski (1993)

³ Holmes et al. (2007)

⁴ de Klein (2001)

⁵ (2001)

growth. Ledgard et al.⁶ found pasture growth was depressed by 35, 45 and 80 % for 2-3 months on sandy loam, silty loam and clay soils after a single grazing event on a wet day. Annual pasture growth on these soils was similarly depressed by 2, 12 and 21 %.

de Klein⁷ concluded that, although various cited studies had found that animal treading could reduce pasture production by up to 38 %, compaction from machinery traffic in a nil grazed system could account for the same magnitude of pasture reduction, and therefore no net gain in pasture production could be attributed to nil grazing systems.

There is, however, inherent flexibility within a nil grazing system and machinery compaction, such as that caused by cutting for silage, would be easier to avoid than compaction caused by stock on a paddock. This is for two reasons: 1) In poor conditions there will be a choice as to whether to cut for silage, strongly influenced by the importance of good quality silage as the principal feed and the fact that a 'cut and carry' based farm is likely to have its own machinery, whereas with stock the choice will be between one paddock and another; and 2) low pressure tyre or track systems are available that reduce compaction even in marginal soil conditions.

Conversion of pasture grown to product

The conversion of feed grown to animal product comprises several stages; the amount of DM grown relative to that which is harvested - pasture harvesting efficiency⁸ - and the amount eaten that is used/converted into product - feed conversion efficiency⁹.

Pasture harvesting efficiency

The total amount of pasture eaten on typical New Zealand dairy farms ranges from approximately 50 % of pasture grown on poorly performing farms to approximately 80 % on high performing, intensive dairy farms¹⁰. However high pasture use efficiency grazing is achieved at the expense of a decrease in the cow's own performance and feed conversion efficiency¹¹. In addition, utilisation of supplements 'fed out' is typically low, approximately 50%¹², and even well managed stack-fed silage losses are typically around 10 %.

In a cut and carry system, the mechanical harvesting has typically > 85% harvesting efficiency. The hard grazing, important for pasture quality and to maintain clover levels, can be simulating through the cutting regime¹³. Feeding losses are also less in a cut and carry system compared with feeding out; in existing operations in Southland, losses associated with in-house feeding are approximately 2¹⁴-3 %¹⁵.

Feed conversion efficiency

Although it is not possible to calculate the feed conversion efficiency in conventionally grazed pastures because the feed intake through grazing by individual cows is not known; there is a strong relationship between feed conversion and milk production¹⁶, and an intimate link in terms of performance with pasture management

The housing of stock can increase the cow's performance and feed conversion efficiency without the additional impact on pasture use, as these are partially decoupled in the cut and carry system. Annual animal feed requirements are less than intensively grazed herds as:

- Less energy is expended walking to and from the parlour twice a day

⁶ (1996)

⁷ (2001)

⁸ Pasture harvesting efficiency = Pasture eaten per ha / pasture produced per ha; %

⁹ feed conversion efficiency = kg milksolids produced/ t DM eaten; %

¹⁰ Holmes et al. (2007)

¹¹ An increase from 2.2 to 4.3 cows/ha resulted in a 37 % decrease of MS/cow production and a 14 % decrease in feed conversion (MacDonald et al., 2001, cited in Holmes et al., 2007).

¹² de Wolde (2009)

¹³ de Klein (2001)

¹⁴ de Wolde (2009)

¹⁵ Aad van Leeuwen (2010). *Personal Communication*.

¹⁶ Holmes et al. (2007)

- Stock are housed so that they are not subject to cold and inclement conditions over winter. Up to 7 kg DM/day/cow may be consumed just in keeping warm¹⁷
- Stock can be maintained in optimal condition without reference to pasture utilisation

So, although New Zealand is a good place to grown grass, grazing it isn't the most efficient way of converting it into product. Table 1 summarizes these findings noting that although the gains are not strictly additive, there will be a cumulative impact.

Table 1. Comparison of Productivity in the two grazing systems

Parameter	Typical productivity in an 'in-situ' grazing system	Potential gains/losses in a 'nil grazing' system
Nutrient return	Annual average pastures 8-17 ¹⁸ t DM/ha	+ 20 % pasture produced ¹⁹
Treading	Annual average pastures 8-17 t DM/ha	0-38 % pasture reduction ²⁰
Pasture harvesting	Typical pasture utilisation of 50-80 % ²¹	+ <35 % pasture utilised ²²
Feed conversion	9.6-19.2 kg DM eaten/day ²³	<36% less food required ²⁴

¹⁷ Herdhomes.co.nz

¹⁸ Range of typical pasture production in New Zealand, NZFMRA (2004)

¹⁹ Based on de Klein (2001)

²⁰ Based on de Klein (2001)

²¹ After Holmes et al. (2007)

²² Based on a harvest efficiency of 85 % compared with 50 -80 %

²³ Homes et al. (2007) – range of feeding requirements for lactating cows with various body weights, milk production and losing, gaining or maintaining body score

²⁴ Based on up to 7 kg/cow/day expended on keeping warm compared with range of feeding requirements

Pillar 2: Protection

“The quantity and quality of soil and water resources must be safeguarded, in equity for future generations. Locally, there may be additional conservation priorities such as the need to maintain genetic diversity or preserve individual plant or animal species.”²⁵

Regional and National policy and reporting alike point to the degradation of water quality from the intensification of agriculture. Last November the Manawatu River was reported to be one of the most polluted rivers in a study by Cawthron that covered Australia, the US, Europe and New Zealand²⁶. Although there have been improvements in water quality over the past 10-15 years, these are mainly due to regulation and subsequent control over many point sources of pollution. The reported facts are as follows.

The State of the Environment report in 2007 found:

- Between 1996 and 2006, sheep and beef numbers decreased by 15 % and 6 % respectively, and dairy and deer numbers increased by 30 % and 35 % respectively
- Over the last decade monitoring results have shown widespread compaction in pastoral and some cropping soil, a loss of SOM and soil structural stability in arable soils, an increase in soil N and high available P in dairy pastures
- Despite the successful control of many point sources of pollution between 1997 and 2007, ‘there has been a nationwide pattern of increasing levels of total nitrogen and dissolved phosphorus in rivers in the national network’

The recent OECD Environmental Performance Review of New Zealand²⁷ concluded:

- While the intensity of water, fertiliser and pesticide use remains on the low side for OECD countries, the review period (1996-2007) saw significant increases and increasing pressures on the environment
- Over 15 % of the population is supplied drinking water that does not meet national drinking water guidelines and the Ministry of Health has declared that it has reached the limits of what can be done with non-regulatory approaches
- Water quality in rivers and lakes has declined in regions dominated by pastoral farming where high nutrient inputs and microbial contamination destabilise natural ecosystems and pose risks to human health
- Farmer compliance with resource consents for the disposal of dairy shed effluent is highly variable
- Environmental expenditure (for pollution abatement and control as well as water supply and nature conservation) has increased in recent years, although it remains low at less than 1 % of GDP

Jay and Morad²⁸ in their assessment of New Zealand’s Dairy Industry state that: “despite the effort by the Fonterra Co-operative group and regional government to promote new environmental management policies and practices, the continuing decline of environmental conditions linked to dairy farming suggest that persuasion and the regulatory frameworks used have not prevented environmental deterioration in areas used for dairying and intensive farming production. The reasons for this decline are that first, it is not easy to ensure compliance with regulations by all farmers, and secondly, improvements in environmental management by farmers are invariably offset by intensification of production, or the conversion of lower intensity land uses such as sheep and beef farming to higher intensity uses such as dairying, cropping, and horticulture.”²⁹

²⁵ Smyth and Dumanski (1993)

²⁶ Reported in the Dominion Post 26/11/2009

²⁷ (2007)

²⁸ (2007)

²⁹ Jay & Morad (2007); cited in Baskaran et al. (2009)

This is the big picture highlighting national and regional environmental issues. What if we drill down to the farm? Dr Alan Sinclair in his Norman Taylor Memorial lecture³⁰ on maintaining soil fertility in pastoral agriculture stated that “in a fully nutrient efficient pasture harvesting system, all nutrients taken up in the herbage which are not removed in animal products are returned evenly to the ground...however grazing is inherently a nutrient-inefficient pasture harvesting system (and) the worst is grazing by dairy cows. We are inclined to regard our grazed pasture system as the epitome of low-cost dairy farming. However, I am coming to the view that the grazing cow costs us a great deal in terms of soil fertility:

- It transfers nutrients to unproductive areas
- It redistributes nutrients unevenly
- It intensifies nutrient leaching
- It intensifies gaseous losses
- It acidifies the soil
- It pollutes the environment
- It damages the soil structure”³¹

For comparison, the specific parameters we have chosen for the ‘protection pillar’ are losses of nutrients and gaseous emissions.

Nutrient Losses

Nutrient transfer

An estimated 7-12% of excretal returns are deposited on nonproductive land, such as tracks, around feed and water troughs and in gateways and lost from the system³², representing both an inefficiency in the reuse of nutrients on farm but also contribute to associated environmental consequences.

In the nil grazing system these nutrient transfers are eliminated. The herd is housed enabling all their excretal nutrients to be collected and utilized resulting in no transfer losses.

Nutrient leaching and redistribution

Grazing animals can return in excess of 75% of ingested herbage N through dung and urine³³. The quantities of N that are deposited greatly exceed the immediate plant requirements in the area of the urine patch at applications equivalent to 300 – 600 kg N/ha and even up to 1000 kg N/ha³⁴, and leaves the excess N subject to leaching losses³⁵. Up to 70% of pasture gets no excretal N at all due to patchy distribution of dung and urine³⁶, and the remainder of the paddock receives more nutrients than it can use.

Studies have shown that the urine N in the soil at the start of the drainage season is directly related to the time of year that urine was deposited³⁷. The later the urine is deposited, the less chance there is of the N being uptaken by pastures and the more vulnerable to leaching. The high leaching losses from over-wintering stock are, in part, due to deposition of much excretal N onto grazed land when corresponding uptake is low³⁸.

With the nil grazing system, the urine patch driven N leaching and patchy redistribution of nutrients is avoided. de Klein and Ledgard³⁹ reported reductions of 55-65% of N leaching losses from nil grazing dairy systems compared to conventional dairy grazing systems. On

³⁰ Sinclair (undated)

³¹ Sinclair (undated)

³² de Klein and Ledgard (2001)

³³ Di and Cameron (2004).

³⁴ Haynes and Williams (1993); Di and Cameron (2004)

³⁵ de Klein and Ledgard (2001)

³⁶ de Klein and Ledgard (2001)

³⁷ Cuttle and Bourne (1993)

³⁸ Monaghan et al. (2004)

³⁹ (2001)

the basis of an average annual farm leaching losses of 40⁴⁰ kg/ha, the nil grazing system would typically have annual leaching losses of 14 – 18 kg N/ha.

Atmospheric losses

New Zealand has an unusual profile of greenhouse gas emissions for a developed nation, with methane and nitrous oxide from the agricultural sector contributing nearly 50 % of total emissions⁴¹. Methane emissions from livestock come mainly from two sources, enteric fermentation and manure⁴², and nitrous oxide mainly from agricultural soils and the processes of nitrification and denitrification⁴³. While the atmospheric concentrations of nitrous oxide (320 parts per billion) and methane (1.8 parts per million) are low compared with carbon dioxide (383 parts per million), on a mass basis their contributions to the greenhouse gas effect referred to as 'global warming potential' (GWP) are much higher⁴⁴. Calculations show that over a 100 year time period, 1 kg of emitted nitrous oxide has the same greenhouse effect as 310 kg of carbon dioxide, while 1 kg of methane has the same greenhouse effect as 21 kg of carbon dioxide.⁴⁵

Methane

For manure the amount of methane emissions depends on the quality and quantity of the manure and on the proportion that decomposes anaerobically. Storage of slurry or manure in liquid form in lagoons, ponds or tanks tends to promote anaerobic decomposition and release methane to the atmosphere⁴⁶.

The increase in the housing of stock and therefore the collection and storage of manures is the main reason for an increase in methane emissions associated with housed systems. In addition, the storage of effluent can significantly increase the N loss through volatilization. This aspect was highlighted by de Klein and Ledgard⁴⁷ who reporting that a nil grazing system could actually increase N losses from the whole system through increased gaseous losses, despite significant reductions in leaching.

The cut and carry system has two advantages over the nil grazing system used by de Klein and Ledgard:

- The effluent storage facilities are covered. This greatly reduces volatilization from the effluent storage facility and also reduces the volume of effluent to be recycled through excluding rainwater from the pond.
- The nil grazing system through the design of the feeding, housing and effluent collection permits a level of management and post processing that would be impossible in the grazing scenario. This concentration of effluent, for example, might permit the addition of an on-farm Anaerobic Digestion ('AD') plant for the production of biogas, heat and biofertiliser⁴⁸, a WETOX plant (catalysed wet air oxidation) producing steam, water, a biofertiliser and acetic acid⁴⁹, or a bio-combined heat and power plant for the gasification of biomass to Syngas, biochar and algal oil for liquid fuel production.⁵⁰

Nitrous oxide

The higher global warming potential of nitrous oxide (N₂O) and its significant contribution to greenhouse gas emissions make the development of N₂O mitigation and abatement tools and

⁴⁰ Average annual losses of N on an NZ dairy farm are 30-50 kg N/ha. 40 kg N/ha annual loss has been chosen as a mid point.

⁴¹ MAF (2008)

⁴² Future Energy Solutions (2005)

⁴³ de Klein et al. (2001)

⁴⁴ Landcare Research (2009)

⁴⁵ Landcare Research (2009)

⁴⁶ Future Energy Solutions (2005)

⁴⁷ (2001)

⁴⁸ Future Energy Solutions (2005)

⁴⁹ MacKay (2010) *Personal Communication*

⁵⁰ Garrett Smith (2010)

management practices an important part of New Zealand's greenhouse gas strategy⁵¹. The nil grazing system already contains some mitigation strategies that are recommended for decreasing N₂O emissions, such as no grazing and depositing dung and urine in the autumn and winter months⁵² collecting and reapplying effluent which reduces losses compared to direct deposition by stock⁵³, and reduction of animal treading.⁵⁴ Indirectly nitrous oxide losses can be decreased by a lower requirement for inorganic N fertilizers due to more efficient reuse of effluent N⁵⁵.

An additional advantage of a cut and carry system is that it facilitates the careful control over animal diet and nutrition. Stock nutrition for reducing greenhouse gas emission is a potentially important area of mitigation, for example adding condensed tannins to silage can result in a 4% decrease in emissions⁵⁶, and reducing N intake in the form of highly degradable protein can reduce N losses by up to 24 %⁵⁷.

These results are summarized in Table 2.

Table 2. Comparison of environmental protection in the two grazing systems

Parameter	Typical 'in-situ' grazing system	Potential gains/losses in a 'nil grazing' system
Nutrient transfer	7-12 % ⁵⁸ excretal returns to non-productive land and lost from system	0 % returns to non productive land
Nitrogen leaching	Annual average leaching from typical New Zealand dairy farm 30-50 ⁵⁹ kg N/ha	55-65 % ⁶⁰ reductions on N leaching
Atmospheric losses		Up to 35 % increase in total N losses due to increase ammonia volatilisation ⁶¹ . Diet manipulation up to 7 % reduction in N ₂ O emissions ⁶² Winter management up to 6 % reduction in N ₂ O emissions ⁶³ Reduced animal treading up to 3 % reduction in N ₂ O emissions ⁶⁴ Reduced fertiliser N up to 4 % reduction in N ₂ O emissions ⁶⁵

⁵¹ de Klein et al. (2001)

⁵² de Klein et al. (2001)

⁵³ Oenema et al. (1997)

⁵⁴ Oenema et al. (1997)

⁵⁵ Bussink (1992)

⁵⁶ Clark et al. (2001)

⁵⁷ Kebreab et al. (2001)

⁵⁸ de Klein and Ledgard (2001)

⁵⁹ OVERSEER v 5.3.5

⁶⁰ de Klein and Ledgard (2001)

⁶¹ de Klein and Ledgard (2001) with uncovered effluent storage and no post processing of effluent

⁶² Clark et al. (2001), Kebreab et al. (2001)

⁶³ Clark et al. (2001)

⁶⁴ Clark et al. (2001)

⁶⁵ Cole et al. (1996)

Pillar 3: Security

“Management methods that promote balance between a land use and prevailing environmental conditions, reduce the risks of production; conversely, methods that destabilize local relationships increase that risk.”⁶⁶

This Pillar invites a consideration of the risk that a given farm system or management practice may not be permitted in the future. We have considered this in the sense that farming systems that are ill suited to their environment have both a higher risk **of** production, (i.e. impact on the wider environment); and a higher risk **to** production, as there is more chance that ill suited systems will be encourage/regulated to change or go elsewhere.

There are many risks to an agricultural system, however, the focus here is the risk that in 20 years, the environmental impact of a farm system is such that regulation is deemed to be required in order to deal with it. Sandal et al⁶⁷ note that ‘it is recognized that, while free operation of competitive markets is ideal, in practice, the presence of some conditions may justify government intervention to enhance social welfare’ and goes on to note that negative externalities is one of these conditions.

So the question becomes; ‘Is this risk real for the current conventional dairy system?’ Several scenarios exist: What is the probability that the dairying under irrigation in Canterbury will become restricted? Will the Regional Councils tighten regulations with respect to land application of dairy effluent to deal with problems of non-compliance? Is there a risk that ‘barn-farming’ will be banned in New Zealand on animal welfare grounds alone? Conversely will in situ grazing be abolished in the Waikato if ‘barn’-farming’ is adopted as the only method to reduce nutrient loadings on the Waikato River?

These risks are real and are already manifest in New Zealand. Some general examples that, although are not directed exclusively at dairying, will affect the industry, include the leaching restrictions in areas around Taupo⁶⁸ and Rotorua⁶⁹ and the proposed ‘One Plan’⁷⁰. All these areas have significant dairy industries. More specifically aimed at dairy industry are resource consents required in many areas for aspects of dairy farming, industry initiatives such as the ‘Clean Streams Accord’ and some early thoughts as to whether dairying may become a prohibited activity in some North Island catchments to deal with water quality issues.

Of all the five pillars this is the most difficult one to assess because it is in effect the end result of how well the dairy industry can manage Pillar 2 (protection of the environment) and Pillar 4 (social acceptability). If new technologies emerge quickly enough to mitigate the environmental consequences of dairy farming then these risks will be minimized but they are unlikely to disappear completely. Furthermore it is not possible to place a monetary value on security and for this reason the comparisons in Table 3 are based on the risk of further and more restrictive regulation being imposed.

Table 3. A comparison of risk of increasing regulation from impacts of the two grazing systems

Parameter	Typical ‘in-situ’ grazing system	Potential gains/losses in a ‘nil grazing’ system
Likelihood of system impacts leading to more restrictive regulation	High	Medium-Low
Likelihood of system impacts leading to reduced regulation	Low	Low

⁶⁶ Smyth and Dumanski (1993)

⁶⁷ Sandal et al. (2008)

⁶⁸ under jurisdiction of Environment Waikato

⁶⁹ under jurisdiction of Environment Bay of Plenty

⁷⁰ Horizons Regional Council

Pillar 4: Acceptability

“Land use methods can be expected to fail, in time, if their social impact is unacceptable. The populations most directly affected by social and economic impact are not necessarily the same.”⁷¹

Key to this statement is the phrase ‘in time’; social opinion has to reach a ‘tipping point’ before any action is taken. ‘Action’ may be the introduction of rules and regulations which restrict certain practices – in other words the action may be ultimately expressed as a risk (Pillar 4). Also what is acceptable is determined by the tension arising from that fact that economic and environmental costs and benefits are not borne equally by all sectors of the population. If the urban population shared in the economic benefits of a profitable dairy industry then some people may be more likely to forgo some of the environmental consequences - there is no absolute measure of acceptability. This dynamic means that ‘acceptability’ may shift over time, an ‘unacceptable’ system may become more accepted and widespread over time, whereas a common system now may wane in terms of acceptability.

Is conventional dairy farming socially acceptable? Baskaren et al.⁷² state that the New Zealand dairy industry receives widespread public criticism of its environmental impacts and in their Canterbury based survey found that 85 % of respondents thought that dairy farming was in harmful to the environment in some way. ‘Dirty dairy’, originally a Fish and Game campaign, is still a term often used (and mis-used) in the regional and national press⁷³. This would suggest that, even if conventional dairy farming is itself currently acceptable, then there may be aspects of it which are not. However, in the media reaction in response to proposed housed dairy systems in the Mackenzie basin, the current system of dairy farming was held up, almost as a paragon of environmental virtue in comparison, despite the ‘widespread criticism of its environmental impacts’.

The reaction to the proposals in the Mackenzie Basin were confounded by several other factors and it is unlikely that a reaction of similar magnitude and heat would have been seen from similar proposals in other regions. However, it does serve as an interesting insight into the current perception of some of the NZ public toward housing of animals. Despite the high degree of ‘unnaturalness’ already in the dairy industry, from animal breeding programs to select for ‘desirable’ characteristics, artificial insemination, mechanical milking, artificial fertiliser used to boost exotic grass species etc, keeping dairy cows outdoors is perceived as natural and housing them, despite clear environmental advantages, is not.

Public pressure and perception are powerful influencers and should not be underestimated. They can break industries or force changes in standards. As an illustration of this, public pressure by citizens in member states has led to the raising of minimum standards of animal welfare, for example by the abolition of battery chicken farming in the EU in 1999⁷⁴.

Once again it is not possible to quantify acceptability in financial terms and hence our assessment is semi-qualitative (Table 4).

Table 4. A comparison of the likelihood of increasing acceptability of the two grazing systems in the next 20 years

Parameter	Typical ‘in-situ’ grazing system	‘Nil grazing’ system
Likelihood of system becoming more acceptable	Low	Medium-High
Likelihood of system becoming less acceptable	Medium-High	Medium-Low

⁷¹ Smyth and Dumanski (1993)

⁷² (2009)

⁷³ NBR (13/04/2009); ODT (19/03/2010); TVNZ (21/04/2010)

⁷⁴ The legislation passed is not due to come into effect fully until 2012

Pillar 5: Economics

"If the land uses being considered are locally not (economically) viable, the use will not survive."⁷⁵

What are the economics of the current dairy system in New Zealand? New Zealand is the world's largest exporter of dairy products, supplying about one-third of global trade. The dairy industry in New Zealand is a significant contributor to the national economy, earning NZ\$10 billion and generating 25% of export revenue for the year ending March 2008⁷⁶. The dairy sector strives to maintain international competitiveness by continued increases in productivity and intensification in the use of inputs⁷⁷.

In their economic survey recently released for 2008-9, Dairy NZ highlighted the poor returns to farmers, in part related to the weather during the season, but also residual problems from the previous year's drought, a fall in the capital value of land, decreasing milk prices and increases in other costs⁷⁸. However, despite the recent downward price trajectory, the trend of increasing milk prices is expected to continue⁷⁹, and although profitability will continue to be strongly linked to milk price, operating expenses and average cost of production per kg milksolids will be an important driver in differentiating profitability between farms. It was noted that operational efficiency can conflict with environmental considerations⁸⁰.

Exclusionary trade practices by North American and European countries, and the high proportions of exports that go to middle and low income countries, mean that the dairy sector is constrained to maintain a strategy of low-cost production⁸¹. Baskaran et al.⁸² go on to state however that the prices paid for dairy products do not reflect the external costs of depleting environmental resources or causing environmental degradation.

These views suggest that the NZ dairy industry remains globally competitive, but that the financial return to many farmers individually is highly variable, and last year hit a decade low. However, common to both is the fact that all of the environmental costs of farming are not internalized and that the industry performance is achieved partially at the expense of the environment in New Zealand. As noted previously, Sandal⁸³ reported that the presence of negative externalities may justify government intervention in the market. Pannell⁸⁴ in a policy framework of public vs private benefits, finds that where the impacts of land management are of private benefit but public cost, the recommended policy intervention tools are negative incentives e.g. polluter pays. This is a pivotal issue and one that will define the industry over the next 20 years. The DairyNZ vision of sustainable profit heavily relies on herds grazing between 12 and 18 t DM/ha⁸⁵. This range clearly represents a step up from current production, however the higher harvesting efficiency through grazing comes at the cost of individual cow performance and greater losses to the environment as harder grazing both increases the risk of soil damage and double deposition of urine patches. Therefore the vision for sustainable profit may not be sustainable in the broader sense. So the question is: "does New Zealand have to face up and accept that this industry, so important to the country's economy, will degrade the environment in order to retain its position in the global export market? Or are there ways of maintaining the low costs per unit production while improving the outlook for the resources that the industry, and the rest of us, rely on?"

What about the economics of the nil grazing system? There is little actual data available for the economics of nil grazing systems in New Zealand, although there are some extended housing systems and over wintering systems (restricted grazing) that are in operation.

⁷⁵ Smyth and Dumanski (1993)

⁷⁶ MAF (2008).

⁷⁷ Baskaran et al. (2009)

⁷⁸ Dairy NZ (2010)

⁷⁹ Glassey and Newman (undated)

⁸⁰ Glassey and Newman (undated)

⁸¹ Jay & Morad (2007), cited in Baskaran et al. (2009)

⁸² (2009)

⁸³ Sandal et al. 2008

⁸⁴ Pannell, 2008

⁸⁵ Glassey and Newman (undated)

In her economic assessment of nil and restricted grazing systems, based on an average 80 ha farm with a stocking rate of 2.5 cows/ha and a farmlet with a stocking rate of 3.3 cows/ha and at a payout of \$3.50, de Klein⁸⁶ found that nil grazing systems ranged from being marginally profitable for the higher stocked farmlet, to having a negative return on investment for the lower stocked average farm. The high cost of capital investment needed was a big factor in the poor return for nil grazing systems, as was the need for additional labour for harvesting silage, applying effluent and cleaning the shed. However, there may be economies of scale that can be achieved with larger farms and herds as well as a high degree of automation that was not considered that can cut annual labour costs considerably. In the same study de Klein found that a restricted grazing option was profitable giving an average 9-17 % return on investment⁸⁷.

In completion of his Masters thesis Mr de Wolde did a study on alternative wintering system for Southland. His economic comparison based on 2005 costs and milksolids at \$4.00/kg highlighted that, although housing had higher costs associated with it, the benefits, through additional milk production and savings in fertiliser due to improved effluent utilisation, were such that the system was potentially more profitable by \$101,000/year on an 500 cow herd.

A recently constructed operation in Morven, South Canterbury, housing for approximately 10 months, the farmer, Mr van Leeuwan, has increased milksolid production to approximately 500 kg MS for his herd of Jersey first-calvers, made the supply more consistent, cut the amount of food that the cows need to consume over winter as they are protected from the cold and wastage has been reduced, improved animal welfare through early warning sign detection by the robotic milkers, has cut artificial fertiliser to zero and is managed with 1-1.5 people for a 500 cow herd (Otago Daily Times, 2010). Many of these clearly represent significant annual operational cost savings to offset against the high capital investment needed to start

In the recent Mackenzie basin hearings, Bob Englebrecht in his reviews of the proposed cut and carry systems stated that "While there is a very significant total capital investment in the development of the cubicle barn dairy farms. The return on total farm capital (which involves land and buildings, livestock, plant and equipment, dairy company shares, and an allowance for seasonal finance) shows a satisfactory result compared with most conventional farming businesses in recent years based on a \$4.50 per kg milksolids payout."

Due to the lack of information on the economics of nil grazing the comparison will be drawn with restricted grazing systems on which there is more data.

⁸⁶ (2001)

⁸⁷ The average return on investment depended on whether an effluent distribution system was already in place on the farm.

Table 5. A comparison of profitability of in situ and restricted grazing systems

Parameter	Typical 'in-situ' grazing system	'Restricted grazing' system
Research	Wintering out costs \$116,000 ⁸⁸	9-17 % return on investment (nil grazing gave a 1 to -10 % return on investment) ⁸⁹ \$101,000 increased profit from housing stock over winter ⁹⁰
Reported	Biggest global exporter of dairy produce, earning \$10 billion in year to March 2008 ⁹¹ . In 2008-9, on farm operating profit dropped below the average for the decade, giving lowest profit margin in at least a decade. Operating return on assets decreased from 6.6 % to 1.6 % and down to -14.6 % for return on total assets ⁹² Milk prices expected to increase ⁹³	
Anecdotal		Satisfactory return on investment compared with conventional farming (extended housing) ⁹⁴ Profit increases of around \$40,000 reported for housing stock over winter in North Island ⁹⁵

⁸⁸ de Wolde (undated), wintering costs based on grazing out over winter including on brassicas fed in situ

⁸⁹ de Klein (2001) For the restricted grazing the average return on investment depended on whether an effluent distribution system was already in place on the farm. For nil grazing scenario the slightly positive return on investment was for the higher intensity farmlet returned a negative return on investment

⁹⁰ de Wolde (undated), wintering costs based on stock housed over winter

⁹¹ MAF (2008)

⁹² Dairy NZ 2008-9 economic survey – Executive Summary for owner-operators

⁹³ Glassey and Newman (undated)

⁹⁴ Englebrecht (2010) in review of economic performance of Mackenzie housing proposals

⁹⁵ Based on three case studies using Herd Homes for winter housing

Discussion and Conclusions

The collective results are summarized in Table 6, where relative positive benefits are shown green and negative effects in red.

In terms of production, both research and anecdotal data clearly show that our nil grazing system increases production and efficiency, both of feed and nutrient use, over the conventional system.

The nil-grazing system also delivers improved environmental protection over the conventional system, by eliminating the urine patch driven N leaching and minimizing fertiliser use although there is the potential for increases in gaseous emissions without good management.

For security, focusing on the risks of the production, the in-situ grazing system has already begun to 'feel' some consequences of its risky practices through increasing regulation. There is no equivalent actual scenario for the cut and carry system, however it is not unreasonable to expect that given the proportion of leaching that is driven by animal deposition, that reduced environmental impacts on soil and water would reduce the risk to the system. This assumes that indoor management is accepted in terms of animal welfare.

The current dairying system is clearly still economically viable, however, this viability is, in part, based on environmental costs being externalized; a situation that is not able to continue unchanged *ad infinitum*, and although the industry is globally competitive, returns to farmers are highly variable. For the nil grazing system, little evidence is available on the economics except for de Klein's Study in 2001, although the economic benefits for over winter and extended housing have been illustrated in several New Zealand examples, removing some of the variability of performance associated with weather, soil damage and animal health⁹⁶. However, if environmental externalities are internalized, or government regulation is justified by their continued presence⁹⁷, then the economic return for the nil grazing systems, capable of more production with lower nutrient losses, becomes more attractive.

Finally to social acceptability: the conventional dairying system receives widespread public criticism, but is currently still 'acceptable' in most parts of the country. Housing of stock is in on the increase in New Zealand whether for just used for winter management or, less commonly, extended housing. The authors are not aware that these systems have caused any degree of public outcry, and within the scientific community have been used as illustrating effective mitigation mechanisms for diffuse pollution from agriculture. However, the public and political reaction to the press coverage on the Mackenzie Basin proposals cannot be overlooked.

Table 6. A summary table illustrating relative sustainability of a nil grazing compared with an in-situ grazing system

	In situ grazing system	Nil grazing system
Productivity	Annual average range of pasture production 8-17 t DM/ha	Up to 39 % increases in pasture production and conversion to product
Protection – water	Significant contributions to degradation of lowland water quality	Up to 65 % decrease in leaching and transfers to non productive land
Protection - air	Significant contributions to New Zealand's GHG emissions	Potential reductions in nitrous oxide emissions by up to 20 % to potential increases of up to 35 % in ammonia volatilisation
Security	High likelihood of system impacts leading to more restrictive regulation	Medium to Low likelihood of system impacts leading to more restrictive regulation

⁹⁶ de Wolde (undated)

⁹⁷ Sandal et al. (2008)

Viability	Globally competitive industry, farmer returns highly variable	Increased profit associated with wintering stock. Satisfactory return on investment for restricted grazing High initial investment required
Acceptability	Medium to high likelihood of system becoming less acceptable	Medium to low likelihood of system becoming less acceptable

....and in 20 years' time

What is rather simple set of results indicates is that according to the parameters chosen, neither system is fully sustainable, but that the nil grazing is more sustainable than the in-situ grazing system. Although in reality, there are many degrees of environmental performance between these two systems, with better performing conventional dairying and restricted or winter housing filling this middle ground.

Looking forward, regulation will force better environmental performance, and a continued drive of intensification on existing land will, in our view, inevitably lead to more farmers restricting or eliminating winter grazing through housing their stock; and as more informed and rational debates occur and existing housing systems are shown to deliver benefits to the environment that people care about, the acceptability of housing stock will increase. In contrast to this view, housing of stock was not mentioned in Glassey and Newman's paper on the 'Future New Zealand Dairy Farms'⁹⁸, nor in EW's report on agricultural change and future scenarios in the Waikato⁹⁹, despite the environmental concerns being recognised, either through housing being considered and subsequently dismissed or not being considered at all.

So, while we are not presenting the fully or partially housed dairy system as '**the**' future for all of NZ's dairy industry, we believe that it is '**a**' future worth considering.

⁹⁸Glassey and Newman (undated)

⁹⁹ Environment Waikato (2009)

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