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The true cost of milk: Environmental deterioration Vs. profit in the New Zealand dairy industry.

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The true cost of milk: Environmental deterioration Vs. profit in the New Zealand dairy industry.

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SUMMARY

Over the past two decades, major increases in production have occurred in the New Zealand dairy industry. This has required the use of externally sourced inputs, particularly fertiliser, feed supplements, and irrigation. Contemporary New Zealand dairy farming practice incurs environmental externalities: impacts that are not paid for by the dairy farmer. Hence, the public is left to deal with these externalities, both regarding the economic responsibility and environmental degradation. This study estimated that the economic cost of environmental externalities is higher than the 2012 dairy export revenue of $11.6 billion.

Key words: New Zealand dairy farming, intensification, externalities, environmental impacts

INTRODUCTION

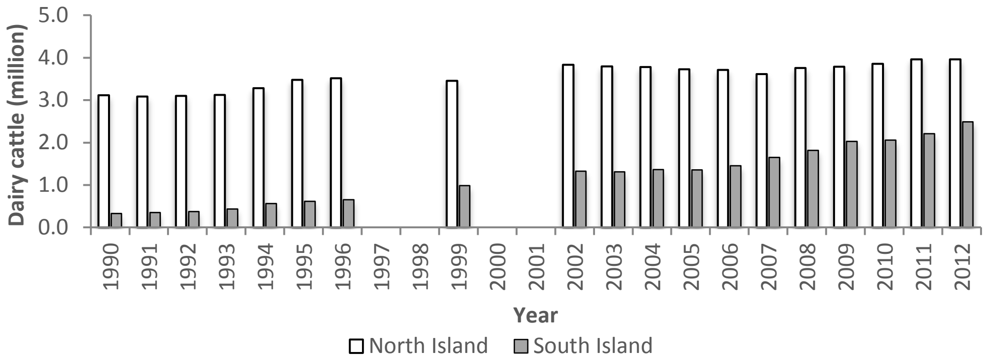
Dairy farming in New Zealand has intensified and expanded, particularly in the past two decades. Meanwhile, production declines have occurred in other agricultural sectors, such as sheep and beef farming. Intensification describes the process that increases outputs per unit area (MacLeod & Moller, 2006). In dairying, intensification has increased the need for external inputs, which have enabled higher stocking rates and the increase of productivity.

Intensification inevitably results in increased environmental effects and externalities. Externalities generally affect the utility or wellbeing of a third party (the public) and are uncompensated by the producer of the effect (Hackett, 1998; Perman et al., 1996; Turner et al., 1994). Thus, the community is left to deal with the costs of the effects (Turner et al., 1994), whether these involve, for example, the cost of cleaning up pollution or the cost of having a degraded environment. Costs are in the form of government remediation funded by public taxes (Abell et al., 2011), or public health costs associated with an unhealthy environment or contamination, among many others. New Zealand is not exempt from this process and the dairy industry is a classic example of externalisation. The dairy industry does not pay for all its environmental pollution and the growth of dairy farming has occurred with little balanced economic evaluation and awareness of the full environmental impacts and costs.

DAIRY PRODUCTION TRENDS

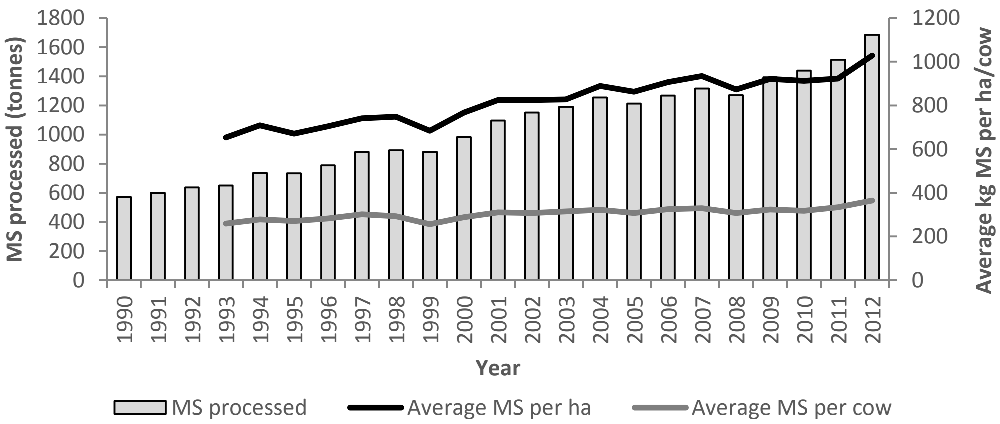
Primary production is New Zealand's main export earner; dairy products contributed to 25% of New Zealand's export revenue in 2012, rising from 13% in 1990, and increased in value by 460% over this time (Statistics New Zealand, 2012). Land in dairying increased by 46% from 1993 to 2012 while dairy cattle numbers almost doubled from 1990 to 2012, from 3.4 million to nearly 6.5 million (Figure 1) (Statistics New Zealand, 2012). During this period, the number of dairy herds decreased by 180%, while the average herd size expanded by 147%. Between 1990 and 2012, milksolids (MS) production increased by 195% from 572 tonnes to 1685 tonnes (Figure 2) (LIC & DairyNZ, 2012). MS production per cow and per hectare increased 40% and 60% respectively between 1993 and 2012 (LIC & DairyNZ, 2012).

Figure 1: Total dairy cattle (including Bobby Calves) in the North and South Islands between 1990 and 2012.



Data source: Statistics New Zealand (2012). Notes: No agricultural production survey relating to dairy was conducted in 1997, 1998, 2000 or 2001.

Figure 2: Total milksolids (MS) produced (left axis) and average kg MS produced per hectare (black line) and per cow (grey line) (right axis) in New Zealand.



Data source: Statistics New Zealand (2012).

DAIRY INPUT TRENDS

Major imported products used for dairy farming that can be traced are palm kernel expeller (as a feed supplement) and fertilisers. Imported products carry their own environmental implications but were not considered in this study.

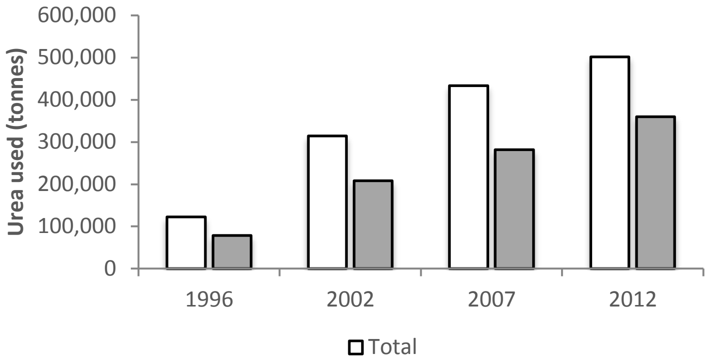
Fertilisers

More nutrients are needed as farming is intensified in varying amounts depending on soil type, crop species (Statistics New Zealand, 2006), and nutrient loss – both from the soil and in agricultural products. Fertilisers commonly used in New Zealand include lime; phosphatic (P) fertilisers such as Superphosphate; nitrogenous (N) fertilisers such as urea and ammonium sulphate; potassic (K) fertilisers; and compound fertilisers containing more than one nutrient, for example, di-ammonium phosphate (DAP). The cost of imported fertilisers for dairy farming was estimated using the proportion of fertiliser used on dairy farms, totalling about $503 million in 2012.

Nitrogen fertiliser

Significant sources of nitrogen applied to dairy farms include nitrogen fertilisers, dung and urine from grazing animals, and farm dairy effluent discharges (Davies-Colley et al., 2003). Urea is the main nitrogen fertiliser used, made from natural gas (produces greenhouse gas (GHG) emissions). Urea use in New Zealand has increased dramatically since the 1980s and dairy used 72% of urea in 2012 (Statistics New Zealand, 2013a). Between 1996 and 2012, urea use for dairying increased by 360% (Figure 3) (Statistics New Zealand, 1998, 2013a). Two-thirds of urea is imported into New Zealand.

Figure 3: Tonnes of urea fertiliser used in New Zealand on all farms and on just dairy farms.

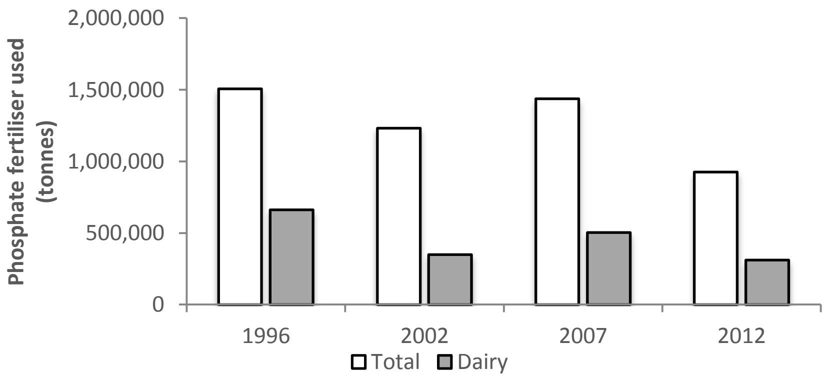


Data source: Statistics New Zealand (1998, 2002, 2007, 2013a). Notes: Data for urea use on dairy farms was only available for years shown.

Phosphorus fertiliser

Global demand for phosphorus is heavily increasing as fertilisers are being excessively used (Rosemarin et al., 2009), primarily for industrialised agriculture (Ashley et al., 2011). Islands, such as Nauru and Christmas Island were a major source of phosphorus before resources become depleted (Pearce, 2011); now phosphate rock is a major source. Phosphate rock is a non-renewable resource that takes 10-15 million years to cycle naturally (Cordell et al., 2009), and there is no synthetic alternative for phosphorus. In 2012, 34% of superphosphate was used on dairy farms (Figure 4) (Statistics New Zealand, 2013a).

Figure 4: Tonnes of phosphate fertiliser used in New Zealand on all farms and on just dairy farms in 1996, 2002, 2007 and 2012.

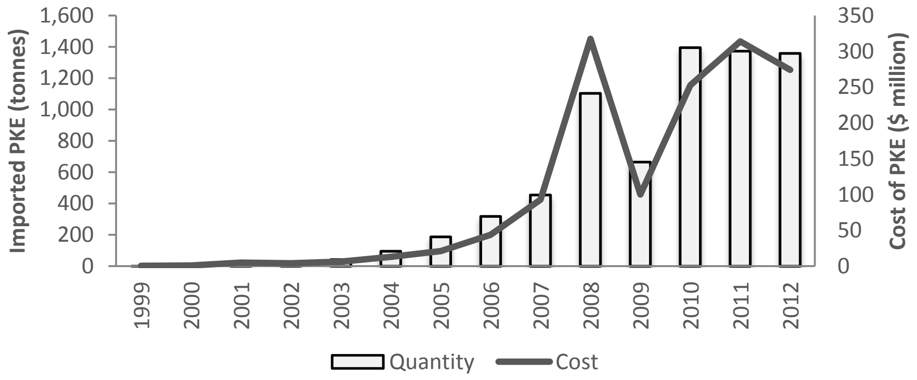


Data source: Statistics New Zealand (1998, 2002, 2007, 2013a). Notes: It is expected that most phosphate use is superphosphate but data is categorised differently between years. In 2012, only estimates on superphosphate use were available.

Feed supplements

Intensification also requires imported feed supplements which are now used by about 85% to 90% of dairy farms (DairyNZ, 2013) with the purpose of grazing cows off the milking area and/or extending lactation periods and increasing stocking rates. A particularly important feed supplement is palm kernel expeller (PKE), a product left after oil extraction from the palm seeds of oil palm. The production of palm oil generates other environmental impacts off farm, including deforestation, biodiversity loss, and GHG emissions. New Zealand is the largest global importer of PKE and imported 30% of the total global trade in 2012 (Index Mundi, 2012), all used for dairy feed. Imports of PKE into New Zealand began in 1992 with 15 tonnes. Since then imports increased substantially to nearly 1.4 million tonnes in 2012 (Figure 5) (Statistics New Zealand, 2013b). In 2012, $274 million was spent on PKE imports into New Zealand (Figure 5) (Statistics New Zealand, 2013b).

Figure 5: Quantity and cost of palm kernel expeller (PKE) imports into New Zealand from 1999 to 2012.



Data source: Statistics New Zealand (2013b)

COST OF DEBT

Dairy farming has required large bank loans to pay for the increasing price of land and cost of production. In 2012, New Zealand's agricultural debt was $47 billion, of which about 65% ($30 billion) was for dairy farming (Reserve Bank of New Zealand, 2013). An estimated $3 billion of interest was paid on dairy loans in 2012.

ENVIRONMENTAL IMPACTS

Evidence shows that agricultural intensification has contributed to environmental deterioration. For example, 96% of rivers in pastoral catchments are too polluted to swim in (Larned et al., 2004); 32% of lakes with the poorest water quality are in pastoral catchments (Verburg et al., 2010); soil resources are deteriorating; and agricultural GHG emissions are increasing (Ministry for the Environment, 2012). Costly and challenging remediation solutions are often needed because pollution is not reduced at the source. Impacts damage New Zealand's 'clean green' image, threaten future food production, and lead to biodiversity loss and degradation of recreational areas.

Freshwater ecosystem impacts

Water quality in New Zealand is on a declining trend, driven by agricultural intensification (Ballantine & Davies-Colley, 2009; Cullen et al., 2006; Larned et al., 2004; Ministry for the Environment, 2009; Parliamentary Commissioner for the Environment, 2004).

Approximately 40% of both streams and lakes are in catchments that have been modified by agriculture or where pasture is the predominant land cover (Ministry for the Environment, 2007a). Rivers and streams in agricultural or urban catchments generally have poorer water quality than those with little or no farming and urban development (Larned et al., 2005; Ledgard et al., 1996; Ministry for the Environment, 2007a; Rodda et al., 1999). Particularly, dairying has been responsible for some of the poorest water quality in rural areas (Davies-Colley & Nagels, 2002; Ministry for the Environment, 2009; Perrie et al., 2012). Intensive dairying practices that eventually impact freshwater include: freshwater demand, increased stocking rates, fertiliser application, vegetation removal, and wetland drainage. These processes have consequences on freshwater arising from: faecal contamination; nutrient pollution; and sedimentation (Ledgard et al., 1996; Willis, 2001).

In the Upper Manawatu Catchment, dairy farms contribute around half of the nutrient load from approximately 17% of the catchment (Dewes, 2012). In the Waikato region, dairying is responsible for 68% of the nitrogen and 42% of phosphorus entering waterways from 22% of the land area (Environment Waikato, 2008). Estimates of nitrogen leaching from dairy farms have ranged from 12-200 kg N/ha/yr, depending on soil type, fertiliser application, supplementary feed given, stocking rate and irrigation. OVERSEER (a nutrient budget computer model) estimated average N leaching on dairy land of 28 kg N/ha/yr, while the New Zealand average from agricultural land (including dairy) was 8 kg N/ha/yr (Ledgard et al., 2000). Livestock urine is the largest source of nitrogen leaching from dairy farms, accounting for as much as 90% of total N leaching (Davies-Colley et al., 2003; de Klein & Ledgard, 2001; Environment Waikato, 2008; Ledgard et al., 2009; Longhurst & Smeaton, 2008; Menneer et al., 2004).

Human health impacts

The presence of faecal matter in freshwater can be revealed by measuring faecal indicators, such as faecal coliforms and *Escherichia coli* (*E.coli*) (Davies-Colley et al., 2003). *E.coli* concentrations frequently exceed guidelines for contact recreation in pastoral catchments and are typically between two and 20 times higher than those in forested catchments (Davies-Colley et al., 2004; Larned et al., 2004). Larned et al. (2004) found that *E.coli* guidelines for contact recreation were exceeded at 96% of 259 pastoral sites from 1998-2000. One dairy cow is estimated to excrete faecal bacteria equivalent to between 14 (Environment Waikato, 2008) and 33 people (Fleming & Ford, 2001), representing concentrations equivalent to over 90 million and up to 215 million people from the total dairy cattle population.

Water contaminated with faecal pathogens affects recreational uses, drinking water quality (Davies-Colley et al., 2003; Ministry for the Environment, 2009; Parliamentary Commissioner for the Environment, 2004) and shellfish (Collins et al., 2007; Donnison & Ross, 1999). Contaminated water can also affect livestock, causing reduced growth, morbidity, or mortality (Smith et al., 1993). Common human health effects from contaminated water include gastro-intestinal diseases (GID); estimates of endemic waterborne GID are around 18,000 and 34,000 cases per annum, although this is predicted to be an under-estimate (Ball, 2006).

Elevated nitrate (NO_3) levels are found in many shallow groundwater aquifers (down to 60 metres), especially in high stocking areas and below dairy land (Ministry for the Environment, 2007b; Parliamentary Commissioner for the Environment, 2004). The Ministry of Health's (MoH) Maximum Acceptable Value (MAV) for nitrate in drinking water is 50 mg/L nitrate (Ministry of Health, 2008), equivalent to 11.3 mg/litre nitrogen as nitrate-N (Cassells & Meister, 2000; Ford & Taylor, 2006). In 2008, around 30% of groundwater sites under dairy land in Waikato did not meet the MoH drinking water guidelines, compared with only 5% from drystock farms and urban wells (Environment Waikato, 2008). Likewise, groundwater testing in the 1980s on Taranaki dairy farms showed that over 40% exceeded nitrate drinking water standards (Ledgard et al., 1996). Testing in Canterbury groundwater wells in 2012 showed 11% of tested wells did not meet the MAV for drinking (Environment Canterbury, 2013b), up from 7% in 2011 (Environment Canterbury, 2013a). Elevated nitrate levels in groundwater are an issue because about 40% of New Zealand's population relies on groundwater for drinking (Rajanayaka et al., 2010). Elevated nitrogen ingestion can lead to certain types of cancers and has been linked with blood disease in infants, known as the blue baby syndrome (Ministry for the Environment, 2007a; Parliamentary Commissioner for the Environment, 2004).

Ecosystem impacts

Ecological effects in surface water have been shown to occur at nitrate levels lower than 1 mg/L, much lower than drinking water levels (Davies-Colley, 2000). Excessive levels of nitrogen and phosphorus increase plant growth, and can cause algal blooms and an over-abundance of aquatic weeds, leading to eutrophication (enhanced phytoplankton growth) (Marsh, 2012; Ministry for the Environment, 2007a; Smith et al., 1993; Tilman, 1999). Eutrophication causes highly fluctuating oxygen levels in water (harmful and deadly for fish) as well as poor water clarity, rending water bodies unsuitable for swimming and degrading aesthetics (Smith et al., 1993). An additional problem is the time it takes between nutrients being applied to the land and reaching water (lag time). This can cause difficulties in predicting nutrient inputs to freshwater, hindering the success of nutrient management programmes.

Impacts on land/soil

Intensification of dairy farming has direct impacts on soil with associated impacts on production, thus affecting potential future land uses. Fertilisers and other agricultural chemicals applied to dairy land often contain heavy metals that can reach high levels in soil, risking the potential to export produce and grow certain crops. Overstocking cows and using heavy machinery can lead to soil compaction, which may limit production and increase runoff. Organic matter, fertility, acidity and physical condition are often used to determine soil quality. Sampling in the Waikato region in 2009 revealed over 80% of dairy pasture sites not meeting at least one soil quality target, and over 30% failing to meet two or more targets (Taylor, 2011).

Compaction

When soil cannot support the weight forced upon it, compaction will occur (Ledgard et al., 1996). Compaction intensifies when soils are wetter, at higher stocking rates, and when animals are grazed during long winter rotations (Ledgard et al., 1996; Mackay, 2008; Pande, 2002; Russell et al., 2001; Sparling & Schipper, 2004). Compaction is measured by soil macroporosity. On half the dairying sites they tested In New Zealand, Sparling and Schipper (2004) found a macroporosity of less than 10%: rates at which pasture production can be adversely affected. Likewise, the Ministry of the Environment (2011) reported that 53% of dairy sites failed to meet macroporosity targets, while Taylor (2011) reported 37% of tested dairy sites failed macroporosity targets in 2009, decreasing from 70% in 2003.

Heavy metal contamination

Many sources of phosphate rock (used in phosphate fertiliser) contain high levels of cadmium (Cd). Samples show that Cd levels in New Zealand's soils are increasing, posing a risk for food products grown on soils with elevated levels (Cadmium Working Group, 2008).

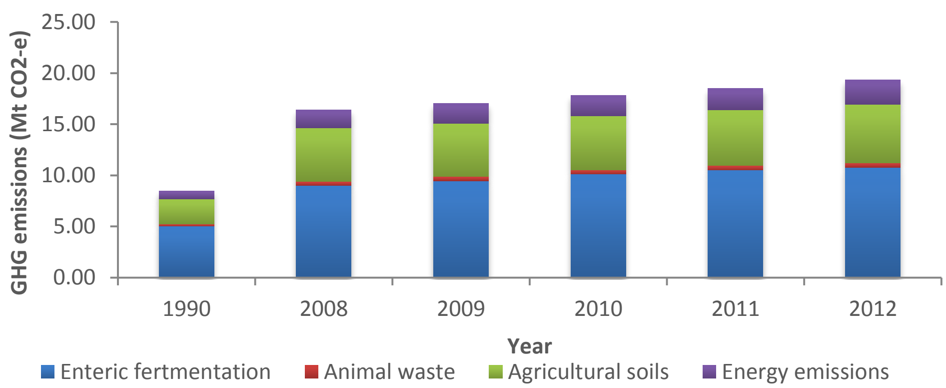
There are currently no national-level standards for the permissible amount of Cd in agricultural or residential soils. A guideline for agricultural soils is 1 mg/kg soil cadmium, but this is not legally binding (Cadmium Working Group, 2008).

In the five years from 2001-2005, approximately 150 tonnes (30 tonnes annually) of Cd was added to agricultural soils by phosphate fertiliser (Cadmium Working Group, 2008). Half of the Cd added to soils in the Waikato region is applied to dairy land, covering 25% of the region. Kim (2005) estimated that 11% of Waikato pastoral soils exceeded the recommended guideline of 1 mg/kg, all on dairy land covering approximately 157,000 ha. If accumulation continued at these rates, all Waikato dairy land would reach guideline levels by 2021. Dairy sites in the Waikato not meeting Cd guidelines increased from 2007 to 2009 from 13% to 19%, respectively (Taylor, 2011). Dairying land had the highest national average Cd concentrations (0.73 mg/kg) and the highest level measured of 2.52 mg/kg (Taylor et al., 2007).

Greenhouse gas emissions

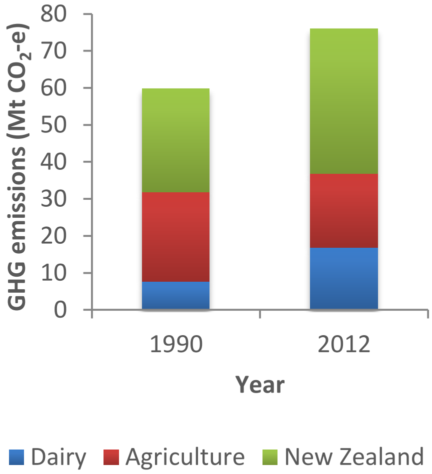
New Zealand's per-capita GHG emissions in 2012, at 18.72 tonnes carbon dioxide equivalents (CO_2-e)[1] per person, were 24th highest in the world and 5th in the OECD (World Resource Institute, 2013). Almost half of New Zealand's GHG emissions are derived from agriculture and about a quarter from dairy farming. Dairy emissions have more than doubled from 1990 to 2012 (Figure 6). Using energy coefficients from previous studies (Saunders & Barber, 2007; Wells, 2001), energy related emissions attributed to farm inputs and production were estimated between 2.1 and 2.4 Mt CO_2 in 2012. In 1990, emissions from enteric fermentation from dairy cattle were 5.03 Mt CO_2-e (23% of the total agricultural enteric emissions), increasing to 10.77 Mt CO_2-e in 2012 (44% of the total). Methane emissions from dairy manure totalled 56% of agricultural manure methane emissions in 2012 (Ministry of Agriculture and Forestry, 2010). Nitrous oxide from agricultural soils includes N_2O emissions derived from animal nitrogen outputs (excreted urine and dung), synthetic nitrogen fertiliser use, and crop residues. Fertiliser emissions have not previously been calculated by land use but a rough estimate was taken for the proportion of urea fertiliser dairy uses (65% in 1990 and 72% from 2008-2012). The estimated total animal and soil emissions from dairy farming in 2012 were 16.96 Mt CO_2-e (46% of total agricultural emissions) and 19.31 Mt CO^2-e including energy emissions (Figure 6). Total dairy, agricultural and New Zealand's emissions are shown in Figure 7.

Figure 6: Total estimated GHG emissions from dairy farms in 1990 and 2008-2012 from different sources.



[1] CO_2-e = carbon dioxide equivalent is used to compare emissions from various GHG based on their global warming potential in the equivalent concentration of carbon dioxide.

Figure 7: Total GHG emissions from dairy farming, all of agriculture and New Zealand in 1990 and 2012.



Notes: Dairy emissions exclude energy emission estimates

VALUATION OF IMPACTS

The costs of some mitigation options to reduce impacts associated with dairy farming have only been occasionally evaluated. Thus, many of the impacts remain un-valued (or under-valued). Despite a lack of impact valuation assessments and knowledge regarding effects, intensification continues. Costs are involved in: remedying impacts, environmental degradation, and legitimising environmental externalities that are largely publically subsidised. Collectively, more cost-effective solutions may involve management practices to minimise the impacts in the first place, rather than paying for clean-up projects. Only a small proportion of the costs have been valued thus far. However, even preliminary investigation reveals an indication of the costly remediation practices.

Removing nitrate from water

Leaching of one kg of nitrate N (NO_3N) from soil will contaminate about 88.5 m^3 of water (88,496 litres) from 0 mg NO_3N/L to 11.3 mg NO_3N/L[2]: the MAV (Maximum Allowable Value) for drinking water standards. Dairy leaching rates were used to estimate the volume of water that dairy farms may contaminate from zero concentrations. To reduce nitrate concentrations by 85 to 95% in water costs at a minimum between \$0.30 and \$1.80 per 1000 litres (Jensen et al., 2012); however, costs vary considerably and can be much higher.

Using the average dairy leaching rate of 28 kg N/ha/yr, the volume of water estimated to reach nitrate levels for drinking water standards (from zero nitrate levels) from dairying land (2.4 million ha) is 5,947 Mm^3. Removal of this nitrate is estimated to cost between \$1.78 and \$10.7 billion. In reality, all of the contaminated water would not be used for drinking. Nevertheless, it represents a degraded natural resource and an externality. Additionally, estimates of nitrate contamination are based on water initially containing no nitrate; however, many groundwater reservoirs presently contain nitrate with some areas exceeding drinking water standards.

[2] Based on the following calculations: 1 kg NO_3N = 1,000,000 mg NO_3N; 1,000,000/11.3 = 88496 L = 88.5 m^3.

Lake remediation

A range of actions have been implemented to reduce nutrient loads in the Rotorua Lakes. Costs for the removal of nitrogen from the Lakes range from $14,000/tonne N (Hamill et al., 2010) to $4 million/tonne N and around $250,000/tonne P (Ford-Robertson, 2013a, 2013b), depending on the removal method. On-farm reduction of nutrients may be cheaper than removing nutrients once they reach wider ecosystems. For example, cutting N fertiliser on 6 dairy farms in the Rotorua catchment was estimated to reduce returns by $46 to $428/ha/yr and the average loss in gross revenue per ha was $173 (Ledgard et al., 2010). The average reduction in N leaching over the 6 six farms was 26 kg N/ha/yr (Ledgard et al., 2010), yielding a reduction in gross margin of $6.62/kg N or $6620/tonne N. Thus, removing nitrogen from lakes was 2-600 times as costly.

Value of water for irrigation

Assessments on an accurate value of water are difficult as water does not have a fixed price. Furthermore, the volume of water that dairy farms use is unknown. A rough estimate of water use could substitute the proportion of irrigated dairy land area as the proportion of water use. Of the area equipped with irrigation, dairy accounted for 49% in 2012 (Statistics New Zealand, 2013a) and in 2010, 5791.2 million m^3 was allocated for irrigation (Rajanayaka et al., 2010); thus, approximately 2802.9 million m^3 per year may be used for dairying. Water has been priced for the proposed Ruataniwha water storage and irrigation scheme at $0.23/$m^3$ (Hawke's Bay Regional Investment Company, 2014). Using this water price, estimated water used for dairy nationally is valued at $644.7 million per year. Although this price may not be representative of water prices in many catchments, it represents another externality of dairy farming.

Costs of compaction

Compaction damage costs can be significant. Thorrold (2000) reviewed the costs of pasture damage on a typical Southland farm growing 12000 kg DM/ha and milking 2.5 cows/ha. A 10% decrease in yield was modelled. Remediation costs will depend on whether the feed is replaced or if production is reduced and range between $84 and $480 per ha. Compaction has been estimated to occur on 37% (Taylor, 2011) to 53% (Ministry for the Environment, 2011) of dairy land. National costs have been estimated at $75 million to over $600 million on dairy land (Table 1).

Table 1: Cost of compaction damage for effected national dairy farming area

Action	Cost ($million)	
	37% effected	53% effected
Replacing feed	$75 - $160	$107 - $229
Reduced production	$256 - $426	$366 - $611

Cost of GHG emissions

If polluters had to pay for their GHG emissions based on a carbon price, the dairy industry would have to pay for 19.31 Mt CO_2-e for on-farm emissions. Recently, the carbon price was very low so the cost would be relatively small ($12.7 million); however, at a price of $25/tonne CO_2-e (previous carbon price) the cost would increase to $483 million (Table 2). Furthermore, potential future prices may increase substantially, generating a cost of almost $2 billion. A range of prices were used to show the annual cost variability for current emissions and to predict possible future scenarios.

Table 2: Potential cost of dairy farming emissions with different carbon prices

Carbon price (NZ$ per tonne CO_2-e)	Cost for on-farm dairy emissions (2012)
$0.09 – March 2013	$1.74 million
$0.66 – May 2013	$12.74 million
$1.00	$19.31 million
$15.00	$289 million
$25.00	$483 million
$50.00	$966 million
$100.00 – Future price?	$1.93 billion

Notes: Future carbon prices are expected to be costly in the 2020s, rising from $50/t to $140/t (Terry, 2012).

Clean green image

Initially used for tourism marketing, New Zealand's 'clean green' image is now fundamental to many of New Zealand's export industries. A study on the value of this image found surveyed international consumers would purchase 54% less dairy products if New Zealand's environment was perceived as being degraded (Ministry for the Environment, 2001). Due to this, the loss in revenue of dairy products was estimated at between $241 and $569 million (Ministry for the Environment, 2001). Other sectors could also be affected.

Summary of environmental costs from dairy

Costs involved in mitigating or remedying impacts on a lower and upper scale have been estimated between $2.76 and almost $14.5 billion nationally (Table 3). Adding the cost of imported fertilisers and PKE, and interest debt payments increases costs to between $6.53 and $18.23 billion. Costs were detracted from the 2012 dairy export revenue. This resulted in the value of dairy as being between $5.10 billion and a loss of $6.60 billion. Thus, this analysis reveals that it is likely that the environmental externalities from dairy farming exceed dairy's export revenue. This is not a present cost to the dairy industry, but a valuation of some of the externalities produced from dairy farming. Nevertheless, it should be questioned whether dairy is beneficial for the country, economically, environmentally and socially, given the many costs and impacts that have not been measured.

Table 3: Summary of costs from dairy farming impacts.

Measure	Scale of measure	Cost ($ million)	
		Lower	Upper[1]
Removing nitrate from drinking water	National water surpassing nitrate drinking water standards from dairy leaching annually	1784	10705
Value of water	Value of water for annual dairy irrigation	644.7	644.7
Cost of compaction	National dairy land affected by compaction	75	611
GHG emissions	Potential annual carbon cost of dairy GHG emissions $0.66 - $100	12.7	1930
Clean green image	Loss of annual value for dairy products if image was degraded	241	569
	National subtotal	**2757.4**	**14459.7**

Notes: [1]The minimum upper limit is the upper value for which value assessments were undertaken. It is still regarded as conservative considering the valuations that were not included. Other benefits that are not included with the revenue include jobs and contributions to other sectors.

CONCLUSION

Although detailed cost assessments have not been carried out for management techniques aimed to reduce dairy farming impacts, from preliminary investigation (and from evidence in other studies), it is likely the cost to clean up effects will be far more than the costs of not polluting in the first place. Although many costs and benefits were omitted, this analysis highlights the urgent need for more research to assess the true value. Independent reviews of the dairy industry are required, involving cost/benefit analyses on all aspects of the industry. If this is not done, costs could escalate to unaffordable rates, if they aren't already.

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