SUSTAINABLE DAIRY FARMING – EUTROPHICATION AND GREENHOUSE GAS MITIGATION

Introduction

Sustainability of economic activity is of mounting concern throughout the world. As knowledge of the various ways business can affect natural systems increases, greater demand is made of producers to ensure sustainability of their business. These demands must be balanced by producers against their own financial sustainability.

The definition of a sustainable business practice can vary across industries, although is generally expressed as practices that meets present needs without compromising the future functioning of ecosystems and the quality of human life (Van Calker et al, 2005). The Australian Federal Government has described sustainability in agriculture as

> *"the use of farming practices and systems which maintain or enhance*
> - *The economic viability of agricultural production*
> - *The natural resource base (including air, soil, water, plants and animals*
> - *Other ecosystems that are influenced by agricultural activities."*

Given the significance and extensiveness of dairy farming activities in Victoria, particularly the writer's local Glenelg Hopkins Catchment area in south west Victoria, this article aims to analyse areas of sustainability concern and possible solutions in this part of the agriculture sector, although much of the discussion may be applicable to herd farming more generally.

Sustainable dairy farming

Dairy farming requires the management of feed for cattle (whether by land grazing or by feed import), management of waste from the animals and from the milking activities, and management of energy input into the dairying process (Van Calker et al, 2005). These dairying issues can result in separate but interrelated problems such as:

1. dryland salinity through land clearing and grazing practices (GHCMA, undated b; GHCMA, undated c);
2. soil acidity from fertiliser input and build-up of organic matter (GHCMA, undated a; DAFF, 2013);
3. erosion due to loss of vegetative cover (DAFF, 2013);
4. eutrophication and water quality degradation from leaching of nutrients into waterways (DPI, 2009; DPI, 2008); and
5. emissions of greenhouse gases (Koneswaran & Nierenberg, 2008).

Given the breadth of the problems and possible solutions, this paper will focus on sustainability efforts relating to eutrophication and greenhouse gas emissions, although in many respects efforts in these two areas have flow-on effects to the other issues identified.

Eutrophication and water quality

Causes for concern

Deficiencies in management of animal effluent such as manure and urine and the use of nitrogen fertiliser to increase the productivity of feeding paddocks have potentially deleterious effects on life in connected waterways, resulting in such impacts as eutrophication (Monaghan et al, 2008; Bartley et al, 2010a), leaching into drinking water and evaporation to contribute to acid rain (Reinhard et al, 1999). As a result of such concerns, legislation requires farmers to contain and manage effluent to ensure it does not pollute waterways or pass onto neighbouring land (DPI, 2009; DPI, 2008).

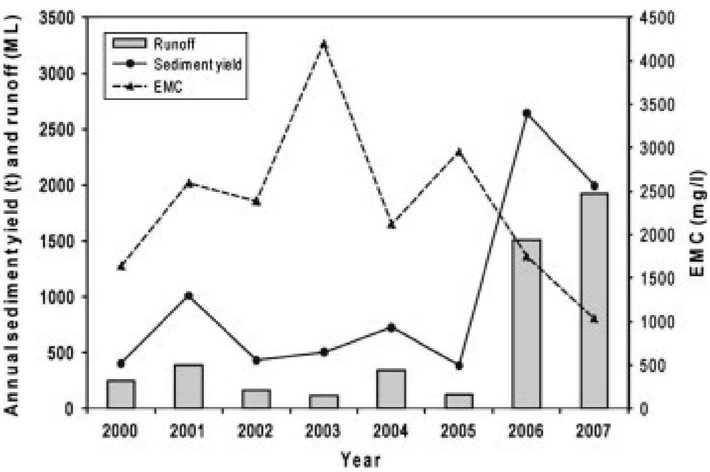
Given the intensification of dairy farming seen as being a requirement to maintain financial viability of dairy businesses (Smith et al, 2013), managing increasing nitrogen inputs (whether from fertiliser or effluent) to maintain pastures to feed more cattle, and the increased production of effluent, avoiding the degradation of waterways are considered unwanted extra costs.

Potential mitigation measures to ensure sustainability

Efforts to find a sustainable solution to this problem have focused on the maintenance of groundcover on farms and the on farm reuse of effluent in place of importing nitrogen fertiliser, thereby reducing the costs of production and meeting the required environmental standards. Such efforts enhance the aims of sustainability as defined above.

Efforts in the Glenelg Hopkins catchment to monitor ground cover has increased to approximately 96% of all private farm holdings (DAFF, 2013). Maintaining ground cover reduces the exposure of the soil to water and wind, with the particular anticipated effect that the soil will hold more water and reduce run-off into nearby waterways, trapping excess sediments and nutrients (Bartley et al, 2010a). Bartley et al (2010a) analysed ground cover in a number of nearby commercial farms in a particular region and measured the relationship between the amount of cover and the amount of water run-off. The study found some success with reduced run off early in the wet season corresponding to increased cover, but longer term studies and greater coverage retention on lower slopes were needed before significant improvements would be seen in total water run off rates.

Figure 1. Runoff, sediment yield and annual event mean concentration (EMC) over the 8 year study conducted by Bartley et al (2010b)



Interestingly, in a related article by the same lead author (Bartley et al, 2010b) increased ground cover resulted in a statistically significant decrease in the amount of sediment that entered the waterway in the course of the same 5 year study. Again, the lower slopes were contributed the most sediment due to the largely sodic nature of those soils due to heavy grazing in those areas, while the upper slopes were less heavily grazed and therefore had stronger plant growth and greater water holding and nutrient holding capacity. The conclusion of the study was that targeted re-vegetation of the lower slopes leading to waterways are likely to result in significant decreases in sediment and nutrient yields reaching waterways.

This study may not in itself provide hope for farmers, seeming as it does to recommend using less land for their farming activities. However, a different method of pasturing livestock could assist. Tim Flannery mentioned the multi paddock grazing method in a 2008 Quarterly Essay (Flannery, 2008), whereby instead of allowing the herd to graze a large area of land, choosing its preferred grasses and leaving the remainder and thereby resulting in large bare patches, the farmer would divide the paddock into small allotments and forcing the herd to eat all the grass in the allotment over a short period of time and then moving them to the next allotment. This would result in the ground being turned into a “bare, dung-filled mess”, but importantly would result in the plants regrowing in nutrient rich soils with greater recovery periods.

A problem with this method would be the reduced ability of the plants to regrow from such devastation and the problem of large amounts of effluent possibly being washed away into waterways, against our stated aims. However, such a program can reduce the grazing on lower slopes as suggested by Bartley et al (2010b).

Further, another study into such a grazing method (Teague et al, 2011) found this method, if managed so that biomass on the land was not degraded to devastatingly low levels from which it could not recover, resulted in greater control of grazing areas including reducing grazing on areas needing greater conservation and greater ground cover retention and soil productivity generally. Such improvements, if focused on areas suggested by Bartley et al (2010b) could realise the improved water and nutrient retention.

The greater foliage retention has a second benefit in the increased uptake of nitrogen. Effluent must either be applied directly to the paddocks or stored for later use, usually in effluent ponds. A recurring problem with the use of effluent for fertilising paddocks is that excess application is usually washed away into waterways, requiring farmers to underutilise it (Reinhard et al, 1999) and ensure removal of excess excrement in paddocks (Smith et al, 2013).

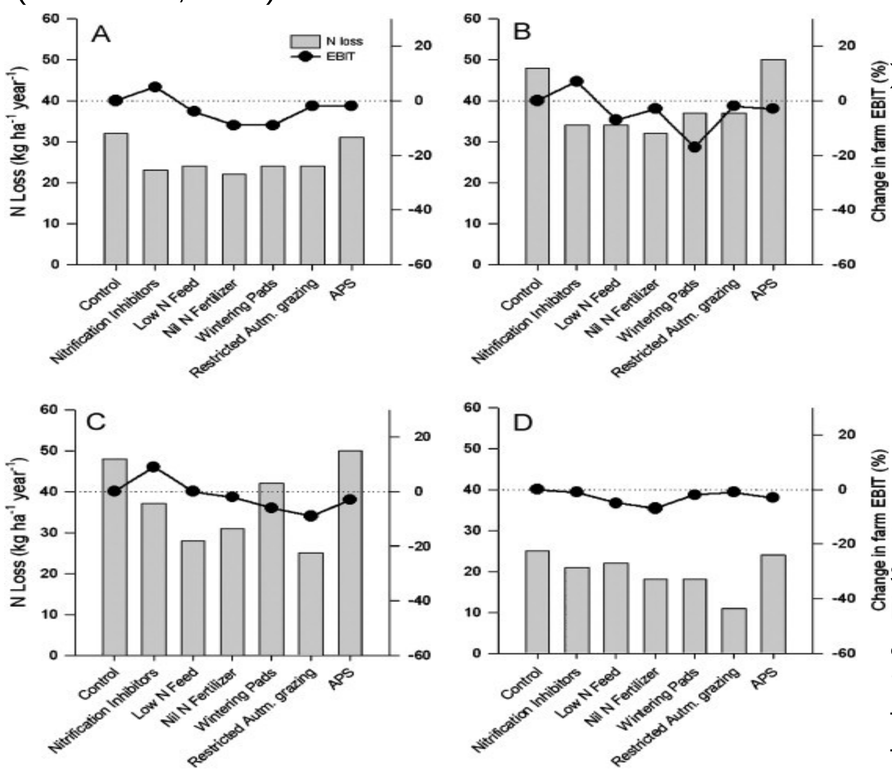


Figure 2. Reduction of nitrogen loss through various methods on four dairy farms and the resultant change in farm earnings before interest and tax, demonstrating effectiveness of nitrogen control and inhibition and such improvements are feasible for the financial viability of the farm. (Monaghan et al, 2008)

However, such recycling of nutrients is beneficial to sustainability, compared to importing nitrogen fertiliser, and can produce extra pasture growth equivalent to that obtained by purchased fertiliser (Roach et al, 2001), also resulting in financial savings. Studies in New Zealand regarding managed use of effluent found that overland flow was a major contributor to nitrogen loss of waterways (Monaghan et al, 2008) but that if the amount of effluent to be applied directly to the land was correct, as little as 2 to 20% of the nitrogen would be leached. Therefore, improving ground cover allows greater effluent application to the land without greater nitrogen leaching and some financial saving (see Figure 2).

Grouping these differing approaches to land management, from methods to decrease the intensity of land use in specific areas, the resultant control over particular problem grazing areas and increased resting and recovery time for grazed lands, flowing on to increased nitrogen uptake and therefore greater effluent reuse capacity of the land, appears to be a viable solution to reducing waterway pollution from dairy farming, greater on-site feed being produced and financial saving in the form of reduced feed and fertiliser needs.

Greenhouse gas emission

Causes for concern

The global warming footprint of agriculture worldwide is estimated to contribute approximately 18% of annual anthropogenic greenhouse gas emissions (Piteski et al, 2009), and increasingly is the focus of sustainability improvements (Koneswaran & Nierenberg, 2008). Sources of greenhouse gas emissions from farming vary widely from land clearing, soil and plant degradation, manure and its storage and use, chemical fertilisers and feed digestion (Piteski et al, 2009).

Potential mitigation measures to ensure sustainability

Some of the improvements listed above will assist in the reduction of dairy based greenhouse gas emissions as they will with eutrophication. For example, monitoring and improving ground cover has the added benefit of increasing soil carbon - increased photosynthesis removes more carbon dioxide to be stored in the plants and the soil (DAFF, 2013), and the use multi-paddock grazing improves ground cover, assisting sustainability in this area (Teague et al, 2011; Flannery, 2008).

The study of Monaghan et al (2008) discussed in the preceding section also looked at the effects of nitrogen leaching mitigation strategies and related greenhouse gas emissions. The farms in the study that used no nitrogen fertiliser eliminated greenhouse gases from the production and transport of the fertiliser to the farm, a change that resulted in greenhouse gas emission reductions of between 17 and 31% across the farms studied.

Apart from reductions and increased storage of carbon dioxide, methane and nitrogen oxide emissions from farms form a considerable part of on-farm emissions. Methane is a by-product of digestion in ruminant animals, while nitrogen oxide emissions most readily occur in the nitrification and denitrification of nitrogen fertiliser and effluent (Piteski et al, 2009).

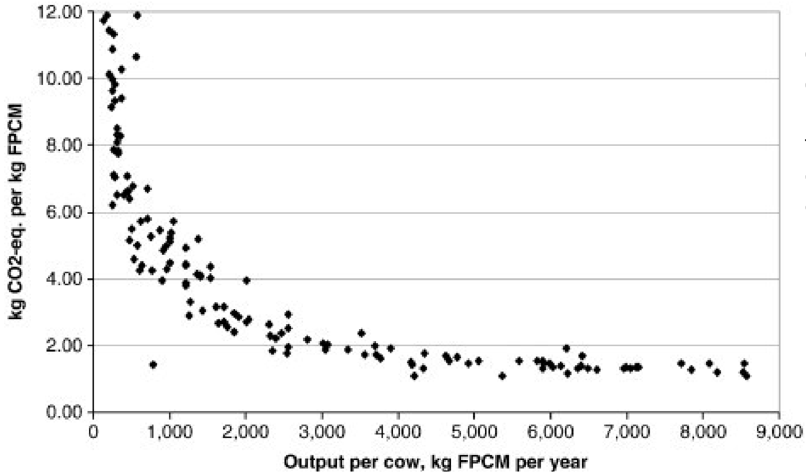


Figure 3. Comparison of kilograms of greenhouse gas emissions (in carbon dioxide equivalent) as against output per cow globally. The data demonstrate that greater intensity of production per cow leads to lower greenhouse gas emissions per kilogram of product (Gerber et al, 2011).

A number of global studies of dairy farms have found a general trend that as efficiencies in milk production per head of cattle increase, resulting nitrogen oxide and methane emissions decrease per litre of kg of milk produced (Piteski et al, 2009; Smith et al, 2008; Gerber et al, 2011; Kristensen et al, 2011). The increases in efficiency have come about by the increasing use of feed concentrates or highly fertilised pasture, resulting in reduced ratio of methane production to milk produced (Figure 3 above) (Smith et al, 2008; Gerber et al, 2011).

Although the studies mentioned in the preceding paragraph do provide evidence for reduced on-site greenhouse gas production, it is not apparent whether carbon dioxide created by the feed concentrates or transport of those inputs has been taken into consideration. A further factor of importance noted by Gerber et al (2011) was that the gains associated with increasing productivity could not be viewed in isolation, as factors such as increased water pollution, and impacts on social and health parameters had been noted by other studies as resulting from increased productivity.

Further, other studies have found the greenhouse gas emissions (particularly in relation to nitrous oxide production) are less per litre or kg of milk when produced through 'organic' methods, being those using no or very limited fertiliser or feed inputs, (Del Prado et al, 2011; Niggli et al, 2009) and that feed with higher energy input will increase methane production (Piteski et al, 2009).

Del Prado et al (2011) ran models comparing a number of organic and conventional dairy farms simulations, accounting for greenhouse gases from inputs and on-site emissions. Organic farms used little or no fertiliser or imported feed, resulting in significant savings in emissions from farm inputs. Further, the studies found, contrary to above, that the increase in energy inputs (such as feed and fertiliser) did not necessarily result in increased milk yields. At the same time, the savings in financial outlay for such inputs resulted in financial sustainability gains.

Finally, manure management efforts were also highlighted by a number of studies as providing improvements to sustainability in the area of greenhouse gas emissions. Higher fixation rates, and therefore lower nitrification and resultant nitrous oxide emissions were noted on organic farms than on conventional farms in a study by Kristensen et al (2011), while the Sims dairy simulation (Del Prado et al, 2011) found that nitrate concentration in leachate was lower in organic and optimised conventional systems, and optimisation of nitrogen application (such as through applying as much nitrogen as will be taken up by plants (Smith et al, 2008)) showed considerable effect in reducing on-site nitrous oxide emissions. Good management techniques reduced or eliminated the need to purchase nitrogen fertiliser, and advances in biofuel technology has led to the possibility of producing fuel from methane emitted from effluent stored in ponds (Piteski et al, 2009), potentially further reducing reliance on fossil fuel use and increasing cost savings for farmers.

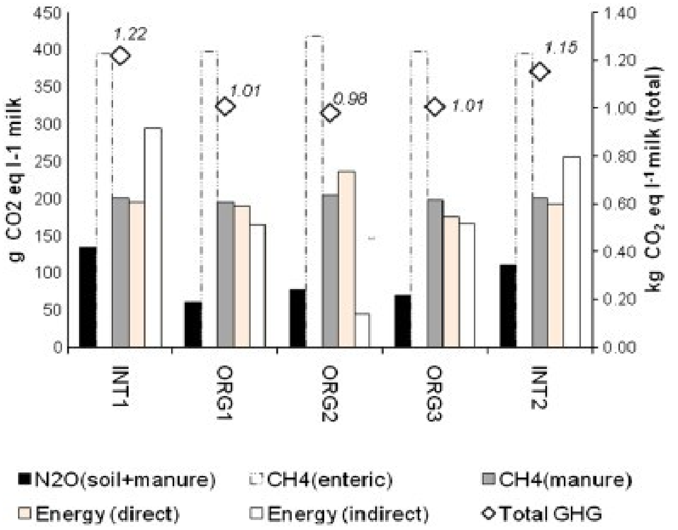


Fig 4. Comparison of total Greenhouse Gas emissions between farms managed organically (ORG1, 2 & 3) and conventionally (INT 1 & 2), and between the multiple types of emissions. (Del Prado et al, 2011)

Conclusion

Effort is being expended in researching sustainability increases in agriculture generally and in dairy farming particularly. This article details the research in to reducing water eutrophication problems and greenhouse gas emissions from dairy farms, with results tending to show that management of ground cover and natural nutrient holding systems, control of animal grazing to increase ground cover, accurate use of effluent in place of imported fertiliser and avoidance of use of imported feed can deliver good results without unsustainably impacting farmers income. Further, many of these mitigation options have positive impacts on a number of negative environmental effects relevant to dairy farming.

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