The Sustainability of Ireland's Livestock Systems

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Summary

- Total Irish agricultural greenhouse gas emissions are approaching 2016 levels. (Irelands dairy and beef carbon footprints are one of the lowest in the world, with plans to reduce further through increased productivity and efficiency, adoption of technologies (e.g. protected urea).
- Blue water use on Irish dairy farms is substantially below most other countries in the world due to the abundance of rainfall, low purchased concentrate and lack of irrigation in the production systems.
- Irish dairying and beef production systems are a significant net contributor to the production of human digestible protein. Even when the opportunity potential of land suitable for arable production is accounted, dairy and dairy beef systems remain land use efficient.
- Land use planning and the location of dairy and beef production systems has a dramatic effect on the net human edible food contribution of Irish beef and dairy.

Introduction

Livestock play a vital role in the global food system, but are questioned because of their impact on the environment, particularly on climate change in the case of ruminants. In addition, for some people the direct (e.g. wheat and other primary grains, etc) and indirect (use of arable suitable land for pasture) feeding of human-edible food to livestock is questioned. On the other hand, the role of livestock in upcycling and recycling non-human edible materials into the food chain is well recognised, as is their contribution to soil health through manure recycling and increasing organic matter in the soil. It is important to recognise that in pasture based settings like the Irish example the manure produced by animals is almost exclusively directly recycled by the animal through the grazing process. Approximately 20% of the manure nutrients are produced during the housing period with the remainder returned to pasture directly by the grazing animal and in most cases the slurry produced indoors is also returned to the area used to produce the forage. This paper examines the performance of Irish dairy and beef production with regard to some of these attributes, and makes some international comparisons where possible, before outlining how further improvements can be progressed in the pursuit of increased industry sustainability.

1. Carbon Footprint

Carbon footprints are calculated to estimate the embedded GHG emissions associated with the production of products. Carbon footprints are calculated using life cycle assessment (LCA) models, where agricultural LCAs typically adopt a cradle to farm gate boundary, meaning all GHG emissions along the supply chain up to the farm gate are accounted. This includes GHG emissions associated with the production of farm inputs and the GHG emissions produced on farm. The main sources of GHG emissions within the farm gate are enteric and manure methane, nitrous oxide associated with soils, and carbon dioxide from fuel use, lime use and from urea fertilisers. Upstream (pre farm gate) GHG emissions are largely associated with the production of purchased feeds, electricity, and the consumption of energy for fertiliser production. The functional unit for dairy and beef LCA's are generally fat and protein corrected milk and carcass weight, respectively. Dairy farms are multifunctional, producing both milk and meat. As the processes in producing these co-products are intertwined, LCA methodologies use an allocation technique to distribute GHG emissions between the co products (milk and meat) using a variety of different approaches from economic to biophysical which make comparison across studies difficult.

It is notoriously difficult to compare the carbon footprint of agricultural products from different countries. The difficulty arises due to inconsistent LCA methodologies being applied across studies (e.g. system boundary – where emissions counting starts and stops). To address these inconsistencies international standards and guidelines around LCA methodology have been published. However there will always be inherent differences in LCA methodologies due to structural differences (e.g. data collection, annual vs monthly time step), and different tiers (e.g. country specific emission conversion factors) being used to calculate GHG emissions. Notwithstanding the above, different approaches have been applied to compare carbon footprints. The 2010 EU JRC report (Leip *et al.* 2010) is commonly referenced when comparing the carbon footprint of beef and dairy. In this report Ireland was ranked among the lowest in the EU. However, it is no longer appropriate to reference this study as it is based on activity data from 2002. Alternatively, O'Brien *et al.* (2014) compared Irish pasture-based dairy system with a high-performance United Kingdom (UK) confinement system, and a top-performing US confinement dairy system, and more recently Sorley *et al.* (2024) compared pasture based systems with indoor systems in Western Europe, both studies using consistent LCA methodological approaches and finding pasture based systems to have lower carbon footprints and GHG emissions per hectare than indoor systems. A New Zealand study by Mazzetto *et al.* (2023) took an alternative approach of compiling and comparing "nationally representative" publications to compare studies. This type of approach should be avoided as the comparisons used had different methodologies (even though the authors tried to correct for approaches), the data was from different years and finally there was a wide variety of approaches used to collect representative data. In reality this is the most important issue with the overall approach as there can be huge differences in individual farms and groups of farms in relation to their carbon footprints.

The FAO's Global Livestock Environmental Assessment Model (GLEAM) presents an option for such comparisons where it calculates GHG emissions from livestock systems in different world regions using a consistent LCA methodology. The GLEAM modelling framework puts the Irish dairy carbon footprint at 1.02 kg CO_2eq /kg of milk which was the lowest in all of the comparisons with New Zealand/Australia (1.14), North America (1.30), EU 27 (1.41) and the global average (2.01). Similarly, GLEAM puts the Irish beef carbon footprint among the lowest of global regions at 15.0kg CO_2eq per kg carcass, lower than the average for the EU (15.8), North America (15.9), South America (52.8), and Australia/New Zealand (18.9). While GLEAM is effective in allowing across region comparisons, it's scope makes it difficult to allow country specific emission factors to be used and the use of a generic structure not optimal for every system type. More complex LCA models have subsequently been developed within countries that better reflect their systems, allow the use of country specific emission factors, and better capture within country actions to reduce emissions which can be difficult to account for within the GLEAM structure.

The most recent published carbon footprint of Irish milk is one of the lowest in the world (Herron *et al.,* 2022). The published analysis shows that the average dairy carbon footprint of Irish milk was 0.97 kg CO_2e/kg fat and protein corrected milk yield (FPCM) (Herron *et al.,* 2022) based on average performance data between 2017 and 2019. When this is updated for 2022 data the average carbon footprint drops to 0.94 kg CO_2e/kg FPCM. Recent Irish research on enteric methane emissions from dairy cows while grazing or indoor on grass silage suggest that the current methane conversion factors is over estimating the emissions from dairy cows in Ireland (Lahart *et al.,* 2024a; Lahart *et al.,* 2024b). When these new emission conversion factors are applied, the Irish carbon footprint for dairy reduces to 0.88 kg CO_2e/kg FPCM.

While Ireland's carbon footprint is in a strong position at present, the research target for the dairy industry sees that footprint drop from 0.88 today to 0.63 kg CO_2e/kg FPCM under the future systems identified in the Teagasc Dairy Roadmap 2030 with technologies that are in place today and are being deployed at farm level today. When sequestration is included within this figure based on 1.8t CO_2e/ha/year the carbon footprint becomes much closer to 0.50 kg CO_2e/kg FPCM for the most technically efficient farms. The reduced emissions are achieved through a reduction in fertiliser N use, substitution of CAN based fertilisers with urea based fertilisers, increased productivity from grazed grass with better dairy cow fertility. Lower levels of supplementary feeds while changing the source of the imported feed ingredients to avoid land use change emissions, and finally the inclusion of feed additives both for slurry methane abatement as well as enteric methane abatement during the non-lactating period where animals are indoors and additives can be mixed into the forage based diet through a TMR.

2. Feed/Food competition

There is considerable debate on the use of human edible food to feed animals and its impact on food security. Current livestock systems are engaged in feed-food competition which needs to be minimised to meet futre food demand. Several metrics have been developed to measure the net contribution of livestock to the supply of human digestible protein (HDP), such as the edible protein conversion ratio (EPCR) and the land-use ratio (LUR). The EPCR compares the amount of HDP in animal feed over the amount of HDP in the animal product. The LUR compares the potential HDP from a crop grown on the land used to produce the livestock feed against the HDP in that livestock produce. There is limited research conducted in this area internationally, particularly around pasture based systems. While food production must increase to satisfy global demand for animal based proteins, there is also an increasing need to minimise associated environmental burdens. Thus there is need to move the question on from not only what people should eat but to also where and how should that food be produced to ensure there is balance in the overall debate.

The analysis in Table 1 (Hennessy *et al.,* 2021) shows that there is significant system differences in terms of EPCR and the LUR. For both metrics dairy has the lowest (best) values. In essence, Table 1 shows that Irish dairy is providing a positive contribution to global HDP production, even where the crop opportunity costs of the land (based on suitability of the land for cropping) used for dairy are taken into account (LUR). When higher LUR values (i.e. >1) are taken into account, in conjunction with some of the negative externalities associated with ruminant based agriculture, there is a question of whether it makes sense that animals are fed human edible feed, or should occupy land that could be used to grow crops for food for humans. From a food security and resource use perspective, there is also a question of whether more of the ruminant products globally should originate from regions and countries where ruminants do not compete with land use for human edible crop production, such as from large parts of the Irish land base.

Table 1 Edible Protein Conversion and Land Use Ratio values of Ireland's ruminant livestock sector.

	Dairy	Dairy Beef	Suckler Beef	Sheep Meat
EPCR	0.18	0.42	0.29	0.21
LUR	0.47	1.08	1.25	0.95

It is clear from Hennessy (2021) that there are substantial differences in the digestibility of foods of different origins. It is common place for the environmental impact of different food types to be compared on a per kg of product or per unit of protein basis. When evaluating one form of food versus another digestibility and nutrient availability must be taken into account. Hennessy *et al.* (2021) showed the digestibility score of one protein source against another can be dramatically different. Depending on the protein source when the digestibility and amino acid profile was taken into account the animal sourced proteins nutritional value increased dramatically relative to plant sourced proteins. Other considerations that need to be included in the overall process are around micro nutrient sources as well as the bioavailability of the nutrients that are offered (Hupertz 2021). There is a need to move to these types of comparisons relative to the required nutrients to ensure that the outcome would include balanced diets as well as more sustainable diets.

3. Water Use

Relatively high rainfall and extremely low water scarcity values means that Ireland has a very low blue water footprint for milk production. A water footprint (WF) measures the amount of water used to produce a product, in this case meat and milk. In general, the WF can be broken into three figures: green, blue and grey. The green WF measures water from precipitation that is stored in the root zone and used to grow the feed consumed by the animals. Blue water is sourced from surface or groundwater and is used in the production process, e.g. animal drinking water or irrigation. Grey water is the soiled water that leaves the system from washings, yards, etc. A analysis across 24 intensively monitored dairy farms has shown that blue water consumption was 6 l water/kg FPCM in Ireland (Murphy *et al.,* 2018). This compares to 110 kg/kg FPCM in the US (Rotz *et al.,* 2024) and 66 L for the Netherlands (De Boer *et al.,* 2013). An Irish study which was completed around the blue water footprint of beef farms showed the average blue water footprint to be 169 l /kg of carcass with only 64 L of that occurring on the farm with the remaining water use being associated with the concentrate production (Murphy *et al.,* 2018). A study of the volumetric water footprint of beef and lamb meat in the United Kingdom (Chatterton *et al.,* 2010) quantified a UK national blue water use of beef at 150 L per kg of carcass.

The differences in blue water use are mainly driven by differences in irrigation across country in conjunction with the blue water use associated with imported feed, coming into the system. Even though Ireland's blue water use is extremely low it can still be reduced through prompt repair of leaks, recycling plate cooler water and integration of high pressure washers in the washing process. While not directly affecting blue water use, there is scope to introduce rainwater-harvesting systems on farm which would help reduce the energy associated with water pumping.

4. Ammonia Emissions

Ammonia emissions are associated with the acidic deposition onto ecosystems, and the formation of secondary particulate matter. Agriculture accounts for 99.4% of the NH_3 emissions in Ireland with 47.7% of the emissions associated with manure housing and storage, 26.4% with slurry spreading, and, on average, 14.0% and 11.2% with N fertiliser and manure deposition at pasture, respectively. Total NH_3 emissions are above the national ceiling target set as part of the NEC (National Emissions Reduction Directive) since 2016, with a substantial jump in NH_3 emissions in 2018 to 142 thousand tonnes. Teagasc produced a marginal abatement cost curve for NH_3 emissions in 2020 (Buckley *et al.*, 2020). This showed the technologies to reduce ammonia in conjunction with the associated costs. The outcome of that analysis showed that in order to reduce NH3 emissions to meet NEC Targets the sector must adopt Low Emissions Slurry spreading technology, in combination with protected urea and covered slurry stores. Since this time period Ireland has reduced its NH_3 emissions by 9.6% through the adoption of such technologies along with changes in livestock populations. This trend is reflected in the Teagasc NFS Sustainability Report where NH_3 emissions per hectare and per kg product have reduced for both dairy and cattle farms. While this trend is positive, further adoption of measures is required to bring national NH_3 emissions under the emissions ceiling.

Going Forward

There will be increased pressures to focus on both water quality and enhancing the biodiversity status of farms. The most recent analysis of the EPA suggests that water quality status in Ireland is stable but not improving. There is a requirement to reduce nutrient loss to water in order for water quality to improve. Key to this process will be identifying the loss pathways and putting mechanisms in place to reduce the loss. The recently launched Teagasc's Better Farming for Water, 8-Actions for change initiative breaks down measures based on nutrient management, farmyard management and land management. A focus on each of these areas will be central to reduce nutrient loss.

There is increasing interest in biodiversity at farm level. Biodiversity (the variety of plant and animal life in a habitat) is declining globally (IPBES, 2019). There are many causes for this decline, some related to farming. Actions can be put in place to reverse the decline. Key to this process is recognising that there is a problem and identifying actions that could help to reduce the loss. On the average farm in Ireland, approximately 10.0% of the farm area can be described as natural or semi natural; these areas include hedgerows, streams, field margins, etc. On beef farms, the level of enriched space is higher than dairy farms. These levels contrast well with European farms. Typically dairy/beef farmers are not high users of pesticides which can be damaging from a biodiversity perspective.

Conclusion

Irish ruminant agriculture performs well form a sustainability perspective when compared to other countries. However there is scope for further progress to be made across all sustainability metrics. There is a requirement to decouple sustainability impacts from the agricultural systems operated. There are technologies that are being implemented at farm level that allows that progress to be made and there is significant progress being made at research level to deliver on a pipeline of new solutions for the future. International comparisons across most metrics suggest that Irish beef and dairy perform well when compared to other countries. There is a requirement for robust infrastructure to be developed to allow comparisons between countries and systems operated within countries in order to draw conclusion on the sustainability of one system against another for a whole range of metrics. However, regardless of the above comparisons, the agrifood industry needs to focus on improving the environmental performance of their production systems.Future International debate on increasing global sustainability through the diet should also include the location of food production as well as the quality of that food relative to human needs at both a macro and a micro level.

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