Securing a sustainable future – sustainability challenges

Laurence Shalloo[1], Siobhan Kavanagh[2] and Deirdre Hennessy[3]

[1]Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork; [2]Teagasc, Signpost Programme, Kells Rd., Kilkenny; [3]School of BEES, UCC, Distillery Fields, North Mall, Cork

Summary

- Policy changes at both national and EU levels will require greater focus on a wide range of sustainability metrics at farm level.
- Irish pasture-based systems perform at a high standard across a whole range of impact categories and metrics.
- There are many currently available technologies that can be immediately implemented by farmers today with favourable impacts on sustainability.
- Future technologies currently being developed/researched will further increase the sustainability of the dairy industry once proved and deployed.

Introduction

The Irish dairy industry has undergone a transformational change since the removal of the EU milk quota in 2015. Since the Irish dairy industry began to prepare for EU milk quota removal in the 2007-2009 period, milk solids output has increased by over 96%. This increased output has been achieved through increased cow numbers, increased milk yield per cow, increased fat and protein percentages, increased grass growth, increased stocking rate, and additional land entering the dairy industry. The largely grass-based systems of milk production have resulted in a low-cost production system that has provided a comparative advantage for the Irish dairy industry within a seasonal profile of milk deliveries. The benefits of the system have been further enhanced through the development of the Economic Breeding Index, which has focussed on selecting a dairy cow with suitable attributes for the system (robust, excellent fertility and survivability, efficient conversion of (mostly grazed) forage to milk, and ability to withstand changes in feed supply).

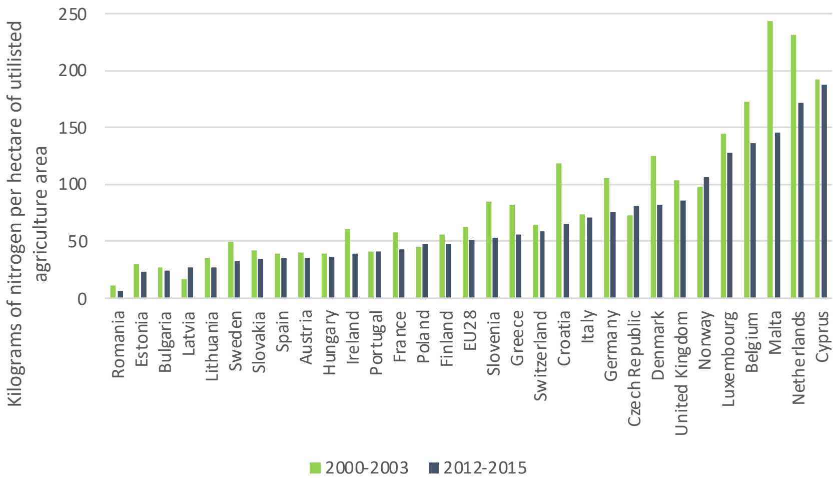
Looking ahead, there are new challenges that the dairy industry has to address as it matures in the current, and indeed future, economic and policy environments. Recent geo-political events have exposed the need for increased feed, fertiliser and energy security. Systems of milk production that rely less on purchased feed, fertiliser and energy are more resilient. Additionally, environmental pressures (greenhouse gas emissions, water quality and biodiversity) require the industry to have a cohesive plan to maintain profitability while addressing these challenges. Widespread and immediate deployment of the currently available solutions at farm level is necessary, coupled with further investment in research to develop new solutions in the medium to long-term, providing options for the industry to meet its overall commitments. The availability of skilled and motivated people to work and lead within the industry is, and will continue to be, a central challenge. Therefore, there is a requirement to ensure that education and training are delivered based on industry requirements and across different career roles, and this will be central to delivering a more vibrant industry in the future. In addition, greater integration between the beef and dairy industries will benefit both sectors. The generation of healthier dairy-beef progeny with better genetic merit for beef traits and reduced age at slaughter will be an essential requirement to develop profitable, simple and sustainable grass based dairy-beef systems.

In order to evaluate the overall performance of the dairy industry, it is important to look at its overall sustainability. There are three sustainability pillars that must be included in any system evaluation: economic, social and environmental. Economic sustainability deals with the financial performance of the business including debt levels, profitability, cost of production, etc. The social element deals with both animal and people related topics. For example, does the farm have good welfare outcomes and standards for the farmer themselves, their employees and their animals? Finally, and equally as important, the environmental impact and use of resources must be considered for the farm (e.g. GHG emissions, nutrient use efficiency, biodiversity etc.). For this paper, key aspects related to social and environmental sustainability will be discussed. Economic sustainability is discussed in the first paper in this Open Day proceedings.

What are the main policy challenges?

Nitrates Directive

Ireland is one year into the 5th Nitrates Derogation. The Nitrates Derogation is the means by which some Irish farmers can surpass a 170 kg per ha limit of organic nitrogen on their grassland area, as set out in the Nitrates Directive. The Nitrates Action Plan outlines the specific measures to protect surface and ground waters from nitrates loss. The current Nitrates Action Plan will be reviewed in 2023. It is extremely important to note that Ireland, relative to the rest of the EU, operates a low surplus nitrogen (Figure 1). The derogation is an important tool for some farmers to farm to their pasture production potential. In non-pasture based systems, as operated in many parts of Europe, slurry exports are used as a tool to manage stocking rates. This is less possible in pasture-based systems, where most of the animal manure is deposited on the pasture by the grazing animal.



Data source: *Eurostate Gross Nutrient Balance, b. EEA_Indicator SEB1019*

Figure 1. *Gross nitrogen balance by country*

The Department of Agriculture, Food and the Marine introduced three new livestock excretion banding rates related to milk yield per cow for dairy cows from 1st January 2023 as part of the Nitrates Action Programme. These are 80 kg nitrogen per cow for cows producing less than 4,500 kg milk per cow per year (Band 1); 92 kg nitrogen per cow for cows producing between 4,501 to 6,500 kg milk per cow per year (Band 2); and 106 kg nitrogen per cow for cows producing more than 6,501 kg milk per cow per year (Band 3). For farms that are above the maximum 250 kg organic nitrogen per ha as a consequence of the introduction of banding, the least negative financial options at farm level to reduce organic nitrogen would be to contract rear all replacement heifers, rear fewer replacement heifers or rent additional land. Exporting slurry is not practical given the quantities to be exported, and also the subsequent negative impact on the soil fertility of the exporting farm as most grassland farms are close to farm phosphorous balance and exporting will create a phosphorous deficit across the whole farm. Reducing cow numbers from optimal will have a significant negative impact on farm profitability. It is therefore likely that farmers will attempt to exhaust other available options before a reduction in herd size is considered.

While some dairy farms will find it very difficult to adjust their farming system to the new organic nitrogen excretion banding at a maximum 250 kg organic nitrogen per ha, reducing the maximum organic nitrogen per ha to 220 kg would cause significantly greater difficulties for these farms. Teagasc research has reported that the combined effect of banding and reducing the maximum organic nitrogen stocking rate from 250-220 kg organic nitrogen per ha could reduce profitability by 29% in the most extreme scenarios.

Biodiversity

There has been a significant decline in biodiversity and ecosystem services during recent decades. Historic Strategies and Directives have failed to halt this decline. More recently, a Nature Restoration Law has been proposed, which aims to restore ecosystems, habitats and species across the EU's land and sea areas. If ratified, the Law will enable long-term and sustained recovery of biodiversity and promote resilient ecosystems. It will also contribute to climate mitigation and climate adaptation, as well as helping Ireland and the EU meet international commitments.

The Nature Restoration Law sets legally (and consequently enforceable) binding targets for the EU and its Member States, with the intention that it will be transposed into law by late 2023/early 2024.

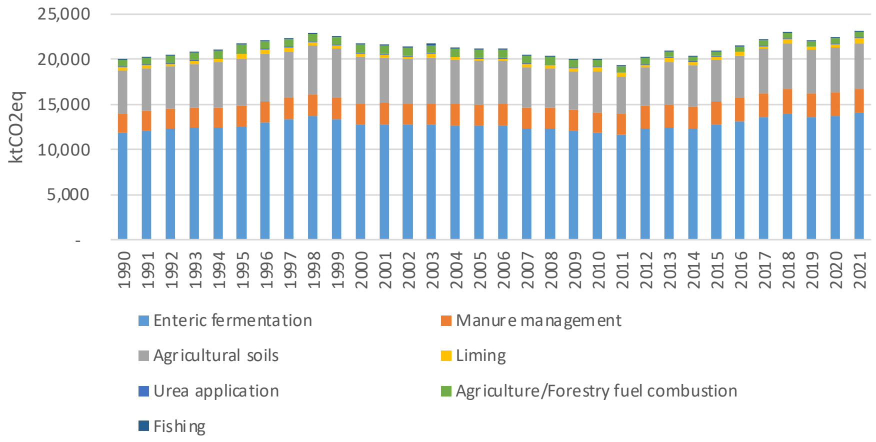
Agriculture must demonstrate improving trends across many metrics including, but not limited to, high diversity landscapes, pollinator index, butterfly index, farmland birds and soil organic carbon from the date of Regulation introduction to December 2030, and continuing thereafter until satisfactory metrics have been achieved. The percentage of agricultural land area required to achieve satisfactory scores has not been defined, but is likely (based on recommendations within the EU Biodiversity Strategy for 2030) to be in the region of 10%.

Restoring agricultural ecosystems (and the services that they deliver) will include retaining and managing landscape features such as buffer strips, hedgerows, stonewalls, field margins, woodland, trees, archaeological features, drains/ditches and ponds. Existing schemes such as ACRES and EIPs can contribute to restoring ecosystems.

Restoring and rewetting drained organic peatlands will also contribute to restoring agricultural ecosystems. In Ireland, however, there is considerable research needed to accurately determine the area of drained peats currently in existence before rewetting plans can be put in place. Further research is required to reverse the decline in biodiversity loss across all land types, and to determine the most appropriate solutions that can be incorporated into the farming systems to enhance the quantity and quality of biodiversity (and associated ecosystems services) on farms.

Greenhouse gas emissions

The Climate Action and Low Carbon Development (Amendment) Bill 2021 set a 'national climate objective' to achieve a climate neutral economy no later than 2050 and a total reduction in GHG emissions of 51% over the period to 2030, with the agricultural sectors target to reduce emissions by 25% by 2030. This poses a significant challenge for Irish agriculture, as methane is the single greatest GHG emitted from livestock production systems and is difficult to reduce. Ireland's GHG emissions from agriculture in 2021 was similar to 1998 (Figure 2). Agricultural emissions declined between 1998 and 2011, followed by an increase as dairy cow numbers increased following EU milk quota removal. It is important to note that current policy reduction targets are more difficult due to the timing of milk quota removal relative to the target reduction baseline of 2018.



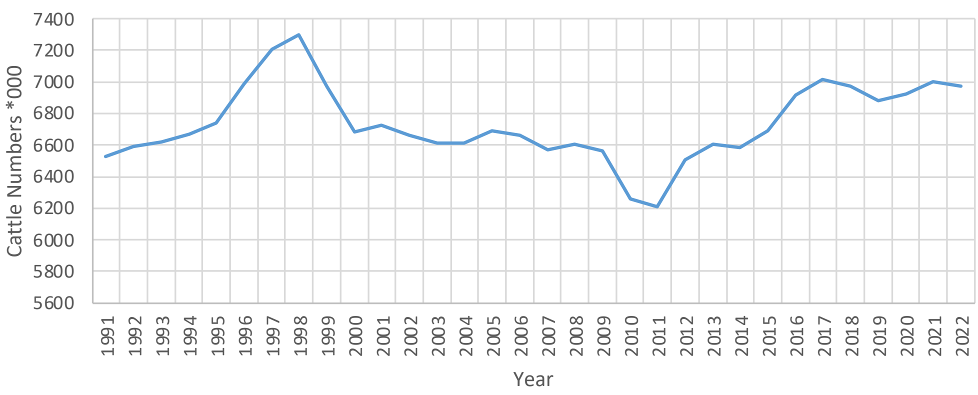
Source: *EPA (2023)*

Figure 2. *Agricultural GHG emissions between 1990 and 2021 using GWP100*

Current situation

Livestock numbers

The total number of cattle in Ireland peaked in 1998 at 7.3 million (Figure 3). Between 1998 and 2011, the total number of cattle was reduced to 6.2 million as the number of dairy cows declined. Between 2011 and 2022, the total number of cattle increased from 6.2 million to 7.0 million. The current total number of cattle is well below (circa 5%) the national peak recorded in 1998.



Source: *CSO (2023)*

Figure 3. *The average number of cattle between June and December over the period 1991-2022*

Cow welfare

Dairy cows in Ireland have access to grazed grass, on average, for 71% of the year and are free to roam within an assigned paddock. Irish pasture-based systems, with average milk yields of just over 450 kg milk solids (MS) per cow, have one of the lowest milk yields per cow in the EU. In general, profitability in Ireland is maximised when grass utilisation per hectare is maximised but not when milk yield per cow is maximised (Hanrahan *et al.*, 2018). In Ireland, the key animal welfare indicators are lameness and somatic cell count (SCC). Somatic cell count is a good indicator of mastitis. Data from the Animal Health Ireland (AHI) *CellCheck* program highlighted that average SCC levels in dairy herds has declined during the last decade, and the average SCC is now close to 180,000 cells per ml (AHI, 2023). In terms of lameness, a recent analysis reported that 6% of cows on a sample of commercial farms had moderate suboptimal mobility, and less than 1% of cows had severe suboptimal mobility. Finally, in relation to dairy cow welfare, herd age profile continues to increase, with the average number of calvings per cow increasing from 3.3 in 2014 to 3.6 in 2022 (ICBF, 2023). The target is for the average parity within the herd to increase to 4.5.

Calf welfare

There are approximately 48% more dairy cows in Ireland now compared with the period from 2007-2009. Incidentally, dairy cow numbers are approximately the same now as they were in 1984 when EU milk quotas were first introduced. These additional cows are resulting in increased numbers of dairy origin calves entering the beef industry.

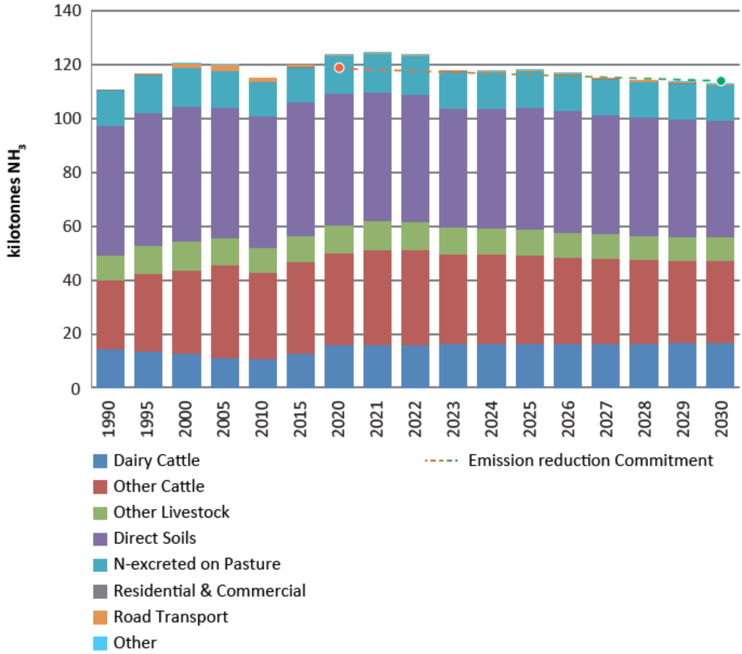
In Ireland, the additional calves provide a significant opportunity for the beef industry to reduce GHG emissions per unit of product and production costs associated with beef production. The dairy industry is now embracing the use of sexed semen to generate replacement heifers and selecting bulls from the Dairy Beef Index (DBI) to generate non-replacement calves. The number of sexed semen straws available in 2023 (driven by demand) was approximately 300,000, which will result in over 100,000 less male dairy calves and provides a significant opportunity to increase the use of high DBI beef straws. Recent research from Teagasc Grange and from the DairyBeef500 programme reported that there is potential to achieve significant profits in dairy calf-to-beef systems. The continuation of the live export of calves is extremely important to satisfy a market demand while helping Ireland meet its policy targets. Maintaining calf welfare during transport is crucial to the integrity of the calf transport process and requires robust monitoring as well as the development of solutions to increase welfare during transport.

Carbon footprint

The carbon footprint of Irish milk is one of the lowest in the world. Based on national activity data from 2017-2019, the average dairy carbon footprint was 0.97 kg CO_2e per kg fat and protein corrected milk yield (FPCM), and when the carbon (C) sequestration is included in the calculation this figure is closer to 0.86 kg CO_2e per kg FPCM (Herron *et al.*, 2022). Analysis based on 2022 data, suggests the footprint has reduced to 0.93kg CO_2 per kg FPCM and with more representative Irish emission factors is 0.86 kg CO_2 e per kg FPCM. While all published studies use different approaches, and some are more robust than others, there are very few comprehensive studies that show a footprint as low as these figures. The New Zealand C footprint, using a similar approach to Ireland, is 0.88 kg CO_2e per kg FPCM, while similar approaches in the US generate C footprints of just over 1.01 kg CO_2e per kg FPCM. While Ireland's C footprint for milk is in a strong position at present, the published strategy for the dairy industry will bring that footprint from 0.97 kg CO_2e per kg FPCM today to 0.73 kg CO_2e per kg FPCM under the future systems identified in the Teagasc Dairy Roadmap. When sequestration is included, this figure will be closer to 0.61 kg CO_2e per kg FPCM. The global average C footprint before 2010 was 2.4 kg CO_2e per kg FPCM (FAO, 2010) with no newer data available. Displacing milk production with an average C footprint (2.4 kg CO_2e per kg FPCM) through expansion of dairy production in Ireland (0.97 kg CO_2e per kg FPCM) can have a substantial effect on reducing global emissions, assuming that the global demand for dairy continues to increase. This analysis does not include the fact that biogenic methane is described as a flow gas, whereas GHG emissions like nitrous oxide (N_2O) and carbon dioxide (CO_2) are known as stock gases. The difference relates to the permanence in the atmosphere. When biogenic methane is stabilised and reduced, the effect on atmospheric concentrations is almost immediate. There is a general scientific agreement that relatively small reductions in biogenic methane across a prolonged period of time will prevent any additional warming from methane and further reductions in methane will result in a reduced warming effect.

Ammonia emissions

Ammonia (NH_3) 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. Total NH_3 emissions are above the national ceiling target since 2016, with a substantial increase in NH_3 emissions in 2018 to 135,200 tonnes. Ireland's national NH_3 emissions ceiling is 116,000 tonnes, set as part of the NEC (National Emissions Reduction Directive). Emissions in 2019 declined by 9,800 tonnes relative to 2018, driven by decreases in livestock numbers, reductions in fertiliser N use, as well as increased use of low emissions slurry spreading technologies (Figure 4). This was followed by another decline in emissions in 2020, and subsequently a slight increase in 2021.

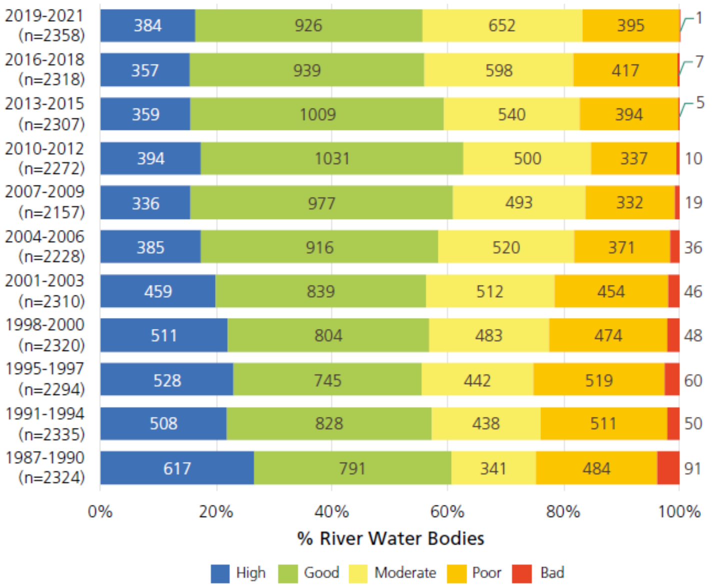


Source: *EPA (2023)*

Figure 4. *Trends in ammonia emissions between 1990 and 2021 with projections to 2030*

Water quality

The EPA publish detailed reports describing the changes in biological quality and nutrient concentrations in water on an ongoing basis. The most recent report on water quality was published in 2022. This report, entitled 'Water quality in Ireland 2016-2021', covers the periods from 1987-1990 through to 2018-2021. The report indicated a consistent and steady reduction in river water bodies described as 'bad' (3.92% in 1987-1990 period and 0.04% in the 2019-2021 period). Just over 60% of rivers were described as having high or good biological status in the 1987-1990 period with the corresponding figures for the 2019-2021 period being 56% (the same as the period 2016-2018). Over the period 2019-2021, the number of rivers classified as moderate increased from 26% to 28% while at the same time the number of rivers classified as poor declined from 18%-17% (Figure 5).



Source: *EPA (2022)*

Figure 5. *Biological river water quality in Ireland over the period 1987-1990 to 2019-2021*

In the same report, when the periods 2013-2018 and 2016-2021 were compared, the number of high and good status rivers declined by 1%, while more rivers increased in quality than declined in quality over the same periods. It must be noted, however, that 2018 has been identified as a very problematic year in the context of nitrate loss, primarily due to drought conditions across the summer period and a slow growth period in the spring. This was compounded by increased use of chemical nitrogen fertiliser at farm level coupled with lengthening of the period when fertiliser could be spread, as well as greater purchased feed use.

The Agricultural Catchments Programme (ACP) has carried out extensive research in six river catchments ranging in size from 4-30 km^2. The catchments have been continuously monitored for a range of biophysical parameters since 2010. The catchments were selected to represent intensively managed agricultural land on different physical settings, and therefore, represent a range of differents types of riskiness for nitrogen (and phosphorus) loss in terms of vertical drainage or lateral runoff risk.

The high frequency monitoring of nitrogen concentration in catchment outlets indicated that both the absolute N concentrations and the dynamics of N loss varied across the catchments. The link between the percentage of land in derogation and the stream water concentration of nitrate-N was not clear, reflecting differences in soil type, land-use and meteorological factors that were evident at the catchment scale of the ACP. For example, Castledockerell (Co. Wexford) has the highest nitrate-N concentration in stream water, despite having the lowest stocking rate organic nitrogen (with only 5% of the catchment in derogation). The ACP research reported that, in general, physical settings tend to override source pressure in terms of nutrient export risk. This highlights the overriding importance of soil type, subsoil geology and groundwater hydrochemistry in controlling nitrogen (and phosphorus) losses to water.

To assess the temporal trends in nitrogen export rates within ACP catchments, an analysis was carried out over 4-year rolling periods (the minimum number of years required for this method), as well as over the whole 12-year period (Table 1). During the last 4-year rolling period (2019-2022), there was a trend for declining nitrate-N concentrations in the Timoleague catchment, stable in the Dunleer and Corduff catchements, and no consistent trend in the Ballycanew, Castledockerell and Cregduff catchments. This in the context of the organic nitrogen stocking rates in the Timoleague catchment increasing from approximately 130 kg organic nitrogen per hectare to greater than 180 kg of organic nitrogen per hectare.

Table 1. *Annual average nitrate-N concentration (mg/l) and the four-year inter-annual trends are indicated with symbols: = no trend, = stable (no change), = ↑ increasing and ↓ = decreasing*

Land –use:	Grass	Grass	Arable	Grass	Grass	Grass
Drainage:	Poor	Well	Well	Moderate	Poor	Well
YEAR	Ballycanew	Timoleague	Castledockerell	Dunleer	Corduff	Cregduff
2010	2.29	5.00	6.22	4.95	1.15	1.36
2011	2.34	5.39	6.48	4.48	1.17	1.65
2012	2.98	6.30	7.13	5.82	1.13	1.19
2013	2.56	5.64	7.21 ↑	4.57 →	1.20	1.14 →
2014	2.50 →	5.45 →	7.15	5.33	1.11 →	1.46 →
2015	2.53 →	7.07 →	7.37	5.22 →	1.25	1.61
2016	2.50 →	5.57 →	7.02 →	3.93 →	0.92 →	0.93 →
2017	2.91	6.49 →	7.42	4.40 →	1.35	1.34 →
2018	2.91	6.64 →	7.41	6.37	2.13	1.21 →
2019	2.73 →	7.15 ↑	7.22 →	8.44 ↑	2.30 ↑	1.39
2020	2.27 ↓	6.30 →	6.96 ↓	5.93	1.43	1.01 →
2021	2.48 →	5.43 →	6.66 ↓	5.51 →	2.20 →	1.05 →
2022	2.85	4.95 ↓	-	6.06 →	2.28 →	1.80 →

Source: *ACP*

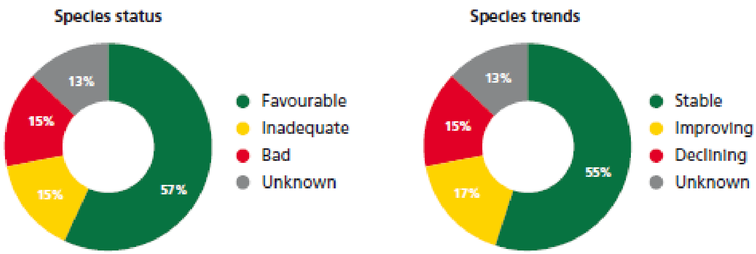
Water footprint

Relatively high rainfall and extremely low water scarcity values means that Ireland has a very low water footprint for milk production. A water footprint measures the amount of water used to produce a good or product, in this case milk. In general, the water footprint can be broken into three figures: green, blue and grey. The green water footprint 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, etc. A recent analysis across 24 intensively monitored dairy farms reported that blue water consumption was 6 L water per kg FPCM yield in Ireland. This compares with 108 L per kg FPCM in Australia and 125 L per kg FPCM yield in the US. The differences in blue water use are mainly driven by differences in irrigation. Even though Ireland's blue water use is very low, it can still be further reduced through prompt repair of leaks, recycling plate cooler water and integration of high pressure washers in the washing process.

Biodiversity

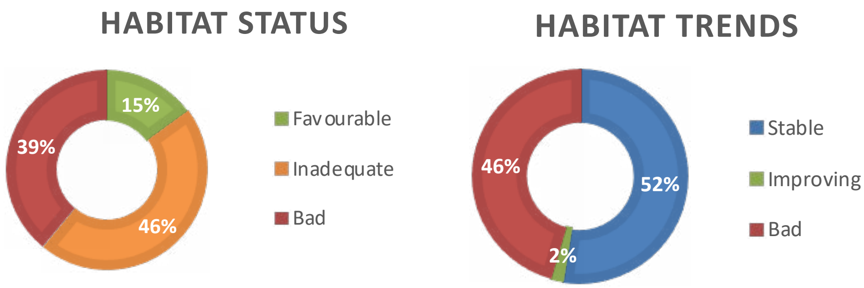
There is increasing emphasis on biodiversity as highlighted by the recent Citizens' Assembly on Biodiversity Loss. Biodiversity (the variety of plant and animal life, and the habitats in which they live) is declining globally. As agriculture is the dominant land use in Ireland, it has an important role to play in helping to reverse the decline in biodiversity. Understanding the actions that can be implemented to reverse the decline is extremely important. The key actions revolve around retaining, enhancing and creating habitats. On the average dairy farm in Ireland, it is estimated that approximately 7% of the farm area can be described as semi natural; these areas include hedgerows, streams, field margins, etc.

Figure 6 illustrates the current status and trends for species protected under the Habitats Directive in Ireland. Presently, the status of 57% of designated species is defined as favourable, while the trend for 72% of designated species is defined as stable or improving. Figure 7 illustrates the current data for habitat status and habitat trends across Ireland; both of these measures currently have poor metrics.



Source: *NPWS article 17 Data (2019)*

Figure 6. *Overall assessment results for the status and trends in species protected under the EU habitats directive in Ireland*



Source: *NPWS article 17 Data (2019)*

Figure 7. *Percentage of habitats in favourable, unfavourable-inadequate or unfavourable-bad condition and percentage of habitats with stable, improving or bad trends*

Current technologies to improve social and environmental sustainability

There are many currently available technologies that can be immediately implemented by farmers that will have positive impacts on sustainability. These technologies are discussed across the impact categories. In most cases, they will not increase costs at farm level and in some cases these measures would help reduce costs and increase profitability.

Cow welfare

Achieving continued improvements in cow welfare requires a focus on farm management, infrastructure and breeding:

- Roadways should be well maintained and upgraded where required. Locomotion scoring of dairy cows should be conducted regularly to pick out cows with suboptimum mobility, which will aid early detection of lameness problems.
- Ensure winter accommodation is suitable with appropriate space allowances.
- It is essential that every dairy herd has a 'herd health and welfare programme' as an essential part of the management system. The EBI, including the emphasis on the health and fertility sub-indices, should be used to identify bulls that are suitable for a pasture-based system.

Calf welfare

Adopting correct calf management practices are critical to ensuring healthy, well-grown calves. Management during the pre-weaning period has implications for subsequent animal health and welfare, and also for subsequent productivity and longevity. When the calf is born, attention needs to be paid to colostrum management and ensuring the calf receives a sufficient volume (3 litres) of high quality colostrum (>50 mg per ml IgG) within the first two hours of life is critical to achieve passive transfer of immunity. At least four feeds of transition milk should follow the initial colostrum feed before the calf moves to high quality whole milk or milk replacer. Calves should be fed three litres of milk twice daily for at least four weeks of life. Fresh water and concentrate should be made available from birth with the aim of encouraging rumen development. Milk volume can be reduced to four litres and fed once daily from four weeks of age, to promote increased concentrate intake and ensure a smooth transition between the pre- and post-weaning periods. When weaning, calves should be weaned gradually to minimise post-weaning reductions in growth rate and to maintain good health and welfare. In addition, the housing environment should allow calves perform to their maximum ability with minimum disease risk, and positively influence the health, growth, development and general welfare of the calf.

Greenhouse gas emissions

The Marginal Abatement Cost Curve (MACC) (Version 3 to be published in July 2023) has identified the most cost-effective pathway to reduce sectoral emissions. The adoption of measures such as reducing our reliance on chemical nitrogen fertiliser, a change of nitrogen fertiliser type to protected urea, using high EBI and high DBI genetics, use of sexed semen, improved animal health, extending the grazing season, and use of white clover are critical to reducing sectoral emissions. Initially, our focus must be on reducing our reliance on chemical nitrogen fertiliser.

- There are a range of proven technologies to reduce reliance on chemical nitrogen fertiliser:
    - Correct soil fertility. Moving from pH 5.5-6.3 can increase soil nitrogen availability for grass growth by between 50-70 kg nitrogen per ha per year, as well as reducing nitrous oxide emissions per kg nitrogen applied. Target soil Index 3 for phosphorus and potassium for optimum sward nutrition.
    - Apply slurry using low emission slurry systems (LESS; e.g. trailing shoe, band spreading) between February and May. The nitrogen fertiliser replacement value of slurry can be increased (25%-50%) by using LESS instead of splash plate and ammonia emissions are reduced.
    - Incorporate white clover on farm. White clover can fix between 80–120 kg nitrogen per ha per year depending on underlying soil fertility and sward management.
    - Use red clover for silage to significantly reduce the requirement for chemical nitrogen fertiliser on silage swards.
- Where chemical nitrogen fertiliser is used, switching from CAN and straight urea to protected urea will directly reduce both GHG and ammonia emissions, while also being cheaper per kg nitrogen applied.

Ammonia emissions

There are a range of options to reduce ammonia emissions on dairy farms. These include reduced crude protein in concentrate feed, use of protected urea instead of ordinary urea or CAN, as well as the use of LESS technology for the application of animal manures. At dairy farm level, the two measures responsible for the vast majority (circa 80%) of the ammonia emission reductions are using protected urea and LESS:

- Protected urea will reduce greenhouse gas and ammonia emissions compared with CAN and straight urea.
- LESS technologies such as trailing shoe and band spreading results in greater retention of the nitrogen in the slurry within the system.

Water quality

The Teagasc ASSAP programme is designed to enable landowners to engage positively in seeking solutions to local problems in relation to water quality through the support of a confidential sustainability advisory service focused on water quality improvement. Contact your local ASSAP advisor and book a consultation. Three key actions have been identified:

- Reduce phosphorus and sediment losses. Use 'break the pathway' measures to prevent run-off overland into the drainage networks. For example, targeted riparian margins and buffer margins, use of low earthen mounds, planting of trees and hedgerows, prevention of livestock access to water, wetland ponds, careful management of critical source areas and sediment traps.
- Reduce nitrogen losses. Ensure soil fertility is optimum for P, K and pH, take soil samples and follow a nutrient management plan. Apply fertiliser/slurry when soil temperature, soil moisture content, growth rates and weather forecast are suitable particularly in the early and late growing season. Quantify the nitrogen surplus on your farm and take measures to reduce the surplus that is available to be lost to water.
- Ensure that your slurry, soiled water, dairy washings, silage effluent and farmyard manure collection and storage facilities meet requirements. Make your contractor aware of the locations of critical source areas, watercourses, drains, etc. on your farm. Ensure appropriate buffers zones are kept when spreading organic manures.

Biodiversity

Biodiversity management on-farm involves retaining, enhancing and creating habitats. It is important to optimise the biodiversity value of existing farmland habitats before new biodiversity measures are established.

- Do not top escaped hedges, side trim only. The biodiversity value is in the canopy and in bank and ground vegetation.
- Side trim topped hedges from a wide base to a triangular profile. Cut the growing point to prevent escaping, leaving the peak as high as possible. Retain occasional thorn saplings and allow them to mature into flowering and fruiting trees.
- Maintain riparian buffer strips. These are strips of permanent vegetation adjacent to rivers and streams that are typically excluded from intensive farming practices. Appropriately managed buffer strips play an important role in maintaining water quality, ensuring bank stability and providing a habitat for biodiversity.
- Quantify the biodiversity enriched area across the overall farm, and develop a plan to increase biodiversity across the rest of the farm.

Future technologies to increase sustainability

New technologies are currently being developed/researched. In time, these will further increase the sustainability of the dairy industry.

Cow health and welfare

Recently published Moorepark research highlighted links between reduced lameness and reduced SCC associated with genetic selection (i.e. better EBI). In the future, it is anticipated that there will be greater emphasis on health traits in the EBI as other issues become less of an issue. For example, a recent study indicated that animals with greater genetic merit for TB resistance are less likely to test positive for TB even though their herd mates may test positive. Data from ICBF indicates that herd replacement rate has declined from 23% in 2013 to 19% in 2022. At the same time, the number of recycled cows in the system has reduced from 16% to 11%, while difficult calvings has declined from 1.8% in 2013 to 1.2%

in 2022. The focus will continue to remain on a pasture-based system with a long grazing season with grazed grass constituting the majority of the dairy cow diet and not on milk yield per cow.

It is anticipated that there will be a substantial growth in the beef-cross offspring coming from the dairy herd, facilitated by increased use of sexed semen. Teagasc Grange research has reported that when Angus calves are compared with Holstein Friesian calves, the Angus calves finish at an earlier age and have a higher carcass value, resulting in both reduced costs of production and higher output. Every spring, there is a period when there is greater calf supply to the market than demand for calves. There are a number of strategies that affect both the supply of calves to the market and the demand for calves. These include increasing the profit potential of the calf, developing profitable production systems for early maturing dairy calf-to-beef, developing and maintaining high welfare animal transport systems that allow calves to move to mainland Europe, investing in labour efficient calf-rearing systems that will facilitate calves remaining on farm, if required, for longer periods, as well as dairy and beef farmers developing relationships that facilitates a model that is beneficial to both parties. The newly developed Commercial Calf Value (CBV) tool will provide the communication mechanism around dairy-beef calf potential profitability.

Greenhouse gas emissions

There is a significant programme of work underway in GHG emissions research that has the potential to markedly reduce the emissions profile from agriculture, as well as providing solutions to reduce emissions at farm level. Enteric methane is estimated based on models that were developed based on international emission factors for methane. Research conducted in recent years across several research groups in Ireland indicated that the emission factor for enteric methane for Ireland is over-estimated. Table 2 summarizes a number of published studies quantifying enteric methane using different techniques between 2010 and 2023. The studies indicated enteric methane emission factors as a percentage of gross energy intake ranging from 4.9%-6.78%. The most recent study, which lasted for more than seven months of the lactation: found that enteric methane emissions were extremely low in the spring, <4.8% of gross energy intake, and then increased as the grazing season progressed. The seasonal pattern of enteric methane emissions within pasture-based systems requires further investigation to increase the understanding of enteric methane emission profiles. A number of studies recently completed suggest that the emission factor used when animals are indoors on grass silage also over-estimates the enteric methane emissions.

Table 2. *Enteric methane measurements across a range of studies carried out with grass in Ireland*

Study	Enteric methane measurement method	Ym* (%)
Wims *et al.*, 2010	SF6	5.9
Ferris *et al.*, 2020	SF6	4.9
Hynes *et al.*, 2016	Respiration chamber	5.6
Lahart *et al.*, 2023	Greenfeed measurement	5.3
Jiao *et al.*, 2014	SF6	5.6
Foley *et al.*, 2008	SF6	6.3
Lovett *et al.*, 2005	SF6	5.64
Hidalgo *et al.*, 2014	SF6	6.78
Mean		5.75

**Ym is the methane conversion rate expressed as a fraction (i.e. the fractional loss of GEI as combustible CH4)*

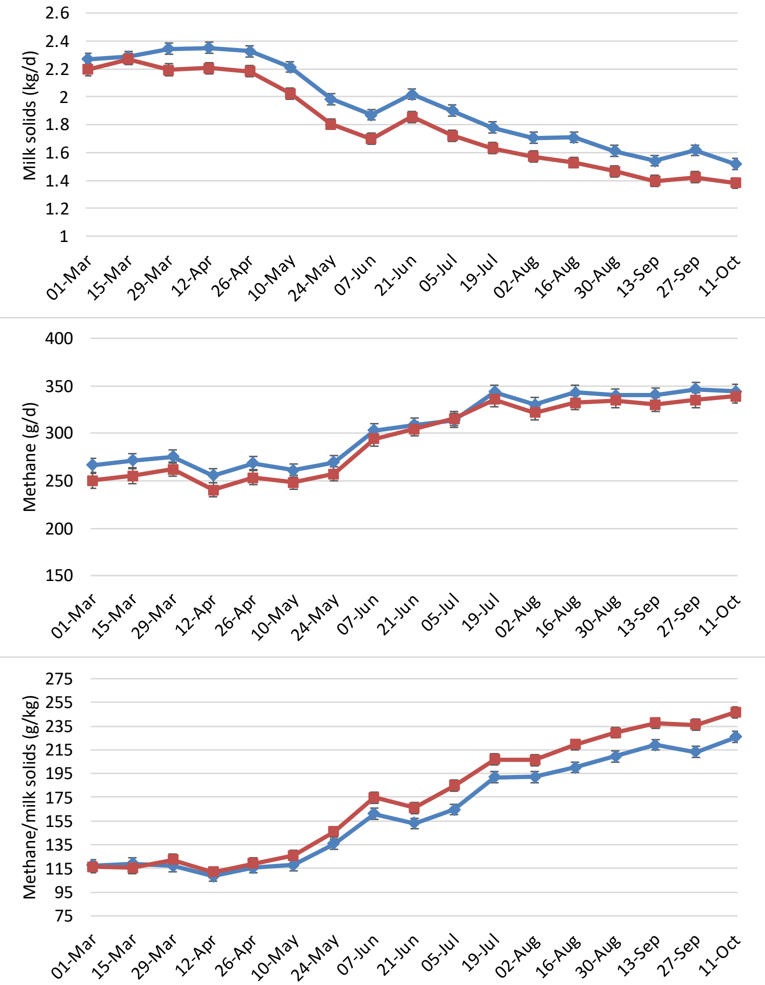


Figure 8. *Graphs showing a) milk solids yield, b) methane emissions and c) the proportion of methane emitted per unit of milk solids for the high economic breeding index (EBI) (blue lines) and national average EBI (orange lines) dairy cows across the experimental period*

Previous studies have reported that increasing EBI results in a reduced carbon footprint but does not result in reduced total emissions. This analysis was completed using models that simulated herd performance. The modelling simulated that enteric methane increased when milk yield increased. When enteric methane emissions were measured in individual cows, however, high EBI cows had similar daily enteric methane emissions to lower EBI cows even though they produced higher milk yield (Figure 8). This means that as EBI increases, the emissions factor should decline to reflect the actual methane output by the animal.

Grass quality and seasonal profile

The results presented in Figure 8 show that there are significant seasonal effects associated with enteric methane emissions from dairy cows. Increasing our understanding of these factors will potentially allow manipulation of grassland management and grass breeding to facilitate the development of strategies to reduce enteric methane emissions from cows consuming pasture-based forages.

Feed additives

There is considerable research being conducted nationally and internationally on the use of feed additives to reduce enteric methane. Significant progress has been made internationally in recent years with products like Bovaer produced by DSM achieving reductions of up to 30% in enteric methane emissions in a TMR feeding system. This product is less effective when pulse fed through the milking parlour and therefore requires further work for effective use in pasture-based systems. Other products such as the red seaweed, Asparagopsis, has shown great promise in studies completed to date. Other products like Halides are also showing significant promise in terms of reductions in enteric methane emissions. An important consideration for widespread use of any supplement to reduce enteric methane will be the ability to produce the material in large volumes with consistent amounts of the active material. Other important features include the absence of residues, a mechanism to feed the product to the animal, a mechanism for counting the emission reductions through the national inventory, and that the products do not have a negative effect on performance. It would also be desirable that the supplements are low cost, of natural origin, and can be combined with other solutions.

Carbon sequestration

Carbon emissions from grassland are part of the land use and land use change sector. Current estimates of carbon sequestration in grassland are based on Tier 1 emission factors, which are international default values. There is currently a significant research programme being undertaken to develop country specific emission factors for Irish soils. Further research is being developed to enhance the activity data around land use and land status. This will be enriched with emissions data from hedgerows to generate national emission removals. It is anticipated that when this research is complete, the combined effects of more accurate country specific emission factors and activity data will present a very different picture regarding emissions removals.

Warming effect associated with GHG emissions

The scientific discussions in the area of additional warming effects associated with biogenic methane and its lifespan is now very clear. Research findings indicate that when biogenic methane is first stabilised and then reduced that all additional warming effects can be removed. Further and faster reductions in methane would result in a reduced warming effect (reduction from the historic warming effects). It is possible, however, that agriculture and the land use sector could be in a position to not be contributing to increased warming before 2040. This would require that biogenic methane is first stabilised and then reduced, changes to the land use land use change emissions associated with updated metrics, activity data, technical changes at farm level, and the development and deployment of new solutions at farm level around N_2O.

Water quality

Analysis carried out of the 5th Nitrate Action Programme coupled with increased ambition in fertiliser nitrogen reductions in the Food Vision strategy, would result in a reduction in nitrate-N leaching of between 5.9 kg per ha (circa 10%) and circa 9 kg per ha (circa 18%), depending on modelling approach used. Reducing organic nitrogen per ha from 250-220 kg nitrogen per ha will only reduce nitrate-N leaching by between an additional 2.2 kg nitrogen per ha or 3.5 kg nitrogen per ha depending on modelling approach used, but it will have a significant financial impact at farm level. Consequently, in order to ensure that the overall approach is robust, a sequential approach to firstly allow the impact of the 5th Nitrate Action Programme and the additional fertiliser reductions in the Food Vision Dairy Group Report to be assessed before introducing any reduction in organic nitrogen limits would be desirable.

Conclusion

Irish dairy farming has undergone a transformation during the last 10 years. Up until 2015, there had been 31 years of the EU milk quota regime, which stifled innovation. Since then, there has been significant expansion due to the pent up capacity in the industry. The next phase of development will have to be based on the principle of decoupling GHG and NO_3 emissions and N loss from production, while advancing the quality and quantity of enriched areas on-farm. All of this is possible and will be the focus of technologies that are introduced onto farms in the coming years. This will all occur at a time when there is increasing investment in research for new solutions and will provide the platform for even greater ambition around sustainability at farm level. It is also clear, however, that grass-based systems of milk production have an important role in sustainable ruminant production globally, and could play an even greater role in the provision of ruminant products in the future. It is necessary to improve the metrics used to evaluate the sustainability of the farms, and to ensure that a robust and balanced assessment of farm sustainability is completed during the process. Additional metrics for water use, feed/food competition, and international emissions comparisons are required.