# Delivering on sustainability

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**Summary**

- On average dairy cows in Ireland have access to pasture for 71% of the year and are managed on farms that operate at low stocking rates (<2.1 livestock units (LU)/ha) with relatively low milk yield per cow
- Cow locomotion/lameness is the key dairy cow welfare consideration on farm
- Calf mortality in Ireland is low when compared internationally. There is an increasing requirement to develop integration strategies between the dairy and beef industries in order to maximise opportunities for animal welfare, the environment and economics
- Total Irish agricultural greenhouse gas emissions currently are similar to 1998. Irelands dairy carbon footprint is one of the lowest in the world with plans to reduce it further through increased productivity and efficiency, movement to urea based fertilisers, and reduced crude protein concentration of bought in concentrate
- Ammonia emissions reduced by 7.2% between 2018 and 2019. Achieving Irelands ammonia emissions target reduction is dependent on the widespread use of protected urea, reduced N fertiliser and the uptake of low emissions slurry spreading technologies
- The most recent water quality report from the EPA (Water Quality in 2020) shows an increase in ecological water quality in Ireland compared to the previous report. Further gains will be possible based on management changes at farm level based on a focus of reducing N surplus and increasing N use efficiency
- 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
- Habitat areas cover approximately 7.5% of the land area on dairy farms with specific plans required to increase the quantity and quality of these areas om all farms
- Irish dairying is a significant net contributor to the production of human digestible protein.

## Introduction

The Irish dairy sector has gone through a transformational change over the past 10 years with a 77% increase in milk output and 43% increase in cow numbers in the period 2007–2009 to 2020 (CSO, 2021). This increase follows a period of stagnation in the dairy industry due to the EU milk quota regime which was introduced in 1984 to stabilise market support expenditure. Ireland's grass-based milk production systems provide a comparative economic advantage due to lower costs of milk production globally. Dairy production in Ireland has a higher margin, even when accounting for unpaid land, labour and capital, than countries such as the UK, Netherlands, France, Germany and Denmark even though the milk price received by Irish farmers is less.

The expansion achieved in the Irish dairy industry is reflective of the pent up capacity as a result of milk quotas as well as the technology developments that had occurred (grassland and genetics) on farms over the proceeding 15–20 years. While this rapid expansion is now stabilising at farm level, the next phase for the dairy industry will be dependent on policy change, with an expectation of steady growth in the industry in future years.

In order to evaluate an industries performance it is important to look at its overall sustainability. There are three pillars to sustainability 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, 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 as importantly, are the environmental and resource considerations for the farm (e.g. GHG emissions, nutrient use efficiency, etc). For this paper a number of the aspects around social and environmental sustainability will be discussed. Economic sustainability is discussed in the first paper in this Open Day proceedings.

Topics discussed include cow welfare, calf welfare, greenhouse gas (GHG) emissions, ammonia ($NH_3$) emissions, water quality, water use, biodiversity and land use planning.

## 1. Cow welfare

Dairy cows in Ireland have, on average, access to grazed grass for 71% of the year and are free to roam around an assigned paddock/paddocks. Irish pasture-based systems, with average milk yields of 430 kg milk solids (MS)/cow, have one of the lowest milk yields per cow in Europe. Irish animals are generally not exposed to production type diseases and issues that are common in countries where milk production per cow is maximised. In general, in Ireland profitability is not maximised where milk production per cow is maximised but is where grass utilisation per hectare is maximised (Hanrahan *et al.*, 2018). In Ireland, the key animal welfare considerations are around lameness and Somatic Cell Count (SCC). Somatic Cell Count is a good indicator of mastitis based diseases on farm. Data from the Animal Health Ireland (AHI) *CellCheck* program shows that the average SCC levels in dairy herds has declined over the past 10 years with average SCC now close to 175,000 cells/ml (AHI, 2021).

In terms of lameness; a recent analysis of 11,742 cows across 68 pasture-based dairy farms in the Munster region shows that just over 30% of cows studied had mild suboptimal mobility, 6% of cows had moderate suboptimal mobility, and less than 1% of cows had severe suboptimal mobility (Figure 1. O'Connor *et al.*, 2019). The category of mild suboptimal mobility requires detection by a trained individual. This compares favourably with most international comparisons.

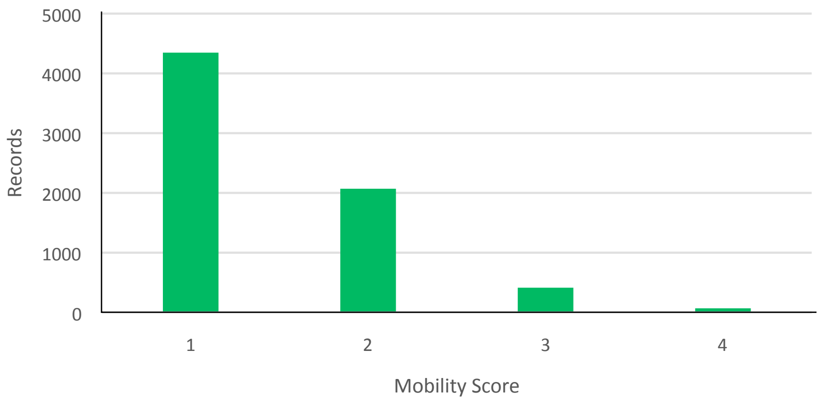


**Figure 1**. *Mobility score on 62 commercial dairy herds in Ireland*

Finally, in relation to dairy cow welfare, herd age profile is ever increasing, with the average number of calvings per cow increasing from 3.3 years in 2014 to 3.6 years in 2020 (ICBF, 2021). The target is for the average parity within the herd to increase to 4.5 in the target system. Clearly, there is a considerable amount of work required to achieve this target in areas of breeding and management, which will result in reduced GHG emissions per unit of product, increased productivity and profitability of the herd as a whole, while at the same time increasing the age profile of the herd.

Key to all of these improvements has been developments in the Economic Breeding Index (EBI). The EBI was launched in 2001 and has economic based traits that select for a balance of characteristics in the animal, from health, longevity, fertility and production.

The index is identifying animals that have a broad balance of characteristics rather than just production, which was the case in the past. Within the dairy industry as a whole, the key to continued dairy cow welfare improvements will be a focus on farm management, infrastructure and breeding.

## 2. Calf welfare

As mentioned earlier there are now approximately 43% more dairy cows in Ireland compared to the period 2007–2009. Incidentally, dairy cow numbers are approximately the same as they were in 1984 when milk quotas were first introduced. These additional cows are increasing the numbers of dairy origin calves entering the beef industry. While difficult to compare, overall calf mortality in Ireland compares favourably with other countries. For example, calf mortality at three months of age in the UK was 6.0%, it was 7.8% up to 55 days of age in the Netherlands, while the figures from Ireland at 28 days of age were 3.6% over the period 2017–2019.

In Ireland, the additional calves provide a significant opportunity for the beef industry to reduce GHG emissions and production costs associated with beef production. Within this context there is a need for the dairy industry to embrace technologies like sexed semen and the Dairy Beef Index. There is also a requirement for leadership within the industry around incentivising earlier age at slaughter and introducing beef pricing strategies that reward carcasses based on the yield of different meat cuts, as well as the costs to process the carcass. The live export of calves is extremely important at satisfying a market demand while reducing the livestock pressures in Ireland. A key component of calf transport centres on animal welfare, which will need to be underpinned with strategies that minimise animal discomfort and stress. While calf mortality in Ireland is low as previously stated, there is a need to ensure that this is maintained at farm level, through appropriate technologies and investment. There is a real need for joined up strategies between the beef and dairy industry to develop profitable beef systems that are early maturing (lower emissions) and can provide a reward to both the dairy and beef farmers, while helping to decarbonise agriculture.

## 3. GHG emissions

The Climate Action and Low Carbon Development (Amendment) Bill 2021, will 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'. Ireland's GHG emissions from agriculture in 2018 were similar to 1998 with emissions in 2019 declining by 4%, the first decline since 2014 (Figure 2. EPA 2021). Agricultural emissions declined between 1998 and 2011 followed by increases as dairy cow numbers have increased.

Cattle numbers peaked in 1998 at 7.6 million (Figure 3; CSO, 2021). Between 1998 and 2011, cattle numbers dropped as cow numbers declined due to increases in milk yield per cow. Between 2011 and 2017, average cattle numbers increased from 6.2 million to 7.0 million. Since 2017, there has been a decline in cattle numbers. In 2020, average cattle numbers were below 1998 by approximately 800,000.

### *Climate action plan*

For the dairy industry, which exited milk quota just over six years ago, the development of carbon budgets will be watched with concern. Clearly, there is a need for agriculture to play its part in GHG emissions reductions. However, in reality anything over a 15% of mitigation (without further research advances) for agriculture, will be extremely difficult to achieve without affecting activity. Within the dairy industry under the milk quota system where there was fixed output, there tended to be stagnation in terms of vibrancy, in terms of investment and most importantly in the introduction of young people to the industry. Clearly, this must be avoided; and the focus of the policy should be to decouple GHG emissions from production and not to cap production. Presently there is a dearth of proven technologies to reduce GHG emissions at farm level. However, there is currently significant investment in GHG emissions reduction technologies at research level, which will increase the possible mitigation strategies. Ireland's competitive position from a GHG emissions perspective means that mitigation strategies that reduce milk production in Ireland have a huge global marginal abatement cost, because in effect GHG emissions will be increasing (decreasing in Ireland and increasing to a greater level internationally) to meet market demand as has been pointed out in a number of studies. Unfortunately, this level of robust scientific information is discounted within the largely unscientific discussions that often happen between vocal groups.

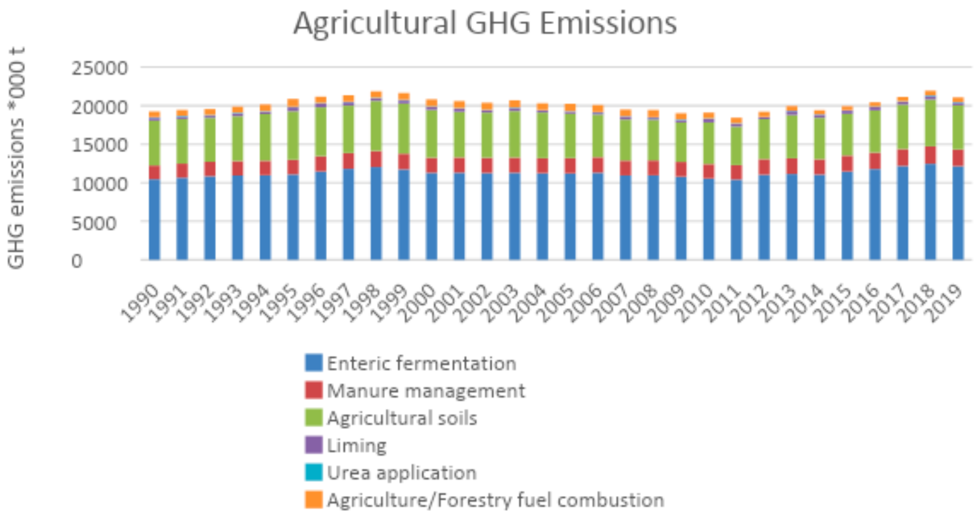


**Figure 2**. *Agricultural GHG emissions between 1990 and 2019 using GWP100*

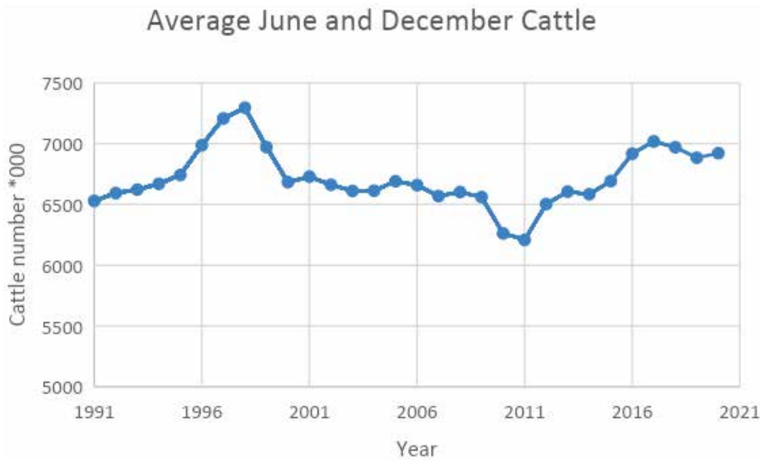


**Figure 3**. *Livestock numbers average June and December over the period 1991–2020 (CSO, 2021)*

### *Carbon footprint*

The carbon footprint of Irish milk is one of the lowest in the world. Recent analysis shows that the average dairy carbon footprint is 0.99 kg $CO_2$e/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 $CO_2$e/kg FPCM (Herron *et al.*, 2021). While all published studies use different approaches and some are more robust than others, there are very few studies that show a footprint anywhere near these figures. The New Zealand C footprint using a similar approach to Ireland is 0.88 kg $CO_2$e/kg FPCM, while similar approaches in the US generate C footprints of just over 1.01 kg $CO_2$e/kg FPCM. While Irelands C footprint is in a strong position at present, the published strategy for the dairy industry will bring that footprint from 0.99 kg $CO_2$e/kg FPCM today to 0.73 kg $CO_2$e/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 $CO_2$e/kg FPCM. The current position and the plan to reduce emissions includes the reduction in fertiliser N use, substitution of CAN based fertilisers with urea based fertilisers, increased productivity from grazed grass with better dairy cow fertility and lower levels of supplementary feeds (less Land Use Change). The current global average C footprint is 2.4 kg $CO_2$e/kg FPCM (FAO, 2010). Expansion of dairy production in Ireland (0.99 kg $CO_2$e/kg FPCM) if displacing milk with an average C footprint (2.4 kg $CO_2$e/kg FPCM) has had a dramatic effect on reducing global emissions.

### *GWP**

The unique properties of biogenic methane and its lifespan in the atmosphere have been discussed extensively over the past number of years. It is now universally accepted that methane is a potent GHG that is short-lived (~10 years) with a high global warming potential (GWP). It is also now generally accepted that if biogenic methane is stable/reducing slightly over a 20 year cycle then there is little additional warming effect as the overall biogenic methane levels decline. While Ireland's agricultural biogenic methane production declined between 1998 and 2011, there has been a steady increase between 2011 and 2017 since the removal of the milk quota regime (Figure 4). The GWP* metric reflects the lifespan of methane in the atmosphere and assumes that 94% of the methane produced today will have disappeared in 20 years' time. This suggests that where biogenic methane production is declining slightly, there is no additional warming effect and essentially means biogenic methane is not contributing to additional warming. However, in the situation where biogenic methane is increasing there is an increasing warming effect using the GWP* metric. For Irish agriculture, it is important that biogenic methane is stabilized and is reduced over time.

Agriculture's achievement of climate neutrality (which climate policy suggests Ireland must achieve by 2050) will be dependent on removing the additional warming effect associated with methane, reducing the emissions associated with nitrogen (N), and finally capturing and storing the residual emissions. Currently, soils act as a net source of emissions (according to inventory calculations), in order to achieve climate neutrality that source will have to be turned into a sink through measurement, management and land use change at farm level.

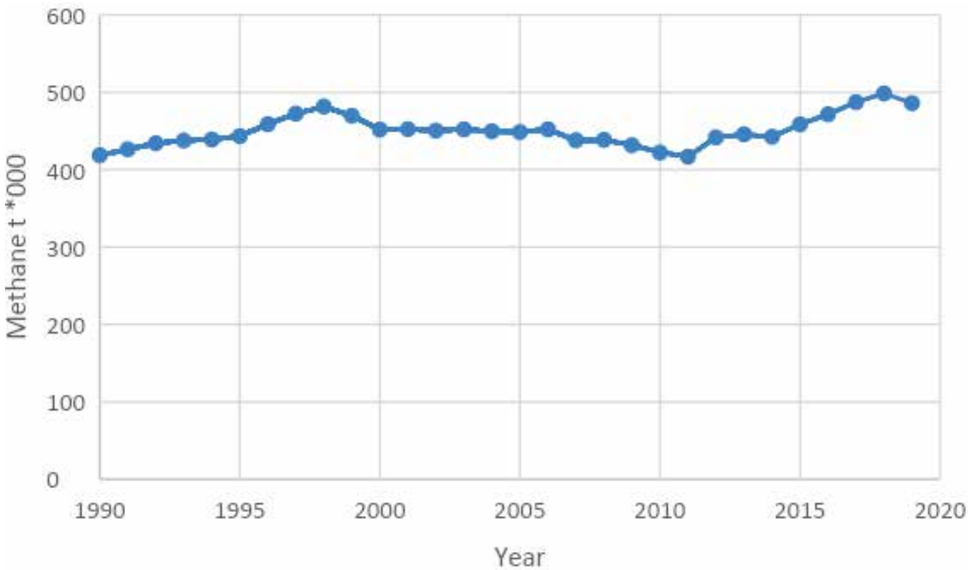


**Figure 4**. *Ireland's methane production over the period 1990–2020*

## 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 47.1% of the emissions associated with manure housing and storage, 30.1% with slurry spreading, and, on average, 12.3% and 10.6% with manure deposition at pasture and N fertiliser, respectively (Figure 5). Total $NH_3$ emissions are above the national ceiling target since 2016, with a substantial jump in $NH_3$ emissions in 2018 to 135.2 thousand tonnes. Ireland's national $NH_3$ emissions ceiling is 116 thousand tonnes, set as part of the NEC (National Emissions Reduction Directive). Emissions in 2019 declined by 9.8 thousand tonne 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 6).

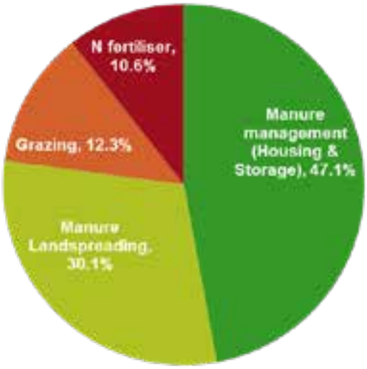


**Figure 5**. *Breakdown of sources of NH3 emissions in Ireland*

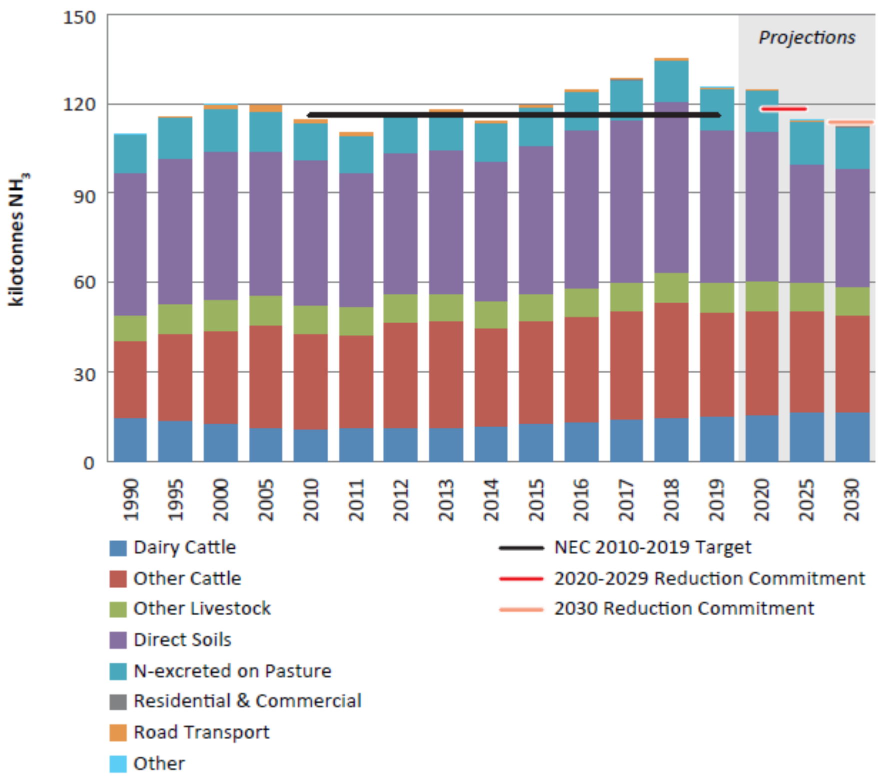


**Figure 6**. *Trends in NH3 emissions between 1990 and 2019 with projections to 2030*

Figure 7 shows the impact of a range of technologies on $NH_3$ emissions and their relative cost (Buckley *et al.*, 2020). Within this analysis, a range of different options to reduce $NH_3$ are proposed. These include reduced crude protein in concentrate feed, use of protected urea instead of ordinary urea, as well as the use of LESS technology for the application of animal manures. In reality, at dairy farm level, the two measures responsible for the vast majority (circa 80%) of the $NH_3$ emissions reductions are the use of protected urea fertiliser and LESS technology. While protected urea has a lower cost (when compared to CAN fertiliser), the use of low emissions slurry spreading technologies have a higher cost. However, with greater N constraints in the future, the value of the N retained within the system will become ever more valuable and the cost implications will be less apparent.

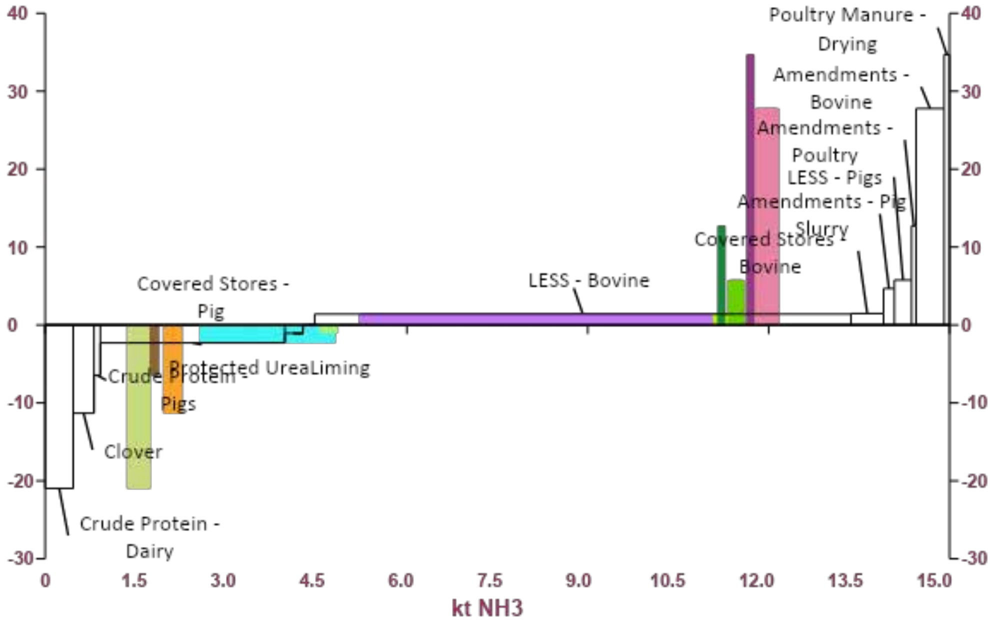


**Figure 7**. *Marginal abatement of NH3 emissions and its related costs*

## 5. Water quality

There are a number of metrics when evaluating water quality that allow the status of the water to be determined. These include the biological status, and the nitrate (NO3) as well as the phosphorous in the water. The biological quality is assessed based on macroinvertebrates and other biological elements and is a subset of overall ecological status. Within rivers, there is currently no environmental quality standards for nitrate. The nitrate standards for drinking water is 50 mg NO3/l. The thresholds for estuarine water quality is 2.6 mg N/l in freshwater at the estuary.

The EPA publish detailed reports describing the change in biological quality and nutrient concentrations on an ongoing basis. The most recent report on water quality was published in July 2021 (Trodd and O'Boyle, 2021). This report, entitled 'Water quality in 2020', covers the periods from 1987–1990 period right up to 2017–2020 period. The report shows that there is a consistent and steady reduction in river water bodies that are described as bad (3.92% in 1987–1990 period and 0.08% in the 2017–2020 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 2017–2020 period being 57%. Of the 1,836 (out of 2,355) river water bodies assessed in 2019 and 2020, 345 showed improvements in quality and 230 declined in quality, resulting in a net improvement in quality in 115 river water bodies (Figure 8).

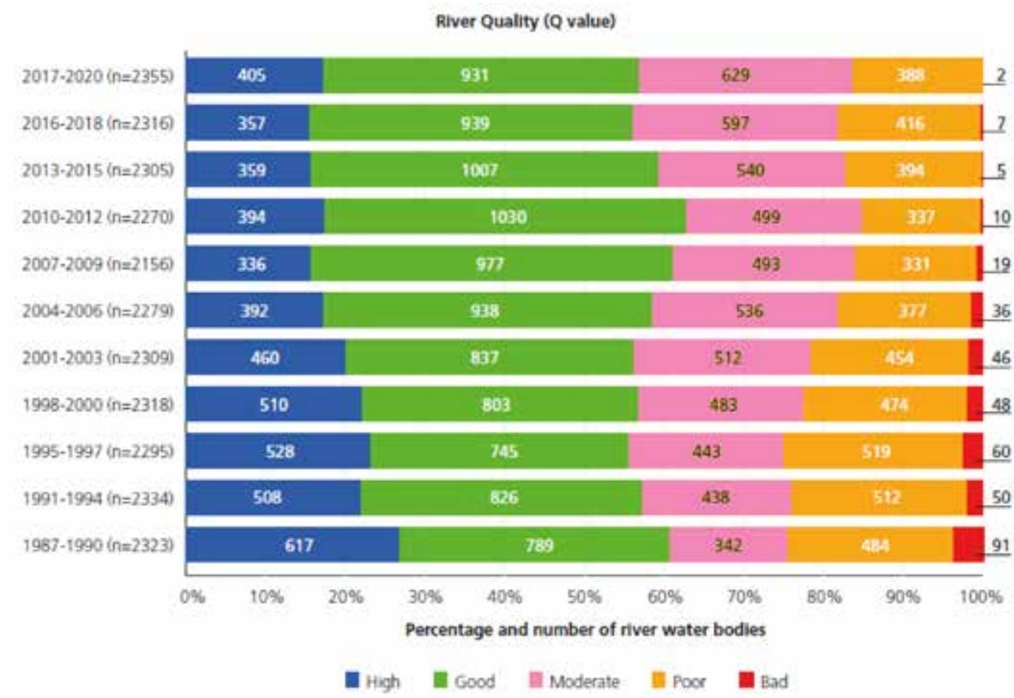


**Figure 8**. *Biological river water quality in Ireland over the period 1987–1990 to 2017–2020*

Recent modelling research completed by Teagasc (Dillon *et al.*, 2021) on NO3 leaching between 2004 and 2020, reported a 23% increase in N loss in 2018 when compared to the average year due to weather patterns observed. The relationships between N surplus and N lost to groundwater across different soil types is shown in Figure 9. It is evident that the risk of NO3 loss is much higher on free draining soils than heavy soils with moderate soils in between.

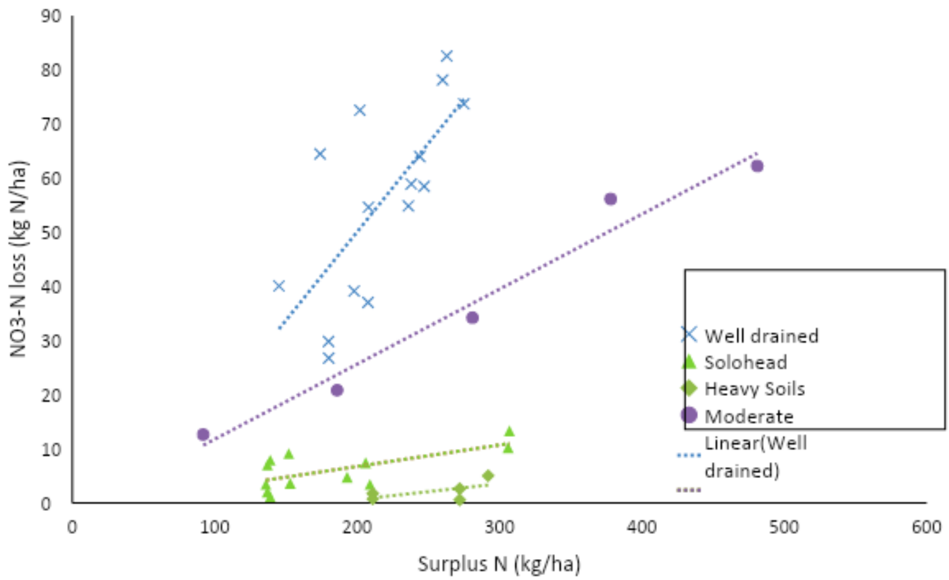


**Figure 9**. *Relationships between surplus N and groundwater NO3-N loss from reviewed studies on the range of different soil types used for pasture-based farming in Ireland*

A recent EPA report (WFD River Basin Management Plan — 3rd Cycle) has identified N reduction loads required to achieve the water quality standard of 2.6 mg N/l in the downstream estuary (Table 1). It is clear that there is significant year-to-year variability in N reduction loads to achieve the standard. There are a range of reasons for differences from year-to-year including dilution (effective drainage influenced by rainfall), surplus N, grass growth and NO3 leaching levels to 1 m and below. This means that a catchment with the same N load across years will have different outcomes in the water and will have different water quality at the estuary. Table 1 identifies the retrospective reductions in total N required across the catchments. Some catchments required virtually no load reductions over the period (e.g. Avoca, Corrib, Dodder, Erne, Fergus, Lee, Maigue, Moy and Tolka), while other catchments showed significant year-to-year variability (e.g. Barrow, Blackwater, Liffey, Nore, Slaney and Suir).

**Table 1. Annual N load reductions (tonnes) required to achieve the environmental water quality standard of 2.6 mg N/l in the downstream estuary. Source: EPA**

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avoca | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bandon | 168 | 0 | 158 | 329 | 231 | 124 | 531 | 124 | 424 | 579 | 616 | 299 |
| Barrow | 3,968 | 4,856 | 1,732 | 2,455 | 1,579 | 2,848 | 1,839 | 1,868 | 2,928 | 8,114 | 3,835 | 3,275 |
| Blackwater | 0 | 751 | 0 | 0 | 0 | 759 | 170 | 2,438 | 862 | 1,638 | 1,629 | 750 |
| Boyne | 56 | 1,284 | 594 | 917 | 89 | 1,544 | 1,124 | 142 | 351 | 1,847 | 2,310 | 933 |
| Corrib | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Deel | 0 | 0 | 33 | 0 | 0 | 0 | 150 | 0 | 136 | 537 | 361 | 111 |
| Dodder | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 5 |
| Erne | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fergus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lee | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 183 | 17 |
| Liffey | 0 | 0 | 0 | 0 | 23 | 48 | 165 | 0 | 0 | 1,123 | 135 | 136 |
| Maigue | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 160 | 437 | 54 |
| Moy | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nore | 623 | 277 | 755 | 419 | 385 | 1,286 | 743 | 470 | 690 | 2,054 | 2,168 | 897 |
| Slaney | 6,561 | 2,593 | 2,040 | 2,824 | 2,877 | 3,371 | 2,288 | 2,088 | 2,366 | 5,995 | 3,290 | 3,299 |
| Suir | 2,778 | 2,633 | 1,255 | 0 | 0 | 0 | 0 | 216 | 445 | 742 | 545 | 783 |
| Tolka | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 22 | 43 | 7 |
| **Total** | **14,154** | **12,394** | **6,567** | **6,944** | **5,184** | **9,991** | **7,010** | **7,346** | **8,257** | **22,811** | **15,552** | |

The total N load reductions entering the water required in individual catchments, expressed as N loss reductions per hectare across all hectares of land, is shown in Table 2. Five catchments require zero reductions (Avoca, Corrib, Erne, Fergus, Moy), eight require reductions of under 3 kg N/ha (Blackwater, Deel, Dodder, Lee, Liffey, Maigue, Suir and Tolka) while four require reductions of over 3 kg N/ha (Bandon, Boyne, Nore, Slaney). The range of reductions of N entering the water required was 0–18.7 kg N/ha. The analysis shows that the Slaney requires considerable attention and investigation as the load reductions required are a multiple of other catchments with the nearest (Bandon) requiring three and half times less of a reduction. In reality not all of the area in a catchment is farmed and therefore to achieve the levels of load reduction entering the water stipulated by the report, significantly higher reductions would be required on a per hectare farmed basis. If this analysis was completed assuming that all of the reductions would be made in the critical source areas for loss identified by the EPA in each catchment, the reductions needed would be much higher again. For example, in the Blackwater catchment the load reductions would correspond to 7.61 kg N/ha, while in the Slaney the reductions required would be 53.5 kg N/ha if all of the reductions are to be achieved within the critical source areas. In reality the load reductions required will be somewhere between the critical source area and total area calculations for each of the catchments.

A recent Teagasc report on potential N loss reduction strategies has identified a range of strategies that will reduce N loss to 1 m soil depth. These include reducing chemical N fertiliser application by 10% (reduced N loss to 1 m is 1.5 kg N/ha), adhering to the Nitrates Directive (50 kg N reduction in fertiliser N reduced N loss to 1 m by 2.9 kg N/ha), and avoiding slurry spreading during the prohibited period (reduced N loss to water by 3.2 kg N/ha) in the paddocks affected. This analysis also indicated that highly stocked land areas are of a particular risk for increased N loss. Increasing the organic N figures per cow would result in a reduction in stocking rate and that reduction would reduce N loss by 1.3 kg N/ha.

When the Teagasc analysis is joined with the EPA N load reductions, it is clear that there is a requirement for a range of actions at farm level to achieve the load reductions stipulated by the EPA.

**Table 2. Annual nitrogen load reductions (kg N/ha) reaching water courses in individual catchments across all hectares required to achieve the environmental water quality standard of 2.6 mg N/l in the downstream estuary**

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avoca | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bandon | 2.76 | 0.00 | 2.60 | 5.41 | 3.80 | 2.04 | 8.73 | 2.04 | 6.97 | 9.52 | 10.13 | 4.91 |
| Barrow | 12.94 | 15.83 | 5.65 | 8.00 | 5.15 | 9.29 | 6.00 | 6.09 | 9.55 | 26.46 | 12.50 | 10.68 |
| Blackwater | 0.00 | 2.26 | 0.00 | 0.00 | 0.00 | 2.28 | 0.51 | 7.33 | 2.59 | 4.93 | 4.90 | 2.26 |
| Boyne | 0.21 | 4.76 | 2.20 | 3.40 | 0.33 | 5.73 | 4.17 | 0.53 | 1.30 | 6.85 | 8.57 | 3.46 |
| Corrib | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Deel | 0.00 | 0.00 | 0.68 | 0.00 | 0.00 | 0.00 | 3.09 | 0.00 | 2.80 | 11.05 | 7.43 | 2.28 |
| Dodder | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.42 | 0.00 | 0.00 | 0.40 |
| Erne | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fergus | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lee | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 1.46 | 0.14 |
| Liffey | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 0.38 | 1.31 | 0.00 | 0.00 | 8.94 | 1.07 | 1.08 |
| Maigue | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.52 | 4.15 | 0.52 |
| Moy | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nore | 2.46 | 1.09 | 2.98 | 1.66 | 1.52 | 5.08 | 2.94 | 1.86 | 2.73 | 8.12 | 8.57 | 3.55 |
| Slaney | 37.24 | 14.72 | 11.58 | 16.03 | 16.33 | 19.13 | 12.99 | 11.85 | 13.43 | 34.02 | 18.67 | 18.73 |
| Suir | 7.70 | 7.29 | 3.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 | 1.23 | 2.06 | 1.51 | 2.17 |
| Tolka | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.82 | 0.00 | 0.00 | 0.00 | 1.51 | 2.95 | 0.48 |
| **Total** | **3.52** | **2.55** | **1.62** | **1.92** | **1.52** | **2.49** | **2.21** | **1.68** | **2.50** | **6.39** | **4.55** | **2.81** |

## 6. Water use

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, 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 farms has shown that blue water consumption was 6 l water/kg FPCM in Ireland (Murphy *et al.*, 2018). This compares to 108 l/kg milk in Australia and 125 L/kg FPCM in the US. The differences in blue water use are mainly driven by differences in irrigation. 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.

## 7. Biodiversity

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 dairy farm in Ireland, approximately 7.5% 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 even higher, however research is required to determine the total proportion allocated to natural or semi natural purposes. These levels contrast well with European farms. Typically, dairy/beef farmers are not high users of insecticides, pesticides or herbicides, which can be damaging from a biodiversity perspective. Figure 10 shows the current status and trends for species protected under the Habitats Directive in Ireland. Presently, the status of 57% of species is defined as favourable, while, positively, the trend for 72% of species is defined as stable or improving.

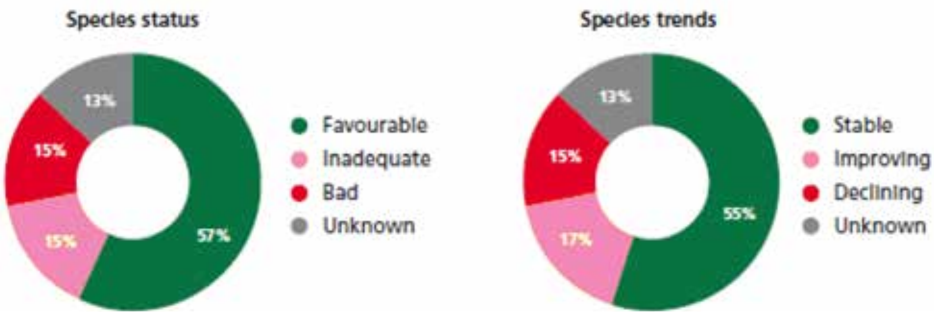


**Figure 10**. *Overall assessment results for the status and trends in species protected under the EU habitats directive in Ireland (Source: NPWS article 17 Data 2019)*

Farming and agriculture have been labelled as the problem when it comes to biodiversity loss. In reality, dairy farmers can help be the solution and are looking for the advice and actions to help protect biodiversity on their farms. The development of effective action plans that can be implemented are key to increasing biodiversity on dairy farms, allowing farms achieve the 10% target area with a higher quality area, while not affecting productivity and profitability. Key strategies should involve protecting existing habitats and not identifying these areas for new C related measures, advancing hedgerows and field margin management (average length is 6 km on dairy farms), protect water courses and buffer zones, and finally there should be a focus on the establishment of new habitats on the farm.

## 8. Land use planning

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. In reality, internationally, there is little of this type of analysis done. While food production must increase to satisfy the increasing demand for animal based proteins, at the same time as there is a focus on reducing associated environmental burdens. Thus there is need to move the question on from not only what people should eat but to also where should that food be produced to ensure there is balance in the overall debate.

The analysis in Table 3 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 3 shows that Irish dairy is providing a positive contribution to global HDP production, even where the opportunity costs of the land used for dairy are taken into account (LUR). Globally, when this type of analysis is completed the LURs tend to be higher. When higher LUR values 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 feed that humans could eat or should land be used to grow crops for food for humans. 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 (poorer land quality) for human edible crop production, such as Ireland. This would require a complete rethink of the global food system and how emissions are counted at a national and international level.

**Table 3. Edible Protein Conversion and Land Use Ratio values of Ireland's ruminant livestock sector (Hennessy, Accepted)**

| | 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 |

## Conclusion

Irish dairy has gone through a transformation over the past 10 years. Up until 2015, there had been 31 years of the EU milk quota systems, which stifled innovation. Since then there has been significant expansion due to the pent up capacity in the industry. This growth is now slowing down and in reality if this level of growth continued into the future, it would not be sustainable. Any future expansion will be based on the principle of decoupling. That is decoupling of GHG and NO3 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 be occurring at a time where there is increasing investment in research for new solutions and will provide the platform for even greater ambition around sustainability at farm level. However, it is also clear that grass-based systems of milk production have a huge role in sustainable ruminant production globally and in reality should play an even greater role in the provision of ruminant products in the future.

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