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DAIRY COUNCIL NORTHERN IRELAND

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EU Sustainable **Dairy**

Combatting the Carbon Challenge

Northern Ireland 2019

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DAIRY COUNCIL NORTHERN IRELAND

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Foreword

Last year's Fact Book, based on the theme of sustainability, proved to be a valuable tool and indeed has been used as a reference document for many people involved in the dairy sector and further afield.

Over the past year there has been a renewed focus on how the dairy sector operates and what measures the sector in Northern Ireland has taken to reduce its impact on the environment. That is why this year's theme is on carbon footprint, with a focus on the improvements and innovations made over the past few decades.

The United Nations Food and Agriculture Organisation (FAO) has recognised that milk is one of the most produced and valuable agriculture commodities worldwide, being produced and consumed in virtually every country in the world. At present, milk and dairy products account for about 14% of global agricultural trade, but the sector is growing fast. The FAO project production to increase by 177 million tonnes by 2025, at an average growth rate of 1.8% per annum in the next 10 years. Over the same period, per capita consumption of dairy products is projected to increase by between 0.8% and 1.7% per year in developing countries, and between 0.5% and 1.1% in developed economies.

The agriculture sector is responsible for 27% of Northern Ireland greenhouse gas emissions[1], in turn Northern Ireland represents 4% of the UK's greenhouse gas emissions[2] and the UK's greenhouse gas emissions account for 1.22% of global greenhouse gas emissions.[3][4] Furthermore, 80% of NI's dairy output is sold outside Northern Ireland.[5]

The dairy sector is an important element of the Northern Ireland economy. It sustains the livelihoods of 3,125 dairy farming families and over 2,000 employees of dairy processors around Northern Ireland. Worth almost £1.5 billion annually, the dairy sector is an important pillar in rural communities throughout Northern Ireland. However, we must also acknowledge that as a sector we are responsible for a variety of emissions, including the biological processes that underpin the daily rhythm of the cow, the feed mix, manure management, the type of technology used, and the packaging and distribution networks.

Northern Ireland farmers and processors know that it is vitally important to look after the environment for future generations, and have already been investing in changes and improvements that are significantly reducing their carbon footprint. For example, the dairy sector has seen a 50% increase in milk production since 1990, yet over the same period fuel and electric emissions have been cut by around 70%, manure emissions by some 27% and enteric fermentation emissions by 30%.[6]

The FAO states that the global dairy sector contributes 4% of the total global anthropogenic GHG emissions. This publication highlights the important work being done by the Agri-food and Biosciences Institute (AFBI) to develop the science base for the application of technology and management practices on farms that will reduce emissions, and demonstrates how these are being used on dairy farms throughout Northern Ireland. The publication also highlights the investment by dairy processors to reduce their emissions, and demonstrates the positive impact that innovation and effective management is having in reducing the dairy sector's carbon footprint.

We are grateful to both the European Milk Forum (EMF) and European Union for support and financial assistance in helping us produce this fact book which, we hope, will lead to continued dialogue amongst key stakeholders across the six European Union countries involved.

Mike Johnston

Dr Mike Johnston MBE, PhD
Chief Executive

[1] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/ghg-inventory-statistical-bulletin-2017-infographic.pdf

[2] https://www.daera-ni.gov.uk/news/northern-ireland-greenhouse-gas-inventory-1990-2017-released

[3] https://www.wri.org/blog/2017/04/interactive-chart-explains-worlds-top-10-emitters-and-how-theyve-changed

[4] https://www.climatewatchdata.org/countries/GBR

[5] Agri-food Strategy Board, 2013

[6] https://www.daera-ni.gov.uk/news/greenhouse-gas-emissions-northern-ireland-dairy-farm-sector

Introduction

Climate change remains one of the greatest environmental challenges that industries across every sector of the economy have to address, both from a sustainability point of view and to ensure that new environmental legislation is adhered to. Research commissioned by the European Milk Forum suggests that 87% of people in Northern Ireland recognise that the climate is changing, and young people (18-28) are the group most concerned about climate change, and the most likely demographic to change their lifestyle in order to reduce their own carbon footprint.

As agriculture is responsible for 27% of total Greenhouse Gas (GHG) emissions in Northern Ireland, there is an increasingly urgent need to reduce the carbon footprint of livestock-based production systems in particular.[7]

Whilst the number of people who would consider adjusting their diet remains relatively low, research shows that 78% of people would be willing to pay slightly more for milk with a lower carbon footprint.

This demonstrates that consumers value dairy as an important part of a nutritious and well-balanced diet, but have high expectations of the sector when it comes to lowering carbon footprint and mitigating against climate change. It is an issue that the dairy sector takes seriously, and a demonstration of why the significant progress that has been made in reducing the carbon footprint over the past number of decades is so important.

Despite the issue of climate change being widely recognised, quantifying and reducing emissions remains a challenge that requires changing long standing practices and being innovative in how we work.

The dairy sector has recognised the importance of reducing the carbon footprint in farming practice, processing and distribution, with extensive work carried out internationally through organisations such as the UN FAO, Global Dairy Platform, Dairy Sustainability Framework, International Dairy Federation, European Milk Forum and more locally in AFBI and CAFRE. This vital research helps to inform our farmers and allows them to make changes in order to reduce their carbon footprint and improve efficiencies throughout the farm.

[7] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/ghg-inventory-statistical-bulletin-2017-infographic.pdf

Chapter 1.

The **carbon** challenge

The **legislative** framework

Internationally, governments across the world are taking a much greater interest in sustainability and the climate, and are passing legislation to introduce more challenging environmental targets. Individual citizens are equally taking the issue much more seriously and an increase in education and public awareness has driven a desire and expectation that businesses across all sectors work harder to reduce their carbon footprint, and has led to individuals adapting their lifestyle to reduce their own carbon footprint.

At the United Nations level, the agreements to date which set out the international legislative context are: the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement.[8]

Supplementary to these international agreements, the UN takes a proactive role in global thought leadership on climate action, hosting an annual UN Climate Change Conference known as the Conference of Parties (COP), with the 2019 COP25 being held in Madrid.[9] Furthermore, this year the Climate Action Summit took place in their New York headquarters on 23rd September 2019.[10]

The UN have also set 17 Sustainable Development Goals, promoting economic growth and sustainability, halting climate change, and tackling poverty and hunger.[11]

In its effort to address climate change and promote sustainability, the European Union has set climate change targets and introduced European Climate Change Programmes in 2000 and then again in 2005, to implement the Kyoto Protocol and to aid the reduction of Greenhouse Gases.[12]

Northern Ireland does not currently have any separate climate change legislation, but greenhouse gas emissions from Northern Ireland contribute to the UK total under the Climate Change Act 2008, and it has a key role to play in meeting our obligations under the Paris Agreement.[16]

In 2014, the European Council adopted the 2030 Climate and Energy framework, introducing EU-wide targets to cut GHG emissions by 40%, improve energy efficiency by 32.5%, and aim for the use of at least 32% renewable energy.[13]

In November 2018, the European Commission presented the 2050 long term strategy, with the ultimate aim of transitioning to a climate-neutral economy by 2050.[14]

The UK Government Climate Change Act commits the UK to an 80% reduction in GHG emissions by 2050 from 1990 baseline levels. There has been a recent amendment to the Climate Change Act that has committed the UK to achieve net zero carbon emissions by 2050.[15]

[8] https://www.un.org/en/sections/issues-depth/climate-change/

[9] https://unfccc.int/news/president-sebastian-pinera-and-minister-carolina-schmidt-launch-cop25-climate-change-summit

[10] https://www.un.org/en/climatechange/un-climate-summit-2019.shtml

[11] https://www.un.org/sustainabledevelopment/

[12] https://ec.europa.eu/clima/policies/eccp/second_en#tab-0-0

[13] https://ec.europa.eu/clima/policies/strategies/2030_en

[14] https://ec.europa.eu/clima/policies/strategies/2050_en#tab-0-0

[15] http://www.legislation.gov.uk/ukpga/2008/27/notes/division/4/1

[16] http://www.legislation.gov.uk/ukpga/2008/27/notes/division/4/1

Reducing **emissions** in NI – **Committee** on **Climate Change** report

The Committee on Climate Change (the CCC) is an independent, statutory body established under the Climate Change Act 2008. Its purpose is to advise the UK Government and devolved administrations on emissions targets and report to Parliament on progress made in reducing greenhouse gas emissions and addressing climate change.[17]

In addition to providing independent advice on setting and meeting carbon budgets and addressing climate change, the CCC monitors progress in reducing emissions and achieving carbon budgets and targets, conducts independent analysis into climate change science, economics and policy, and engages with a wide range of organisations and individuals to share evidence and analysis.

For example, the CCC has recognised that 30% of all greenhouse gas emissions in Northern Ireland are from agriculture, compared to 10% in the rest of the UK, and the farming sector in Northern Ireland tends to have a higher proportion of livestock than is the case in Great Britain.[19] Agriculture will therefore be more challenging to decarbonise in the next decade than most other sectors in our cost-effective path to the fifth carbon budget.

> *"The Committee on Climate Change has identified that Northern Ireland has unique characteristics that bring different opportunities and challenges for decarbonisation compared to the rest of the United Kingdom.[18] Any approach to decarbonisation strategy must therefore take into consideration the particular economic and political circumstances that pertain specifically to Northern Ireland."*

[17] https://www.theccc.org.uk

[18] https://www.theccc.org.uk/publication/reducing-emissions-in-northern-ireland/

[19] https://www.theccc.org.uk/publication/reducing-emissions-in-northern-ireland/

What do we **mean** by **carbon** footprint?

Carbon footprinting helps to quantify the amount of greenhouse gases produced which are expressed in carbon dioxide equivalents.

The Intergovernmental Panel on Climate Change (IPCC) defines 'carbon footprint' as the amount of carbon dioxide released into the atmosphere from the activities of particular individuals, organisations or communities. By reducing our carbon footprint, we can help to tackle climate change and help to protect the planet for future generations.

Virtually everything we do has an impact. Even the food we buy has a carbon footprint attached to it. From the machinery used in the growing process, to further production in factories along with packaging and transportation to shops and supermarkets, and then ultimately the energy and heat used in the cooking process, which all adds to the carbon footprint.

In agriculture the main greenhouse gases are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) which are converted to carbon dioxide equivalents using a multiplying factor equivalent to their 100 year global warming potential.

Currently, there is a dialogue between various governments across the world around the drive to become 'carbon neutral', and 'carbon offsetting' is often mentioned. This doesn't necessarily mean zero emissions, but rather a reduction in emissions or indeed that greater levels of investment are made in environmental programmes that offset emissions from other activities.[20]

[20] https://www.carbonfootprint.com

How is **carbon footprint** measured?

For the agriculture sector it is important to accurately quantify the emissions, in order to identify strategies and measures to ultimately reduce them. Scientists use a carbon footprint calculator to give an estimate of carbon footprint. This can be a complex endeavour as separate models omit or include different variables and factors in their calculations which can lead to divergent results. There are also many challenges in calculating a carbon footprint, and the variation globally in system boundaries, allocation methodology and emission factors makes direct comparisons difficult.

In Northern Ireland, the Agri-Food and Biosciences Institute (AFBI) has developed the BovIS carbon footprint calculator to assist the local dairy sector in establishing a baseline and demonstrate its low carbon footprint relative to other EU member states.[21] This calculator has been independently verified against international standards (PAS 2050; International Dairy Federation), and also validated by comparing the greenhouse gas emissions generated by the calculator for nine Northern Ireland farms, with those obtained from three other GHG calculators used in France and the Netherlands.

This validation work suggests that the total GHG emissions, and emissions per kilogram of milk, were relatively similar across the four calculators, with individual farm variation captured accurately and consistently across all calculators. This verification and comparison provides confidence in the ability of the AFBI calculator to estimate GHG emissions for Northern Ireland dairy farms, and in its ability to be an important tool in the development of mitigation strategies to reduce GHG emissions at farm level. Local dairy farmers can use this calculator to estimate the quantity of GHG emissions per litre of milk produced. The easy-to-use calculator accounts for all activities within a farm that are sources of GHG emissions, such as emissions from rumen fermentation, manure management, fertiliser manufacture and application, and concentrate usage and transportation. The calculator uses the latest research findings from AFBI and other national and international scientific studies.

How does it work?

The online calculator is available to all farmers through the DAERA Online services portal. Located within the suite of BovIS applications, users are guided through a user-friendly e-questionnaire. The information required relates to farm management and annual production, such as: land area for grass and cereal production, number of cows and heifers and milk production, concentrate input and grazing management, fertiliser input and manure management, and fuel and electricity used.

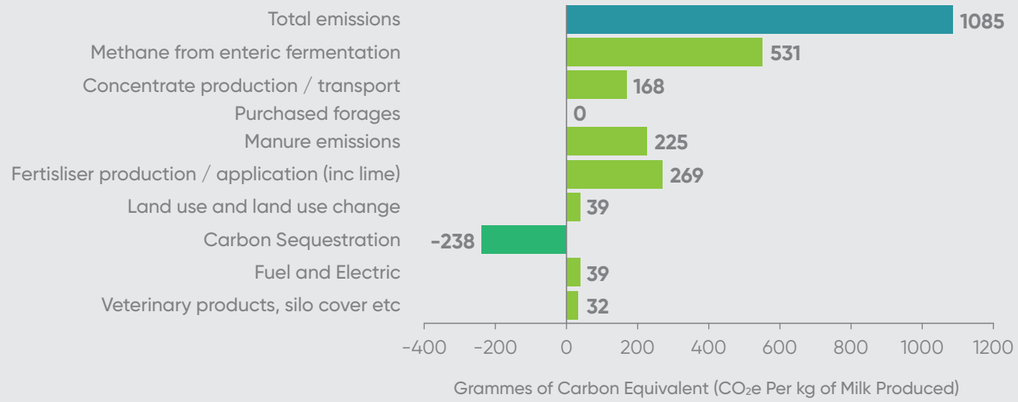
[21] https://www.afbini.gov.uk/news/afbi-develops-carbon-calculator-northern-ireland-dairy-farms

For certain values that are difficult to produce, a range of default factors are provided by the application. The calculator produces a summary report which shows the emissions produced by each part of the farming system. Through calculating their carbon footprint, farmers can investigate ways to reduce the GHG emissions from their dairy enterprise.

The figure below shows the footprint of a typical moderate concentrate input dairy herd in Northern Ireland. The carbon footprint of this system was calculated to be 1085 g of CO_2e/kg milk (blue bar in the below figure), with over 50% coming as methane production from enteric fermentation. To put this into context, the average Northern Ireland Household emits 3.38 tonnes of CO_2 per annum. Fertiliser usage was the second largest source of emissions, particularly as this includes emissions during manufacturing and transport of fertiliser as well as losses on the farm. The third highest source of GHG emissions was from manure, which was at a relatively similar level to the applied fertiliser. Carbon sequestration by permanent grassland offset approximately 18% of the GHG emissions produced by the farm (green bar in the figure below) therefore reducing the overall footprint.

Through understanding the farming system, potential GHG mitigation strategies can be explored. Using this moderate input farm as an example, reducing the age at first calving from 27 to 24 months of age reduces the overall dairy GHG footprint by 7%. This reduced footprint was a result of fewer heifers in total on the farm which also meant that less land, forage, fertiliser and concentrate was required.

The Greenhouse gas footprint of a moderate input Northern Ireland dairy system *(AFBI 2015)*[22]



NI Carbon Intensity Indicators 2019

406 gCO_2/kWh	10.7 tCO_2e per person	139 gCO_2/km	3.38 tCO_2e
Emissions per unit of electricity generated 2017	Greenhouse gas emissions per capita 2017	Average carbon dioxide emissions of licenced cars in Northern Ireland 2018	Residential greenhouse gas emissions per household 2017

[22] https://www.afbini.gov.uk/news/afbi-develops-carbon-calculator-northern-ireland-dairy-farms

Dairy sector **globally**

It is a diverse sector in terms of scale, production systems and geography, but what the sector shares is a desire to produce highly nutritious food in a sustainable and responsible way to meet the demands of a growing population.

An analysis undertaken by the UN Food and Agriculture Organisation (FAO) calculated greenhouse gas emissions from the dairy sector over a ten year time period, highlighted the progress that has been made and provides guidance on areas where future action should be considered.

The same study also reports reductions of GHG emissions per litre of milk produced in all regions of the world, whilst at the same time showing significant increases in production due to a higher demand for milk and dairy products, meaning that absolute emissions have risen in most regions.

Organisations such as the Dairy Sustainability Framework work to find new and innovative ways of reducing GHG emissions from farms and businesses across the globe in an economically and environmentally sustainable way.

The Principles of the Dairy Sustainability Framework[24]

The Dairy Sustainability Framework has been designed on the following three principles:

Align

Ensure regional or localised sustainability programmes are aligned under the sector's vision for sustainability.

Connect

Bring together all regional and local activity and share this with the membership to increase the speed of solution finding.

Progress

Through a collaborative and focussed framework, the speed of activity and subsequent progress is accelerated.

Dairy Sustainability Framework 2019[23]

133 million
dairy farms

600 million
people live on dairy farms

400 million
additional people are supported by the full time jobs that are created in support of dairy farming

240 million
people are directly or indirectly employed in the dairy sector

37 million
farms are female headed with
80 million
women engaged in dairy farming to some extent

[23] dairysustainabilityframework.org

[24] https://dairysustainabilityframework.org/the-gdaa/programmes-of-the-gdaa/the-dairy-sustainability-framework/

Q&A

With Brian Lindsay, Development Director of the Dairy Sustainability Framework

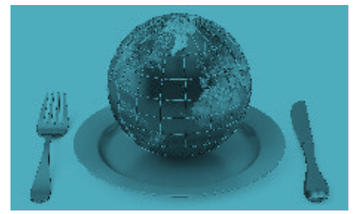
How big of a challenge is climate change for the dairy sector?

The dairy sector itself is made up of more than one billion people, and comprised of some 133 million dairy farms across the world, which includes 80 million women who work on these farms with 37 million being female headed. The vast scale of the sector and vast number of geographies illustrates the challenge associated with reducing the amount of GHG produced.

Climate change, along with population growth, poverty alleviation, environmental degradation and global food insecurity presents a significant challenge to the sector.

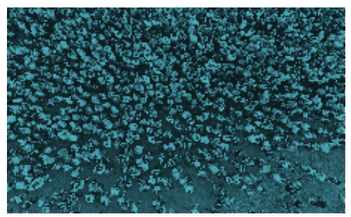
In addition to reducing the environmental impact from dairy production the sector also has to meet society's needs for healthy, nutritious products. Dairy farmers are having to adapt their production systems as climate change is also impacting on how they operate. The dairy sector therefore needs to continue to reduce its greenhouse gas emissions and work towards a low carbon future.

World population is expected to grow to 9 billion by 2050*



Food production will need to increase by 70% to feed the world by 2050*

Global 'middle class' will triple by 2030*



70% of the world population will live in cities by 2050*

70% of suitable agricultural lands are already in use or under protection*

52% of 2050 projected population could have severe water scarcity*

*Courtesy of Brian Lindsay, 2019. * 2009, FAO's Director General on 'How to Feed the World in 2050'. 'Population and Development Review, 35: 837–839.*

How can the dairy sector meet this challenge?

The good news is that there are many opportunities within the sector to limit climate change by reducing emissions. It is important to have reliable, up to date science based evidence at hand, presented in a clear way that can easily be understood, so that best practice and knowledge is able to be shared across the wider dairy sector.

How successful has the sector been in reducing emissions?

Overall there is certainly a good story to tell. Whilst absolute GHG emissions have increased by 18% between 2005 and 2015 (FAO/GDP 2019), this is down to the fact that overall milk production has increased by some 30% over the same period in order to meet consumer demand. Importantly, milk yield has increased by 15%; a clear indication that the dairy sector is implementing changes to significantly improve efficiencies, and it is important to note that without dairy farmers implementing a number of efficiency based management strategies, total GHG emissions from the dairy industry would have increased by 38%.

In fact, emission intensities (GHG per kg of milk) have declined by almost 11% over the same period. These declines are recorded in all dairy regions of the globe reflecting continued improvements in on-farm efficiency, achieved through improved animal performance through improved genetics and nutrition and enhanced management strategies.

Is this the picture across the globe?

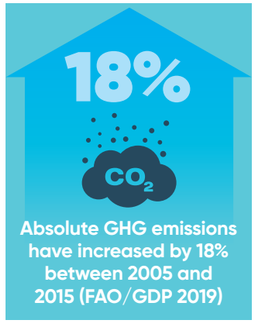
There remains a distinct difference in emission intensities between regions; generally, emission intensity of milk production is lowest in more developed dairy regions (ranging between 1.3 to 1.4 kg CO_2 eq. per kg fat-and-protein corrected milk in 2015) while developing dairy regions such as South Asia, Sub-Saharan Africa, West Asia and North Africa have higher emission intensities (ranging between 4.1 to 6.7 kg CO_2 eq. per kg fat-and-protein corrected milk in 2015). It is exciting to witness the improvements being made in these regions also.

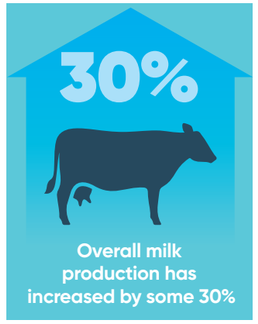
It is important to note that variations within regions regardless of geography also exist, mainly down to differences in management practices which are within the control of farmers.

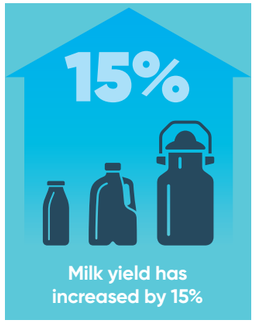
What can farms do to reduce their emissions?

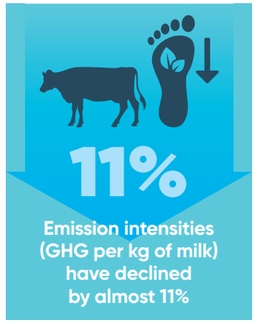
The dairy sector recognises that like any food production system, they are users of natural resources and have a role to play in reducing emissions. All agriculture has many options to reduce emissions and it is about individual farms understanding how they can make the greatest impact. There is no one size fits all!

Agriculture including dairy will therefore also need to address how any residual emissions will be offset. Achieving substantial net reductions in GHG emissions from the dairy sector will require action in the three broad areas of 1) improving efficiencies; 2) capturing and sequestering carbon; and 3) better linking dairy production to the circular bio-economy such as substituting mineral fertiliser with strategic use of livestock manure.









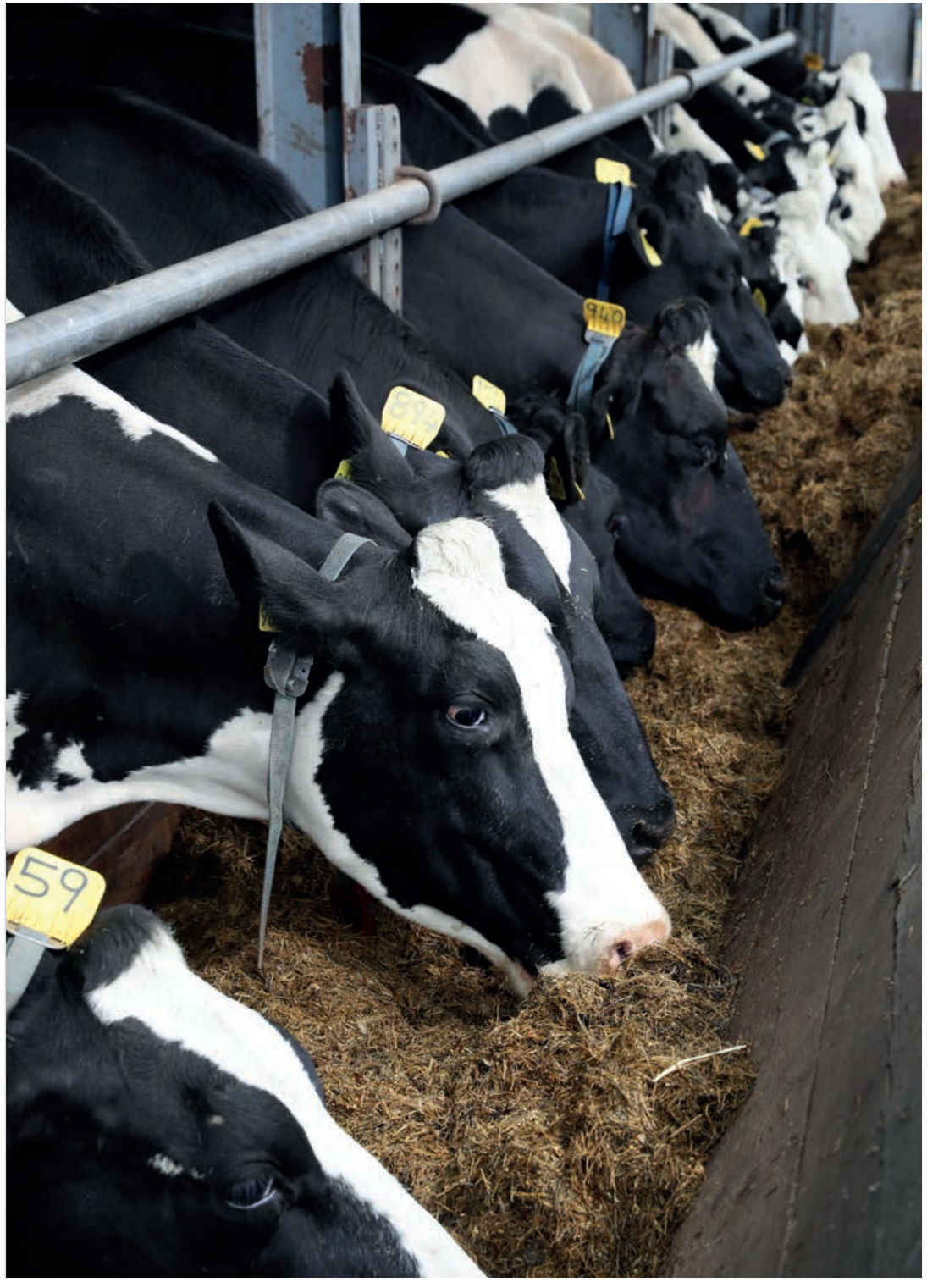
What specifically should farmers be doing?

After investing efforts in continuously improving the dairy herd genetic profile, the role of feeding is fundamental to allow those genetics to be optimised. Improving forage production in terms of output and quality can definitely make a positive impact.

Research and development activities are also proving promising options for the future with developments such as rumen modification and selecting for low methane generating cows, though these are still some time off general commercial availability.

What about grassland and manure management?

Grassland management is important; carbon sequestration, adopting the most efficient grazing practices and pasture management helps farms to capture carbon and mitigate other emissions. In terms of manure management it is important to ensure storage cover, manure disposition and use of efficient application and incorporation into the system, as well as generating biogas from aerobic digestion processes are all possible, though we must recognize each farm has differing circumstances and the mix of options applied may well be very different between different farms and their respective systems of production.



Dairy sector in **Northern Ireland**

At the start of 2017, the Department of Agriculture, Environment and Rural Affairs (DAERA) published a report entitled *Greenhouse Gas Emissions on NI dairy farms; a carbon footprint time series study.*[25] That report provides average carbon footprints for dairy farms between 1990-2014, using the BovIS Dairy Greenhouse Gas (GHG) calculator developed by AFBI. It also identifies the key drivers of variability in carbon footprint between farms and considers the top 25% and bottom 25% when ranked in terms of their carbon footprint.

Dairy Sector in Northern Ireland:

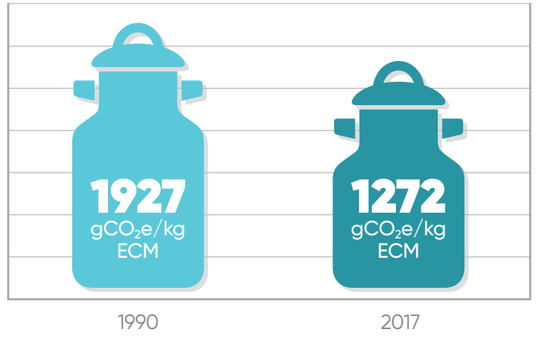
The study demonstrated that dairy farming has made substantial progress in reducing its emissions on a per unit of production basis (30.7%). This is because Northern Ireland has experienced continued growth in its milk production over the period (67% increase since 1990), driven mainly through increases in yield per cow, thus spreading the emissions burden associated with each cow. The milk yield per cow was also the principle factor accounting for the variation of carbon footprint between individual dairy farms.

The report also identified that an additional factor which caused variation in carbon footprint levels between dairy farms was the proportion of their total stock that were lactating dairy cows. This also had an inverse relationship with carbon footprint levels. As the number of dairy replacements increased, both their associated costs and emissions have to be spread over the milk produced, thus highlighting the importance of minimising replacement rates and meeting target calving ages.

Other factors, such as land quality, management capabilities, and genetic potential are all factors in carbon footprint, as are innovations on the farm such as using low energy appliances or generating their renewable energy (e.g. solar panels).

Most recently, in October 2019 the Department for Agriculture, Environment and Rural Affairs published the fourth *'Northern Ireland carbon intensity indicators 2019'* which shows total emissions (excluding sequestration) related to milk production decreased from a population average of 1,927 (CO_2e/kg ECM) in 1990 to 1,272 (CO_2e/kg ECM) in 2017.[26] Whilst milk production in the dairy sector has expanded by 73% since 1990, the total number of dairy cows over this period has increased by only 14%, meaning this improvement in carbon footprint has been driven by substantial increases in milk yield per cow.[27]

Emissions intensity of milk production *(DAERA 2019)*



[25] https://pdfs.semanticscholar.org/aef9/69a1b8fb26bee4c11bc154f6058d073b6c93.pdf

[26] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/northern-ireland-carbon-intensity-indicators-2019.pdf

[275] https://www.daera-ni.gov.uk/sites/default/files/publications/daera/northern-ireland-carbon-intensity-indicators-2019.pdf

"The recent publication clearly shows the progress made by the local dairy industry which has achieved a 30.7% reduction in the amount of carbon it takes to produce a litre of milk since 1990. This has been achieved while dairy cow numbers have remained relatively steady and production has increased by over 60%, clearly demonstrating the benefits brought about by increased efficiency, technological improvements and structural change, all of which play a part in the Efficient Farming approach."

Former DAERA Minister Michelle McIlveen, January 2017

Northern Ireland milk's **'low carbon'** credentials

Research indicates that the carbon footprint of dairy farms in Northern Ireland is appreciably lower than those of dairy farms in many other regions of Northwest Europe. The DAIRYMAN INTERREG Project, a significant piece of work involving some 132 dairy farms across 10 regions of Northwest Europe, indicated that the average GHG emissions per unit ECM (total emissions per kg of energy corrected milk) on Northern Ireland farms is 0.97 kg CO_2e/kg ECM. This was the second lowest in the study, and is an indication of the significant achievement by Northern Ireland dairy farmers.[28]

AFBI's research has demonstrated that the biggest driver of reducing carbon footprint in milk production is production efficiency. A clear understanding of how soils, livestock, the natural environment and effective land management interact with one another is vitally important if dairy farms in Northern Ireland are to continue the reduction of carbon footprint.

"Generally, the results demonstrate that the carbon footprint of contrasting milk production systems is very similar, provided the most efficient breed is used within the system."

[28] https://www.afbini.gov.uk/news/afbi-develops-carbon-calculator-northern-ireland-dairy-farms

AFBI: 'Efficiency key to minimising the carbon footprint of milk production'[29]

A high concentrate input housed system was compared to a medium concentrate input grazing system involving either Holstein-Friesian or cross-bred (Jersey × Holstein-Friesian) cows. The grazing cows were offered 1 kg of concentrate/day during a 199-day grazing period and grass silage and concentrates when indoors. The other group of cows were housed indoors throughout the lactation and offered grass silage and concentrates. Full-lactation concentrate intakes were 791 and 2,905 kg/cow for the grazing and housed cows, respectively. Total emissions allocated to milk production were 36% greater for the housed cows, due to higher emissions related to dietary concentrate supplementation, manure management and enteric fermentation. In contrast, total emissions per kg of energy corrected milk (ECM) were similar with both systems (1.04 and 1.03 kg CO_2e/kg ECM, respectively). Total emissions from Holstein-Friesian cows, when housed indoors, were 9% higher than from the cross-bred cows, reflecting higher milk yields, intakes and replacement rates with the former. Emissions per kg of ECM were 3% lower with Holstein-Friesian cows than with the cross-bred cows, when housed, a consequence of the poorer response of crossbred cows to concentrate supplementation. Generally, the results demonstrate that the carbon footprint of contrasting milk production systems is very similar, provided the most efficient breed is used within the system.

[28] https://www.afbini.gov.uk/news/afbi-develops-carbon-calculator-northern-ireland-dairy-farms

Chapter 2.

Applied **research**

The **Agri-Food** and **Biosciences Institute** (AFBI)

The Agri-Food and Biosciences Institute (AFBI) is a multi-disciplinary organisation with 650 staff involved in high technology research and development, diagnostic and analytical testing for DAERA and other Government departments, public bodies and commercial companies in Northern Ireland, and further afield.

The three main areas of work at AFBI are: natural and marine environment, animal, plant and human health and welfare, and sustainable livestock production.

The primary dairy research themes are:

- Precision nutrition
- Reducing and replacing proteins
- Improving grass utilisation
- Environmental sustainability – Greenhouse Gases, Phosphorus, Ammonia
- Farm systems modelling

There are ongoing research projects at AFBI exploring ways in which the dairy sector in Northern Ireland can lower carbon footprint and greenhouse gas emissions, as well as identifying innovative methods that can be employed at farm level to promote sustainability, mitigate against climate change and reduce the environmental impact of the dairy sector.

A team of research scientists at AFBI- Dr Debbie McConnell, Dr Rodrigo Olave, and Dr Dario Fornara manage the dairy grassland, soil biochemistry, and agroforestry research programmes, respectively.

Although there are a number of factors which influence carbon efficiency in dairy systems, the research team at AFBI focuses on two key areas: grassland management and enteric methane emissions from animals.

Grassland

Within Northern Ireland, 91% of the utilised agricultural area is grassland with 58% of dairy cow diets in Northern Ireland being made up of forage and predominantly grazed or ensiled grass. The cool humid climate in Northern Ireland is suitable for high grassland productivity, with a 250 – 265 day growing season and 1138mm of annual rainfall.

Well-managed grazed grass remains the lowest cost feed stuff available to dairy, beef and sheep farmers in Northern Ireland and according to benchmarking results, feed and forage costs remain the single largest driver of profit on dairy farms within any system. Recent figures suggest a difference in profit of +£264 per cow between farms with high forage efficiency (top 25% ranked milk from forage production) compared with low forage efficiency (bottom 25% ranked on milk from forage production). Thus, improving performance from forage is associated with increased profit on dairy farms, and increased use of home-grown feeds reduces exposure to input price volatility.

According to Dr McConnell, as well as affordability, the increasing use of home-grown forages, especially grass, provides opportunity to lower environmental footprint. Data from AFBI in 2017 showed that for each additional tonne of utilised grass dry matter produced on farm, and with an improvement in grass quality, phosphorus surpluses on farm could be reduced by as much as 8.3kg P/ha, reducing potential phosphorus loss to the environment. In addition, the volume of water required to grow forages such as grass and silage is 690m^3/t and 540m^3/t respectively, which is significantly lower than the amounts of water required to grow concentrates with soya using 2640m^3/t, barley utilising 740m3/t and rape meal consuming 730m^3/t of water. The following table outlines the volume of water required to grow a tonne of various feed types.

Feed Type	Water required m^3/t
Grass	690m^3/t
Silage	540m^3/t
Soya	2,640m^3/t
Barley	740m^3/t
Rape Meal	730m^3/t

In addition, recent research at AFBI has highlighted how managing grasslands for improved productivity can also drive improvements in carbon sequestration. This can be achieved through appropriate use of slurries and organic manures, correcting soil pH and reseeding.

Carbon Sequestration

Slurry

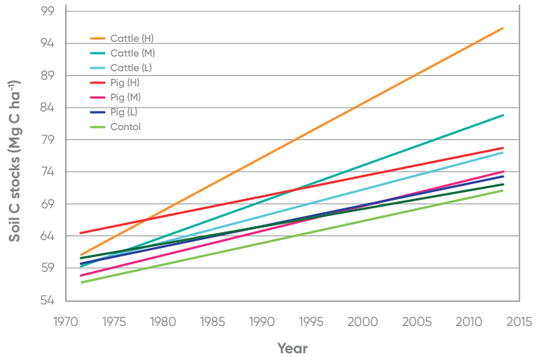
In 1970, a long-term slurry trial was established at AFBI – Hillsborough to determine the impacts of organic manure application on grassland productivity, soil health and carbon sequestration. Measurements of both grass offtake and soil organic matter were gathered over the 50 year period.

The treatments were:

- Control (unfertilised)
- Inorganic fertiliser application (NPK equivalent to 200 kg N ha^{-1} yr^{-1})
- Pig slurry applied at rates of 50, 100, 200 m^3 ha^{-1} yr^{-1}
- Cattle slurry applied at rates of 50, 100, 200 m^3 ha^{-1} yr^{-1}.

Four key observations were made from the trial:

- Adding organic manures to soils bolstered carbon sequestrations compared to soils receiving inorganic or no fertiliser
- Continued slurry amendments increased carbon sequestration rates:
  - Control (no slurry): 0.35t C/ha/yr
  - Cattle slurry (200m^3/ha): 0.86t C/ha/yr
- Sequestration rates were higher for cattle slurry compared with pig slurry
  - All soils continuing to sequester carbon after 50 years
- There is no evident reduction in carbon sequestration rates over time.



This research has highlighted the potential of NI soils to continue to sequester carbon over a long time period. Previous evidence from the Intergovernmental Panel on Climate Change estimated that carbon sequestration potential can be reached after 20 years; however AFBI data shows this is not the case. The cool, temperate climate in Northern Ireland is likely to be one of the contributing factors to this.

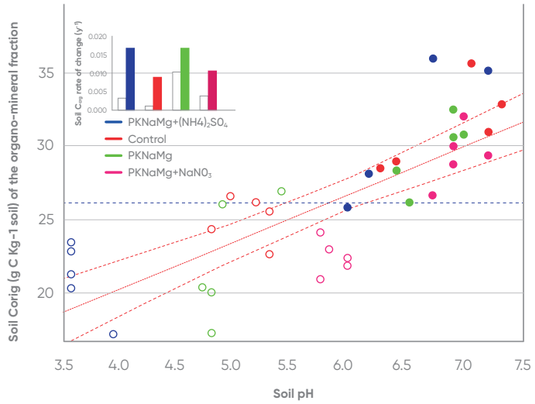
Both inorganic and organic fertilisers improved carbon sequestration rates due to the presence of nitrogen. Nitrogen is essential to bind carbon in the soil and addition of fertiliser N or N in organic manures can be a cost-effective way of growing a feed base. AFBI trials have indicated that for every kilogram of N fertiliser applied, 21 kg DM grass will be produced. This equates to a 3.6:1 return on investment.

Cattle slurry amendments outperformed pig slurry due to the presence of lignocelluloses and slowly digestible organic matter compounds; and there is also high levels of carbon in cattle slurry which aided sequestration. Furthermore it is thought that highly biodegradable pig slurry stimulates a priming effect in the soil mineralising native soil carbon and fresh root-derived material.

Soil

Recently AFBI has conducted a large scale study which investigates the *soil fertility status of commercial farms in Northern Ireland*. With over 12,000 fields from 522 sampled it was discovered that 43% of soils have sub optimal pH and require lime. Based on scientific research if the pH was corrected through lime, grass yields would increase resulting in a fivefold return on the lime investment. Correcting soil pH would lead to more effective and efficient use of applied nutrients helping deliver improved production and reduce nutrient loss to waterways.[30]

In addition to improving grassland productivity, positive relationships between soil pH and carbon sequestration have been identified. Long-term grassland plot studies established at Rothamsted, Harpenden spanning over a century show an increase in carbon sequestration rate as soil pH rises. This increase is believed to be due to an increase in microbial activity within the soil which aids the drawdown of carbon into stores in the soil. Carbon sequestration increases between 200 and 2,000% were identified in these long term plots from improvements in soil pH.



Reseeding

Previous research has shown that the act of reseeding grassland soils has been associated with a short-term release of carbon dioxide. However little was known about the impact of reseeding on sequestration. Using soil cores and field histories for 126 productive grassland field sites across Northern Ireland, AFBI scientists were able to investigate the longer term impact of reseeding on carbon stores. From the results, there was no negative impact of reseeding on carbon sequestration, with the improvement in grassland productivity associated with reseeding, stimulating greater microbial activity in the soil and in turn promoting carbon storage. This indicates that the short term release of carbon dioxide from soil immediately after reseeding can offset by the longer term improvement in grass growth.

[30] https://www.afbini.gov.uk/news/afbi-delivers-uks-most-extensive-and-comprehensive-soil-sampling-scheme

GrassCheck

Essential to ensuring good grassland productivity, and in turn high levels of carbon sequestration, is measurement and monitoring of grass growth throughout the season. However currently only 13% of farms are estimated to regularly measure grass.

GrassCheck NI was established in 1998 to monitor grass growth throughout the growing season. There is 20 years of continuous data on grass growth and quality at two core locations: CAFRE, Greenmount and AFBI, Hillsborough.

Long-term weather records, weekly herbage mass and quality measurements, and grass growth forecasts are published throughout the grazing season.

In 2017, GrassCheck expanded to include data recording of grass growth and grassland management on commercial farms, and since 2018, 48 dairy, beef and sheep farmers participate in the project, from a range of different production systems, land types, growth potential, and management intensity. This has assisted farmers in improving grassland productivity through providing more localised data on grass growth and weather conditions. A detailed dataset collected from these farms, including information such as nutrient application, soil temperature and moisture levels, stocking rates and grazing events helps understand the drivers behind high grassland productivity on commercial farms in Northern Ireland.

The research aims of the project are:

- Provide a detailed understanding of grass growth potential across Northern Ireland
- Identify actual variability in grass production and quality on commercial farms
- Provide a core evidence base for policy on the grassland productivity of Northern Ireland farms

Knowledge exchange benefit:

- Provides weekly bulletin to assist farmers in grassland management decisions
- 7 and 14 days predictions of grass growth to aid planning for grazing/grass-based systems.

Animal enteric methane **emmissions**

All ruminants produce methane gas when food is digested in the rumen, enteric methane accounts for 44% of on farm emissions. Primary digestive microorganisms break down foods into simple products (amino acids and sugars), and these are fermented to produce Volatile Fatty Acids, H_2 and CO_2.

The H_2 is rapidly taken up and utilised by methanogens, and CH_4 is produced, methane (CH_4) is a Greenhouse Gas with a global warming potential of approximately 25 times than that of CO_2. The current research AFBI are carrying out on CH_4 *emissions from ruminants* involves large animal respiration calorimeters which were installed at AFBI in 1993. Since installation over 1,500 animals have been subject to 'energy metabolism' measurements.

This has provided an extensive data base on CH_4 production from a wide range of animal types, physiological stages and diets and data has been extensively mined and key drivers of CH_4 production identified for 'indoor diets'. This data has established a strong link between milk yield and carbon efficiency, and demonstrated a limited impact of either system or breed type on carbon efficiency.

Heifer rearing and **fertility**

There are various factors that affect carbon efficiency in dairy production systems and functional traits are equally important as poor performance in these areas can lead to an increased number of heifers on the farm and cows not achieving their mature milk yield potential.

Improving fertility also contributes to lowering GHG emissions as any strategy which will improve longevity without reducing cow performance, will reduce both methane and nitrous oxide emissions.

Replacement rate and age at first calving has a significant effect on GHG emissions as 23% of emissions on average Northern Ireland systems are due to heifer rearing, and research shows that Greenhouse Gas production is significantly lower when first calving takes place at 24 months.

Use of indices such as £PLI (Profitable Lifetime Index) will allow cows with good functional performance to be selected, Garnsworthy et al (2004) found that improving fertility would reduce farm methane emissions by 24%.[31]

[31] https://www.researchgate.net/publication/223787834_The_environmental_impact_of_fertility_in_dairy_cows_A_modelling_approach_to_predict_methane_and_ammonia_emissions

Ongoing **work** at **AFBI**

AFBI Precision Grassland Platform

The AFBI Precision Grassland Platform aims to use new technologies to better understand and manage dairy cows in a grazing environment. The platform integrates soil, plant, animal and climate data to improve understanding and management of grasslands, which will in turn influence the environmental footprint of the grazing system. The platform infrastructure covers dairy and beef systems (78ha), and looks at soil using technologies such as Normalised Difference Vegetation Index (NDVI), Satellite, Lidar, animal based data feeds, and using GPS to analyse soil, fertiliser and slurry application. The platform also encompasses in-field animal monitoring such as rumination, activity, concentrate feed stations and live streams of data to an online platform for rapid decision making for grassland management.

Other research on carbon efficiency that AFBI are undertaking includes looking at *dietary additives* such as 'biological additives' like probiotics, and 'novel plants' for example essential oils and seaweeds. AFBI are also looking at the impact of improved *diet quality* on carbon efficiency, and *genetic selection*, in terms of higher performing animals (lower production per unit product), more efficient animals (high 'residual feed intakes'), and genetically low CH_4 emitters.

Considerable improvements have been made in carbon efficiency in NI farms in the last few decades. Northern Ireland grasslands have a key role to play in sequestering carbon and good grassland management practices such as liming, reseeding, targeted nutrient use will help achieve this, and improving technical efficiency on farm remains a key driver of carbon efficiency – targeting production and functional traits are essential.

Soil carbon sequestration - Dr Dario Fornara AFBI

Agricultural grasslands account for over 90% of the area farmed in Northern Ireland and thus represent a very important land use type, which is crucial for sustaining the beef and dairy cattle sectors. Agriculture, however, is responsible for 27% of total Greenhouse Gas (GHG) emissions in Northern Ireland and there is an increasingly urgent need to reduce the carbon (C) footprint of these livestock-based production systems. Grasslands can significantly sequester carbon in their soils thus contributing to offset GHG emissions and improve both environmental and economic sustainability of the agri-food sector.

Over the last five years AFBI's research has been particularly focussing on three key areas, which include:

- Quantification of soil carbon sequestration potential of agricultural grasslands under common management practices;
- Understanding of what biogeochemical mechanisms might influence soil carbon gains and losses in managed grasslands and thus soil carbon stock changes across years;
- Quantification of the economic value of enhanced soil carbon stocks for livestock farming systems across Northern Ireland.[32]

Agriculture is responsible for 27% of Northern Ireland's total GHG emissions (mostly as CH_4 and N_2O; = ~ 5.4t CO_2-e)

Agriculture is responsible for 91% of Northern Ireland's NH_3 emissions; with the cattle sector making up 71% of emissions

In Northern Ireland, there is currently 112,000 ha forest and approximately 60,000 ha of hedgerows[33]

[33] *'Benefits of trees and hedgerows on carbon emissions from dairy farms'* (2019) Olave, Carolan - Dairy4Future Workshop

Farm woodland systems

Northern Ireland has a landscape rich in woodland, hedgerows, and agroforestry which can act as a carbon sink, helping dairy farms to offset greenhouse gas emissions, contribute to the national carbon budget, and increase grass utilisation and biodiversity.[34]

AFBI has been involved in agroforestry research since 1989 investigating the effects of tree density, pasture production and ecosystems services delivery. Blair, Olave, and McAdam (2018) define hedgerows, as "an agroforestry system, combining trees/ shrubs and agriculture on the same land", and highlight the environmental benefits of hedgerows as a vehicle for carbon storage, as well as having different functions as food or food plus wood crops, and being used to facilitate grazing management.

According to AFBI, trees can be successfully integrated and grown in pasture as well as "providing effective interception and 're-capturing' of ammonia losses on to the vegetation, allowing immediate deposition to the immediate tree surroundings, rather than further dispersal".[36]

[34] *'Benefits of trees and hedgerows on carbon emissions from dairy farms'* (2019) Olave, Carolan - Dairy4Future Workshop
[35] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 242
[36] *'Benefits of trees and hedgerows on carbon emissions from dairy farms'* (2019) Olave, Carolan - Dairy4Future Workshop

Research case study **one**: **Farm** woodland **systems**

The planting of more trees, hedgerows and nurturing agroforestry systems will take time with the beneficial effects coming years later.[37]

Hedges form a large part of the topography of Northern Ireland, comprising approximately 3% of Northern Ireland's landscape. They have been often overlooked in the study of carbon sequestration and storage potential to date, with UK landscape scale models of carbon sequestration ignoring a potentially significant sink for atmospheric CO_2 by neglecting to account for hedgerows in GHG inventories.[38]

Hedges form a large part of the topography of Northern Ireland, comprising approximately 3% of Northern Ireland's landscape.

It is difficult to calculate general carbon storage of hedgerows due to variations across location and species composition as well as differing maintenance practices.[39] Varying maintenance can affect regrowth, as well as input and storage rates, for example, clippings from trimmed hedges that are burnt in turn omit CO_2 in to the atmosphere.[40] Blair, Olave, and McAdam (2018) estimate carbon storage in the range 5 t C ha^{-1} to 131 t C ha^{-1} and carbon input rates from 0.37 t C ha^{-1} yr^{-1}.[41]

Sitzia et al. (2014), have found carbon stocks are higher under a hedge than in the surrounding cropped land and hedgerow soils are usually disturbed, where humification processes show similar patterns to those in a forested soil.[42] In fact, Van Vooren et al (2017) found that hedgerows increased carbon stocks by up to 114% compared to treeless areas.[43] Blair, Olave, and McAdam (2018) suggest soil organic carbon (SOC) stocks under hedge range from 5t C ha^{-1} to 360t C ha^{-1}.[44]

Hedgerows increased carbon stocks by up to 114% compared to treeless areas.

[37] *'Benefits of trees and hedgerows on carbon emissions from dairy farms'* (2019) Olave, Carolan- Dairy4Future Workshop
[38] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 242
[39] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 243
[40] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 243
[41] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 243
[42] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review' (2018)* Blair, Olave, McAdam p. 244
[43] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 244
[44] *'Hedgerows as form of agroforestry to sequester and store carbon in agricultural landscapes: a review'* (2018) Blair, Olave, McAdam p. 244

Ploughing

While research shows the effects of ploughing and reseeding on the ability of grasslands to act as a carbon sink, Blair et al (2018) have found that ploughing temperate grasslands caused the system to become a carbon source for approximately 100 days before returning to being a carbon sink. "These changes are likely attributed to the loss of photosynthetic material rather than effects of ploughing per se". [45]

Scientists at AFBI have been monitoring grassland soils for over 43 years and found that, "permanent grassland soils have not reached carbon saturation after 43 years of intensive management (i.e. three grass cuts and three nutrient applications every year since 1970). Even soils not receiving any nutrient addition showed C sequestration rates of 0.35MgC ha^{-1} yr^{-1} (35 gCm^{-2} yr^{-1}/ within 0–15 cm soil depth). The application of high rates of cattle slurry significantly contributed to increase soil C sequestration up to 0.86MgC ha^{-1} yr^{-1} (86 gCm^{-2} yr^{-1})."[46]

In terms of ploughing, land-based sequestration models can fail to account for different management practice and big differences in local carbon fluxes.[47]

Ploughing disrupts soil and causes CO_2 loss, however, the practice of ploughing aerates soil and lends to the introduction of nutrients which sustains high harvest yields.[48] By contrast, non-ploughed soil is denser with more moisture and "carbon is protected from decomposition due to physical protection within soil aggregates (Ogle et al., 2012)."[49]

Blair et al (2018) list the various management practices for grassland reseeding: "conventional ploughing, where soil is inverted from a depth of 20–30 cm, minimum tillage, which disrupts only topsoil (~5 cm depth) and over seeding, where new seed is sown into an existing sward (Schulz et al., 2014)".

It was also found that four times more CO_2 is released after ploughing, however, the regrowth of vegetative grass cover from reseeding, subsequently converts ploughed plots in to sinks months after ploughing.[50] Blair et al (2018) found that there could be a benefit to carrying out ploughing in the autumn, as the low temperatures reduce the release of CO_2 through lower root and microbial activity.

AFBI has recently bid for additional funding to cover the cost of updating its Greenhouse Gas Emissions Calculator to include woodland, hedgerow and grassland sequestration and to update the emission factors based on the latest research results. This will also allow for an update on emission factors for other currently permitted beneficial farm activities such as low emission spreading and protected urea. These updates will then transfer into practice on farms by allowing farm businesses to make land and herd management decisions based on the latest available science.

[45] *'The effect of ploughing intensity on the carbon flux of temperate agricultural grasslands'* (2018) Blair, Olave, Smyth, Sherry and Reid p. 8
[46] *'Long-term nutrient fertislization and the carbon balance of permanent grassland: any evidence for sustainable intensification?'* (2016) Fornara, Wasson, Christie, Watson pp. 4981
[47] *'The effect of ploughing intensity on the carbon flux of temperate agricultural grasslands* (2018) Blair, Olave, Smyth, Sherry and Reid p. 1
[48] *'The effect of ploughing intensity on the carbon flux of temperate agricultural grasslands* (2018) Blair, Olave, Smyth, Sherry and Reid p. 1
[49] *'The effect of ploughing intensity on the carbon flux of temperate agricultural grasslands* (2018) Blair, Olave, Smyth, Sherry and Reid p. 1
[50] *'The effect of ploughing intensity on the carbon flux of temperate agricultural grasslands* (2018) Blair, Olave, Smyth, Sherry and Reid p. 7

Chapter 3.

On-farm **innovation**

Farm case study **one**: **Hall Donnell Farm** – Ballymagorry, Strabane

Derick, Sylvia and Hall Donnell farm 210 acres beside Ballymagorry village, just north of Strabane, Co Tyrone, Northern Ireland. The farmyard is centrally situated, with approximately 50 acres accessible for milking robot grazing and the remainder either across the road or on outlying farms.

Farm Objectives

1. To maximise overall farm profit
2. To have a labour efficient working environment
3. To utilise forage both grazed and ensiled to its full potential
4. To make efficient use of nutrients (fertiliser and slurry) while meeting current nitrates legislation.

Herd Management and Performance

Currently there are 110 Holstein/Friesian dairy cows on the farm with a further 45 replacement heifers at various stages. The herd was predominantly autumn/ winter calving, but is now being spread out to suit the robot system.

Herd Performance: CAFRE Benchmarking

Benchmark performance	2018/19
Cow numbers	110
Milk yield (litres/cow/year)	8,166
Butterfat (%)	3.94
Protein (%)	3.22
Concentrates (kg/cow)	2,344
Milk from forage (litres/cow/year)	2,957
Feed Rate (kg/litre milk produced)	0.29

Winter Management

High quality silage is fed to all stock while housed. Milking cows are housed as one group and fed according to yield through the robot up to a maximum of 9kg of concentrates, then topped up at a rate of 0.45kg/litre through the out of parlour feeders. All cows are dried off for 8 – 10 weeks. Silage & straw fed with diet feeder. Low potassium silage is specifically made for this purpose.

Spring/ Summer Management

The Donnells operate a flexible grazing system depending on weather and ground conditions. Cows are normally turned out in late March and housed full time in early November.

An A & B grazing system is operated through a grazing gate with C being housed and fed silage at night. Cows have access to graze (A) from 1am – 7am, then when they return to the robot they have the option of going to graze again (B) from 7am – 6pm, before being housed for the remainder of the evening. Approximately 3.5 acres are grazed each day on a 14 day rotation.

Nutrient Management

Slurry is applied by trailing shoe, with emphasis placed on producing high quality silage, and in terms of grassland management, swards are reseeded regularly to maintain both grazing and silage performance.

Energy and Efficiency Measures

In the last year, solar panels have generated 1653.85 units of electricity on site, with any excess sold back to the grid. Presently, the electricity generated doesn't neatly coincide with the energy demands of the farm, but the Donnells hope to install battery storage in the near future to completely eliminate their mains electricity usage.

Two additional measures have also helped reduce the carbon footprint of the farm; the LED lighting replaced traditional bulbs, with the equivalent of 6 lights using the same amount of energy to power one of the traditional light bulbs and, the Smart Heat system recovers the heat that is generated and otherwise lost in the milk cooling process to produce hot water.

Electricity used	£3,399.54
Units electricity sold	1,653.85
ROC payment (electricity used or sold)	£2,961.00
Positive income	£915.41

A borehole is in the process of being constructed on the farm to reduce reliance on mains water.

Farm Developments	
1990	Automated calf feeding
Mid 2000's	Extensive hedge planting programme
2004	Trailing shoe used for slurry application to reduce fertiliser use
2005	Smart Heat
2011	Solar Panels installed
2011	Robot Scrapper installed to improve cow cleanliness & reduce labour
2013	Cow handling facilities including shedding gate recently completed
2015	New bulk milk tank installed February
April 2018	Two GEA Monoboxes installed
Present	Presently a borehole is being constructed to source water to use on the farm

Farm case study **two**: **Hugh Harbinson Farm** – Aghadowey, Coleraine

Hugh Harbison is a third generation farmer who manages the family farm in Aghadowey, six miles south of Coleraine. The farm has 100 acres of grassland and has a herd of 180 dairy cows. The farm has been in the family for more than 50 years and his father Thompson, who himself took over the farm at only 16 years old, can still be seen working alongside his son and daughter-in-law.

Hugh has been trying to breed a smaller cow to suit their production system and improve the efficiency of the cow in converting grass to butter fat and protein.

Hugh also invested in a new milking parlour two years ago which has introduced new feed to yield technology so that each cow has an individualised and accurate feed allocation depending on how much milk they are producing. The new parlour has resulted in more comfortable cows, and Hugh maintains that happier cows produce more milk.

Low Emission Slurry Spreading (LESS) is carried out by Dribble bar and trailing shoe, which applies slurry to the soil with precision which minimises emissions.

Fallen trees are collected from around the expansive woodland area adjacent to the farm to power the wood fired boiler. The hot water generated is used to wash out the milking parlour and warm the milk for the calves.

The farm has also invested in solar panels which provide enough energy for the electric fencing around the fields.

The farm is located on the site of an old linen mill, and there are still ponds and a vast woodland area on the farm. Hugh's father, Thompson, has planted hedges and trees over the years and been awarded various conservation awards such as the Grassland Society Conservation Award and also an All-Ireland Conservation Award. The vast area of woodland acts as a carbon sink and is important in reducing the overall carbon footprint of the farm.

The geographical location of the farm means that they get high volumes of rain water, and in keeping with the high efficiency approach, Hugh captures the rain water and uses it to wash the collection yard and milking parlour.

"My generation is much more environmentally aware. They want tasty food that has low food milage and low carbon footprint."

Hugh Harbinson

In 2018 an Efficiency and Sustainability Report was carried out on the farm. This carbon analysis helped to establish a carbon baseline for the farm and use it to benchmark against other farms across the UK and Europe. The Harbisons were also able to use the data to drive efficiencies in their business and establish that their farm fared well against competitors with a lower carbon footprint and greater levels of efficiency.

Key Stats
Autumn block calving over a 12 week period from a fertile herd which has a calving index of 377 days and a 16% replacement rate
Current herd yield is approximately 8,200 litres per cow
Milk is of high quality with a butterfat of 4.34%, protein 3.47%, bactocount of 27 and somatic cell count of 144
High milk quality has resulted in a milk price of 30 pence per litre on average over this period
The herd is efficient as this yield is produced from 2.27 tonnes of concentrate feed, resulting in a feed rate of 0.28kg/litre with 3679 litres produced from forage

The assessment carried out by Alltech, established that the farm generated 1,184 g CO_2/kg FPCM, which was well above the Alltech average of 1,231 g CO_2/kg FPCM.

The report found that the Harbison farm featured in the top 10% of farms in terms of milk produced per cow, by producing a larger volume of milk this allows your carbon emissions to be offset against a larger volume of product. The Alltech average for milk produced per cow was 7,436 litres per cow per year and the average milk produced per cow on the Harbison cow was 8,219 litres per cow per year.

The report established that if Hugh managed to make a 5% reduction in the carbon footprint of the farm, he could save:

- 59 tonnes of CO_2 per 1 million litres of milk produced, which could equate to:
  - 27 cars off the road a year
  - 36 houses' annual electricity use.

Chapter 4.

Dairy **companies**

Pritchitts – **Lakeland** Dairies

Pritchitts is a Lakeland Dairies Company that has been focussing on reducing the carbon emissions from its manufacturing processes for the past two decades.

Progress can be tracked back to the turn of the century when the company successfully lobbied to have the natural gas pipeline extended to Newtownards, and in 2000 they were able to replace heavy oil fuel with natural gas.

> *"To date the Newtownards based UHT and powder blending facility has reduced the carbon intensity of its manufacturing process by 88% over the past 20 years."*

This success has been due to a combination of capital investment and behaviour change programmes that have delivered significant energy efficiency gains and buy-in from staff. Over the course of 20 years the technologies available have changed radically and keeping up to date with these changes has been central to delivering the reductions. For instance, the facility was the first dairy in the UK or Ireland to introduce a Combined Heat and Power (CHP) Set in 2003. Since 2017 the CHP has been powered by renewable biogas generated from food wastes, including wastes from Pritchitts' own factory.

The focus to reduce the carbon emissions from the manufacturing process is ongoing. Lakeland Dairies was the first dairy company to sign a Prosperity Agreement with the Northern Ireland Environment Agency. As part of this Agreement, Pritchitts is committed to further reducing the carbon intensity of its manufacturing processes by 50% by 2021 from a 2016 baseline.

Pritchitts understands that it needs to play its part in helping deliver the wider societal environmental change we need to see. To encourage uptake of electric vehicles, free electric car charge points are provided for staff and visitors, using green electricity generated on site.

Milestones	
1999	Pritchitts successfully lobbied for Natural Gas pipeline to reach Newtownards ahead of planned schedule
2000	Natural gas replaces Heavy Fuel Oil as a power source. Natural gas is far less polluting than Heavy Fuel Oil
2001	Installed reverse osmosis (RO) plant as a more energy efficient way of concentrating skimmed milk
2002	Installed a variable speed drive (VSD) air compressor to save electricity. Variable speed drives allow the power supplied to an electric motor to vary depending on its requirements at any one time, therefore saving energy
2003	Installed CHP set with waste heat from power generation used in manufacturing processes
2004	Reverse Osmosis plant capacity increased
2005	New centralised hot water system utilising CHP waste heat
2006	New fridge plant with increased energy efficiency installed
2007	Assorted optimised VSD schemes on factory pumps
2008	Cooling systems installed to improve working conditions in an energy efficient way
2009	Programme to modernise factory lighting started. Buffer tank added to hot water system
2010	Programme of pipework insulation, and improvements to steam traps and condensate recovery
2011	More VSD pumps and lighting upgrades
2012	Existing CHP set replaced with a new and larger model, creating more heat for the factory
2013	New indirect steriliser installed to enable growing white milk market to be serviced with much less energy
2014	New state of the art automated, lights-out warehouse installed. Reducing lorry and forklift truck movements
2015	Work commences on higher speed processing of our complex formulated products
2016	New Packing Hall opened with good insulation and with heat recovery in ventilation system
2017	New high speed packing line. Commence use of biogas gas as fuel for the CHP set (gas from food waste)
2018	Second high speed packing line. Large VSD air compressor installed for optimum energy efficiency

Dale Farm
Dunmanbridge

Dale Farm Co-operative Ltd is the largest UK farmer owned dairy cooperative, owned by 1,300 farmers with a collective milk pool of one billion litres. Dale Farm Group produces a wide range of products such as liquid milk, butter and spreads, yoghurts, cheese, powder and ice cream.

Dale Farm is committed to leading the way in sustainability – with a strategy in place to constantly assess processes and facilities to identify ways in which the business can reduce its carbon footprint and increase efficiency.

An example of increasing its process efficiency while reducing its carbon footprint was a project that installed a heat recovery system using warm whey from the cheese vats to preheat milk prior to pasteurisation in the cheese milk pasteurisers. Steam consumption is reduced by 40% which equates to 410 kgs/hr.

500 kWh/hr

The cold water produced in the heat exchange process is then used to cool whey in the whey pasteurisers, and reduces the electrical load on the chilled water plant by around 500kWh/hr.

As part of its sustainability strategy, in August 2019 Dale Farm and NIEA signed a Prosperity Agreement with the Northern Ireland Environment Agency – a voluntary agreement that aims to provide a boost to the environment whilst supporting business competitiveness, and is the latest to be signed by NIEA and a Northern Ireland business. This signifies the journey Dale Farm has been on in recent years where environmental consideration has been given high priority.

Continued reduction in its environmental footprint is being achieved by energy efficient projects such as:

- Installation of a new a new 125cu meter/hour Dissolved air flotation plant at Dunmanbridge, this has increased by 10% the reduction of the Chemical Oxygen Demand of the crude effluent. This reduction means there is less organic matter to treat in the biological stage as biological treatment requires significant electrical energy to add oxygen to the process.
- Installation of replacement air blowers and air diffusion membranes in the three aeration tanks have increased efficiency.
- A new chiller has been installed at Dunmanbridge, this will replace 2 existing chillers, this is calculated to reduce the electrical demand by 3000 Kwh/day.

Since its launch in summer 2018, in the first year of operation the solar farm has supplied Dale Farm's production plant with 6 Million kWh of electricity – that's enough electricity to power 1,800 homes for a year

As previously reported in August 2018, Dale Farm launched the largest 'self-consumption' solar farm (37ac) in Ireland at its Dunmanbridge cheese processing facility.

The move, which guarantees 20 years of green energy for the company, is understood to be one of the largest Private Solar Farms in dairy worldwide and has been designed and delivered in partnership with Dublin company, CES Energy.

> *"...as part of its sustainability strategy, in August 2019 Dale Farm and NIEA signed a Prosperity Agreement with the Northern Ireland Environment Agency – a voluntary agreement that aims to provide a boost to the environment whilst supporting business competitiveness, and is the latest to be signed by NIEA and a Northern Ireland business..."*

The current investment is the gas conversion project which is progressing well with two of the three boilers converted from using heavy fuel oil to natural gas, and the other will be converted by the end of the year. Conversion from heavy fuel oil to natural gas will deliver the following environmental benefits:

1. **Reduction in Carbon Dioxide emissions:** Natural gas emits less carbon dioxide per Kwh heat generated, it is anticipated that we will reduce emissions by 4,500 tonnes.
2. **Reduced risk to the environment:** Heavy fuel oil is delivered to site in bulk tankers approximately 30,000 litres per tanker, the oil is transferred by pumping into one of two 200,000 litre storage tanks. After conversion there will be no transfer and storage of heavy fuel oil reducing the risk of accidental spillage. Dunmanbridge is situated adjacent to the river Lissan which is a sensitive water course.
3. **Reduced combustion emissions:** The combustion of natural gas is much cleaner with less combustion products such as particulate, SOx & NOx.
4. **Increased fuel efficiency:** The retro fitting of new boiler combustion equipment and flue gas economisers will increase fuel efficiency by up to 3%.
5. **Reduced transport movements:** Each year there are approximately 196 loads of heavy fuel oil transported onto site, conversion will eliminate these movements.

> *"During summer 2019, there were significant periods of time the site was running exclusively off solar energy and consuming no mains power."*

Chapter 5.

Nutrition

Healthy diets from **sustainable** food **systems**

In 2010, the United Nations Food and Agriculture Organization (FAO) defined the four pillars of a sustainable diet as: Health, Economics, Society, and the Environment.

Each pillar plays an equally important role in ensuring that the diet in question provides the appropriate level of nutrition, in an affordable, accessible way, with minimal negative impact on the environment.

Professor Adam Drewnowski, Director of the Centre of Public Health Nutrition at the University of Washington has observed that that many approaches to sustainable diet modelling often overlook the nutritional dimension, instead focussing on the environmental credentials with little or no regard for nutrition. For example, calculating the carbon footprint of our diet per kg of food weight rather than in relation to the nutrients a food provides.

> *"...In other words, a diet cannot be considered a sustainable diet, if it doesn't meet the nutritional need of the community it is designed to serve...."*

Health

Economics

Society

Environment

Where models do give due attention to health and nutrition, it is often the case that they measure the nutritional value of the diet based on energy (calorie) density rather than ensuring that the food systems are rich in nutrients.

A better way of profiling a 'sustainable diet' would be to move away from energy density modelling and refer to the nutrient content of the foods. Properly addressing the nutritional need will allow the discussion to move from simply sustainable diets to 'healthy diets with low impact on the environment'.

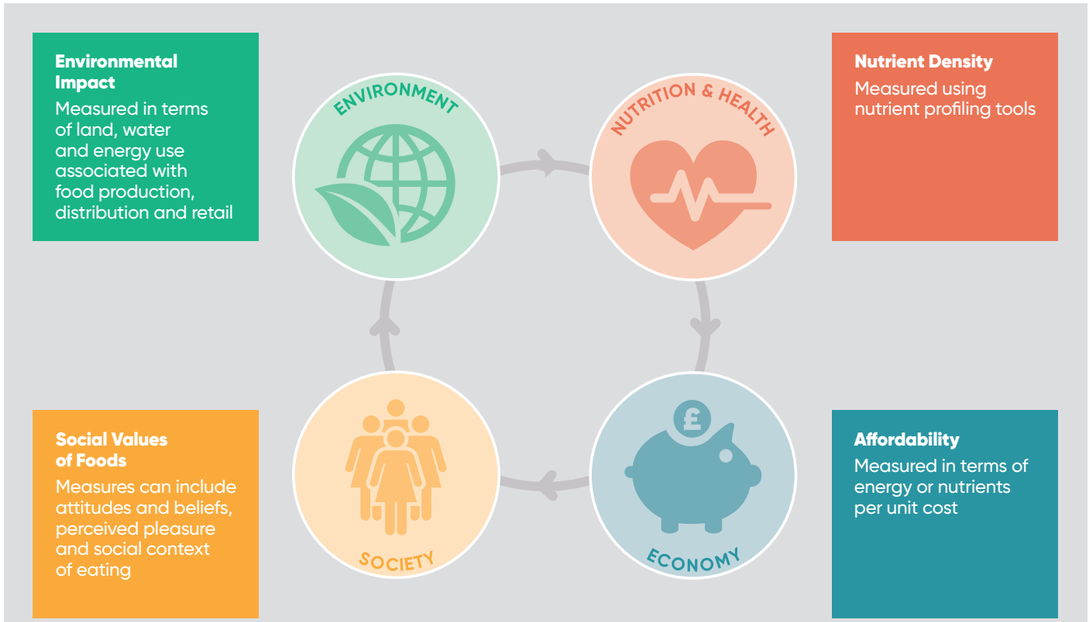
Similarly, measures of the affordability of a diet frequently look at calorie density (kcal per £) but Professor Drewnowski maintains that a more accurate picture can be gained by building an overall nutrient profile.

This process can involve dividing nutrients into two categories, those we want to encourage (for example; calcium, fibre, magnesium, vitamins A, C, E, K and D), and those we may want to discourage (saturated fat, added sugars and sodium).

Newly developed methods also now focus on protein quality, separating animal and plant proteins, distinguishing the usually higher quality animal proteins such as milk.

Once this information on nutrient density or other measures of diet quality is available, the data can then be used for a wide range of purposes including innovation, product development, and reformation or for comparing against other food models. It may be in the future that ways can also be found to take into account the health effects of a food, which may go beyond the nutrients it contains.

Nutrition



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Important contribution of dairy foods to the European and Northern Ireland diet

Milk and dairy foods make an important contribution to the nutritional quality of the European diet. In many countries, including Northern Ireland, they are the main providers of calcium. Dairy also makes significant contributions to the intake of many other nutrients including high-quality protein, riboflavin, vitamin B12, phosphorus, vitamin A, iodine, zinc and potassium.

In Northern Ireland, the dairy food group is the largest contributor to intakes of calcium, iodine, vitamin B2 and vitamin B12, supplying around a third of adults' intakes and even more in children and teenagers.

Nutrients	4-10 years	11-18 years	19-64 years
Protein	21	15	13
Calcium	45	37	37
Potassium	22	15	12
Iodine	55	44	35
Zinc	23	16	15
Vitamin A	24	18	17
Vitamin B2	43	32	29
Vitamin B12	54	40	35

Contribution (%) of dairy foods to nutrient intakes in Northern Ireland[51]

[51] Reference: National Diet and Nutrition Survey. Results from Years 5-9 (combined) of the Rolling Programme (2012/13-2016/17): Northern Ireland
* Vitamin B12 results for years 1-4 of the Rolling Programme

A **healthier** diet is also more **sustainable**

A discussion with Professor Ian Givens

Professor Ian Givens, Director of the Institute for Food, Nutrition and Health at the University of Reading believes that we should focus on improving public health in Western populations, as this will also have sustainability benefits. He also stresses that the current public debate on a sustainable diet is too simplistic, as the division between animal and plant-based foods doesn't take the nutritional aspect into account.

High-dairy diets are often healthier than low-dairy diets

The debate is focussed on the dichotomy between animal and plant-based foods with animal foods often categorised as 'bad' for the environment and for health, and plant foods as 'good'. But he argues it is much more complex than that.

Even animal foods cannot be categorised so simply, *"It is not correct to talk about animal-based foods like that, every food is different"*. He stresses that there are differences between dairy products and red processed meat and that the current rush to replace animal proteins with plant proteins can result in nutrition deficiencies, *"Some foods, like dairy, provide high quality protein and are nutrient dense. That is unique compared to plant products"*. Professor Givens elaborates that, *"proteins aren't just proteins"*, they are made up of different kinds of amino acids, and the amino acids that dairy products provide is uniquely well fitted to human needs.

The UN Food and Agriculture Organization states that sustainable diets are:

- protective and respectful of biodiversity and ecosystems
- culturally acceptable and accessible
- economically fair and affordable
- nutritionally adequate, safe and healthy.

Nutrition

Professor Givens agrees that all four dimensions: nutrition, climate/environment, economy and culture should be taken into account but, unfortunately, often they are not particularly the nutritional aspects.

Moreover, he points to a recent study in the UK, showing that diets with a high intake of dairy products often are healthier than low dairy diets, *"Low dairy diets are correlated with a higher intake of fizzy drinks, sugar and a lower intake of greens and vegetables than dairy-rich diets"*.

Improving public health is sustainable

When talking about sustainability, Professor Givens believes that it would be beneficial to invest in improving public health, as this would result in more sustainable diets as well. Diets like the New Nordic Diet are both healthier and more environmentally sustainable than the way we eat currently in many western countries, however, he also acknowledges that improving public health is extremely difficult.

About Professor Ian Givens:

Ian Givens is a Professor of Food Chain Nutrition and Director of the Institute for Food, Nutrition and Health at the University of Reading. He has background training in biochemistry and nutrition, and his research interests focus on the relationship between consumption of animal-derived foods across the key life stages, nutrient supply and chronic disease risk with particular emphasis on dairy foods.