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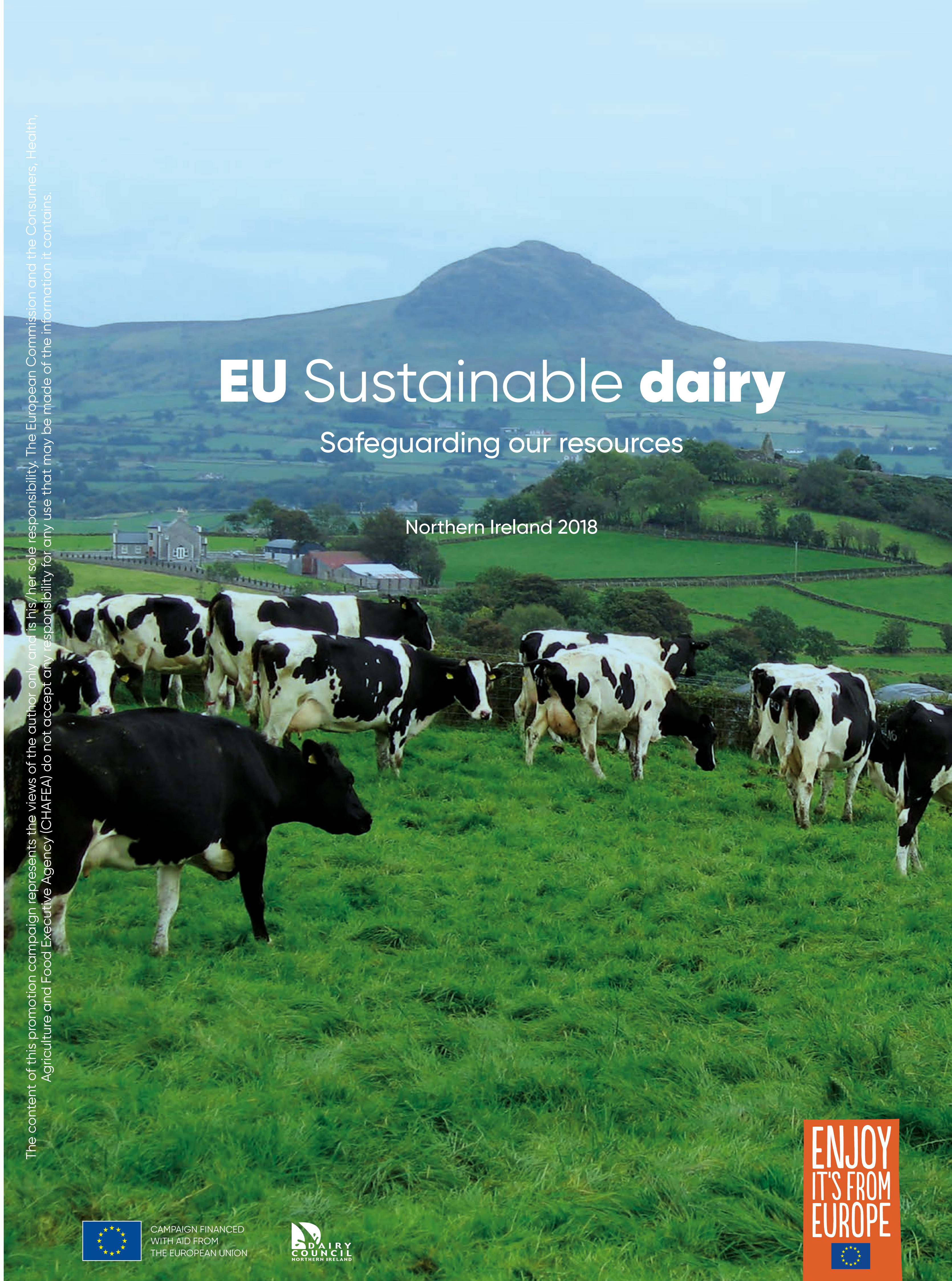
ENJOY IT'S FROM EUROPE

CAMPAIGN FINANCED WITH AID FROM THE EUROPEAN UNION

DAIRY COUNCIL NORTHERN IRELAND



EU Sustainable **dairy**

Safeguarding our resources

Northern Ireland 2018

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DAIRY COUNCIL NORTHERN IRELAND

ENJOY IT'S FROM EUROPE

Foreword

Nutritious and safe food from Northern Ireland's dairy sector has helped underpin the health and well-being of multiple generations and makes an important contribution to the economic performance of the region.

The sector has sustained the livelihoods of thousands of farmers who act as the custodians of the land and created large-scale employment in high performing dairy processing plants that produce award-winning food. The dairy sector recognises its responsibility to produce high quality milk and dairy products, from farm to fork, in ways that are efficient and safeguard our environment.

At each stage in the dairy supply chain the sector has been, and continues to make significant progress to reduce its environmental footprint.

In a number of key areas – emission of greenhouse gases, waste, pollutants and energy efficiency – significant improvements have been made on our journey of continuing to improve our environmental sustainability.

A recent study by the UN Food and Agriculture Organisation (FAO) reported that between 2005-2015, global dairy Greenhouse Gas emission intensity dropped by almost 11%. During that time, milk production increased by 30% and absolute emissions from the dairy sector by 18%. According to FAO, had the dairy sector not made efficiency gains, the emissions would have increased by 38%.

This publication recognises many of the important achievements and positive progress made by the Northern Ireland dairy sector in meeting the evolving environmental challenges. These stand as a testament to the hard work and commitment across the entire supply chain, including government and other partners, in a collective pursuit of improved environmental sustainability of the sector.

However, we recognise that we cannot afford to be complacent and we are committed to continuing to reduce our environmental footprint throughout the supply chain.

This fact book has been produced with support from the European Milk Forum (EMF) and financial assistance from the European Union. The EMF 'Sustainable Dairy' initiative is co-ordinating a new and informed dialogue with key stakeholders on the environmental actions being taken in six EU countries. We are grateful to the EMF and EU for their support as we highlight the positive contribution that the dairy sector is making towards the environmental sustainability agenda in Northern Ireland.

Mike Johnston

Dr Mike Johnston MBE, PhD
Chief Executive

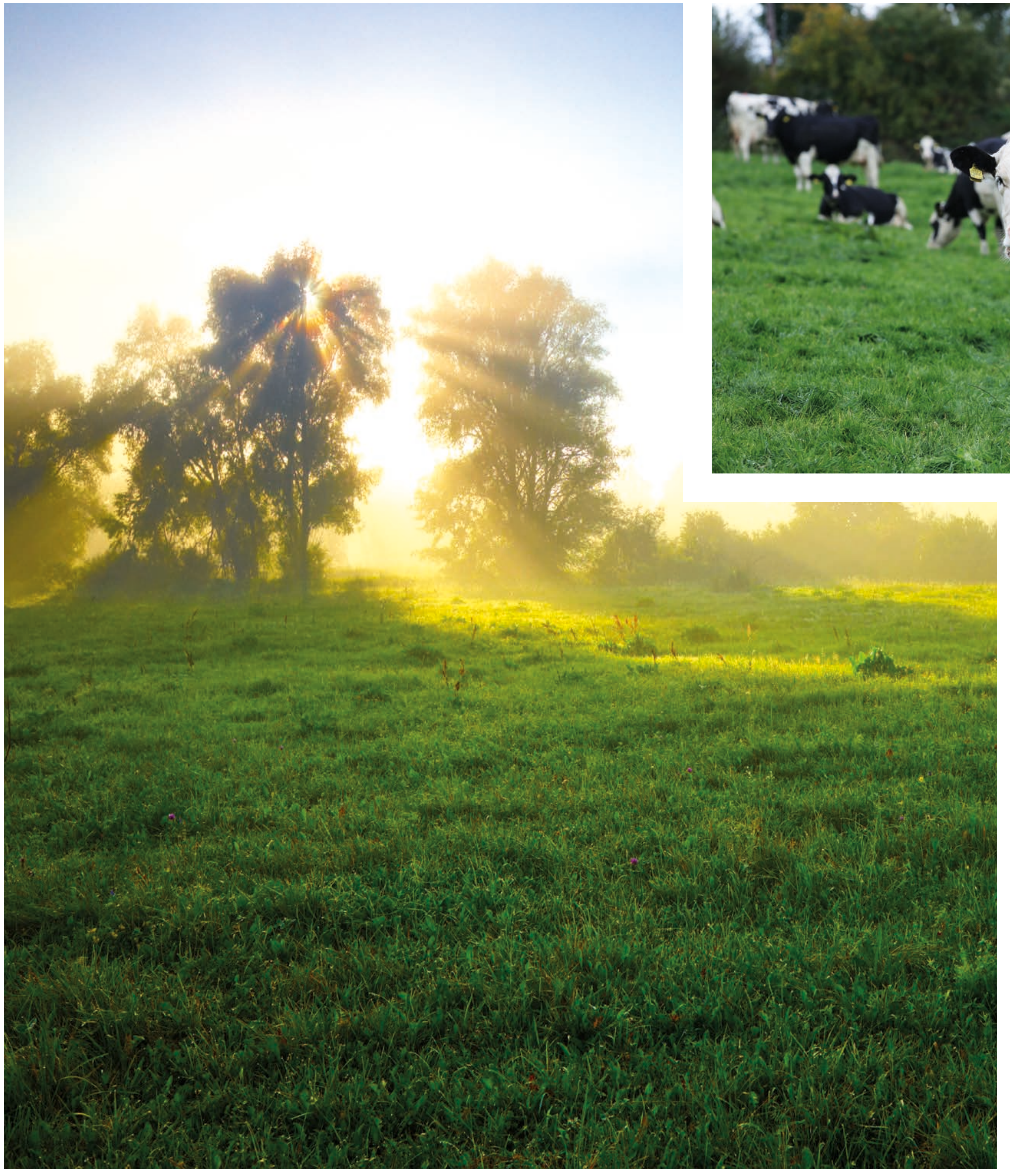
Introduction

The dairy sector acknowledges that sustainable development and climate change are pressing challenges, that must be acted on. The dairy sector is committed to contribute to solving these issues.

EU Sustainable Dairy

Over the last few decades we have witnessed an emerging transition towards sustainability, from the Brundlandt Report defining sustainable development in 1987 to the UN Sustainable Development Goals adopted by world leaders in 2015. Both stressing the need for cross sectoral commitment to achieve a sustainable future.

The UN 2030 Agenda and Sustainable Development Goals establish a holistic concept of sustainability where all dimensions must be taken into account: Climate, environment, health, economic growth, circular production and consumption, clean water, biodiversity, equality and more.



Clearly, the dairy sector plays an important part in this transition, securing a nutritious and healthy diet for the global population and as a key economic driver, and providing significant levels of employment the world over. Most importantly, the dairy sector is key to managing ecosystems, supporting biodiversity and addressing environmental degradation and climate change.

Therefore, in October 2016 the global dairy sector represented by the International Dairy Federation (IDF) and the UN Food and Agriculture Organization (FAO) formally committed itself to push this sustainable transformation by signing a declaration that the global dairy sector is working with the UN Sustainable Development Framework. The declaration was signed in Rotterdam and is referred to as the Rotterdam Declaration (FAO, 2016).

Through this fact book and other programme activities, the European dairy sector is taking stock of the successes to date and assessing the work which still needs to be done.

With this publication the European dairy sector is taking a stock on the sustainable transformation up until this point. How far have we come? And what challenges still lie ahead of us?

Chapter 1.

Climate **change**

Climate is **changing**, so is the **dairy** sector

The world and our climate are changing in fundamental ways that challenge every aspect of modern society. Yet as the global population continues to grow, previous strategies for food production and resource usage have led to increased emissions of greenhouse gases (GHG), a lack of biodiversity and natural eco-system imbalances in some regions.

The United Nation anticipates that resource usage will double by 2050[i], highlighting the urgent need to radically revise our approach to production if we are to both arrest adverse climate change and meet the growing demand for safe and healthy foods. This combined challenge was also acknowledged in the international Paris climate agreement in 2015[ii], which set binding commitments to limit global temperature rise and recognised that these efforts must not threaten production and food security.

Without action to tackle the GHG emissions, climate change is projected to have consequences affecting all aspects of life, varying in severity according to regional and local factors. The Climate Change Risk Assessment (CCRA)[iii] anticipates that, in future, Northern Ireland could face greater climate variability and an increase in extreme weather events.

Dairy: a contributor and part of the **solution**

The dairy sector has a crucial role in supporting nutritious and balanced diets and also in the responsible management of ecosystems and taking proactive actions to address environmental degradation and climate change, while promoting biodiversity. It holds a key role in promoting and delivering sustainability and sustainable development and over the last three decades, the sector has evolved to achieve better sustainable growth ambitions and environmental outcomes.

Like all forms of food production, including plant-based foods, the dairy sector is an emitter of greenhouse gases and must be ready to take on the responsibility of reducing its impact on the climate. However, efficient, innovative and well-managed farms and dairy processing businesses are contributing positively to social, economic and environmental outcomes.

Size and scale of the Dairy Sector in Northern Ireland[iv]

£662m overall value of output of milk in 2017

50% of the aggregate gross margin estimates for the main agricultural sectors are from dairy production

14% of NI farms are dairy farms

4% of civil employment in NI is linked to agriculture as a whole (double UK level)

2.2bn Ltrs total milk output in 2017 in Northern Ireland

36% reduction in the number of farms in NI since 2008

7,220 Ltrs average gross milk yield per cow in 2017

85.5 ha average of NI dairy farm size

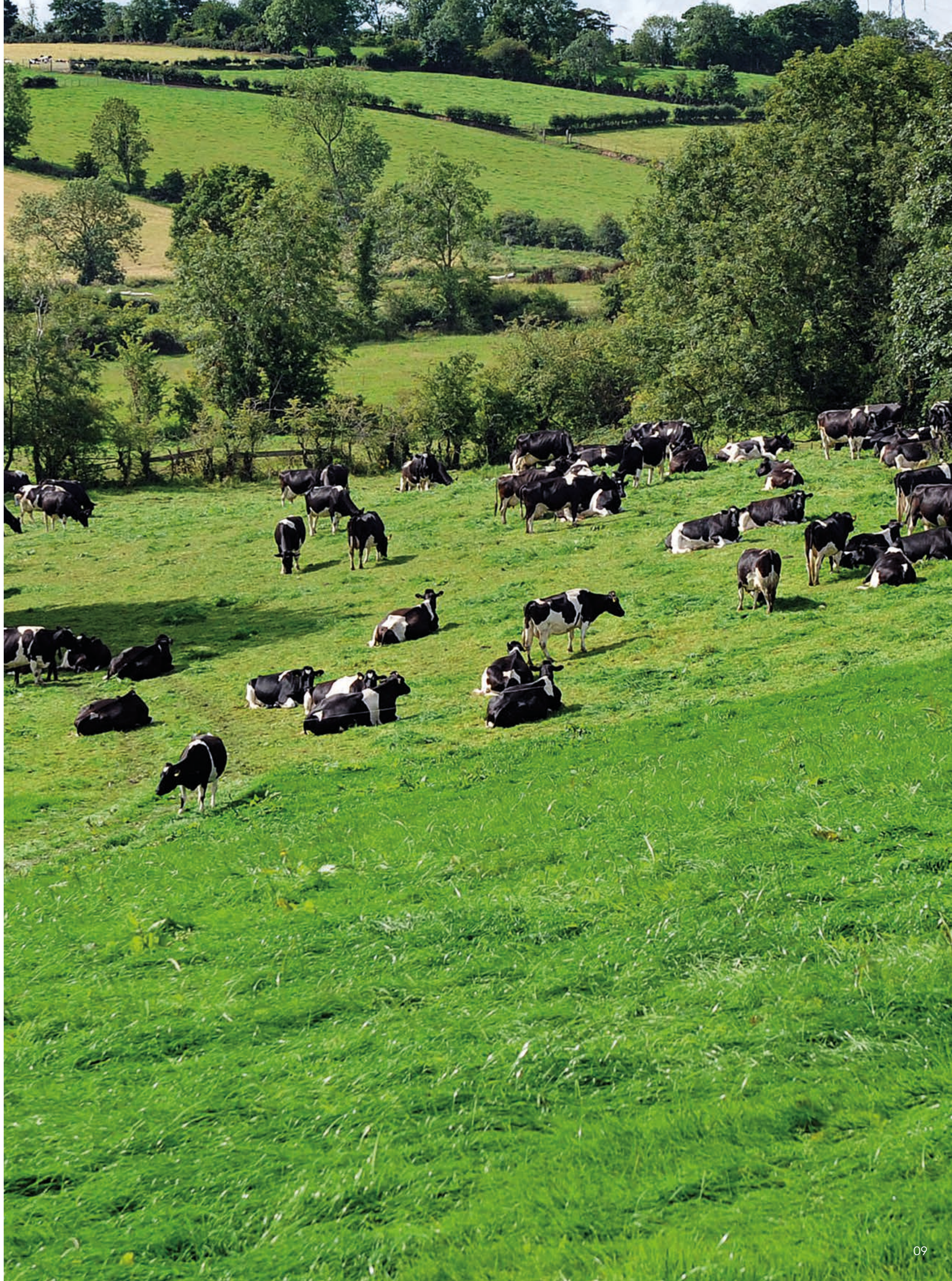
76% of the total land area in NI is used by agriculture

66% of dairy cows are in herds of 100 or more cows

92 average number of dairy cows per herd

315,800 dairy cows in Northern Ireland

50%+ annual milk production increase since 1990



Greenhouse gases in the dairy sector

An accepted driver of climate change is the emission of greenhouse gases (GHGs) from human activity such as production of energy, transportation, agriculture, manufacturing and household emissions.

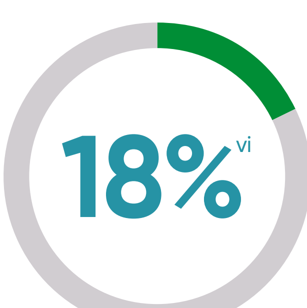
The largest emitter of greenhouse gases is the energy sector which, in 2014, produced 35% of the world's GHG emissions and 59% of those in Europe. Agriculture is the second largest contributor to climate change globally, accounting for 24% of all global greenhouse gas emissions and 10% of those in Europe in 2014.

In Northern Ireland, the nature of GHG emissions and the economic importance of the agriculture sector locally, mean that it is the largest source sector of emissions at 28%[v] – highlighting the sector's need for a concerted effort to make production as efficient as possible.

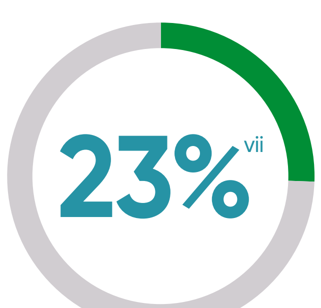
Greenhouse Gas emissions from dairy and agricultural activities differ from other sectors – where carbon dioxide is the primary greenhouse gas – and a different approach is required. The emissions most associated with agriculture (methane, nitrous oxide and ammonia, which causes nitrogen deposition) are the outputs of complex natural processes. The agri-food sector is taking firm action to minimise emissions and the interaction between farmers, industry leads and applied researchers have resulted in wide-ranging step changes in productivity, efficiency and environmental outcomes.

The most effective way for local agriculture to contribute to GHG reduction targets, without cutting or displacing production, is to continue reducing the quantity of carbon it takes to produce each unit of food.

Since 1990

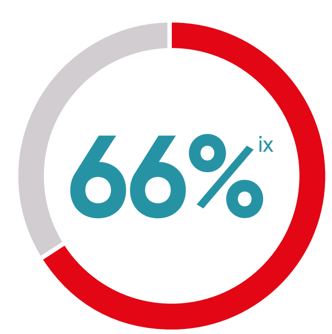


Reduction in European GHG emissions



Reduction in European agriculture GHG emissions

Increase in European transport GHG emissions



Increase in European aviation and maritime transportation GHG emissions

"...we will soon be able to demonstrate that the carbon intensity of milk production has reduced in the order of 25% since 1990, marking significant progress and confirming our dairy industry as one of the most sustainable and efficient suppliers to home and export markets."

Michelle McIlveen MLA, Minister of Agriculture, Environment and Rural Affairs, December 2016

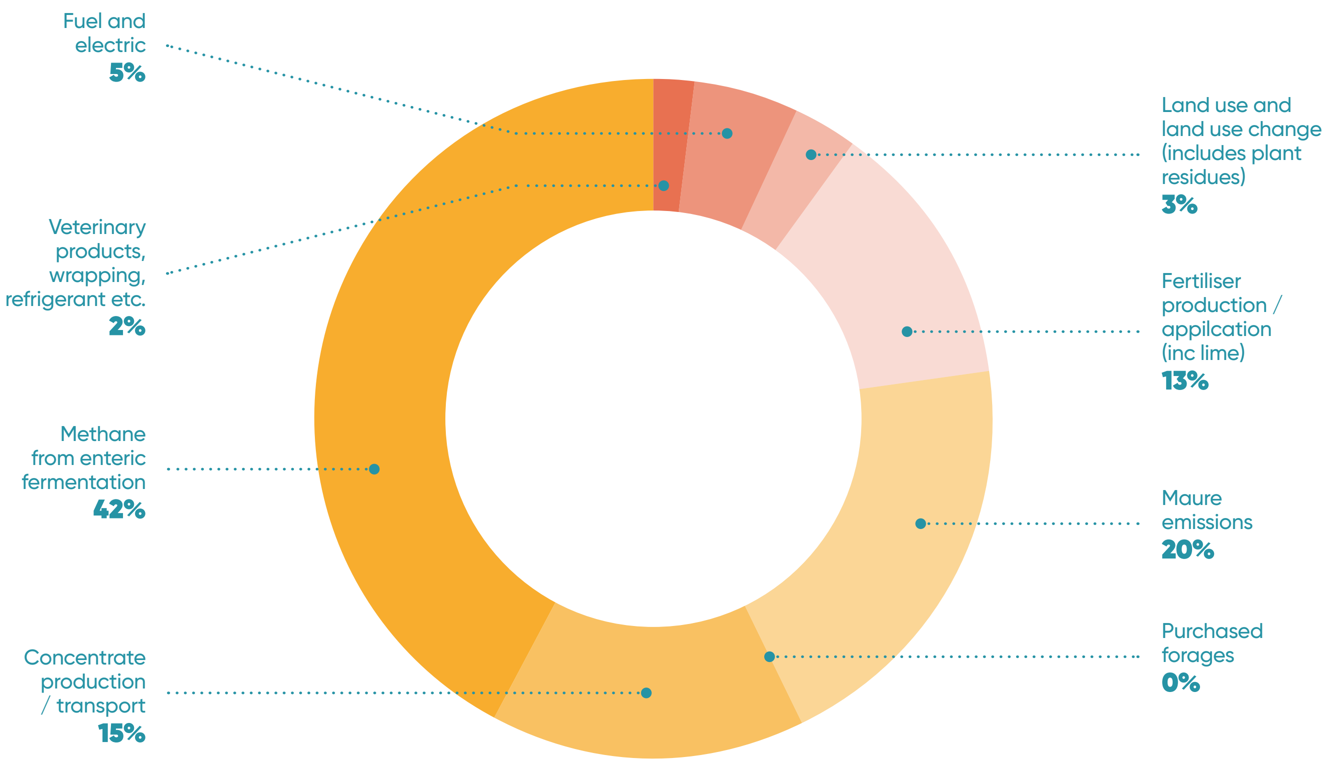
The increasingly efficient use of resources and practices have paid dividends in the last 25 years:

30.7%	5.2%
Dairy farming has reduced its carbon footprint by almost a third between 1990-2014	Agriculture sector reduction in greenhouse emissions between 1990-2014

Between 1990 and 2017 milk production in Northern Ireland has achieved the following reductions:

27%	49%	68%	30%
Reduction in manure emissions	Reduction in fertiliser production/application (incl. lime) emissions	Reduction in fuel & electric emissions	Reduction in methane from enteric fermentation emissions

Emissions intensity of milk production by source[xii]



Climate change **targets** and obligations

The UK Climate Change Act 2008, which extends to Northern Ireland, requires an 80% reduction in emissions across all sectors by 2050. In Europe, the Climate and Energy Package 2030 sets out an EU obligation to reduce total emissions by 40% by 2030. International commitments were renewed in the 2015 Paris Climate Agreement.

While this recognises the need to protect food security, it also increases expectations on all sectors to further reduce emissions and hold global temperature rise below 2˚C. The relationship between farming and the natural resources depends on the broader framework of environmental policy, including the Common Agricultural Policy and the wider European Environmental Action Programme.

These policy frameworks recognise the link between efficient farming practice and beneficial impacts on the wider environment and support action to conserve and protect the natural environment.

[i] United Nations International Resource Panel Report 2017
[ii] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[iii] https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Northern-Ireland-National-Summary.pdf
[iv] DAERA Statistical Review of Northern Ireland Agriculture 2017
[v] Efficient Farming cuts Greenhouse Gases Implementation Plan 2016 – 2020
[vi] 1990-2011: Changes in EU-27 GHG emissions by sector
[vii] 1990-2011: Changes in EU-27 GHG emissions by sector
[viii] 1990-2011: Changes in EU-27 GHG emissions by sector
[ix] 1990-2011: Changes in EU-27 GHG emissions by sector
[x] Greenhouse Gas Emissions on Northern Ireland Dairy Farms 2017
[xi] Greenhouse Gas Emissions on Northern Ireland Dairy Farms 2017
[xii] Greenhouse Gas Emissions on Northern Ireland Dairy Farms 2017
[xiii] https://ec.europa.eu/clima/policies/strategies/2030_en

Chapter 2.

Applied **research**

On farm **research**

The interaction between farmers, industry and applied research has resulted in a real step change in productivity, efficiency and environmental sustainability.

The Agri-Food and Biosciences Institute (AFBI) has established an excellent connectivity with dairy farmers and the wider agri-food industry, providing a two-way process that has enabled new practises and technologies to advance across a wide range of scientific disciplines – from soil to society and farming. This has led to a number of ground-breaking insights that have improved farm sustainability, efficiency and environmental impact nationally and internationally.

About AFBI

The Agri-Food & Biosciences Institute (AFBI) was established in 2006 by bringing together the Science Service of the then Department of Agriculture and Rural Development with the Agricultural Research Institute of Northern Ireland (ARINI). It carries out high technology research and development, statutory, analytical, and diagnostic testing functions for DAERA and other Government departments, public bodies and commercial companies.

As a non-departmental public body (NDPB) of the Department of Agriculture, Environment and Rural Affairs, AFBI is innovative and entrepreneurial in its approach to business development. It has forged new partnerships with other scientific institutes and research organisations and extended the range of services it offers. This enables AFBI's unique breadth of scientific capabilities in the areas of agriculture, animal health, food, environment and biosciences to be offered to a wider prospective national and international customer base.

Greenhouse **gas emissions** from dairying

Producing milk efficiently will typically have positive effects on the GHG emissions from the Northern Ireland dairy farms. While there are many actions that farms can and are taking to improve this process, successful strategies are typically rooted in an informed understanding of the relationship between soils, livestock, environment and farm management.

In recent years, AFBI research alongside other national and international scientific studies has led to the development of an important new tool that accurately calculates the GHG footprint per litre of milk across a range of different milk production systems.

The easy-to-use 'BovIS GHG 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 production and transportation. Ultimately this information is giving farmers the means to review where inefficiencies may exist and develop mitigation strategies that will help reduce carbon footprint.

Results from the BovIS GHG calculator on data collected at AFBI Hillsborough demonstrate that production efficiency, rather than the specific production system itself, is the key determinant of the carbon footprint of milk production.

How does it **work**?

The online calculator is available to all producers and, located with the suite of BovIS applications, users are guided through a user-friendly e-questionnaire collecting information that relates to farm management and annual production. This includes the 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.

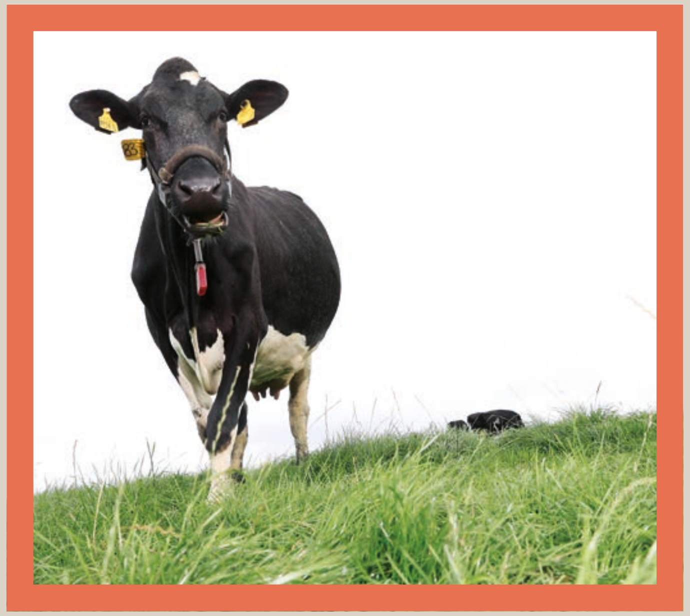
The calculator then produces a summary report which shows the emissions produced by each part of the farming system. Through calculating their carbon footprint, producers can investigate ways to reduce the GHG emissions from their dairy enterprise.

> *"In the last 25 years, Northern Ireland dairy farms have reduced their GHG emissions by 30.7%, putting them among the best performing in Europe..."*

'Low Carbon' credentials of Northern Ireland milk

In the last 25 years, Northern Ireland dairy farms have reduced their GHG emissions by 30.7%, putting them among the best performing in Europe. In a major interregional study involving 132 pilot dairy farms across 10 regions of Northwest Europe, average GHG emissions per unit ECM on Northern Ireland farms (0.97 kg CO2e/kg ECM) proved to be the second lowest.

With greater knowledge and insight from the BovIS GHG calculator, farms are placing greater emphasis on heifer rearing, dry cow management and milk compositional quality in order to realise better more effective management of the farm and, in doing so, produce milk with a lower carbon footprint.



Development of new **feed rationing systems** for dairy cows (UK Feed-into-Milk Models)

AFBI research has shown that high-yielding dairy cows need 30-40% more energy to maintain their body activities than had been recommended through previous feed rationing systems.

That ground-breaking discovery was made using the indirect open-circuit respiration calorimeter chambers, a state-of-the-art facility which AFBI has been using to measure energy utilisation efficiencies of dairy cows since 1992.

As a result a new DEFRA-funded project called 'Feed Into Milk' was set up. A major objective was to develop a new energy rationing system using calorimeter data from dairy cows gathered by AFBI and the University of Reading.

The new energy rationing system is now used across the UK to formulate rations for dairy cows and has even been adopted as a reference programme to compare the production efficiencies of dairy systems throughout the EU.

'Feed Into Milk' is a valuable tool which dairy farmers can use to calculate the forage and concentrate needs for a dairy herd in a way that boosts production efficiency and also cuts environmental pollution – for example, through manure nitrogen and methane emissions.

The 'Feed Into Milk' models can even be used to develop carbon calculators for dairy cattle, so that farmers can estimate levels of greenhouse gases emitted by their production system and draw up emission-cutting strategies tailored to conditions on their own farm.

Loss of **phosphorus** to **water** on dairy farms

A productive dairy industry and clean water, are both essential for the future socio-economic development of Northern Ireland (NI). The majority of our drinking water comes from surface water-bodies, which also support important local fisheries, tourism and recreation. Efforts are needed to reduce the amounts of phosphorus (P) entering and polluting these water-bodies.

Over the past 20 years investment by the NI dairy sector in infrastructure and in more efficient nutrient management practices has contributed to a significant improvement in water quality. Compared to other regions of the British Isles, NI had the fastest level of improvement in water quality between 2009 and 2015. But, since then, water quality has begun to deteriorate again.

Increased efficiency in farm nutrient management has been evidenced by a decline in the regional agricultural P surplus, from 17 kg P ha^{-1} to 12 kg P ha^{-1}, primarily as a result of a major reduction in P fertiliser usage (Figure 1).

Phosphorus surpluses on many dairy farms, however, remain well above 5 kg P ha^{-1}, which AFBI considers to be the target level needed to balance agricultural and water quality objectives. Achieving this target could be challenging for the dairy sector owing to its increasing reliance on P-containing concentrate feeds; and this in fact has contributed to a recent reversal in the downward trend in the regional agricultural P surplus (Figure 1).

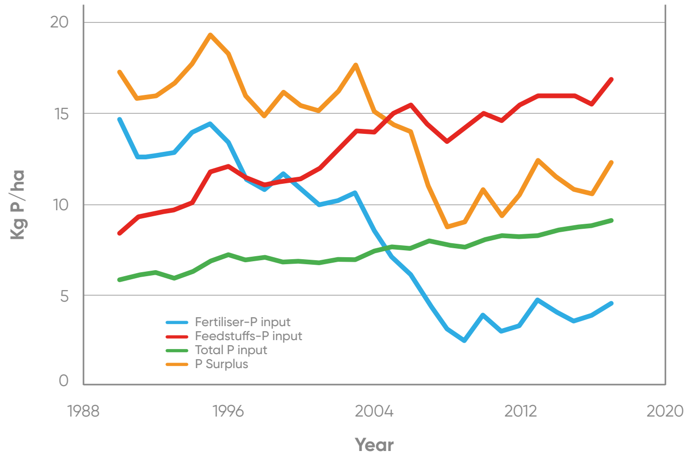


Figure 1: Changes in P inputs, outputs and surpluses for NI agriculture, 1990-2017.

Excessive use of P in NI agriculture has resulted in the P enrichment of many soils. An AFBI survey has indicated that 50% of soils on dairy farms have soil P indices greater than the index 2 optimum for grassland. Even if manure-P is exported off farms, AFBI research suggests that between 10 and 20 years may be needed for P levels in these soils to decline to the optimum level. Clearly, other interventions are needed to reverse soil P build-up and reduce the risk of P run-off to waterbodies.

More than a third of water bodies in NI are below the targets required for good water quality due to elevated P levels, and the majority of these are located in areas of high agricultural intensity. Owing to differences in soil type, topography, hydrology and geology, catchments vary in their ability to cope with agricultural P pressures. Accordingly, AFBI is working across a wide range of catchments to identify 'win-win' solutions which address this variability, and support productive agriculture whilst simultaneously reducing P export to waterbodies.

Case study **two**

Sustainably reducing **P surpluses**

The key to improving profitability and simultaneously reducing farm P surplus, is to produce and feed more high quality grass to dairy cattle and minimise costly concentrate usage.

AFBI scientists researched the effects on dairy farm profitability and farm P surpluses of increased usage of improved quality grass/forage DM in an average dairy farm situation.

For the purpose of the exercise, the average dairy farm was chosen with a dairy cow stocking rate of 1.77 DCE/ha, 600 kg dairy cow producing 7,700 l milk/year, grazing 205 days/year. The amounts of grass, silage and concentrate DM typically utilised, the ME content of the grass and forage, the amount of milk produced, and the P balance for the farm were estimated. The impact of increasing grass/forage DM quality and utilisation on concentrate usage, farm P surplus, milk output and farm profitability were then evaluated using the SAC model.

Moving from the average NI dairy system to one where the quality of the additional grass/forage DM is improved from average to good and utilisation increased by 1 t DM/ha, was shown to lower P inputs, increase milk yield and P outputs, and reduce the farm P surplus from 11 kg P/ha to 3 kg P/ha. More importantly, it increased farm profits by £334/ha at a milk price of 28p/l.

In other words, there is a clear 'win-win' for the economy and the environment, if dairy farmers invest in utilising more improved quality grass and forage for milk production.

Chapter 3.

On-farm **innovation**

Promoting **on-farm innovation** skills

The College of Agriculture and Rural Enterprise (CARFE) is an integral part of the Northern Ireland Department of Agriculture, Environment and Rural Affairs' Food and Farming Group. It supports the Agri-Food sector through industry training, knowledge & technology transfer, benchmarking and business development planning.

The college also provides a range of training programmes aimed at farmers, farm family members and those who work in the food and land-based industries. These training opportunities support the development of new technical and practical skills with dedicated teams devoted to food business development, innovation and energy and waste management.

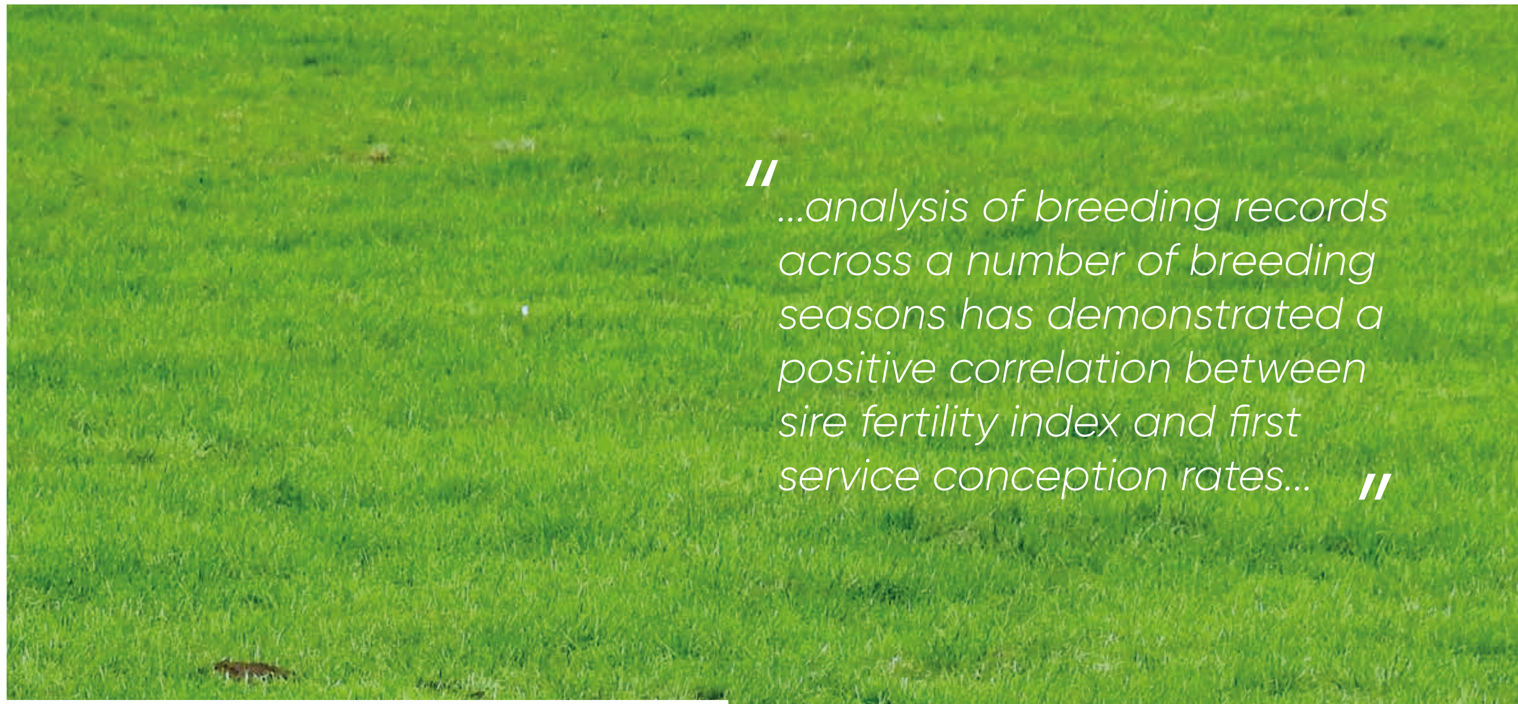
Located just two miles from Antrim town, the Greenmount Campus is home to agricultural, horticultural and environmental training. The 210 hectares around the campus are used for a range of farming practices and hosts the CAFRE Dairy Herd. The land is managed in an environmentally sustainable manner to promote wildlife and protect habitats and enable CAFRE technologists and advisers to demonstrate and promote the latest advances in agriculture and land use.

Knowledge and Technology **Transfer**

The CAFRE Dairying Team has developed a wide range of knowledge and technology transfer projects that demonstrate best management practice across key issues facing Northern Ireland dairy farmers. Project findings are demonstrated to dairy farmers and CAFRE students through Business Development Groups, visits to the CAFRE dairy herd, CAFRE and DAERA websites, social media platforms and industry initiatives.

The wide range of initiatives include, but are not limited to:

Breeding Project	This Project aims to improve the genetic merit of the CAFRE Dairy Herd through sire selection and genomic analysis and to demonstrate to students and farmers the benefits of genetic improvement and the adoption of breeding technologies. Key objectives for this project include increasing the use on commercial dairy farms of: £PLI in the selection of replacement sires • Herd genetic summary data as a means of identifying specific herd breeding programme priorities • Fertility Index (FI) sire PTA (Predicted Transmitting Ability) • Lifespan (L) sire PTA • Individual animal genomic analysis • Planned cross breeding programmes.
Dairy-4-Future	This important project looks at how new technologies can improve dairy farms' long term future through the development of innovative and efficient dairy systems and increased cooperation between research and development stakeholder groups. It involves 10 pilot dairy farms in Northern Ireland and is part of a four-year EU Interreg funded project with a consortium of eleven partners from the Atlantic region of western Europe. Results from the project are expected to contribute towards the competitiveness, sustainability and resilience of dairy farms.
Energy Efficiency	CAFRE has developed energy efficiency support tools that can help farmers to assess the technologies available to them and, by populating with information bespoke to their farm, support more informed decision to be taken on usage or investment. A 'variable speed vacuum pump' decision support tool is already available online. Technologies associated with this project include: • Heat recovery systems • High flow rate plate cooling systems • Optimising bulk milk tank cleaning systems and compressors • Optimising milking parlour cleaning systems • Optimising plate cooling systems • Variable speed vacuum pumps – installing new variable speed vacuum pumps
Manure N Loading & P Balance	Best practice in nutrient management planning is applied on the CAFRE Dairy farm with soil analysis undertaken on all land on a three year cycle. Slurry and farmyard manure are applied to grassland and crops to optimise use of the nutrients contained in these manures and to minimise the need for chemical phosphorus (P) fertiliser. The dairy enterprise is managed to demonstrate compliance with the requirements of a Nitrates Directive Derogation. The project demonstrates the practical measures that can be taken to ensure high quality grass is grazed and ensiled in order to optimise milk from forage and reduce concentrate feed requirements while keeping the forage area P surplus well below the derogation requirement.



"...analysis of breeding records across a number of breeding seasons has demonstrated a positive correlation between sire fertility index and first service conception rates..."

CAFRE Dairy Herd

The 180 cow CAFRE Dairy Herd is used to train full and part-time students in practical dairy herd management skills including milking, feeding and health management. The CAFRE Dairy Herd is also used to demonstrate best management practice to students, dairy farmers, and international trade delegations through a series of Knowledge and Technology Transfer projects.

The CAFRE Dairy Breeding Project works to improve the genetic merit of the Dairy Herd through sire selection and genomic analysis and to demonstrate to students and farmers the benefits of genetic improvement and the adoption of breeding technologies. Within the Dairy Herd, analysis of breeding records across a number of breeding seasons has demonstrated a positive correlation between sire fertility index and first service conception rates and with reduced calving interval. Genomic analysis has indicated a number of very high £PLI heifers with excellent milk protein and fertility PTAs.

The CAFRE dairy farm extends to 161.7 hectares. Land use on the farm includes grassland (72.3%) and an arable rotation of forage maize, cereals, and potatoes on a proportion of the land. Best practice in nutrient management planning is applied on the farm with soil analysis undertaken on all land on a three year cycle. Slurry and farmyard manure are applied to grassland and crops to optimise use of the nutrients contained in these manures and to minimise the need for chemical phosphorus (P) fertiliser.

Martin Mulholland
Senior Dairying Technologist
College of Agriculture
Food and Rural Enterprise (CAFRE)

Best **management practice** across **dairy farms**

While almost all sections of society are impacted by a changing climate, the challenge for the dairy sector is acute.

Martin Mullholland Senior Dairying Technologist at CAFRE explains, "In the last year the climate itself has given dairy farmers very significant challenges. The period from August 2017 until late April 2018 was characterised by very persistent wet weather which resulted in 2017 being the worst harvest in living memory with countless crops that were unable to be harvested and which was followed by a cold, wet and late spring. More recently the record breaking heatwave and prolonged dry weather has also resulted in severe fodder shortages for many farmers.

He adds, "These problems all lead to less efficient farming because for example additional concentrate must be fed to animals to compensate for a loss of quantity and/or quality of forage, lower animal performance is achieved, and unharvested crops and lower crop yields all mean that efficiency gains have not been achieved on many farms."

If society is to meet the challenge of a changing climate, it is critical that attitudes and behaviours change. It is in this area where the College of Agriculture, Food and Rural Enterprise (CAFRE) has been actively transferring knowledge and technologies that can accelerate farms towards positive climate actions.

At the heart of this process is CAFRE's dedicated Dairying Technology Team which has developed innovative knowledge and technology transfer projects that embed best management practice across dairy farms. Demonstrations related to milk production cover a broad range of practical applications that gear farms towards lower emissions, greater efficiency, better performance and, conversely, better profitability.

"...unharvested crops and lower crop yields all mean that efficiency gains have not been achieved on many farms."

The demonstrations include:

- GHG benchmarking of the CAFRE dairy herd;
- Soil analysis on a three-year cycle;
- Nutrient management planning;
- Low emission slurry spreading equipment;
- Urease inhibitor fertilisers;
- Covered slurry stores to reduce ammonia emissions;
- Slurry aeration;
- Genetic selection to improve animal health and fertility;
- 24-month calving of heifers;
- Veterinary assisted fertility management;
- Feed efficiency;
- High flow rate plate cooling;
- Variable speed vacuum pumping;
- Heat recovery from milk cooling;
- Selective dry cow therapy;
- Antimicrobial and health benchmarking;
- LEAF accreditation; and
- Constructed wetland dirty water treatment

In addition to these efforts, 47 Dairy Business Development Groups (BDG) have been established and involve more than 800 dairy farmers with meetings taking place at least eight times per year. As part of the Business Development Groups, farmers are expected to benchmark their farms in some form either physically, or by a full physical and financial benchmark each year.

Martin says "One recent benchmarking development is the margin over concentrates (MOC) application. A farmer sends seven pieces of information to his advisers each month and gets timely information back on average milk yield, concentrate and fertiliser use, efficient use of concentrates.

When recorded over a 12 month period the farmer is able to analyse very useful rolling 12 month averages. This is a step change in benchmarking and is rapidly gaining in popularity with dairy farmers who are BDG members."

While CAFRE does not have a remit to conduct research, it is a partner in an EU Atlantic Interreg Dairy Farm Sustainability Project "Dairy-5-Future" which aims to study and improve economic, environmental and social sustainability across dairy farms in the Atlantic regions of UK, Ireland, France, Spain and Portugal. The College is also involved in the Northern Ireland industry led Greenhouse Gas Implementation Partnership which has an implementation plan to cut GHG emissions on a carbon intensity basis.

Case study **one**

Slurry **management**

Slurry from housed livestock contains valuable nutrients that should be recycled back to the land, in an environmentally sustainable manner.

Flooring systems in the CAFRE dairy cow sheds and also in the maiden heifer rearing accommodation have been installed using Dutch designed flooring products. The purpose of these grooved floors is to reduce ammonia emissions from faeces and urine deposited by the animals, through minimising contact between the urine and faeces. The floors also provide a good gripping surface for the cattle, which is important to reduce injuries and enhance the expression of natural heats. These solid floors are scraped regularly, up to 10 times per day in winter, which also reduces ammonia emissions. Slated areas have plastic flaps across the slurry channels to minimise gaseous exchange between the headspace of the below ground tanks and the air in the building, thus further reducing ammonia losses.

The majority of slurry produced is kept in covered above ground stores. This cover reduces the storage capacity required, as rainwater is not collected and also reduce gaseous exchange with air in order to reduce ammonia loss.

Another slurry management technique is to use a 'low rate' aeration system, which greatly reduces both methane and hydrogen sulphide production during slurry storage. This has positive environmental benefits including reduced methane emissions, and also reduces the risk of injury or death of people and animals from slurry gases released when below ground tanks are mixed. Slurry is always in a mixed state and ready for spreading whenever conditions allow, which is another very important feature of this storage system.

Slurry is land spread by trailing shoe or band spreading systems to reduce ammonia loss during the field operations. This improves the fertiliser N value of the slurry. Emphasis is placed on applying slurry to silage fields and arable land in spring at a rate of approximately 3,500 gallons per acre. Nitrogen in slurry is better utilised in spring as a result of reduced ammonia losses, leaving more N available for grass growth. CAFRE nutrient management calculators are used to assess the quantity of chemical N fertiliser required for the grass crop production in addition to the slurry nutrients. Long term grazing land does not receive slurry, as soil analysis of these fields indicates that the P and K nutrients are at optimal levels. Slurry will also be applied after 1st and 2nd cut silage, at approximately 2,500 gallons per acre, with subsequent bagged fertiliser applications reflecting the amount of slurry applied. Soil analysis indicates that P and K status of fields used mainly for silage are very similar to those in long term grazing and are mostly optimal for production, indicating good nutrient and soil management across the farm.

A simple and easy to use method to determine slurry dry matter content and by proxy, N, P & K content, has been developed by CAFRE. This 'pour-test' involves pouring 500ml of thoroughly mixed slurry onto a flat surface and measuring the diameter of the resultant pool of slurry. The diameter of the slurry pool is highly correlated with the slurry dry matter. The diameter measurement can be entered into an application currently under development, which estimates the nutrient content, nutrient fertiliser value and the distance the slurry can feasibly be transported prior to spreading depending on soil analysis and timing and method of application."

Case study **two**

CAFRE Dairy Unit

The dairy unit at Greenmount Campus is a 'best in class' demonstration facility designed to meet the education and training needs of agriculture students, showcase new and innovative technologies and transfer the knowledge and learning directly to the dairy sector.

It enables greater exploration in a number of topline areas include milking routine, feeding, cow health, analysing herd physical and financial performance.

Opened in 2014, the £2.5m facility features a range of innovations that collectively address a wide range of environmental issues including greenhouse gas mitigation; energy efficiency and efficient technical production systems. Compliant with the environmental Best Practice and Legislation, the dairy unit also promotes improved cow management and welfare, labour efficiency and the adoption of new IT including robust data capture.

The dairy unit has been designed to demonstrate environmental best practice with technologies to allow efficient use of the inputs required for milk production while reducing the carbon footprint of livestock farming and highlighting GHG mitigation technologies.

The design features include:

- milk cooling using high flow rate plate cooling;
- heat recovery from milk cooling;
- variable speed vacuum pump;
- biomass fuelled space heating;
- ammonia volatilization emission reduction slurry management technologies;
- rapid removal of fresh slurry for anaerobic digestion in future; and
- rainwater harvesting.

Farm case study **1**: **Robert Bryson** – Carrick House Farm, Loughbrickland, County Down

Robert Bryson runs Carrick House farm on an uncomplicated high output grass-based grazing system focussed on making the most out of the land available.

Keeping the herd out at grass for as long as possible during the year allows. He also pays close attention to the herd fertility with an aim of raising a herd with high-performing genetic qualities to maximise their milk output.

To achieve this all 315 acres of the farm are in grass – with a herd of 185 cows producing an average 9,000 litres per cow each year, with just over 3,900 litres from forage, with a lifetime performance of 40,000 litres.

The farm has been in his family for four generations since the early 1900s and he took over the running of the farm after graduating from Queen's University Belfast with a degree in Agriculture. At that time, it was a mixed livestock farm but Robert has since focussed exclusively on building a highly performing dairy herd.

315 acres	135 milking	45 replacement heifers raised each year

Slurry and Fertiliser Management

The organic slurry gathered on site contains enough phosphorous to keep soil balances correct, nitrogen is applied and potassium is applied on sulphur. Maintaining moderately acidic soil conditions is a vital component of growing high volumes of grass, so liming is used to achieve a target of a 6.5 Ph in all of the fields. Soil sampling allows Robert to monitor the soil on a regular basis and target the right areas appropriately.

Grazing Management

All 315 acres of the farm are in grass, and since no crops are grown on the farm, the only ploughing that takes place is for reseeding purposes. Robert aims to reseed 10% of the farm each year and focuses on simple mixes of 2/3 diploid and 1/3 tetraploid seed with similar heading dates to ensure a resilient grass covering which allows the herd to graze for as long as possible.

In line with the grass-based approach, the cattle are out grazing early in the springtime, targeting the end of February depending on conditions, starting at 2-3 hours per day and increasing throughout the season.

The cows are out full time (day and night) by the end of March, irrespective of their calving status and milk yield.

Carrick House operates a 21-day grazing rotation, which is longer at the start of the grazing season, shortening in mid-season and lengthened again towards autumn to build grass covers at the end of the year. Shortening the grazing rotation during the summer helps achieve a higher grass output – allowing the grass cover to go down to 4-5cm would have a negative impact on the milk yield, so it's a calculated compromise.

Some fields are grazed between 8 and 9 times a year, and others are grazed less often to allow them to be cut for silage.

Concentrate is fed through the parlour twice a day – and a computerised feed to yield system identifies the individual cow and calculates the most appropriate feed requirement, taking into consideration the milk yield amongst other factors.

Milking 2 times a day	Average milk yield of 9,000 litres per cow each year	Feed rate: 0.25kg per litre	Milk from forage: 3,932 litres per cow each year

Herd Management

Robert takes an active role in the breeding selection process – paying careful attention to feet health, calving ease, and fertility to maximise the Profitable Lifetime Index (PLI) of his herd.

Calving is almost entirely Spring/Summer and the vast majority of calves are born out at grass with little to no intervention.

The selection of high PLI bulls and a well managed grazing system means that the cows have a high output – producing an average of 9,000 litres of milk per cow each year with 3,900 litres of milk from forage, which is mainly grass.

Carrick House also aims to have young cows calving for the first time at two years of age, with some heifers calving as young as 21 months, which brings forward the first lactation period and has a positive impact on the environmental and economic credentials of the farm.

Farm case study **2**: **Thomas Steele** – Rowreagh Farm, Kircubbin, County Down

The Steele family has been farming at Rowreagh for four generations and Thomas Steele has taken over the running of the farm.

The large 1,000 acre dairy farm is situated in the Strangford and Lecale Area of Outstanding Natural Beauty (AONB) and enjoys panoramic views of Strangford Lough.

In recent years, Rowreagh has been involved in a number of projects with the Agri-Food and Biosciences Institute (AFBI) including the INTERREG IVB Dairyman Project.

Thomas is Vice Chair of his local DAERA-funded business development group; a network of local dairy farmers sharing best practice and comparing crop and milk yield data to help benchmark their performance.

When Thomas took over the family business, he decided that he wanted to operate a state-of-the art high yield dairy farm, which minimised its impact on the environment and made the best possible use of existing resources.

1,000 acres	Over 500 milking	400 followers

Since then, they have installed a new parlour and grown the herd significantly. The heard is composed of just over 500 high-yield Friesians each producing an average of 10,000 litres per annum, and 400 followers.

The fully housed herd currently averages an impressive of 10,500kgs of milk solid per cow, at 3.98% butterfat and 3.23% protein.

Energy Efficiency

In 2009 the Steele's installed a state-of-the-art 60-point rotary parlour which operates 3 times a day and allows 500 cows to be milked in just 2 hours.

Installing a variable speed vacuum pump, which only provides a vacuum when required and utilising a high volume cooling plate has meant energy consumption and significantly lower utility bills. The cooling plate heats water used to clean the parlour with the natural body heat carried by the milk as it passes into the tank.

Installing a timed LED lighting system, which adjusts as daylight changes throughout the year, has reduced electricity usage by a third.

Water Management

The farm used to require 6,000 gallons of water per day for cleaning, but the recent installation of a rooftop water catchment system means rainwater is now harvested and stored on site. That, coupled with a move away from the former high volume washing system to a pressure-based system has had a significant impact how this resource is used at Rowreagh.

Feed Utilisation

Feeding 500+ housed cattle 12 months of the year can be very costly but a Total Mixed Ration (TMR) of grass silage and maize is utilised to ensure the herd is fed a nutritious diet, which also maximises yield. Wheat and barley are used for whole crop and straw bedding for young calves.

The crops are produced on a four-cut system, and the good drainage on the land means the maize can be grown on organic manure alone.

The high cost of protein has led Thomas to grow Lucerne, a high protein, nitrogen fixing crop, which has helped to reduce the amount of Protein being brought in from other sources.

Herd Management

In a bid to lower the impact of his dairy herd on the environment, Thomas is working with fertility advisers to produce high genetic cattle. Thomas aims to reach the first lactation in the young cows' at 24 months, and the current average is just below that at 23 and a half months.

Milking 3 times a day	Averaging 10,000 litres per cow each year

Slurry and Fertiliser Management

Slurry is spread using a trailing shoe to minimise the ammonia input and reduce nitrogen emissions. Growing Lucerne on site reduces the need to spread on each field every year.

Soil sampling has been carried out for the past 20 years and slurry is spread using GPS, allowing Rowreagh to specify the exact nutrients required and tailor the distribution accordingly. A variable rate spreader is also utilised to tailor distribution and match the spreading pattern to current soil conditions. This system has resulted in a 10% saving in fertiliser usage.

Slurry is stored below the housing in tanks and an overnight bubble aeration system provides added safety and keeps the slurry ready for use when required.

Chapter 4.

Dairy **processing**

Environmental policy and **commitments**

While climate change is a global issue, Northern Ireland is actively contributing to a range of climate change targets and actions at a number of levels.

At the highest level is the Paris Agreement signed by 195 countries and the EU in December 2015. This is a legally binding agreement requiring all signatories to reduce GHG emissions to limit global temperature rise to 2˚C and goes further by stating that efforts should be pursued to limit to 1.5 degrees.

In Northern Ireland policy regarding climate change is highly influenced by the European Union (EU) which has a target of reducing GHG emissions from 1990 levels by 20% by 2020 and 40% by 2030. These targets ensure that the EU is on the cost-effective track towards meeting its objective of cutting emissions by at least 80% by 2050.

From this EU-wide target, Member States developed their own targets. The United Kingdom (UK) Government has set a UK-wide target under the Climate Change Act 2008. This mandates a reduction of at least 34% in emissions by 2020 and 80% by 2050. It also introduced legally binding five-year carbon budgets setting a limit to the amount of greenhouse gases the UK can emit.

At a regional level, while there are no specific targets for Northern Ireland in the UK Climate Change Act 2008, it is implicit that Northern Ireland contributes to the UK effort of reducing emissions by at least 80% in 2050 from 1990 levels. Moreover, in its Programme for Government (PfG) 2011-15, the Northern Ireland Executive set a target of continuing to work towards a reduction in GHG emissions by at least 35% on 1990 levels by 2025.

Although there is no direct cap set on dairy farming emissions, the sector is playing an active role and against a 1990 baseline has secured a 30.7% reduction in GHG emissions on a per unit of production basis.

Dairy sector supply **chain**

The Northern Ireland dairy sector has world class expertise in the processing and distribution of fresh dairy products, particularly fresh pasteurised liquid milk. It is recognised as a trusted provider of products that are safe, nutritious, affordable and appetising.

Each step of the dairy supply chain – from dairy farming to dairy transport, processing and distribution – operates in accordance with high standards of production and often exceeds statutory obligations for safety, efficiency and quality.

Dairy Farming	Dairy production
Roughly 14% of all farms in Northern Ireland are dairy farms and, since 1990, output has increased by 50% to produce more than 2.2bn litres of milk each year. Two thirds of the 315,800 dairy cows in Northern Ireland are in herds of 100 or more cows and on average each dairy farm is 85.5ha in size. Good stockmanship, farm management and adherence to farm assurance standards, has helped ensure that cows are healthy and well kept.	Northern Ireland milk collection is designed to be efficient, flexible and dynamic with companies complying with the highest standards demanded by the industry's assurance scheme for milk haulage. Milk purchasing and processing is led by well-established processing companies which are mostly farmer-owned and controlled co-operatives. Dairy processing involves the preparation of liquid milk for human consumption and the separation of its different constituents for the manufacture of a range of other dairy products such as butter, cheese and whey powder, cream and yogurt.

Fast facts

Milk powders and cheese

Account for the highest volumes of milk processed in NI[i]

1/3

Of NI's milk production is exported to the ROI for both processing and drinking milk use[ii]

80%

Of NI's dairy output is sold outside Northern Ireland[iii]

8

Companies are responsible for 80% of NI dairy production[iii]

[i] The impact of climate change on dairy production, February 2017 - SafeFood
[ii] The impact of climate change on dairy production, February 2017 - SafeFood
[iii] Agri-food Strategy Board, 2013
[iv] Agri-food Strategy Board, 2013

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 850 million litres.

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

At its Cookstown-based facility, Dunmanbridge, Dale Farm manufactures a range of milk powders and cheddar cheese for the retail and food service markets. Its goals of growing a profitable, efficient and sustainable agri-food business are underpinned by priorities that support cost reductions, environmental compliance, and reducing its environmental impact.

These aspirations are clustered around four ambitious and measurable actions:

- **Maintaining environmental compliance**
- **Maximising resource utilisation key metrics including energy, product waste, water, chemical use and waste**
- **Integrating formal environmental management systems to all aspects of the business**
- **Developing the use of renewable energy resources**

Three-year energy efficiency and renewable resource usage targets are set against a 2016 baseline and Dale Farm's aims, by 2021, are to:

- **Decrease energy consumption by 10% (Kwh/tonne processed)**
- **Reduce carbon dioxide emissions by 15%**
- **Increase the use of renewable energy by 15%**

These targets are managed on site through the site ISO 14001 2015 environmental management system with input from the group capital engineering team.

Case study **one**

Energy management is a key activity in Dale Farm operations both in utilisation and generation. This has been championed by the Group Operations Director forming strategic partnerships with external businesses. The projects have generated 5.7 million Kwh of renewable electricity.

Increasing energy efficiency

Throughout 2017, Dunmanbridge achieved a 10% decrease on energy consumption per tonne of milk processed compared to 2016. This impact was achieved by development of projects such as:

- Recovery of heat from Boiler Flash Steam
- Increasing size of Boiler Hot-Well and return system to maximise condensate return and its use
- Installation of Reverse Osmosis treatment of boiler feed water, this reduces boiler feed water chemical consumption and boiler blowdown frequency and duration
- Compressor Replacements

The operation is also scheduled to convert to natural gas during 2018, a move that will reduce carbon dioxide emissions by 4500 tonnes per year. Separately, the cooperative is undertaking a major project around rationalising farm and secondary haulage transport with the aim of achieving an annual reduction of 800tonnes carbon dioxide.

Solar-power at Dunmanbridge

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.

All the power generated is used on the Dunmanbridge site, rather than being exported to the grid. It is expected to reduce the cooperative's carbon footprint by 20% and deliver multimillion-pound savings in energy costs.

The move follows previous efforts which saw the fitting of solar panels to the roofs of Dale Farm House Belfast, Pennybridge central distribution Ballymena and Dromona Cullybackey distribution warehouse. Collectively 112,000 Kwh of renewable electricity was generated in 2017 alone.

Routing of effluent sludge cake to anaerobic digestion

All the effluent sludge at Dunmanbridge is used as a feed stock for anaerobic digesters, all waste water is treated by dissolved air flotation followed by a membrane bio-reactor and up to 2500cu meters of water is treated each day.

The Dissolved Air Flotation and Biological sludge generated is concentrated using a decanting centrifuge to produce a cake, the production of a cake reduces transport movements 75%. The cake is used as a feed stock for an anaerobic process producing biogas, the biogas is then separated into the methane and carbon dioxide fractions.

The cake supplies generated displaces grid electricity. The digestate is then used on land as a fertiliser, helping to produce the grass that produces the milk -an example of the circular economy in action.

Case study **two**

Lakeland Dairies

Lakeland Dairies manufactures ultra-heat treated (UHT) dairy and dairy alternative products at its Newtownards based operation.

Lakeland Dairies, which has two dairy processing sites in Northern Ireland, is a leading farmer-owned dairy co-operative with a heritage of over 120 years in dairy farming and milk processing. It is a global supplier of dairy foodservice products and food ingredients bringing together over 750 family farms producing 600 million litres of high-quality, sustainable, pasture-based milk in Northern Ireland. The cooperative has also been a longstanding champion for the sustainability of its farmers, their farms and their communities.

Lakeland aims to meet its ambition of being a regenerative company by 2040 by concentrating its sustainability efforts across three aims:

- Being carbon positive;
- Wasting nothing; and
- Enhancing the environment.

This strategy recognises the need to address each step of its value chain – from farmers to factories and customers – and sets five-year sustainability targets that align with the business' planning cycle and the UN Sustainable Development Goals.

Healthy, safe and prosperous

In June 2018, Lakeland Dairies in Northern Ireland became the first dairy processor to secure a voluntary Prosperity Agreement with the Northern Ireland Environment Agency (NIEA). The agreement aims to improve environmental and business outcomes for both organisations and sets commitments to deliver ambitious advancements in resource and energy efficiency and reductions in carbon emissions from factory operations.

The Agreement will help the cooperative as a business and across its sphere of influence to respond positively to key environmental challenges. One of the most important aspects of the Agreement is its commitment to work with NIEA and the wider units in DAERA, as well as with farmers to identify ways to reduce ammonia emissions arising from dairy farms.

It also reinforces Lakeland Dairies work to help farmers better understand land quality and nutrient requirements and to continue their support for biodiversity and habitat protection.

Case study **two**

Key facts

30% Of NI milk comes from Lakeland Dairy farmers

50% Volume of farms Lakeland expects to participate in soil sampling analysis by 2021

Achievements to date

1ST Dairy in the British Isles to introduce a Combined Heat and Power (CHP) plant in 2005

80% Reduction in carbon dioxide per litre of product achieved from 1999 to 2013

£6M Investment in automated warehousing facility which has helped reduce haulage and forklift truck emissions

100% Of electricity purchased from the grid is from renewable sources

25% Reduction in water usage per litre of product achieved by process efficiencies

4.8 ACRES Natural habitat owned by Pritchitts at Newtownards managed for the benefit of pollinators

Lakeland's sustainability priorities 2016 – 2021

	PRIORITY	TARGET
Our farmers	Increase farmers' understanding of land quality and nutrient requirements	50% of our farmers to have undertaken analysis of their soils
	Improve the environmental performance of our farms	Deliver an awareness raising campaign around best practice in terms of resource efficiency and methane reduction
	Reduce antibiotic use on our farms	Implement a programme of best practice awareness raising to reduce antibiotic use. Activities to include farm walks, working with statutory agencies and publication of relevant articles
	Help our farmers adapt to climate change threats	Develop online business resilience toolkit
Our factory	Reduce the carbon footprint of our operations	Reduce carbon dioxide generated per litre of product by 50%
	Increase process efficiency to reduce food waste during production	Reduce the absolute loss of raw materials from our manufacturing process
	Divert unavoidable food waste to people in need	Divert potential unavoidable food waste to people in need
	Increase understanding of the environmental impacts and the associated financial costs of our business	Produce an environmental profit and loss account for the Newtownards manufacturing site
Our customers	Reduce the environmental impact of our product distribution.	Understand the carbon footprint of our product distribution. Develop and implement reduction plan with transport providers
	Reduce sugar content of our products	Reduce sugar content of relevant products in line with the Government's Childhood Obesity Strategy

Chapter 5.

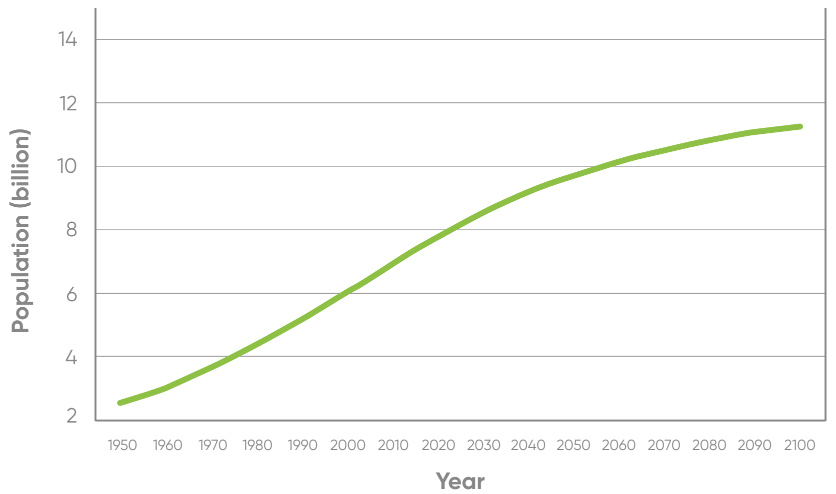
Nutrition

Introduction

What is sustainable diet and why is it relevant? It is too simplistic to look only at climate impact?

How do we feed a growing population?

Data from the UN's Food and Agriculture Organization, FAO shows that one billion people suffer from hunger and a further billion people suffer from "hidden hunger", which is nutritional deprivation even when the supply of foods is sufficient, because of a poor diet quality.



Source: United Nations, Department of Economic and Social Affairs, Population Divsion (2017). World Population Prospects: The 2017 Revision. http://esa.un.org/unpd/wpp/

This need for available, affordable and nutritious diets for the growing global population is challenged by the need to reduce our use of resources and impact on the planet. How can these conflicting demands be met?

The need for a holistic concept of sustainable diet

In our search for new ways of producing and consuming foods in a sustainable manner we must first start with a concept of sustainable diets. Such a definition has been established by the UN Food and Agriculture Organization in 2010 with its publication Sustainable Diets and Biodiversity:

"Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (FAO, 2010).

Sustainable diets are **protective** and respectful of biodiversity and ecosystems, **culturally** acceptable, accessible, **economically** fair and affordable; **nutritionally** adequate, safe and healthy.

Unfolding the Four **Dimensions**

1. Climate impact of specific foods

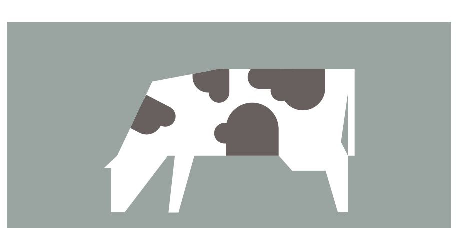
Carbon footprint is only part of the picture

Today the metrics for measuring the sustainability of foods is often solely linked to emissions of greenhouse gasses (GHGE) per kg food. When looking solely at this metric, animal products in general emit more carbon than plant-based products per kg of the product. Thus theoretically, carbon emission from diets could be reduced by eating only plant-based food.

But in reality, the calories and nutrients lost by avoiding animal products must be compensated by a lot of other plant-based products, which also have environmental footprint. In the LiveWell study a database was created that linked nutrient composition and GHGE data for 82 food groups, and models were built based on UK diet. The conclusion of the study showed that a sustainable diet that meets dietary requirements for health with lower GHGEs can be achieved without eliminating meat or reducing dairy product consumption. *(Source: Am J Clin Nutr doi: 10.3945/ajcn.112.038729.)*

A similar approach has been applied in The Netherlands, with a nutrient calculation model, and the conclusions confirm that consuming less dairy product does not reduce the GHG emission of the diet, because when omitting dairy, which is very nutrient-rich, the nutrients have to be provided by other foods.

When you add up the environmental effects of products that replace dairy, the same carbon emissions and land use are the result. Simply shifting between basic food groups to obtain a more sustainable diet gives disappointing results. *(Source: Dr Stephan Peters, Decreasing the environmental footprint of our diet, Nutrition Magazine.)*



Livestock at the world level use **2 billion ha** of **grasslands** of which only **700 million** could be used as **cropland**.

57% of the land used for **feed production** is **not suitable** for **food production**.

(Source: Mottet,A de Haan,C, Falucci,A et al. (2017).

Climate change and emission of greenhouse gases cannot be the sole dimension on which we assess the sustainability of foods. We must also consider the environmental footprint, nutritional value, economy and food culture.

Livestock: On our plates or eating at our table?

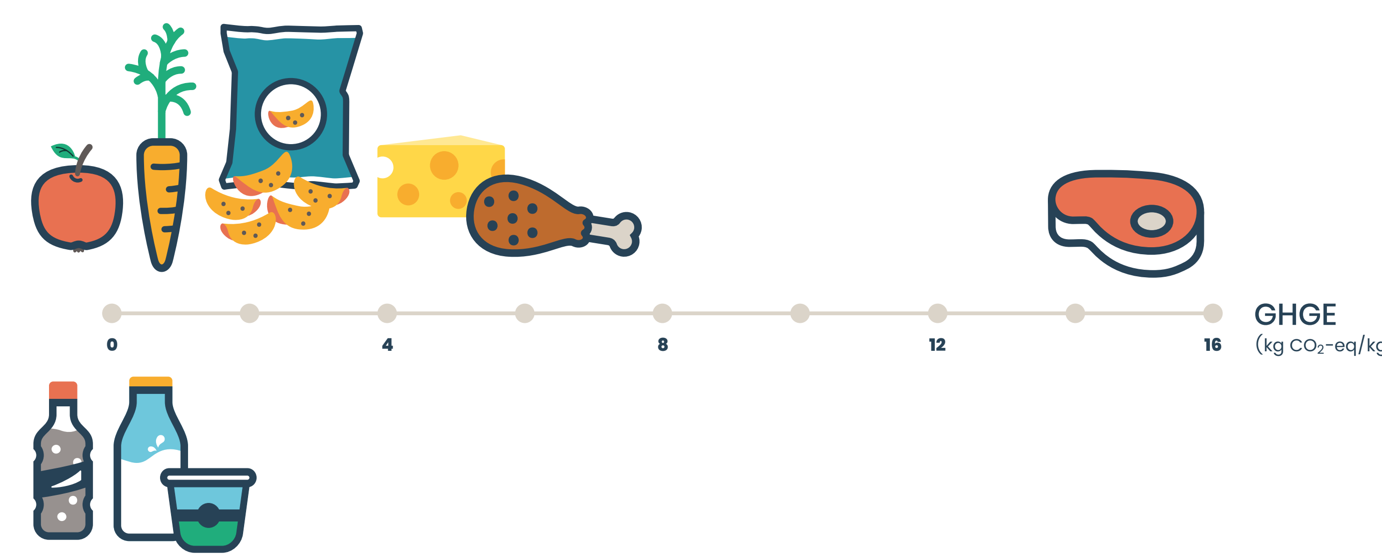
A new analysis of the feed vs. food debate (source: Global Food Security, vol.14, p. 1-8). Researchers from the USDA and Virginia Tech conducted an analysis of the impacts of removing animals from US agriculture and warned that changing one facet of a complex ecosystem has ripple effects and unexpected collateral impact.

As much of the land in the US is unsuitable for high value crops, the research indicated that over 57 % of the additional food produced would have to come from grains such as corn and soybean. The overall reduction in greenhouse gas emissions was lower than expected at just 2.6 % and given that the plant-only system increased the probability of population deficiencies of calcium, vitamin A, vitamin B12 and important fatty acids, it was not considered a viable option.

A decrease, equivalent to the full GHG attributed by animals, was not realized because of the need to synthesize fertilizers to replace animal manures, dispose of human-inedible byproduct feeds that had been used as feed for animals, and produce additional crops on land previously used by animals. Feeding an entire population solely with plant-based products is thus a very complex scenario, which has been shown to be ineffective as a solution to sustainability challenges. *(Source: White RR, Hall MB. Nutritional and greenhouse gas impacts of removing animals from US agriculture. Proc Natl Acad Sci 2017; 114:E10301-E10308.)*

If we only focus on the environmental and climate impact of the foods, we risk running counter to the human nutritional needs which must also be a key dimension when we measure sustainability. In the context of more holistic dietary guidelines, the health effect of foods as such or dietary patterns is also increasingly taken into account. This goes beyond merely looking at the nutritional value or nutritional composition of foods.

Plant-based vs. animal foods is too simplistic:



(Source: Darmon)

Unfolding the Four **Dimensions**

2. Nutritional value

Nutritional profiling is key

Nutritional value is often measured with the twin concept of energy density and nutrient density of foods, which is measured in kilocalories per 100g and nutrients per 100g or nutrients per 100 kcal.

When looking at nutrient profiling of foods based on kilocalories, fruits and vegetables provide very few calories per serving, whereas milk and dairy products provide more calories per serving. At the other end of the scale with energy dense foods we find grain snacks, sweets and chocolate as well as fats and oils *(Drewnowski, 2018)*.

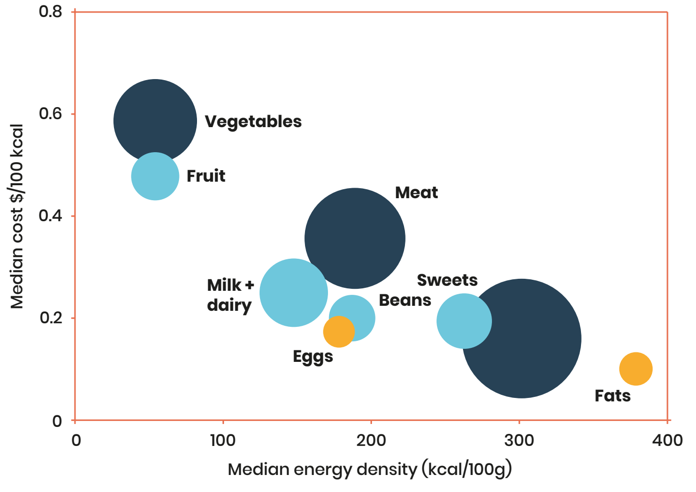
When we compare this to the measure of carbon footprints, we see that vegetables and fruits were also the group of foods that have the lowest carbon footprint per kg of product. But if these foods do not provide the necessary number of calories or nutrients, they cannot constitute a nutritionally adequate diet by themselves *(Drewnowski, 2018)*.

These measures of nutritional value of different food groups demonstrate why it is important to couple the nutritional profiling with the carbon footprint. Moreover, we must also be attentive to the affordability and cultural appropriateness of the different foods.

3. Economy

Empty calories are the cheapest

Empty calories are often cheap whereas more nutrition-rich diets in general are more expensive, current research shows *(Drewnowski, 2018)*. The affordability of food is measured in terms of calories per penny, and by coupling this metric with the nutrient profiling and carbon footprint, we can determine which food is both climate, nutrient and wallet-friendly.



Unfolding the Four **Dimensions**

4. Food culture

A sustainable diet must meet the norms

Different cultural, religious, political and social norms shape our views on food. While proteins from insects or green algae may meet a nutritional demand, they have different degrees of sensory or cultural appeal. In our search for the sustainable diet we must take these factors into account as they have major impact on food choices, both regionally and globally.

Selection of dietary sources of protein, in particular, may be determined by religion, society, and culture, in addition to economy. Furthermore, the amount and quality of protein from meat and dairy are higher than can be obtained from any plant foods. As the search for affordable, nutrient-rich foods continues, the social and cultural drivers of food choice need to be addressed too *(Drewnowski, 2018)*.

Conclusion

Designing the sustainable diet

In designing a sustainable diet, the quantity consumed, must be taken into consideration first *(Source: Masset G. et al, Which functional unit to identify sustainable foods? Public Health Nutrition, 2015)*.

In fact, the total quantity of food consumed explains a larger part of its greenhouse gas footprint than the carbon intensity of the item itself. Furthermore, if the dairy products are replaced by other items, the CO2 equivalent per calorie of the substituting food item must also be considered *(Source : Vieux F. et al, Greenhouse gas emissions of self-selected individual diets in France: Changing the diet structure or consuming less? Ecological Economics, 2012)*.

A limit to working with complex modelling for a sustainable diet is that models contain only limited environmental data on a limited number of products. This is still an emerging field of research, and the peer reviewed science on the matter is still sparse. There is still an incomplete coverage of relevant environmental areas of concern and associated metrics.

So far the majority of studies take only greenhouse gas emissions into account, ignoring carbon storage under grassland and ecosystem services provided by ruminant production like biodiversity maintenance. It is thus too early to drive any strong conclusions.