EIT Food NORTH-WEST

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Achieving Net Zero Targets in the Ruminant Livestock Industry in the UK and Ireland

A White Paper produced by EIT Food North-West in collaboration with Innovate UK KTN

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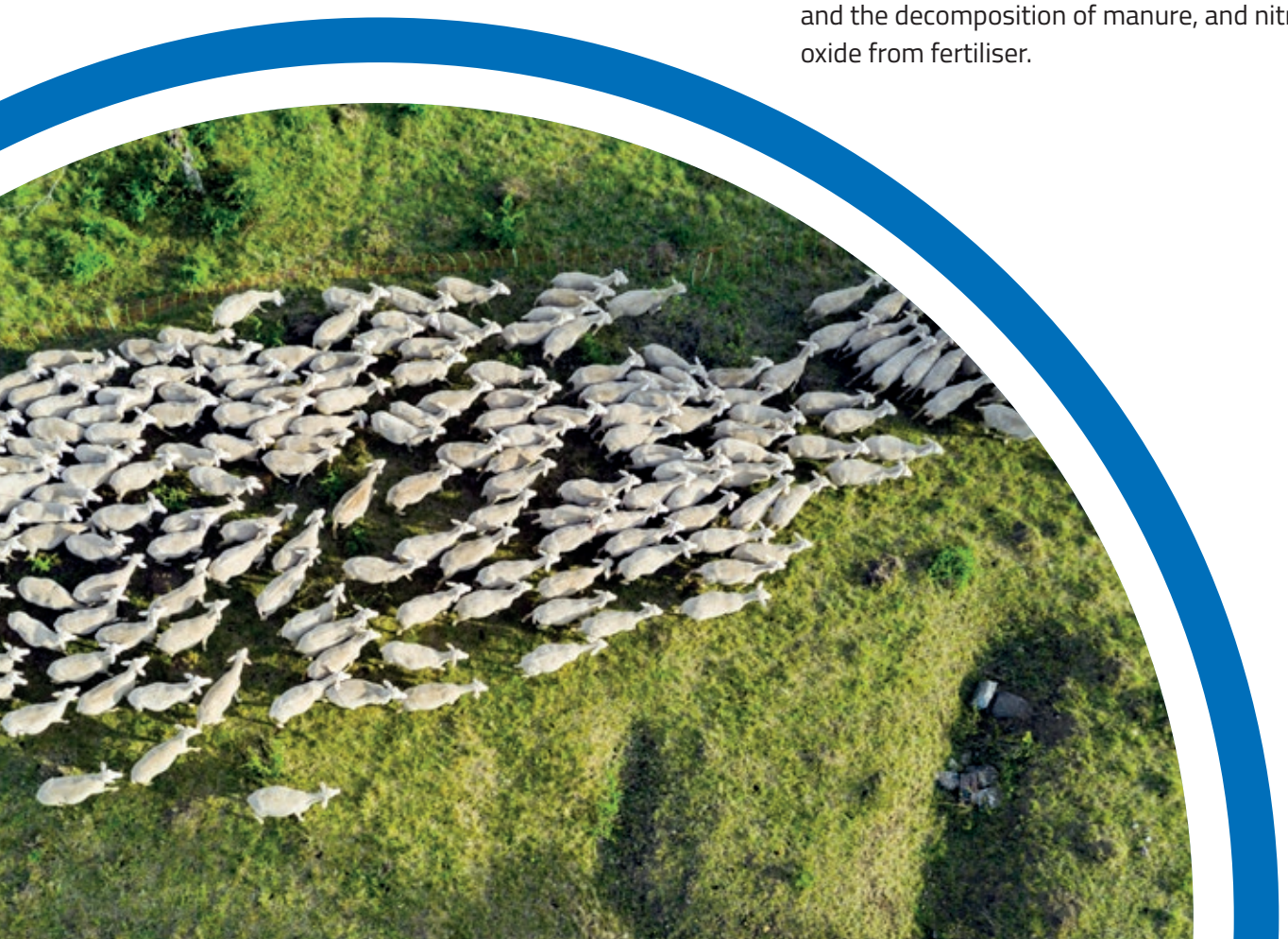
Executive Summary

To achieve the ambition of Net Zero emissions by 2050 and to limit global warming to 1.5° Celsius, there is an urgent need to implement greenhouse gas (GHG) mitigation actions and strategies.

In the UK and Ireland, extreme weather events associated with global climate change pose a substantial risk to farmers and food security as well as threatening potential environmental, societal, and economical benefits.

In the UK, agriculture is the source of 10% of total GHG emissions, whilst in Ireland this sector is responsible for 37.5% of the country's total GHG emissions. This includes methane emissions produced from the natural digestive processes associated with ruminant livestock and the decomposition of manure, and nitrous oxide from fertiliser.



Ruminant livestock such as dairy and beef cattle and sheep have a higher carbon footprint than other livestock. However, agriculture can also help reduce negative impacts on the environment, for example by capturing carbon in its soils and through planting hedgerows and trees.

For the livestock industry to achieve Net Zero targets, input or support will be required from all players along the supply chain. For example, actions from policymakers, additional scientific evidence, and the deployment of innovative solutions from researchers as a well as acceptance from consumers will be required.

The aim of this White Paper is to consider the challenges that UK and Ireland's ruminant livestock sector faces in achieving Net Zero and to highlight potential solutions that would enable this transition. Six priority areas have been identified and recommended including:

1. **Standardisation of GHG data to establish baselines and enable benchmarking**
2. **Cut methane emissions by optimising the age of ruminant livestock slaughter**
3. **Rewarding farmers through policies**
4. **Expanding the network of demonstrator farms to underpin research, facilitate knowledge transfer and accelerate transition to Net Zero**
5. **Promote land management strategies for Net Zero**
6. **Ensuring a more holistic response by improving the understanding of the complexity of carbon sequestration**

These priority areas need to be implemented while recognising the diversity across different ruminant livestock systems, species, and geographies. Furthermore, no single measure will be effective in isolation, instead a combination of solutions selected from a menu of options will be required to reach the best result.

Introduction

Climate change, which is mainly caused by the production of Greenhouse Gases (GHGs), is causing extreme weather events such as more intense rainfall and flooding, increased heat and drought. These extreme weather conditions are having an adverse impact on agriculture and the ability of the sector to feed a growing population and provide food security. Tackling emissions from agriculture, which account for approximately 14% of GHGs globally, is an urgent issue.

As part of a global strategy to reduce GHG emissions and rising global temperatures, the UK and many other governments have set an ambitious goal of Net Zero across all major sectors including agriculture by 2050; with the UK agriculture sector setting itself the aspirational target of achieving Net Zero by 2040. GHG emissions from UK agriculture account for approximately 45.4 million tonnes of carbon dioxide equivalent (CO_2e), that is about 10% of the country's total emission.

This figure is significantly lower than other UK industrial sectors, where the primary GHG emission is carbon dioxide due to the burning of fossil fuels. By comparison, only 1% of the UK's CO_2 emissions are from agriculture. However, farming is responsible for around 70% of the UK's nitrous oxide (N_2O) and 50% methane (CH_4) emissions produced from fertilisers and grazing ruminant livestock, respectively.

In Ireland the agriculture sector, which is dominated by grass-based ruminant livestock farming, was directly responsible for 37.5% of the country's total GHGs emissions in 2021. This high share of emissions reflects the country's low population density, negligible heavy industry, and a high portion of dairy, beef and sheep farming in its economic activity.

- For example, for every person in Ireland, there are 1.4 bovines, compared with 0.14 per person in the UK.

British beef has a GHG footprint equivalent to only 50% of the global average. This is in part due to the UK's efficient production systems, climate and geography which make it one of the most sustainable places in the world to produce beef and lamb. Likewise, milk and meat produced in Ireland have GHG emissions intensity per kilogram of product that are among the lowest in the world. Currently, Ireland's Government has committed to a 25% cut in GHG emissions from agriculture by 2030 but is under pressure to find ways and comply with meeting the European Union's goal of reaching Net Zero by 2050.

However, unlike most other sectors, livestock farming can also act as a sink by capturing and storing carbon in its soils and through planting hedgerows and trees, thus reducing the concentration of carbon dioxide, which is the longest lasting GHG in the atmosphere.

As the agriculture industry keeps striving to further reduce its carbon footprint and to reflect the broad range of livestock production systems existing within the UK and Ireland, it will require a diverse portfolio with a range of potential optional solutions along with policies and widespread adoption to tackle emissions and stabilise them to Net Zero.

With this in mind, EIT Food North-West has developed this White Paper.

The paper centres on six priority recommendations generated at a virtual workshop on this topic, which were then further supported with additional research and information.

About the Workshops

Developed and led by EIT Food North-West with the support of Innovate UK KTN, two workshops were held on the 27th July and 7th September 2021. These brought together a range of experts and key stakeholders from the livestock and agrifood industries and academia as well as governmental and non-governmental organisations, including:

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Through several sessions involving a combination of individual and group exercises and focusing on three pillars - environment, socioeconomics, and innovations - the participants were tasked with considering the livestock industry's contribution to the GHG crisis and identifying the challenges this creates for achieving Net Zero. Potential solutions to overcome these challenges were proposed and these were then ranked and formulated into a set of six actionable, priority recommendations, which are outlined in this White Paper.

It is important to note that over the past few years there have been several excellent reports including those from Centre for Innovation Excellence in Livestock (CIEL), University College London's Institute of Sustainable Resources (UCL), Royal Agricultural Society of England (RASE), and National Farmers Union (NFU), outlining how the agriculture and the livestock sectors in the UK and Ireland are working towards achieving Net Zero, and the recommendations in this White Paper serve to build on and reinforce some of the findings. (See additional reading)

The following sections outline the six priority areas and recommendations, where each first considers the situation and challenges facing the ruminant livestock industry and then proposes a range of potential solutions for consideration to help achieve a transition to Net Zero.

PRIORITY RECOMMENDATION 1

Standardisation of GHG data to establish baselines and enable benchmarking.

To enable the ruminant livestock industry to have access to appropriate tools to reduce environmental impact, it is vital that fit-for-purpose metrics, including a baseline reference point with accurate and appropriate GHG data is used for benchmarking livestock farming systems. This evidence-based approach will allow the effects of any changes or interventions aimed at reducing GHGs to be monitored and verified over time.

However, an accurate assessment of GHGs from agriculture is more challenging than many other sectors where CO_2 emissions from fossil fuels account for most of their footprint. Currently, GHG data from the majority of farms is not being captured in the UK and Ireland. Therefore, an immediate need exists for a standard suite of tools to measure GHG emissions from livestock production systems so that individual enterprises, farms, sectors and industries may be compared and contrasted under the same methodologies and system boundaries.

Considerations and solutions identified and discussed at the workshop include:

1a. To support all countries committed to reporting GHGs, the global livestock sector urgently needs internationally agreed and standardised measurement systems(s) and tools for GHG quantification and benchmarking to ensure transparency and allow comparison with other sectors and markets;

- There are two approaches that are used to quantify GHG emissions in agriculture. These are: a) The inventory approach developed by the IPCC and, b) life cycle assessment. While both share common approaches to GHG calculations, the results they deliver can often look very different so care must be taken to avoid misrepresentations.
- IPCC focusses mostly on-farm-based emissions within a given territory such as the UK. However, life cycle assessment of a food product will record all emissions associated with the production of that product within defined system boundaries. This means UK and Ireland's livestock can incur substantial GHGs associated with overseas land use change and the production of feed supplies, such as soya.

1b. The Global Warming Potential (GWP) metric, GPW100, used to assess and report GHG emission data from agriculture is considered outdated and mechanisms to replace it with the more realistic GWP* metric need to be established. The GWP100 metric compares the different GHG's to carbon dioxide over a 100-year time period, but it assumes inaccurately that all GHGs accumulate in a linear way and as a result overestimates the warming potential of methane. GWP* is now regarded by many experts as a better metric as it takes into consideration that atmospheric methane degrades over a short timeframe, thereby accounting for differences in how short-lived and longer-lived climate pollutants warm the atmosphere. (However, the 'global cooling' effect typically demonstrated by GWP* calculation will only cool the planet long-term if methane emissions continue to decrease into the future.)

1c. Blueprints must be developed for GHG data gathering to ensure standardised data collection across farms.

- Data coverage taken from farms is typically limited to a few parameters and needs to be more comprehensive, as a variety of important specific spatial and temporal farming practices which influence emissions are not captured by this methodology.
- Data should include appropriate genetic data sets and data on farming practice such as innovations in breeding, vaccine and treatment of infectious diseases and improvements in husbandry and land management.
- Inventories need to be fair i.e. for certain farm types it will not be possible to improve systems or measure certain parameters and this needs to be taken into account when developing policies.

1d. Improving use and management of nitrogen in livestock farms to reduce GHG emissions.

- Accurately measuring a farm's nitrogen balance by determining the nitrogen introduced onto the farm through feeds, stock, fertiliser etc and any nitrogen captured through soil improvement, compared to the nitrogen leaving the farm through end products such as milk or meat is vital. This measurement should allow quantification of nitrogen lost to the environment.

1e. Introduce broad-based 'holistic' approaches to reduce the overall burden on the environment.

- A baseline for all the relevant aspects of the farm, including its operations, main outputs, and environmental impacts. This will include collecting and organising information and data on the quantity and cost of inputs and outputs. A key issue to address will be the choice of a standard measurement system to ensure transparency and allow comparison with other operations, sectors or markets.
- There is an urgent need to develop ways of benchmarking carbon capture and other environmental metrics e.g. water use, biodiversity.
- Also there needs to be clarity around 'who owns the data' and how farmers can access their reported data so they can take any necessary practical actions.

1f. There is a need to invest in methods/ technologies that will enable data from externalities of livestock production to be better quantified, i.e. negative and positive side-effects that arise from production and consumption, but which are not priced by the market such as the destruction or building of natural habitats, loss or increase in biodiversity, or positive or negative effects on human and animal health and welfare.

PRIORITY RECOMMENDATION 2

Cut methane emissions by optimising the age of ruminant livestock slaughter

In agriculture, approximately 80% of methane emissions originate from ruminant livestock as a by-product of their natural enteric digestive process while approximately 20% of methane emissions result from the decomposition of manure under anaerobic (without oxygen) conditions. Compared to CO_2, methane has a high potency but short half-life, therefore curbing its production and emissions by ruminant livestock at source is a strategy that will achieve disproportionately positive benefits for tackling Net Zero and climate change in the near term.

As such, one effective approach is to incentivise the slaughter of ruminant livestock at a younger age or 'quicker finishing' so that they emit less methane. However, for this to be practical it requires optimising the animals efficiency and lifetime performance so that it produces the same or more kgs of beef or litres of milk per animal in a reduced time frame.

However, the production systems for beef and dairy cattle and sheep are heterogenous and complex. They depend on the animal, breed, sex, diet, their health and welfare, how active they are and where they are reared, which all have an effect on the environmental impact.

Therefore, to support slaughter at an earlier age, new methods, technologies and solutions need to be developed in the areas of animal breeding and livestock health, animal husbandry, welfare and productivity to deliver further needed improvements in efficiency, while at the same time lowering environmental impact through reducing methane, and other GHG emissions.

Potential R&D solutions identified during the workshop include:

2a. Genetic improvement of livestock by expanding and expediting breeding programmes and the application of new genetic technologies, tools, genomic testing and selection to introduce new heritable traits into ruminant livestock, including;

- Breeding animals that are more efficient, healthier or disease resistant, and therefore emit less methane.
- Utilise software programmes or apps that enable performance recording including weight measurement data to support a careful selection and culling process to increase the rate of genetic gains.
- Improving reproductive efficiency to cut emissions, by applying new methodologies that use genomics, phenotypic observations, and other practices to maximise fertility (fecundity) and optimise neonatal survival. This also needs to be interlinked with good nutrition and grazing management and avoiding stress due to handling or moving to different pastures.
- Support for industry-wide adoption of improved genetics to promote a better national herd(s) or flock(s) so they are more consistent in performance, enabling efficiency, and helping to stabilise and decrease total enteric methane emissions from the dairy, beef and sheep sectors.

2b. Improving feed conversion efficiency to reduce methane emission:

- Select breeds with microbial communities that are associated with reduced methane emissions.
- Use genomic technologies to understand and manipulate or program specific rumen microbes including methanogens.
- Explore new feed additives that reduce methane emissions such as those derived from seaweed, garlic or different methane suppressing fats and oils.
- Further develop and commercialise interventions that reduce methane emissions such as methane inhibitors, vaccines etc.

2c. Understanding and improving feed formulations to reduce methane production whilst maximising growth potential.

- UK and Ireland management systems in some ruminant livestock such as suckler cows or sheep are often based upon extensive, pasture-based grazing. These systems, especially in upland farms can have longer production cycles which can increase emissions. Improving efficiency in grass-based production should be a high priority for both research and on-farm innovation. Improvement by addition of legumes for increased protein content, palatability, and therapeutic helminthic properties, for example.

- Commercial feeds are more digestible and less fibrous than traditional forage-based feeds increasing the partition of energy into body weight or milk yield and lowering potential emissions but may have animal health and wellbeing consequences.
- There needs to be a greater understanding of the constituents of feed at a national level, where they originate and how any changes to land use may impact the industry's footprint and overall security of supply.

2d. Optimising ruminant health and welfare for efficient milk and meat production.

- Increase vaccine R&D and extend vaccination programmes to prevent and control endemic diseases such as those responsible for respiratory and reproductive problems.
- Promote good reproductive and fertility management practices and those that reduce stress and maximise animal comfort e.g. invest in developing improved livestock monitoring systems such as activity sensors, data recording apps or weight measures that are non-invasive.

PRIORITY RECOMMENDATION 3

Rewarding farmers through policies

In addition to shifting consumer diets and preferences, farmers in the UK and Ireland are facing policy changes as a result of the UK leaving the EU as well as the impact of more extreme weather.

However, as agriculture is in a unique position to mitigate the impacts of climate change, it is critical that policymakers fully understand the challenges and potential solutions around the transition to Net Zero to enable a sustainable, resilient future for the livestock farming sector.

To drive change, it is important that policies, are science-based with real evidence around what does and does not make a difference. As transition policies are being formulated, the involvement of farmers and other representative organisations will be essential to provide 'real-farm' practical insights. This will support farmers' engagement and confidence in policies and any proposed impact solutions.

Considerations and solutions discussed at the workshop included:

3a. Policy should consider and reward positive outcomes in meeting targets and not be designed to provide perverse incentives that hinder the livestock sector.

- When linking trade policy with governmental commitments on climate it is important to ensure that the emissions crisis is not simply offshored to other producer countries that are supplying meat or dairy products to the UK and Ireland.
- Exporting meat production and its associated emissions to other countries should be discouraged, as producing meat locally contributes to increased security of supply.

3b. Ensure technologies that reduce emissions are affordable and maintain livestock performance.

3c. Promote R&D that reduce GHG emissions.

- Policy should encourage the identification of technical solutions, such as changing ruminant diets and methane/carbon capture and, reducing the age of slaughter of livestock, to address consumer demand and the UK's 'Global Methane Pledge' commitment and better resource management.
- Investments in better standards, tools, robotics and digital technologies is needed to help support policies and drive change in farming methods e.g. data on GHG emissions and capture is essential at both the macro and micro level of farming. Large (aggregated) datasets will help in policy strategy and planning at a national and regional level as well as inform decision making, while granular data will provide details and insights to help farmers to deliver sustainable productivity gains and manage the environment better. Achieving this will require more investments in machine learning, Artificial Intelligence (AI) and Internet of Things (IoT).

3d. Increase the use of waste-stream products in livestock.

- Domestically produced by- or co-product feeds that humans either cannot eat e.g. wheat straw or will not eat e.g. bakery waste, should be increased in intensive livestock diets where possible and economically viable. This would release land for other crops and reduce fertiliser use and emissions from growing feed, as such feeds only have a proportion of total crop resources and GHG emissions allocated to them.

3e. New policies and subsidies need to encourage and reward farmers.

- Comprehensive economic valuation of natural capital and new systems must be established to ensure farmers are sufficiently rewarded for their contribution to meeting national and local decarbonisation goals while ensuring food security.
- Policy on-farm emissions must account for the impact of grazing livestock in sequestering carbon to soils.
- Farmers need supportive policy to help them deliver improved soil and water quality management and boost biodiversity. This in turn will support rural transition and the priority for more rapid progress to rural decarbonisation and the need to correct damage to soil quality over many decades.
- Structural funds will need to be available to support the rebalance and production of different livestock systems or fodder crops if farms are to deliver Net Zero. If ecosystem services are genuinely something of value, then the provider should be compensated but currently these services are not paid for to the farm.
- Low profit margins within the ruminant sector requires farmers to derive economic benefits within a reasonable time frame from low carbon farming, together with and an understanding of the cost effectiveness of different solutions.
- There needs to be a consistent and trusted framework for carbon credits and accountancy; this will require appropriate regulation.
- Implementation of carbon credit schemes will need safeguards to ensure that the farming industry is able to claim its own credits and not just act as a vehicle for other more profitable, polluting industries such as transport and energy, to claim the carbon credits achieved.

3f. There are huge variations in GHG emissions in livestock production systems from different geographies and this needs to be considered within policy development (and also in the dialogue with consumers). A balance must be achieved, such that the most efficient use is made of both grazing on land unsuitable for arable crops, plus intensive rearing and finishing systems.

- Net Zero is an industry target but it may not always be appropriate or achievable for all individual businesses within the livestock sector; this needs to be considered in designing interventions and regulations.

3g. Policies introduced must not penalise one sector of farming.

- For example, within beef systems, the dairy sector's role in providing calves should not be underestimated. Therefore, the resources and GHG emissions invested (in conception and birth) may be allocated to the dairy sector, reducing their environmental impacts compared to suckler-bred beef cattle.

3h. Hill farming in particular needs ongoing support not only to become more profitable and resilient but also to protect biodiversity.

- Rural Communities: There is a need to mobilise rural communities, particularly in isolated and marginal areas, to allow them to play their part in the decarbonisation process. This must include access to extra funding for development of rural infrastructure to meet specific rural needs, especially in remote farming areas.

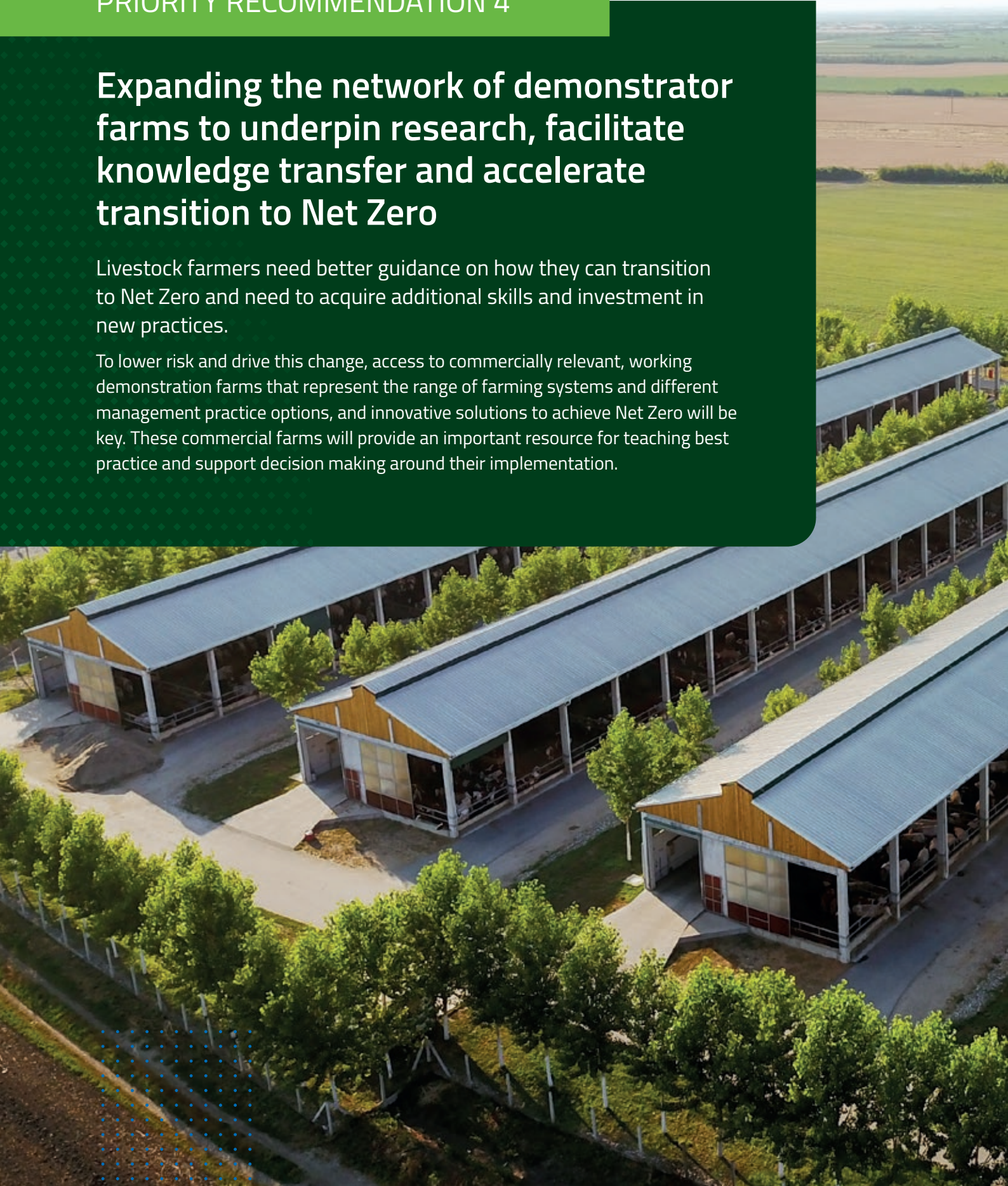
3i. It is necessary to avoid making the reporting process excessively complex or favouring one size or type of farm business over another and offer flexibility to respond to improved knowledge and practice.

PRIORITY RECOMMENDATION 4

Expanding the network of demonstrator farms to underpin research, facilitate knowledge transfer and accelerate transition to Net Zero

Livestock farmers need better guidance on how they can transition to Net Zero and need to acquire additional skills and investment in new practices.

To lower risk and drive this change, access to commercially relevant, working demonstration farms that represent the range of farming systems and different management practice options, and innovative solutions to achieve Net Zero will be key. These commercial farms will provide an important resource for teaching best practice and support decision making around their implementation.



In addition to providing peer-to-peer teaching and hands-on training, commercial demonstration farms also play a vital role in carrying out research programs. Discussions at the workshop centred on:

4a. Accelerate the uptake of sustainable farming practices.

- **Emerging technologies and the existing network of commercial demonstration farm sites should be extended by increasing the number of model commercial farms.**

4b. New technology is crucial towards obtaining Net Zero.

- More support for research and demonstration projects across the UK and Ireland, ranging from basic science to pilot projects, in different geographies and landscapes to clarify what actions and interventions are effective and quantify these effects is needed.
- Business sustainability and financial implications are important drivers when implementing strategies to support Net Zero. Therefore, developing economic cost/benefit working models are needed to show farmers the future potential of low impact farming with efficiency benefits. These also need to highlight the balance between productivity, environmental and socioeconomic benefit.
- Demonstration farms need to provide a mechanism for including farmers and their needs as early as possible in the development of innovations to ensure they address end-user requirements.

4c. Support for R&D around building the evidence base for mitigation interventions and technologies as well as refining existing technologies and practices to increase their applicability.

- Further research and knowledge transfer aimed especially at innovative practices and technology options that support GHG emission reductions, and carbon capture and storage, are urgently needed.
- Smart or precision livestock farming aims to achieve more productive, efficient, and sustainable farm operations by employing smart technologies to monitor key performance indicators of livestock continuously and automatically in the areas of animal health, productivity and environmental capacity. Through ICT (information and Communication Technologies) and IoT (Internet of Things) more performance related data can be collected from the animals, for example through image recognition software, wearables, as well as weight and sound monitoring. These technologies can aid in supporting the rearing of healthier animals and managing herds more efficiently as well as promoting and certifying positive animal welfare practices.

4d. Investment in precision livestock systems and technologies plus easy access to demonstration farms.

- Precision livestock farming systems can help to curb inefficiencies and waste. Better data collection and its use will facilitate assessment of variations related to operations, species or breeds.
- Environmental monitoring and sensors to improve livestock health management, particularly in intensively stocked environments.
- Biosensors and wearable technologies like thermal and vision sensors measure changes in body temperature and walking gait to detect medical problems in their early stages and potentially provide the individual animal with the necessary care they require.
- Soil sensors enable farmers to precisely measure the nutrient composition of their soil. This data will help them to plant the most beneficial feed crops and add exactly the right amount of additional nutrients required, reducing the need for excessive fertiliser use.
- Drones can be used to create high-resolution images of farmland, allowing farmers to examine the land in real-time. They can help monitor feed crops and health, flooding extent and weed patches. Livestock in herds can also be monitored using cameras or robots to track the animals' health and check they have enough pasture to graze on.

PRIORITY RECOMMENDATION 5

Promote land management strategies for Net Zero

In addition to associated GHG emissions, livestock production has a significant impact on land and soil, water resources, and biodiversity. In the UK and Ireland, farmland occupies approximately three quarters of the land mass with around 65% 'permanent' grassland. Therefore, farmers have an important role as stewards of the land and the surrounding ecosystem in which their farm is located. However, for generations livestock land use has primarily focused on food production as opposed to other services that land can provide, thus, to enable Net Zero a complete reconsideration of livestock land management practices is required.

Whilst achieving Net Zero is a key objective of the livestock sector, the implementation and uptake of low carbon practices needs to be seen within the wider context of sustainability and resilience. . One solution would be transitioning to agroecological or regenerative agriculture practices which are systems of farming designed to enrich soils, increase biodiversity, improve watersheds and enhance ecosystem services.

It is therefore important to create a specific optimised sustainability plan that looks at existing opportunities and constraints for the whole farm and its land on an individual basis, as well as including factors that may arise from climate change e.g. drought, flooding, rising temperatures, invasive species, and pest and disease risks.

The workshop participants discussed several land management strategies and practices that could potentially help mitigate the negative effects of livestock GHG emissions and climate change, while supporting wider sustainability:

5a. Encouraging consumers to eat slightly less but better-quality meat and dairy products, is one obvious mechanism to release land so that more trees and hedgerows can be planted to capture carbon dioxide emissions. However, this strategy needs to place emphasis on continuing livestock production via 'sustainable approaches' such as regenerative farming methods.

- In particular, targeting least productive land for land use change, domestic food production can be maintained while supporting environmental goals (according to the Food Strategy)

5b. Fewer animals with improved production efficiency will result in more land being available for capturing carbon within the farm. The scale of this carbon capture will depend on the nature of the afforestation or other strategies adopted, along with land type and location.

- For livestock systems, mitigations for improving production efficiency through, for example, improved fertility, health and genetic gain, requires investment and system changes on farms (see section recommendation 1 for more details).

5c. A healthy fertile soil is one of the most vital resources that farmers have. An improved understanding of soil health on individual livestock farms is required to resolve which current practices have the best environmental and economic impacts for grazing systems and crops grown for animal feed. This can then lead to future innovations.

- Land management practices need to protect and improve soils and these need to be supported by standards and rewards.

5d. Replacing synthetic nitrogen fertiliser which is produced using a high energy intensive process with manure or slurries. Priority solutions for improving management and application of manures and slurries include:

- Ensure amply sized manure and slurry storage, and always cover to prevent rain entering or gases like ammonia escaping.
- Prevent any liquid discharge from slurry storage that can contribute to pollution and eutrophication of water bodies.
- Use acid or other additives such as nitrification or urease inhibitors to reduce N_2O emissions from stored manure, this will also bring benefits by reducing the level of associated airborne ammonia (NH_3) which is harmful to human and animal health.
- Practice low emission slurry spreading techniques, such as trailing shoe or slot injection. These should also aim to reduce soil compaction and degradation.

- Carry out soil testing and adopt precision application of manure and fertiliser that is targeted – spatial and temporal.
- Support research that aims to improve the efficiency and precision of manure applications such as helping farmers to calculate more accurately the quantity of nitrogen-based fertilisers needed, which in turn requires development of technologies to automatically monitor the nitrogen content of soil.
- Identify N_02 hotspots or regions that need improvement.

5e. Generation of renewable energy on farm through anaerobic digestion (AD) of manure can bring additional farming income.

- In addition, digestate which is a by-product of the AD process and is rich in phosphorous, carbon and nitrogen can form a key ingredient in the production of organic fertilisers, which can be used to replace chemical fertiliser. Furthermore, the rising cost of these fossil-fuel-based fertilisers means there will be a greater reward on nutrients available from manure.

5f. While the National Inventory model accounts for AD, it only accounts for changes in GHG emissions during manure storage and spreading and does not account for any fossil-fuel energy that AD could offset. This is currently accounted for in the National Inventory for energy use. This is an area that deserves further modelling through carbon calculators and at a national level.

- Benefits of renewable energy production are increasingly valuable against a backdrop of stringent climate and environmental policy, rising carbon and energy prices and wider corporate decarbonisation commitments.
- Collaboration with other industries, such as the energy and transport sectors, is also warranted, especially regarding this mitigation which creates energy from the farm process.
- Provide targeted support to accelerate the development of the market for biomethane from sustainable waste sources such as manure via upcoming policy initiatives.

5g. Innovative technologies that are being developed as next generation manure treatments warrant urgent further research to enable commercialisation.

- For example, the creation of bioreactors that utilise insects such as Black Soldier Fly larvae to consume manure on-farm and convert its nutrients into high protein, high energy larval insect mass that can be used as animal feed. In addition to reducing agricultural waste through this circular economy approach, this feeds innovation also provides a local solution by reducing the GHGs associated with imported grains or legumes e.g. soya, and any potential issues associated with deforestation or land use change.

5h. Change feeding techniques and feed sources by pasturing feeding or using home-grown protein sources for animal feed, co- and by-products in livestock feeds, and new technology e.g. precision feeding.

- Reduce the use of imported feedstocks. Novel, home-grown feed products are critical to reducing reliance on imported soya and stimulating local production of crops can generate additional sources of income for UK and Ireland's farmers.

5i. There is increasing evidence of the advantages of mixed farming for soil health, with grass leys being used more within arable rotations to improve soil health, livestock also have a key role within these systems. Create diverse swards by planting multi-species of grass, legumes and herbal leys which offer benefits for livestock performance, soil health and biodiversity. Also by including legumes in the mix, nitrogen can be 'fixed' from the atmosphere i.e. nitrogen is converted into nitrogen compounds useful for other biochemical processes:

- Unique plant varieties root at different depths which means collectively they obtain minerals, nutrients, and water to maximise the whole soil profile.
- Within a diverse herbal ley, diseases find it very difficult to transmit between plants as they are typically species specific.
- Including some herbal plants with anthelmintic properties such as chicory or sainfoin can serve to reduce any internal parasite burden in the grazing ruminant.
- Legumes i.e. plants such as beans, peas, alfalfa, and clover, play an important role in sustainable agriculture due to the nitrogen-fixing bacteria in legume root nodules. Dead legume plant matter also releases nitrogen back into the soil, which creates fertile soil for future crops in rotational systems.

5j. Grazing livestock can be set stocked i.e. left in a field often for many weeks or months at a time or rotationally grazed i.e. moved through a series of paddocks on a regular basis enabling pastures to have rest periods. Rotational grazing minimises soil damage and reduces the need for inorganic fertilisers through manure, and in turn, improving soil ecological function and enhancing biodiversity. It is important for farmers to find an optimal sustainable system that suits their business.

- Consider introducing 'Mob grazing', which involves regularly moving animals together as a tight group or 'mob' on a relatively small patch of land after a short period i.e. every few days to fresh grazing. Offering fresh pasture often is found to increase grass utilisation and production. The regular moves ensure the animals only eat the best bits of the near-mature plants. Keeping the animals in tight groups means that those parts of the plant that are not eaten get trampled onto the soil surface acting as a protective blanket to prevent soil-associated emissions and providing additional nutrients for the soil microbes. Increasing grass productivity generally increases carbon formation in the roots, with some theories implying that mob grazing leads to better soil carbon storage than other forms of grazing.

5k. Create a silvopasture which involves integrating trees within grazing land. Trees capture carbon, while providing protection from rain, sun and wind for livestock, as well as additional grazing material in the form of foliage which could provide additional minerals and thereby benefit animal health. Depending on the tree type, it can also give extra income, either from fruit/nut harvesting or timber/wood chip harvest.

5l. Buffer and protect water courses by establishing grass and/or woodland buffer strips alongside watercourses, or sensitive habitats, to intercept any overland flow, trap sediment, pesticides and prevent access for livestock.

5m. Sustainability, climate impact assurance labelling schemes need to be developed that include measures that seek to increase the flow of information about the emissions associated with different livestock products. This can help consumers and producers to better align their consumption and production preferences with the emission profiles of these products.

- Common metrics and standards to measure the carbon footprint of livestock and other food products are needed to enable consumers to make informed decisions on their purchases. This is crucial if food labelling on sustainability is to be widely introduced in the retail sector.

5n. Retailers and food processors are promoting the use of regenerative practices to attract consumers and demonstrate their commitment to Net Zero and sustainability targets. This will require investment in for example, blockchain technology. Whilst relatively new to the agricultural sector, blockchain could be a useful tool in tracking both the lifecycle of animals from farm-to-fork while also accounting for GHG emissions at every stage of the process and providing consumers a traceable product.

5o. Expand training and advisory service for farmers and land managers to support any appropriate changes to land management practice as well as negotiating any new or complex available funding. It is key that farmers receive guaranteed funding for the long-term and take the optimal environmental actions to support a financially sustainable business.

PRIORITY RECOMMENDATION 6

Ensuring a more holistic response by improving the understanding of the complexity of carbon sequestration

Soil carbon sequestration is noted as a crucial climate mitigation measure in the 2022 IPCC report, as well as being highlighted in the EU Farm to Fork Strategy and Ag-Climatise.

Soil can directly capture and store carbon or indirectly provide nutrients for other carbon cycling systems. Understanding the nature and composition of the soil and its quality requirements helps generate higher grass and other fodder crop yields, support planting of appropriate hedgerows and trees, as well as playing a role in mitigating the GHGs and climate change.

The science of carbon sequestration and how this will function at a practical level in the long term is still uncertain. Scientists are unsure on how much carbon UK and Ireland's livestock systems are sequestering and what is the full potential available, although it is widely agreed that soil carbon does not increase without limit, but eventually reaches a saturated level.

The more efficiently we can produce livestock, and the more carbon we can store in the landscape, the closer we get to carbon neutrality. However, we need to understand the sequestration element of the carbon cycle to a much greater extent. The workshop participants discussed the following:

6a. Measuring and quantification of carbon sequestration in soils

- There is a need for more scientific data and modelling on the ability of soils across the UK to sequester carbon as currently this presents a major knowledge gap, yet it could have a notable positive impact for some areas of the UK.

6b. Improving carbon sequestration of soils.

- Reducing periods when soils are bare (e.g. in fields which used to grow spring-sown crops which are 'bare' over winter), incorporating cover crops, minimising soil disturbance and increasing species composition and diversity of grassland can all provide part of the solution to minimising carbon loss and optimising carbon building at farm level.
- Loss of soil carbon, of which soil microbes are a living part, is a primary indicator of soil degradation. Recycling carbon-rich by-products of rural, urban and industrial activities back to soil can help to rebuild organic soil carbon and presents an opportunity to mitigate climate change as part of a circular economy approach to sustainable waste management.

6c. Support evidence-based research programmes that underpin soil management.

- Provide evidence to support a variety of nature-friendly farming systems e.g. regenerative systems, silvopasture, and rewilding, which should be incentivised and valued. Such systems increase biodiversity and focus upon building carbon stores in soils and above ground e.g. plants, hedges, woodland, whilst curbing emissions from excessive fertiliser use and soil disturbance.

6d. A soil carbon marketplace is emerging whereby livestock farmers are being paid for practices that sequester carbon into soils, by investors looking to champion sustainable farming or offset their emissions. While this has the potential to provide annual revenues for farmers and landowners, its application must not be to the detriment of food production and security.

6e. Carbon sequestration by agricultural land is not part of the accounting inventory [for agricultural businesses] but it needs to be a fair indication of the sector's contribution to Net Zero targets.

6f. Explore the development of a regulatory framework for certification of carbon removals based on robust and transparent carbon accounting to monitor and verify the authenticity of carbon removals.

6g. There needs to be methods of rewarding and incentivising farmers - such as branding of low carbon meat and dairy products, so that consumers know what they are buying.

6h. It must be understood that certain soil strategies may not be universal in their application, and only implementable across different soil types, landscapes and farms. The overriding aim must be to provide long-term clarity against which farmers can make vital long-term investment and management decisions, and ensure soils fulfil their primary responsibility, that of supporting safe, nutritious, and profitable food

- N_2O emissions from stored manure, this will also bring benefits by reducing the level of associated airborne ammonia (NH_3) which is harmful to human and animal health.
- Practice low emission slurry spreading techniques, such as trailing shoe or slot injection. These should also aim to reduce soil compaction and degradation.
- Carry out soil testing and adopt precision application of manure and fertiliser that is targeted – spatial and temporal.
- Support research that aims to improve the efficiency and precision of manure applications such as helping farmers to calculate more accurately the quantity of nitrogen-based fertilisers needed, which in turn requires development of technologies to automatically monitor the nitrogen content of soil.
- Identify NO_2 hotspots or regions that need improvement.

This White Paper outlines six priority recommendations that could support the ruminant livestock sector in the UK and Ireland as it transitions towards carbon neutral farming and its ambition of achieving Net Zero.

While certain mitigation strategies are already successfully in play, there is an urgent need for GHG data standardisation globally, for scientific evidence to support the strategies including a better understanding of carbon sequestration, and new research and innovations. In the UK and Ireland, the sector is diverse and varies across different ruminant livestock systems, species, and geographies and this needs to be taken into consideration when shaping the overall mitigation strategies and it's important that any policies developed are fair and just for all stakeholders.

No measure will work in isolation to realise the full GHG emission reduction potential, instead a combination of solutions selected from a menu of existing options will be required to reach the best results for individual farms.

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Additional Reading

Animal Frontiers 2021
Sustainability of Ruminant Livestock Production in Ireland

CIEL Report 2022
Net Zero & Livestock – How Farmers can Reduce Emissions

CIEL REPORT 2020
Net Zero Carbon and UK Livestock

Climate Change Committee 2020
Land Use: Policies for Net Zero UK

DEFRA Report 2022
Agriculture in the UK Evidence Pack

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Nature-based solutions; rhetoric or Reality? The Potential contribution of Nature-based solutions to Net Zero in the UK.

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Ireland's 2030 Carbon Emissions Targets – An Economic Impact Assessment for the Agricultural Sector

National Farmers Union Toolkit 2022
Rethinking Ruminants: the facts about British red meat and dairy

National Farmers Union Report 2019
Achieving Net Zero; Farming's 2040 goal

Nature Friendly Farming Network Report 2021
Rethinking Farming – A Practical Guide for Farming, Nature & Climate

Royal Agricultural Society of England 2022
Farm of the Future: Journey to Net Zero

Soil Association Report 2022
Saving our Soils: Healthy soils for our climate, nature and health

UCL Report 2022
Towards Net Zero in UK Agriculture

WWF Scotland Report 2019
Delivering on Net Zero; Scottish Agriculture

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Supported by the European Institute of Innovation and Technology (EIT), a body of the European Union, we invest in projects, organisations and individuals that share our goals for a healthy and sustainable food system. We unlock innovation potential in businesses and universities, and create and scale agrifood startups to bring new technologies and products to market. We equip entrepreneurs and professionals with the skills needed to transform the food system and put consumers at the heart of our work, helping build trust by reconnecting them to the origins of their food.

We are one of nine innovation communities established by the European Institute for Innovation & Technology (EIT), an independent EU body set up in 2008 to drive innovation and entrepreneurship across Europe.

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