CIEL

Centre for Innovation Excellence in Livestock

NET ZERO CARBON & UK LIVESTOCK

Preface - CIEL CEO

CIEL has a goal to ensure future research supports the sector's ambition to deliver net zero carbon. However, achieving this requires a strong consensus on where the industry is currently and a clear understanding of the areas which can contribute the most towards achieving this ambition.

The impact of UK livestock production systems on the environment and perceptions surrounding this topic are evident across the sector, the media and wider society, but what is lacking is a consistent and independent voice on the latest scientific truth. Different groups and organisations discuss the carbon impact of agriculture, and livestock in particular, and what is needed to reach the net zero carbon goal. There is however a lot of rhetoric, emotive language and seemingly contradictory facts on the subject.

Livestock farming and its impact on land-use is unique in major industrial sectors in that it provides both a sink for carbon as well as being a source of carbon emissions. It is this biological interaction that we need to gain greater scientific insight on, to inform discussions, define industry baselines with industry buy-in and identify critical knowledge gaps that we must address in the short and medium term in order to deliver net zero carbon commitments.

For these reasons, CIEL has commissioned this report to span the UK livestock production systems and join up existing streams of research. It is written by a consortium of scientists from eight leading universities and institutions, involving prominent, world leading environmental and livestock scientists.

Experts from a further six research organisations have endorsed the opportunities identified and recommendations made within this work. The report provides a summary of what is currently known about the carbon impact of the main livestock production systems in the UK, based on the best science and evidence available.

This is a huge, complex area which is not possible to cover completely in one publication. Therefore the report identifies and focuses on critical opportunities where changes can be made immediately and where there are significant knowledge gaps to address to deliver further gains. Ultimately it provides a roadmap for the future of livestock production systems in a net zero carbon era, setting out the challenge and a pathway forward.

Our industry has the responsibility for ensuring consumers are supplied with healthy, safe food produced with high standards of animal welfare and low environmental impact. Although there are still challenges to overcome, it is a priority to use a science and evidence-based approach to tackling carbon emissions, that can inform best practice, offer solutions and provide future guidance to policymakers.

CIEL is committed to supporting collaborative work that drives the UK forward in delivering improvements towards net zero carbon for livestock production systems.

L E Chapman

Lyndsay Chapman, CIEL CEO

Lyndsay Chapman

Research partners

Our thanks go to our partners in the research consortium who have written and been involved in the production of this report, and to those who have endorsed it.

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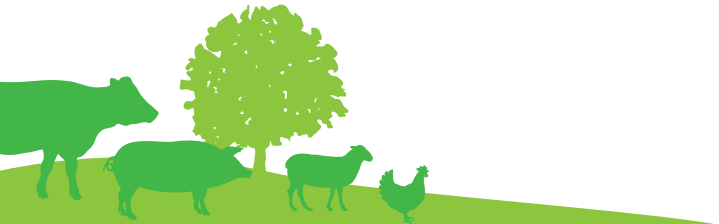


Executive summary

Climate change is the greatest environmental challenge currently facing our planet and the way we live. Addressing this will require concerted and coordinated efforts to reduce greenhouse gas emissions from human activity. Farmed livestock are one source of such emissions.

This report quantifies current emissions associated with UK livestock food production and assesses technologies that can put this industry on an immediate trajectory to deliver a key component of the net zero carbon goals for UK agriculture and the UK as a whole.

The UK farmgate value of livestock products is over £12 billion per year. We import £10 billion and export £4 billion worth of livestock products each year – which makes the UK broadly 60 - 70% self-sufficient, on a calorific basis, for meat, milk and eggs. The livestock industry is vitally important to the economy and provides society with an essential source of high-quality protein and other micro-nutrients. It also manages our landscapes and supports rural communities.

Food production is part of a cycle whereby energy from the sun and carbon dioxide from the air are converted into plant nutrients. Some of these are incorporated into soils, while others are eaten by animals which upgrade them to high-quality protein for human diets. Animals produce carbon dioxide and ruminant animals produce methane, both of which are greenhouse gases. Whilst methane is cycled in the atmosphere, some of which is converted to carbon dioxide, the presence of methane in the atmosphere significantly impacts global warming.

Since no biological processes are 100% efficient, we cannot expect to maintain an efficient food production system without emissions. However, we must work to eliminate, as far as possible, net losses of carbon into the atmosphere, and to reduce the levels of greenhouse gases emitted to decelerate and eventually halt global warming. Livestock agriculture can make a contribution to achieving this.

The Committee on Climate Change has recommended a 64% reduction in greenhouse gas emissions from the agriculture and land-use sector to meet a 2050 net zero carbon target in the UK. Whilst livestock does not have a specific target, it is considered that the same target is appropriate. The fact that this is not a 100% reduction reflects the natural biology of food production, as well as the importance of food security to the UK.

A 64% reduction from 2018 baseline livestock emissions (total 29.1Mt CO_2-eq) is 18.6Mt CO_2-eq. Over the 32 years between 2018 to 2050, this is a reduction rate of 0.58Mt CO_2-eq/year. To achieve this will require application of a range of mitigation and carbon removal strategies. For all agricultural emissions, a recent assessment of cost-effective mitigation strategies available concluded there is the potential to reduce emissions by 7.1Mt CO_2-eq by 2035. This is only 19% of the goal for total agricultural emissions, leaving 81% to be delivered between 2035 and 2050.

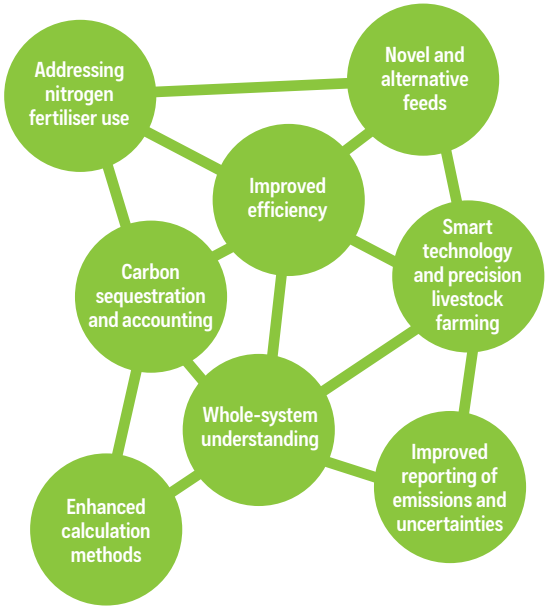
In the most recent national inventory assessment of the UK's emissions, agriculture was responsible for 10% in 2018 (45.4Mt CO_2-eq), with nitrous oxide and methane emissions accounting for 31% and 56% of this respectively. Most methane emissions (87%) originate from ruminants as part of their natural digestive process, so almost half (49%) of all agricultural emissions come from ruminant livestock [1]. Other emissions come from nitrous oxide, produced from the application of nitrogen fertilisers and livestock manures, and from the production of imported feedstuffs, such as soya (which if associated with land use change, such as deforestation, can be very significant).

Ruminant farming is considered a major source of greenhouse gas emissions in UK agriculture, but changes effected here can reduce UK emissions significantly.

Much of the focus for livestock is around reducing emissions at source, on-farm. However, maximising carbon capture will also be important in soils, hedgerows and woods. Off-farm emission load can also be reduced through sourcing of inputs that have low carbon footprints themselves, such as green energy or locally produced inputs (such as fertiliser and feed).

An important part of working towards net zero includes the accurate accounting of greenhouse gases. However, this is complicated within agriculture. There are two accounting systems in common use to assess carbon footprints, each with different assumptions. Our net zero carbon targets are based on inventory accounting, which relates only to emissions originating in the UK. This method of accounting forms the basis of international climate change treaties. Another method, life cycle assessment, includes emissions occurring in other countries for imported products associated with food production, such as animal feed (e.g. soya imported from the Americas), or fertiliser chemicals. As such, it provides a more globally holistic view of the carbon footprint for any product. However, because of the interconnected natural world, life cycle assessments must make assumptions about system boundaries, and these can vary considerably from assessment to assessment. So, careful consideration of accounting method and assumptions made is needed to avoid misinterpretation of data and unintended consequences. For instance, we can lower the UK inventory carbon footprint by replacing home grown feedstuffs with imported equivalents, but this will negatively impact global emissions if those imports have a higher footprint overall.

This report has identified the following eight areas of opportunity to advance the livestock industry towards net zero carbon at pace and with efficacy. To maximise speed of uptake and rate of change, most require coordinated and collaborative work within and across sectors, between farmers, food processors and their supply chain partners, and partnerships between government, scientists and consumers.



On-farm

1. Improved efficiency

Significant opportunities exist to further improve the efficiency of resource utilisation in the form of fertilisers, feeds and manure management on livestock farms using currently known and proven technologies and strategies. Furthermore, new approaches and solutions need to be developed in the areas of animal husbandry, plant and animal breeding and livestock health, welfare and productivity to deliver further needed improvements in efficiency. However, there is also a need to avoid improvements in efficiency solely being used to increase production output (and hence increase or maintain current emissions).

2. Novel and alternative feeds

Addressing the carbon footprints associated with feed production and utilisation, and designing diets and feed ingredients/supplements to improve nutrient utilisation, and reduce methane emissions, will offer huge potential towards efficiency improvements and thus net zero. For ruminants, a greater understanding of rumen microbial ecology may offer solutions to lower methane through microbial manipulation and reducing methane producing archaea (e.g. through gut microbial programming or dietary supplements). Use of home-grown sources (especially protein), will reduce reliance on imported soya and the impacts associated with deforestation. Use of co- and by-products in livestock feeds, especially those which do not contribute to the competition between food and feed, will significantly reduce impacts.

3. Addressing nitrogen fertiliser use

New fertiliser formulations including new approaches to manufacturing (e.g. more environmentally friendly nitric acid production), nitrification inhibitors, and urease inhibitors, coupled with improved timing and rates of application and soil management, have the potential to contribute to significant reductions in nitrous oxide emissions and nitrate leaching. Reduction of inorganic fertiliser through the implementation of novel and alternative species mixtures for grassland hold promise, such as those including atmospheric nitrogen-fixing leguminous clovers or deep-rooting grassland plants. Furthermore, breeding targets to improve persistency and nutritional value of these species will increase their use in seed mixtures and uptake by the industry.

4. Smart technology and precision livestock farming

In the livestock sector, further development and new approaches to animal genotyping and phenotyping, including greater understanding of the rumen microbiome, precision feeding, precision animal surveillance, land use, and manure management, which is tailored to the natural variability between animals, will reduce emissions. Advances in remote sensing can be used to guide the precision application of fertiliser and manure, to mitigate hotspots of emissions on farm (e.g. nitrate leaching and nitrous oxide). Precision application of manures and other organic matter returns also offer opportunities to improve arable systems (soil health and nutrient provision) and offset their emissions by replacing/reducing inorganic fertiliser use as a direct benefit from the livestock sector.

5. Carbon sequestration and accounting

Mitigation alone will not achieve net zero in livestock farming. Carbon sequestration by the natural landscape and other approaches to remove greenhouse gases from the atmosphere, can contribute significantly to balancing emissions from livestock. Carbon accounting will need to include the potential of certain land-types for carbon sequestration. Moreover, where relevant, these land-based benefits need to be credited to the livestock sector (e.g. hedgerows on-farm and land set-aside for forestry). Land use, including improvement of soil health will play a critical role in contributing to this, but there remain large uncertainties about the relative contributions of land management, where land remains under different land use, as opposed to land use change where a new land use such as forestry, is introduced.

Decision support tools

6. Whole-system understanding

As the industry moves towards the target of net zero emissions, multiple interventions and modifications to farming systems will need to be implemented. The complexity of interactions between component farming systems requires an understanding of how these interactions will influence overall emission reductions, as well as other sustainability metrics such as economic performance, human health and other issues surrounding pollution such as waterbody quality. The wider impacts of system management, both within and between them, on the environment and agricultural productivity also need to be studied, to ensure trade-offs are identified and understood to identify appropriate "best case scenarios", and subsequently manage them as far as possible. The challenge of climate change offers the UK livestock industry a unique opportunity to achieve true sustainability in a holistic manner, if emphasis is placed on systems improvements.

7. Enhanced calculation methods

Significant opportunity exists to reduce the uncertainties with regard to calculating the quantities of greenhouse gas emissions, as well as how to account for the warming effect of methane on the atmosphere. There is growing evidence to support an approach that treats methane more appropriately as a short-lived greenhouse gas, differently to carbon dioxide and nitrous oxide, both of which have longer atmospheric residencies in the order of hundreds of years, compared to methane's ~12 to 15 years.

8. Improved reporting of emissions and uncertainties

Past improvements to reporting of emissions have helped identify opportunities for mitigation that target the highest emission sources and hotspots. Further development of our inventory reporting will help to reduce uncertainties in emission estimates and produce more effective mitigation interventions, as well as simultaneously recognising complementary interactions across sectors, rather than simply pitting sectors against each other as rivals, which has become commonplace due to current reporting practices. Future reporting needs to have improved spatial and temporal resolution to accurately reflect the complexities of land-based management interventions. This will also support the development of more effective and refined farm-based emission tools.

In order to harness the opportunities identified above we recommend immediate action in three key areas to deliver what is required in the next 5 to 10 years if we are to achieve our goal for emissions reduction. These recommendations deserve urgent attention by leaders in the food and farming sectors, government and science.

Investment

The application of current technologies will not achieve net zero, but new solutions continue to emerge. In order for the UK to minimise its greenhouse gas emissions, significant investment will be needed to advance the development of innovation in terms of both mitigations and carbon capture technologies.

The impact of many mitigations and carbon capture technologies is currently based on a number of assumptions linked with scientific investigations. As such, investment is also required to refine and quantify the impact of some key mitigations and carbon capture technologies, individually and collectively, to better inform accounting practices and decision support tools.

In order to inform investment decisions on a national and regional scale, significant modelling is required at macro and micro levels to test the economic and environmental impact of a large range of scenarios, while considering the diversity of livestock farming across the UK. This modelling will be key in order to put in place informed action plans aligned with the opportunities and constraints of regional areas. Ideally, this modelling also needs to be cognisant of wider sustainability issues.

Carbon accounting

Accounting for greenhouse gases from agriculture at national and international level is complicated, and overall can confuse the achievement of goals. This report recommends that improved transparency in the way in which we report the emissions of greenhouse gases from agriculture and livestock is needed. Reporting must fully consider on-farm mitigation and carbon offsetting for the production of that product (i.e. interventions on-farm/sectors to mitigate and off-set are fully taken into account to reduce the farm/sector's carbon cost). To achieve this there needs to be an improved representation of farm management interventions in space and time, in order to provide a better representation of mitigation opportunities.

Carbon accounting tools for use by the industry are effective, but further improvements are required to achieve the transparency noted above, as well as levels of accuracy required. Furthermore, linked with knowledge exchange above, the widespread adoption and uptake of state-of-the-art carbon accounting tools on-farm is needed, to enable farmers to track and reduce on-farm emissions including both carbon reduction and offsetting potential.

Education, knowledge exchange and adoption

Education programmes and knowledge exchange needs to accelerate and increase adoption of mitigation technologies with immediate effect, since significant opportunity exists to reduce greenhouse gas emissions through the implementation of currently available and proven approaches, which also align to win-win improvements in efficiency and profitability on-farm. The knowledge to be exchanged needs to be consistent and far reaching with the audiences spanning both farming and society, to ensure the effective roll out of new technologies as well as evidence based advice surrounding the benefits of responsible consumption of high-quality animal-based products, to align with public health advice and the new National Food Strategy. Scientists, technical support organisations and government need to play a key role in realising effective education and knowledge exchange.

In order to maximise the impact of knowledge exchange across all farming systems and individuals involved, barriers to adoption need to be addressed. A wide range of methodologies and incentives, including financial, will be required with flexibility to encourage and reward through multi sector approaches.

Achieving net zero carbon in the livestock sector is a major challenge. Furthermore, it is important to note that net zero carbon does not equate to sustainability. Reducing carbon emissions is a vital component of sustainable livestock systems, given climate change is our greatest global challenge, but it is not our sole challenge. A single focus on carbon may compromise gains needed in other sustainability metrics, such as food security and food quality, nutrient management, animal welfare, biodiversity, viability of rural communities and long-term farm profitability. This is an opportunity to tackle climate change while building systems that will help to deliver a sustainable farm and food future for our nation.

Acknowledgements

CIEL is gratefully acknowledged for having the foresight and leading on the commissioning and funding of the delivery of this important report, which focuses on the livestock industry within the UK and its challenges and opportunities to achieve a net zero carbon status against policy targets over the coming decades.

To maximise coverage of all potential eventualities in terms of the impact of livestock on climate change (and vice versa), this report has been compiled by a cohort of world leading, interdisciplinary academics covering, but not limited to, the fields of environmental science, nutrition and soil science from all corners of the UK.

As chair of the consortium which delivered this report, I wish to acknowledge the immense efforts invested by Dr Sarah Buckingham, from Scotland's Rural College, and Dr Graham McAuliffe, from Rothamsted Research, as the main authors of this report, under the expert supervision of Prof Bob Rees (Scotland's Rural College) and Prof Michael Lee (Rothamsted Research).

Key inputs were also provided by Prof Phil Garnsworthy (The University of Nottingham), Prof Ilias Kyriazakis (Queen's University Belfast), Prof Dave Chadwick (Bangor University), Dr Amanda Thomson (UK Centre of Ecology & Hydrology), Dr Steven Morrison (Agri-Food and Biosciences Institute) and Ms Becky Willson (Duchy College).

We are also extremely grateful to many others within these organisations and across the wider CIEL family of academics for their input, comments and guidance as the report developed. The list following demonstrates the wide range of individuals contributing, at various stages, to the report. I am very grateful for the challenges these individuals presented as well as their understanding of the complexity of delivering a report such as this and one which aimed to have wide spread agreement across a large and significant body of livestock and environmental scientists across the whole of the UK.

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Collectively, the body of scientists noted to the left, who have delivered and endorsed this report and its recommendations, offer a significant breadth and depth of knowledge surrounding the global 'livestock carbon debate'. As a consortium we trust the information reported here provides an authoritative overview of evidence and guidance for policy makers, industry, NGOs and scientists to design effective roadmaps for the UK livestock sector.

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