Tackling Greenhouse Gas Emissions On Grazing Livestock Farms

White Paper

By

The Andersons Centre

Authors:

Michael Haverty

James Webster

The Andersons Centre

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About Us

Michael Haverty is a Partner and Senior Research Consultant specialising in international trade, market development and agricultural policy issues. He has been involved in numerous projects examining the impact of Brexit on UK and Irish agriculture and in recent years, has become increasingly involved in examining policy reform and its potential effects on food and farming, particularly from an environmental perspective. He has appeared before several parliamentary committees to give evidence on trade-related issues. He comes from a grazing livestock farming background.

Email: mhaverty@theandersonscentre.co.uk **Tel:** +44 (0) 7900 907 902

James Webster is a Senior Agribusiness Analyst and specialises in arable markets. Since joining The Andersons Centre, James has been involved in projects looking at developments in policy, and its environmental focus. Previously, James worked for five years with the Agriculture and Horticulture Development Board (AHDB) and comes from an arable farming background.

Email: jwebster@theandersonscentre.co.uk **Tel:** +44 (0) 7717 088 409

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Web: www.theandersonscentre.co.uk **Email:** enquiries@theandersonscentre.co.uk **Tel:** +44 (0)1664 503 200

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EXECUTIVE SUMMARY

Were it not for Covid-19, Brexit, and the Russia-Ukraine conflict, addressing climate change would have already been the central challenge facing UK and European agriculture. That said, recent record temperatures are bringing climate change into sharp focus, especially in farming. Climate change considerations are now a cornerstone of the emerging agricultural policy frameworks across the UK and in terms of EU CAP reform.

The challenge with Greenhouse Gas (GHG) emissions is especially prevalent in grazing livestock. This white paper examines the key issues in measuring and tackling GHG emissions across UK and EU livestock farming. Its key findings are;

- Whilst the current tools and methodologies used to calculate GHG emissions are imperfect, there is no excuse for inaction. Improvement against an imperfect measure is still progress. This is much better, and more urgently needed, than seeking perfection from the outset.
- There is an urgent need for a robust, and globally agreed, framework to quantify GHG emissions and their impact on global warming. Whilst multiple tools and methodologies can co-exist, a globally-defined minimum set of standards is crucial. Having a standardised way of calculating carbon accounts in the same way that financial accounts are standardised would be helpful.
- There are grounds for methane to be treated separately as a GHG. Even within methane, clear distinctions are needed between methane from enteric fermentation and methane emitted from fossil fuels. The former is recycled, if livestock populations and feeding methods remain largely the same over time; the latter is 'new' methane which has a much more potent impact, especially as methane production from energy (38%) accounts for a similar share of global output as agricultural methane (40%). Waste has a 20% share, much of this is food waste and needs reducing with urgency.
- 'Doing the right thing' environmentally can also help farm businesses in terms of improving productivity. These 'win-wins' (e.g. reducing inorganic nitrogen fertiliser) need to be deployed widely and urgently. Yet, this will only get farming so far.
- To get to Net Zero a step-change in practices will be needed, as will some financial incentives for farmers to reduce net GHG emissions, particularly by sequestering carbon. Many farmers are adopting a wait-and-see attitude until there are clear commercial opportunities. Whilst many farmers want to do-the-right-thing, businesses need to be sustainable both environmentally and financially.
- Due to its structure, agriculture is unlikely to be included in the new UK emissions trading scheme any time soon. Any income stream from carbon reduction is therefore likely to come through the offsetting market.
- There are barriers to the development of a carbon (offsetting) market in farming. The key one is the issue of 'permanence' and whether the carbon reduction purchasers are buying will actually be taken out of the climate for the long-term. This is the reason markets are more developed in the forestry sector where woodland planting is a long-term commitment (and can be relatively easily verified).
- Whilst concerns with GHG emissions are rightly a core policy-making focus, it is vital that progress in this area does not lead to carbon leaking and environmental degradation elsewhere. Future policy requires a balanced approach across these issues.

Across the UK and Europe, targets are now in place. Whilst more work is needed in terms of plans and strategies, the key now is effective action. Without this, the best plans and targets become, yet another, source of waste. There is much to be done and farmers are central to the solution.

1 INTRODUCTION

Were it not for Covid-19, Brexit, and the Russia-Ukraine conflict, climate change would already have been the central challenge facing UK and European farming. That said, recent record temperatures are bringing climate change into sharp focus, especially in farming. Climate change considerations are a cornerstone of Environmental Land Management (ELM) in England and will be for other UK agricultural policy frameworks. It is also featuring prominently in the Common Agricultural Policy (CAP) reform as the EU seeks to implement its Green Deal and Farm-to-Fork strategic initiatives.

The Greenhouse Gas (GHG) emissions challenge is particularly prevalent within the grazing livestock sector, especially beef. Yet, the methodologies used to estimate emissions are subject to intense debate.

This white paper examines some of the key issues in measuring GHG emissions from livestock farming and how GHG emissions from livestock could be reduced in the years ahead.

Section 2 reviews the **Existing Policy Frameworks and Targets** regarding GHG emissions at a UK and European Union level, and their implications for livestock farming. Section 3 examines the much-debated methodologies for **Estimating Livestock GHG Emissions**. It compares the relative contribution of methane to global warming under the GWP^{100} and GWP* methodologies. It then looks at emissions from grazing livestock in detail.

Sections 3 and 4, **Tackling Grazing Livestock Emissions** and **Conclusions and Next Steps**, discuss some of the ways in which the grazing livestock sector can address emissions. Opportunities presented by the Sustainable Farming Incentive (SFI) and the woodland and peatland initiatives published by The UK Government are examined. These sections also consider some of the methods discussed in wider literature which may assist in reducing farm level emissions, but which require industry scale change and investment such as improved genetics and changes to slaughter age and diet.

2 POLICY FRAMEWORK AND TARGETS

Both the UK and the EU have committed, under the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC), to drastically cut GHG emissions in the coming decades. Importantly, the Biden administration has also re-committed the US to the Paris Agreement. Finally, at the COP26 summit in Glasgow, the UK joined the EU and US in pledging to cut methane emissions by 30% from 2020 to 2030. Below, we look at UK and EU targets in an agricultural context.

2.1 UK Targets

The UK Government has committed that emissions will be at 68% of 1990 levels by 2030[1]. This commitment is known as a Nationally Determined Contribution (NDC). NDCs form the building blocks to the global commitment under the Paris Agreement to limit global warming to below 2°C of pre-industrial levels, and ideally limiting temperature rises to 1.5°C. These 2030 commitments are also springboards to achieving 'net zero' emissions by 2050 (i.e. where all GHG emissions are balanced by equivalent sequestrations of GHG) in both the UK and the EU.

The UK's overall commitment is translated into five-year Carbon Budgets[2] - as advised by the Committee on Climate Change (CCC). The first ran from 2008 to 2012 inclusive, the second 2013 to 2017 and the third 2018 to 2022. The first two were met and current projections suggest the current carbon budget will also be achieved (just). However, the fourth and fifth budgets for the period 2023 to 2032 look unlikely to be hit and this covers the period of Paris commitment. The sixth budget for the 2033 to 2037 was drawn-up in 2021 and seeks to take the UK to more than three-quarters of the way to reaching net-zero by 2050. *It is arguable that the UK has met its targets up to now by doing the relatively 'easy' things. Getting from the current* *position towards Net Zero will require a step-change in the way society operates.*

Within the Sixth Carbon budget[3] the CCC envisages widespread change in farming and land use as well as a shift in consumer diets. The report states that agricultural emissions stood at 54.6 $MtCO_2e$ (million tonnes of carbon dioxide equivalent) in 2018. This is 10% of total UK GHG emissions (GHGs). The CCC states that completely decarbonising the agricultural sector is not possible (on current understanding) due to the inherent biological and chemical processes in crop and livestock production. Therefore, to reach net zero, some carbon offsetting and sequestration will be needed.

2.2 EU Targets

Under the Paris Agreement, the EU committed that its GHG emissions would be at 60% of 1990 levels by 2030 (i.e. at least a 40% reduction)[4].

The European Green Deal[5] is the EU's flagship policy to implement its Paris commitments and to seek to make Europe the first carbon-neutral continent by 2050. It goes beyond just the GHG emissions aspects of sustainability to include biodiversity, natural resources' utilisation, promoting the circular economy and reducing pollution.

Part of the Green Deal is the new Farm to Fork Strategy seeking, amongst other things, to develop a more environmentally friendly food system.

From a trade perspective, there are proposals to design and introduce a border carbon tax which could eventually result in agriculture being included within an Emissions Trading Scheme. It is also likely to mean that the sustainable development chapters of trade agreements will become more prominent.

Like the UK, EU agricultural emissions account for about 10% of its total emissions[6] and notably, 70% of its agricultural emissions come from livestock.

2.3 Implications of Targets for Livestock Farming

Livestock emissions also account for a substantial proportion of emissions from UK agriculture. The latest estimates from the Department for Business, Energy, and Industrial Strategy (BEIS), published in June 2022, suggest that GHG emissions from livestock (enteric fermentation and wastes) account for 62% of agricultural emissions[7]. These estimates suggest that reducing emissions from livestock will be a core focus for the UK.

Agricultural policy is seen as a key means to influence farm-level practices and drive down agricultural emissions. Both the UK's Agriculture Act[8] and the emerging EU CAP reform reflect this. In the EU's case, approximately 40% of the CAP budget is expected to be devoted to climate objectives[9].

In the UK, the National Food Strategy (primarily focusing on England) attracted attention in calling for a 30% reduction in meat consumption to assist with achieving Britain's emissions targets[10]. The sixth climate budget goes further, suggesting a 20% cut in meat and dairy consumption by 2035 and a further 15% cut by 2050, under its balanced pathway to net zero for agriculture. Notably, the Government's Food Strategy White Paper[11], compiled in response to the National Food Strategy, did not specify any cuts to meat and dairy consumption leaving open the scope for innovation to achieve emissions reduction targets.

In Ireland, the grazing livestock sector has been the subject of much debate in the lead-up to the Irish Government finally agreeing, in July 2022, to a target of reducing Ireland's agricultural emissions by 25% by 2030[12]. Many industry experts believe that this target is not achievable without a significant reduction in cattle numbers.

Similar debates are taking place elsewhere in the EU and in the UK. Serious questions are being posed about the grazing livestock sector's future viability in many regions. That said, there are steps which can be taken by the sector to tackle its emissions challenge. These are examined below but firstly; it is important to examine how livestock GHG emissions are currently estimated.

3 ESTIMATING LIVESTOCK GHG EMISSIONS

3.1 Global Warming Potential (GWP^{100}) Methodology

Within agricultural emissions targets, and especially livestock, CO_2 is not the biggest issue. Methane (CH_4) and nitrous oxide (N_2O) are bigger factors based on the most prevalent Global Warming Potential measure, GWP^{100}, which attempts to measure the potential warming impact of each GHG over a 100-year period. This measure, widely adopted by the Intergovernmental Panel on Climate Change (IPCC) and national Governments to quantify emissions, converts each unit (tonne) of GHG into a carbon dioxide equivalent (CO_2e). This allows total emissions to be expressed as a single value. Figure 1 shows the various factors involved.

Based on this methodology, over 100 years, 1 tonne of methane equates to 28 tonnes of CO_2e, thus indicating that methane is a highly potent GHG. Nitrous oxide (closely linked with fertiliser application) is estimated to be even more potent, with 1 tonne equating 265 tonnes of CO_2e.

However, this method of using a single measure to convert each GHG into a CO_2e has attracted much debate, with several scientists claiming methane behaves very differently in the atmosphere than CO_2, so the actual contribution of each gas to global temperature change is quite different.

Relative to CO_2, methane is a short-lived gas. Each tonne emitted has a lifetime of approximately 12 years. Whilst its trace effects can last longer, its effect on temperature change is virtually reduced to zero after 20 years[13]. It is, argued that if livestock populations are staying the same, the long-term effects of methane are minimal. Using the GWP* methodology (more below), methane from the cattle living 20 years' ago will have disappeared and be replaced by methane from today's cattle, whose impact will also have disappeared in 20 years' time.

As such, it is argued that methane behaves like a recycled gas. Methane that is emitted into the atmosphere today eventually dissolves into water vapour (i.e. the hydrogen molecules join with oxygen) and CO_2 (i.e. carbon molecules join with oxygen)[14]. It is claimed that this CO_2 is then 'recycled' into the soil by grass and other trees and plants. As cattle, for instance, graze this grass, they take in carbohydrates which are converted into food (milk, beef). Some of it is passed back into the atmosphere as methane and the cycle begins again.

These scientists contend that, as long as livestock populations are not increasing, they will not be contributing significantly to global warming. This is in contrast to CO_2 which is a 'stock' gas. Each additional tonne of CO_2 emitted lasts for centuries in the atmosphere, and is cumulative, unless action is taken to actively remove it (e.g. via sequestration).

Figure 1: Greenhouse Gases

Comparison of Key Farming Greenhouse Gasses			
	Carbon Dioxide (CO_2)	Methane (CH_4)	Nitrous Oxide (N_2O)
Lifetime in Atmosphere	No single lifetime can be given	12 years	121 years
CO_2e after 20 years	1	84	264
CO_2e after 100 years	1	28	265

Source: IPCC[15]

3.2 GWP* Methodology

Critics of the GWP^{100} methodology claim that the conversion rate used is based on treating methane as if it were a 'stock' gas similar to CO_2, when it is, in effect recycled. *This has led researchers at Oxford University to develop an alternative GWP measure, GWP*[16], which it is claimed more accurately reflects the behaviour of methane in the atmosphere, and its resultant influence on global warming.*

Therefore, GWP* is put forward as an alternative measure. They state that GWP* relates cumulative CO_2 emissions to date with the current rate of emission of short-lived climate pollutants (SLCPs), such as methane[17]. *It is argued that methane-induced warming is dependent on whether methane emissions are stable or are increasing via new* *emissions [18]. It is only if livestock numbers are increasing, that a global warming effect ensues. Otherwise, there is only a limited warming effect.*

To achieve a neutral effect on future global warming, proponents of GWP estimated that emissions from livestock need to decrease by 0.3% per annum[19]. Any further decreases, they claim would have a cooling effect on global temperatures. However, if methane emissions increase versus the current baseline, they would have a much more pronounced impact on temperature change using GWP*, even vis-à-vis GWP[100]. These different effects under GWP* are depicted in Figure 2 below.*

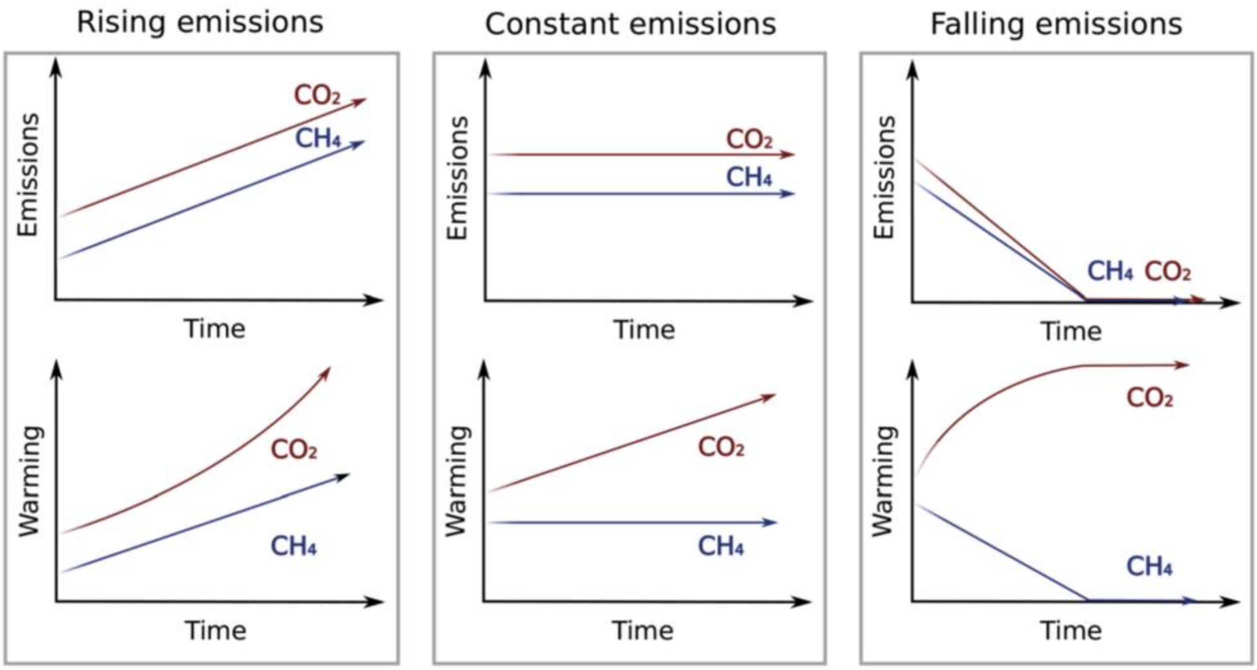
Accordingly, the proponents of GWP* suggest that it more accurately estimates the impact of both long-lived and short-lived GHGs on global warming over a wide range of timescales.

Figure 3 shows that whilst agriculture may be the biggest individual source of global methane emissions, with a 40% share, it is closely followed by the energy sector (38%). Importantly, most of these methane emissions are derived from fossil fuels which have been stored beneath the Earth's surface for millions of years. These methane emissions are much more damaging as they are 'new' emissions (i.e. not recycled in the same manner as most methane from agriculture).

Notably, waste-related methane emissions are also substantial (20% of the global total). Food waste is a major contributor to this and it is incumbent on all agri-food industry stakeholders, and society generally, to minimise waste with urgency.

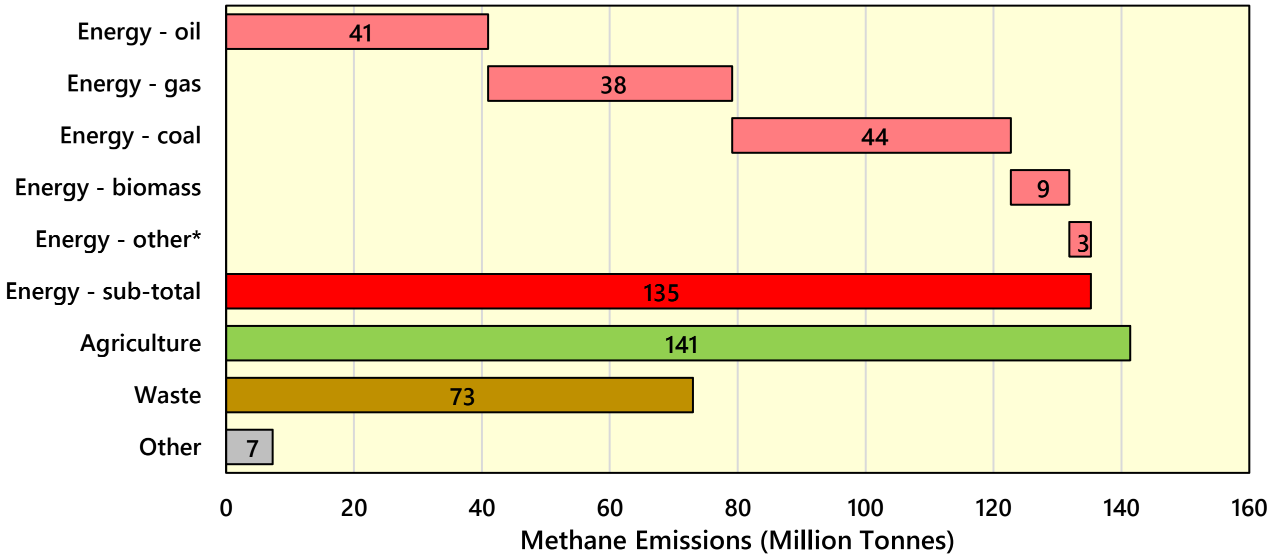
The GWP measure will be scrutinised by the IPCC in its 6th Assessment Report which is due for release in late 2022 or early 2023. Whichever methodology is used, the combined effect of all GHGs need to be considered. Whilst livestock-based methane emissions might well decrease at a rate beyond 0.3%, thus having a cooling effect, other GHG emissions are set to continue to rise, meaning that global temperatures will continue to increase.*

Figure 2: Illustration of how global mean temperatures respond to different emissions trends



Source: Oxford University[20]

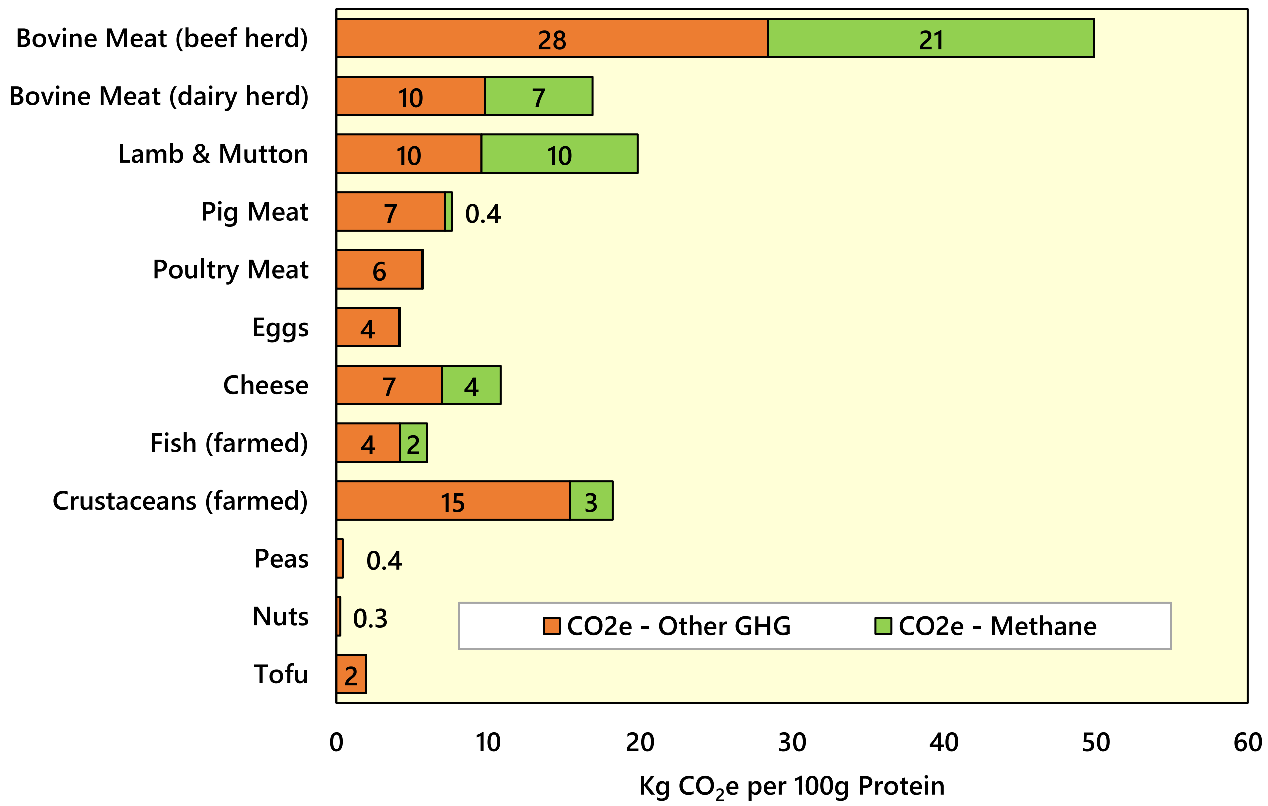
Figure 3: Estimated Global Methane Emissions by Source



Source: International Energy Agency (IEA)[21]

Notes: Data for Agriculture, Waste and Other categories are based on 2018-19 base year, all energy estimates are based on 2021 data. * The Energy - other category is assumed to consist of satellite-detected large leaks.

Figure 4: GHG Emissions from Protein-Rich Foods, Methane versus Other GHG (Kg CO_2e per 100g Protein)



Source: Poore and Nemecek (2018)

3.3 Analysis of Grazing Livestock GHG Emissions

Given the disagreements on which GHG measurement method to use, an analysis of agricultural emissions on the basis of methane and non-methane sources offers useful insights. Figure 4, based on data from an influential global study by Poore and Nemecek[22], gives this breakdown for a series of protein-rich agricultural products. This study uses a variety of data sources. For the conversion of methane into CO_2e, it uses the IPCC (AR5) GWP^{100} conversion rate, as depicted in Figure 1. As this study utilises a variety of data sources, it is not necessarily following the IPCC methodology to the letter. It is used here to indicate the contribution of methane to total GHG emissions.

This global study estimates that methane accounts for 43% of emissions from the beef (suckler) herd and 42% of dairy-beef herd emissions. Dairy-beef emissions are much lower than for suckler beef as most of the emissions from the cow are attributed to milk and other dairy products. Half of lamb emissions are also due to methane. Just under two-thirds of cheese emissions are attributed to methane. However, for pig meat, methane represents just 6% of emissions based on the global average. There are minimal methane emissions in chicken and egg production.

Some methane emissions also occur in aquaculture and account for one-third of GHG emissions from farmed fish and 15% of emissions from crustaceans.

Using the GWP* rationale, if cattle populations are holding steady, then the methane currently emitted will be recycled after 20 years. That would appear to nearly halve the problem for cattle-farming. GWP* also takes account of the carbon sequestration that takes place via grassland. This is another major challenge with the GWP^{100} methodology, as used by the IPCC, because the emissions attributed to grazing livestock do not consider the mitigating impact of sequestration via grassland (instead these are attributed to Land Use, Land Use Change and Forestry - LULUCF).

The emergence of GWP may provide some comfort to grazing livestock farming, in that it is not as bad as it has been painted. Some might argue that livestock populations will remain the same and will, therefore, have no further effect on global warming. However, there has been a big increase in livestock populations in the past century, and much of this has occurred in recent decades in some regions. Therefore, it would be unwise to argue the 'technicalities' too much when society is expecting farming to do its bit on emissions. Especially given the extent to which support payments fund incomes in the UK and European grazing livestock sectors.*

4 TACKLING GRAZING LIVESTOCK EMISSIONS

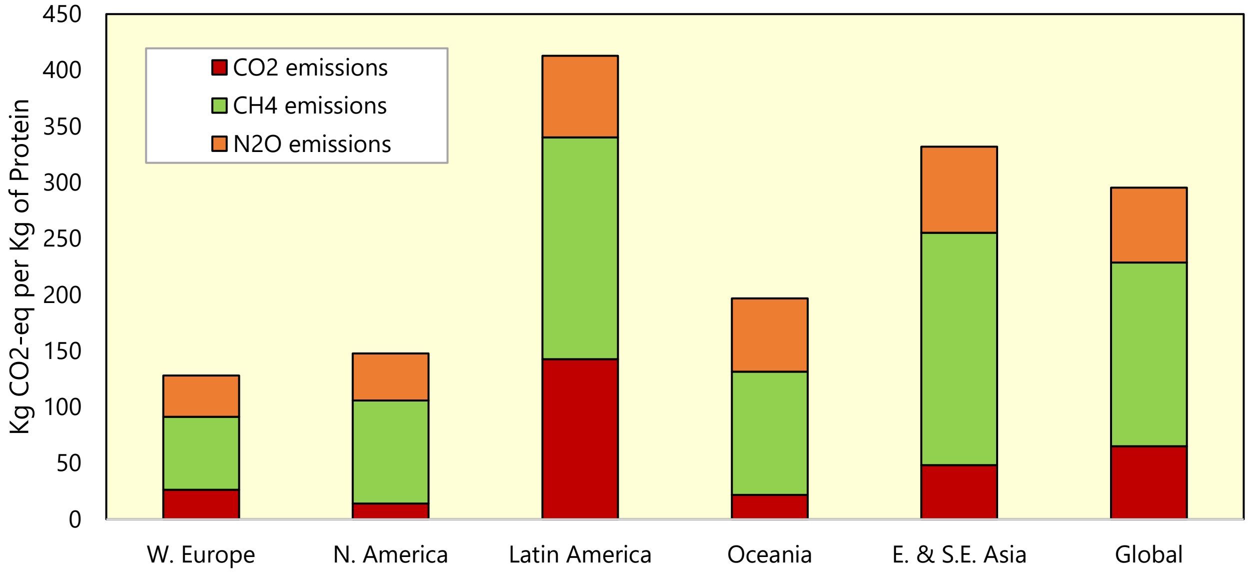
4.1 Regional Variations in GHG Emissions

The above analysis chiefly focuses on GHG emissions from grazing livestock at the global level. Of course, such top-level averages hide a great deal of variation, even between continents.

The Poore and Nemecek study did reveal that beef herd emissions in Europe are at about 47% of the global average and are about a quarter of the GHG emissions in Latin American beef herds. Further, a UN FAO study using 2017 data[23] showed that for beef (see Figure 5), Western European emissions are 2.3 times more efficient than the global average when converted into CO_2e terms. This study also segmented emissions in terms of CO_2, methane (CH_4) and nitrous oxide (N_2O). Similar to the Poore and Nemecek study, it shows that methane emissions are about half of total GHG emissions for Western Europe. Although CO_2 emissions account for about 20%, it also reveals that there is significant scope to reduce N_2O emissions (mostly arising from fertiliser) in Western Europe.

There are a wide range of policy initiatives underway to tackle GHG emissions in grazing livestock. This White Paper looks at two main areas, namely, emissions trading and offsetting as well as actions which can be taken at the farm-level.

Figure 5: Beef Greenhouse Gases Comparison in CO_2e Terms Using the GWP[100] Methodology



Source: FAO - Global Livestock Environmental Assessment Model (GLEAM)

Note: The results are based on aggregated meat emissions from beef cattle (incl. grass, mixed systems & feed lots).

4.2 Emissions Trading and Offsetting Initiatives

4.2.1 Carbon Markets – Emissions Trading

'Carbon markets' are a generic term for all mechanisms designed to use market forces to reduce emissions. Most economists see the use of such market mechanisms as the most efficient way of reducing GHGs.

The main market for carbon to date has been under the EU Emissions Trading Scheme (ETS)[24].

The UK was instrumental in the establishment of the EU ETS. Following the UK's exit from the European Union it has established its own UK ETS which commenced in 2021[25]. Importantly, agriculture is not included within either ETS and this looks set to continue in the short-term.

Both the EU and UK schemes work by setting a cap on the total amount of GHGs that can be emitted by energy-intensive industries, including aviation, power generation, and steel manufacturing. The cap is then reduced over time. Companies can either invest to reduce their emissions, in line with their free allowance, or buy carbon allowances from other business that have 'spare' ones (possibly because they have reduced their emissions more). Investment in emissions reduction is then directed, by the market, to where it is the most effective.

The EU ETS was set up in 2006 but languished for some years as too many permits (the right to emit one tonne of CO_2e) were granted. However, in recent years, the price of an EU carbon permit has risen. Since March 2022, values have moved between €75 and €90, having been as low as €5 in mid-2017[26].

As outlined above, the EU's Green Deal is targeting carbon neutrality by 2050 at the latest, with policy mechanisms supporting that long-term aim expected to include a higher carbon price. The EU also intends to introduce a Carbon Border Adjustment Mechanism (CBAM), potentially coming into force in January 2026, after a 3-year transition[27]. This would see a levy, proportionate to the carbon content of certain imported goods, applied at its border[28]. At present the scope of the CBAM is on energy, materials (i.e. cement and metals), and fertiliser. The European Parliament foresees the phasing in of the CBAM from 2027 with free allowances ending in the EU ETS by 2032.

This needs to be monitored closely from a UK perspective, should the scope of the CBAM widen over time to include agricultural products (e.g.

sheepmeat). At present a widening of scope in this direction seems some way off. In future, there may be a link between the UK and EU ETS, particularly with the introduction of a CBAM by the EU.

The first auction of the UK ETS took place in May 2021. The clearing price for the auction was set a £43.99 per tonne of CO_2e. The clearing price, the price at which all allowances will theoretically be sold, has risen through subsequent auctions.

The UK Government is also continuing to look at the option of a 'carbon tax'[29], especially to cover sectors not included in emissions trading. This might encompass agriculture. Although the Government has consulted on the option[30], there is no detail on the timetable or rules for implementation.

Other territories (e.g. China[31], California, New Zealand[32]) also operate ETSs and it is reported that there are 25 ETSs globally, with a further 22 under development. In June 2020, New Zealand completed a comprehensive series of reforms which strengthened the NZ ETS. The subsequent legislation includes a carbon price for agricultural from 2025. A separate system to the NZ ETS has been proposed, with a farm level split gas levy/rebate system. The system would charge for emissions of methane and other carbon emissions. Reductions to levy payments are proposed for actions which reduce emission. The revenue from the proposed scheme would be used to aid research and development into on-farm emissions.

Globally, turnover related to emissions trading rose 34% year-on-year to reach €194bn (£163bn) in 2019[33]. *One of the goals of international climate diplomacy over the next few years will be to link these various systems together to achieve a global carbon market. Given that GHG emissions are a global problem, a global emissions exchange sounds like a sensible approach.*

The key point for farming is that, unlike New Zealand, it is not included as an eligible sector in either the UK or EU ETS. Whilst this means that it is not restricted in its emissions, it can also not generate carbon permits for sale by reducing its emissions. The scope of the ETS may be expanded in future, in which case opportunities would present themselves. However, as a sector characterised by small and medium enterprises (SMEs) it is assumed that the requirements of taking part in an ETS would be too burdensome. There is no indication that farming will be brought into these schemes in the near future. That said, in December 2021, the EU Commission issued a communique on carbon farming setting out short- to medium-term actions to address current challenges and to upscale this green (carbon farming) business model.[34] However, these measures mainly centre on promoting carbon farming under the CAP, improving measurement methodologies and verification frameworks, as well as improving knowledge, data management and advisory services to land managers.

The other key point for grazing livestock farming is the conversion rate used by ETSs in converting methane into CO_2. The New Zealand ETS for instance, uses the 2006 IPCC guidelines which are based on the GWP^{100} methodology.

As illustrated above, the method used to calculate emissions is intensely debated. At COP26, there was no agreement reached on the methodology for calculating methane emissions, although several countries have pledged to cut methane emissions by 30% by 2030, versus 2020 levels.

4.2.2 Carbon Offsets

A 'carbon offset' is a way to compensate for emissions by funding an equivalent carbon dioxide saving elsewhere. They are often contrasted with 'carbon insetting' where firms try and reduce emissions from their own activities and operations within their wider supply chain. *Carbon offsets are somewhat controversial in environmental circles – they are often equated with 'indulgences' sold by the mediaeval Catholic Church – they allow the sin (GHG emissions) to be wiped-out by the payment of money. The underlying bad behaviour is not addressed.*

In farming terms, carbon offsetting has attracted much attention as it appears a potential source of new revenue – changing land-management practices to soak up carbon and earning income from doing so by selling offsets. However, there are barriers to the development of this new market as set out below.

There are two key requirements for offsetting;

- **Additionality:** whatever action is being done, and paid for, would not have happened without the offset – i.e. there is no credit for something that would have happened anyway.
- **Permanence:** the offset should be creating genuine long-term GHG reductions and will not just be undone in a year or two's time.

Additionality can be quite hard to prove – and it is where most the criticism of offsets arises. The permanence issue is an important one for farming. With yearly cropping cycles and the ability to change land use almost instantaneously (i.e. ploughing grassland), it is difficult to prove that any changes will be permanent – without an annual audit. This is why forestry and peatland schemes have been favoured – there is a relatively permanent and visible change in the land use (see below for more details). There is work ongoing on a UK Farm Soil Carbon Code[35] and Hedgerow Carbon Code[36]. Demonstrating the permanence and additionality of soil carbon is more challenging, as such a national standard is not expected imminently.

There are schemes in place to audit carbon offsetting. Overall, the British Standards Institute (BSI) has produced the internationally recognised PAS 2060 standard[37] on carbon neutrality. There is also a Quality Assurance Standard for Carbon Offsetting[38] as well as the ISO 14001 Standard[39] on environmental management.

There are three main certification schemes for offsets;

- **Verified Carbon Standard (VCS):** operated by VERRA[40], produces what it calls Verified Carbon Units.
- **Gold Standard Voluntary Emissions Reductions (VER):**[41] Gold Standard is a not-for-profit organisation headquartered in Geneva, Switzerland.
- **Plan Vivo:**[42] produces 'Plan Vivo Certificates' (PVCs) for certified projects with each PVC representing 1 tonne of CO_2e emissions reductions alongside other non-carbon benefits (climate adaptation, biodiversity protection, water provision, etc.), which can then be sold on the voluntary carbon market to generate funds for project activities.

Under the 1997 Kyoto Protocol some industries in developed countries were required to reduce their GHG emissions, including reducing carbon, and then offset to reach net-zero. These Certified Emission Reductions (CER) offsets are issued by the United Nations[43] under the Clean Development Mechanism (CDM). These 'compulsory' offsets can only be created in developing countries. *As such, the opportunities for farming in the UK to create compulsory offsets is restricted. There have been discussions on allowing offsetting schemes in developed nations, but this has not happened as yet.*

'Voluntary' offsetting schemes are operational in the UK. These can be used by companies and individuals outside of the UN framework. Markets and mechanisms are less well developed than for CER offsets at present as more focus has been on the compulsory offsets.

The certification bodies outlined above will audit both compulsory and voluntary schemes.

A selection of companies offering carbon offsetting in the UK can be found here.[44] An example is Carbon Footprint.[45] Some more international examples can be found here.[46] Many airlines run their own offsetting programmes as offsetting the GHG generated by taking a flight is one of the areas where offsetting has gained the greatest traction.

A task force[47] was set up under Mark Carney, the former Governor of the Bank of England, to promote the carbon offsetting market. This has two key objectives; firstly, to expand the market and secondly to 'legitimise' the market by establishing a framework to regulate and standardise the price and quality of carbon units across projects. This body was disbanded in 2021 and superseded by the Integrity Council for Voluntary Carbon Markets (Integrity Council), with Mark Carney remaining on the advisory board. This body has recently initiated a public consultation[48] on its proposals to establish a definitive and consistent global benchmark for high-integrity carbon credits. In other words, guidelines for determining a "good" carbon offset.

This consultation is open until September 2022, with an Integrity Council report thereafter. The Integrity Council's guidelines may well help drive the further development of the sector. There are also calls for the National Infrastructure Scheme to include carbon reduction mechanisms.[49]

4.3 Farm-Level Initiatives - Agriculture

Whilst looking at global level emissions and territorial-based initiatives is a useful exercise; it is also important to examine emissions from a farm-level perspective. The CCC published a report[50] into UK land use in January 2020. This set out the following actions to help reduce UK emissions;

- **Low-carbon Farming Practices:** practices such as controlled release fertilisers, improving livestock health, and slurry management.
- **Afforestation and Agro-forestry:** increasing UK forestry cover from 13% to at least 17% by 2050 by planting around 30,000 hectares or more of broadleaf and conifer woodland each year. In addition, 2% of the agricultural area should be devoted to agro-forestry (planting trees whilst maintaining the agricultural use). Additional hedgerow planting is also recommended.
- **Peatlands:** restoring at least 50% of upland peat and 25% of lowland peat. This equates to 7% of the UK's land area.
- **Bio-energy Crops:** increase the growing of energy crops by around 23,000 hectares each year so that by 2050 they make up 3% of total land use. *The report states that energy crops are faster growing than new woodland, but also cautions that the negative impacts of energy crops need to be managed.*
- **Reducing Meat and Milk Consumption:** (i.e. beef, lamb, and dairy) by at least 20% per person. *The report implicitly recognises that this might be the most contentious recommendation. It states that such a reduction would bring consumption within healthy eating guidelines and can drive sufficient release of land to support the proposed changes in tree planting and bioenergy crops. It calculates that, alongside expected population growth, it implies around a 10% reduction in cattle and sheep numbers by 2050 compared with 2017 levels. The report points out that this compares with a reduction of around 20% in numbers over the past two decades.*
- **Reducing Food Waste:** the 13.6m tonnes of food waste produced annually should be reduced by 20%.

The NFU has set out its own target that goal of reaching net zero GHG emissions across the whole of agriculture in England and Wales by 2040. This is to be achieved through three 'pillars' with similar themes to the CCC;

- **Boosting productive efficiency and reducing emissions** – better use of fertilisers and slurries, reduced emissions from ruminants through better feeding and genetics, greater use of anaerobic digestions, precision farming to reduce inputs, improved soil management, energy efficiency (including electrification of machinery), improved health and disease resistance in animals and crops (including using gene editing techniques). The total GHG savings are estimated at 11.5 $MtCO_2e$ per year.

- **Capturing carbon in soils and vegetation** – soil management, hedgerows, tree planting and peatland restoration. The total GHG savings are estimated at 9 $MtCO_2e$ per year.
- **Coupling bioenergy to carbon capture, utilisation and storage** –growing energy crops and then capturing underground the carbon produced in their combustion. The total GHG savings are estimated at 26 $MtCO_2e$ per year.

Note that the figures do not precisely align with the CCC as they are for England and Wales only and have a different base year. It can be seen that the biggest savings come from carbon capture and storage[51]. Some would argue that this is 'cheating' as it involves using a technology that has not yet been proven at scale either technically or economically.

4.4 Grazing Livestock Farms – Other Initiatives

Several of the action-steps proposed above directly affect livestock farming, particularly the CCC suggestion on reducing meat and milk consumption by 20% per person. Given the seriousness of the global warming challenge posed to humanity, all actions merit consideration. However, this should also include examining how a 20% reduction in the emissions' of meat and milk could be achieved via alternative means. Below are some additional points which merit further consideration.

A recent study by the Centre for Innovation and Excellence in Livestock (CIEL) provided a highly-useful overview of farm-level actions which could be undertaken to reduce GHG emissions[52]. It examined emissions across both grazing and intensive livestock and found that methane emissions could be reduced by 23% and ammonia emissions by 15% if the most widescale and effective techniques were adopted across UK farms.

For grazing livestock, these mitigation approaches are grouped into nutrition-based and management-based strategies.

- **Nutrition-based:** focus on feed and forage management, encompassing low crude protein diets, feed additives & methane inhibitors and dietary content. It also includes grassland management actions such as the utilisation of grass-legume mixtures, multi-species swards and increasing grazing frequency.
- **Management-based:** include animal-related actions focusing on genetic improvement, improved fertility, reduced age at first calving, reduced age at slaughter, and improved animal health. Manure and fertiliser related actions were also examined, including covering slurry stores, anaerobic digestion, low emission slurry spreading, and nitrification and urease inhibitors.

Whilst the report acknowledged that it would be ambitious to have widespread adoption of these measures at a UK scale, it suggested that there was potential to substantially reduce GHG emissions from UK grazing livestock, including;

- **Dairy sector** – net GHG reduction of 15%
- **Beef sector** – 23% reduction, with reduced methane from enteric fermentation being the main contributor to this decrease
- **Sheep sector** – reductions of 28-39% were achieved on case study farms, but CIEL acknowledged that it would not be possible to apply all actions to all UK sheep farms. It projected that by offering methane inhibitors alone (with an effectiveness level of 30%) to all lowland sheep farms, UK sheep sector emissions could be reduced by 10%.

The report also suggested that these reductions could be achieved without impacting on productivity (i.e. milk or meat output), although ongoing productivity improvements would by themselves lead to a 13% reduction in dairy cow numbers and a 5% reduction in suckler cows. The resultant freed-up land up was assumed to be afforested and the associated carbon sequestration contributed to the decreases listed above.

The CIEL report also acknowledged that further research is needed in several areas and that some of the mitigation strategies (e.g. feeding 3-NOP methane inhibitor) are not yet available in the UK.

4.4.1 Carbon Sequestration via Grassland

As mentioned previously, the grazing livestock sector has a major issue with how emissions from meat, particularly cattle and sheep, are presented using the IPCC methodology. This is because sequestration via grassland tends not to be included when calculating the carbon footprint of beef or lamb. Previous estimates suggest that such sequestration could mitigate anywhere between 13-40% of 'gross' emissions from grazing livestock. Furthermore, it is suggested that the sequestration taking place on pasture could be further improved.[53] That said, there is a limit to which soil-carbon levels can be improved. Beyond an optimal level of soil-carbon, soils can take on more peat-like characteristics. This can reduce productivity. Therefore, whilst there is scope to improve sequestration via grassland, it should not be seen as a panacea. Additional initiatives are needed.

4.4.2 Genetics and Reducing Slaughter Age

Extensive research has already taken place into how certain genetic characteristics can improve the efficiency of feed conversion into body mass whilst reducing methane emissions via enteric fermentation. As the CIEL study above reports, improved genetics also has a key role in reducing age at slaughter which can have an even more significant bearing on GHG emissions over an animal's lifetime. Several studies suggest that genetics has the potential to lower GHG emissions from meat by 10-20%[54]. A recent Irish study suggests that better genetics could reduce methane emissions of beef cattle by 30% for the same level of productivity via better breeding.[55]

4.4.3 Animal Feeds and Additives

The gains from genetics can be further enhanced by introducing additives to animal feeds which aid the process of digestion whilst minimising methane emitted via enteric fermentation. Seaweed-based and organic additives (e.g. 3-NOP[56]) are thought to offer significant potential. Other supplements are also being investigated. Such additives need to be embraced, provided that they in-turn do not result the emergence of new environmental issues. For instance, many of the seaweed products trialled are sourced in the Pacific. Trials are ongoing to look at seaweeds indigenous to the UK and Ireland[57].

4.4.4 Adopting a Precision-Farming Approach

Precision farming uptake in cropping has risen significantly in the past decade. Some technologies including yield mapping and variable rate application of fertiliser have become mainstream. Undoubtedly, precision farming can help productive efficiency by minimising input usage on less-productive land. Such innovations also have scope to generate significant efficiencies in livestock farming, although uptake is slower, which is unsurprising in upland areas particularly.

Under the UK's Farming Investment Fund, grants are available covering part of the purchase of some precision-farming technologies, this will help to some to move towards precision-farming[58].

The precision farming approach could be taken further. Lower yielding areas of the farm could be considered for alternative activities such as tree-planting. This, in turn, could facilitate the establishment of shelter belts which can improve feed-conversion rates, and reduce finishing times.

4.4.5 Woodland and Peatland Initiatives

As alluded to above, the establishment of woodland, whether in the form of smaller shelter belts or more extensive plantations, has the potential to sequester large volumes of CO_2 on livestock farms. Peat restoration will also offer opportunities for some. Key developments include;

- **Woodland Carbon Code (WCC):** this is the voluntary standard for UK woodland creation projects where CO_2 is being sequestered.[59] Under the Code, plantings that meet certain conditions are granted Woodland Carbon Units (WCU). A WCU is a tonne of CO_2 which has been sequestered in a WCC-verified woodland. A WCU is verified five years after planting of new woodland then every ten years thereafter. These are used as offsets by companies wishing to voluntarily reduce their overall GHG emissions and by those companies that are required to report their emissions to the Government. However, they are not currently eligible for international offsetting.

- ***Woodland Carbon Guarantee Scheme:*** The Government aims to 'kick-start' the UK market in carbon offsets with the Woodland Carbon Guarantee[60] (WCG) scheme. It has a budget of £50m. Those planting new woodlands that are compliant with the WCC have an option to sell the WCU to the Government for a guaranteed price every 5 or 10 years up to 2055/56. This aims to provide an additional and reliable long-term income from woodland. If the land manager prefers, they can sell their CO_2 on the open market rather than to the Government.

  The price received is set by an online reverse auction. Land managers calculate a CO_2 price that is acceptable to them and put in a bid at that level. The Government then accepts bids up to a certain level. A series of auctions will take place every 6 months for up to 5 years and began in early 2020. The price in the first auction in February 2020 was £24.11 per WCU. At the second and third auctions the was £19.71 and £17.31[61], respectively.

  The WCG can be claimed in addition to any planting grants under, for example, the Countryside Stewardship, the Woodland Carbon Fund or the HS2 Woodland Fund. Planting must not have started prior to the WCG being applied for.

  Brand new plantings of trees do not sequester much CO_2. It is only in the latter growth stages that they absorb significant quantities of the gas. Businesses can buy a Pending Issuance Unit (PIU) which is effectively a 'promise to deliver' a WCU in the future, based on predicted sequestration (i.e. growth of the wood). It is not 'guaranteed' and cannot be used to report against UK-based emissions until verified. However, it allows companies to plan to compensate for future UK-based emissions or make credible Environmental, Social and Governance (ESG) statements in support of woodland creation.

  WCU and PIU are held in the UK Land Carbon Registry[62] managed by IHS Markit. Every 10 years, projects are checked and, if performing well, verified. At each of these points, PIUs delivered are converted to WCUs. Around 6.1 million tCO_2e had been validated through Woodland Carbon Code projects in the UK, as at September 2021[63]. UK companies are paying between £7 and £20 per tonne CO_2 for purchases of Pending Issuance Units.

- ***Peat Restoration:*** there is a Peatland Code[64] for peat restoration that works in a similar way to the WCC. Obviously, it is rather more site-specific than the planting of woodland but offers additional opportunities for land managers in the grazing livestock sector.

4.4.6 Biodiversity Net Gain

A further way in which livestock farmers may be able to benefit from changes in environmental legislation, is by providing for Biodiversity Net Gain (BNG). The BNG targets are primarily aimed at the development sectors, such as housing, and require an increase in biodiversity of a site once developed.

For some sites, delivering BNG on-site will not necessarily be possible. Where this is not possible there may be scope for farmers to deliver off-site BNG for developers, in return for payment. This may be particularly attractive for unproductive land. However, the site would be tied into a covenant restricting usage of the land for a period of time.

A key point to emphasise with offsetting initiatives is that if other companies are involved in the purchasing of WCUs/PIUs, then the CO_2 sequestered will be allocated against the emissions of those companies and cannot also be allocated towards on-farm emissions – otherwise it is double-counting. This is a significant danger for schemes which are not properly audited. Farmers must resist the temptation to do this, otherwise their efforts will lose a lot of credibility due to a lack of transparency. For some livestock farms, a decision will need to be made whether the units of carbon sequestered via woodland should be attributed to its farming enterprises or sold under offsetting initiatives. Whilst there is scope for price premiums for farm produce to be sold as carbon neutral, the mechanisms to achieve and verify this need to be established.

4.5 Grazing Livestock Farms – Sustainable Farming Incentive

One of the key policy developments for agriculture in relation to tackling GHG emissions is the launch, in December 2021, of the Sustainable Farming Incentive (SFI) in England. There are several schemes within the SFI which will offer some support to English livestock farming. Future schemes are also anticipated in other parts of the UK. The devolved administrations are at different stages of policy formulation. Therefore, it could take some time before the details of these schemes emerge.

Currently, the improved grassland soils standard is the main SFI standard of relevance to grazing livestock and is now open for applications[65]. Payments, currently ranging from £28 to £58 per hectare, are based on a number of activities, aimed at measuring and improving soil organic matter, this in turn would help improve the sequestration of carbon. There is also a moorland standard[66] with a payment rate of just over £10 per hectare which is also focused on improving carbon storage.

Over time, new standards will be introduced, aiming to support farmers in tackling the emissions from grazing livestock. These standards include (indicative introduction year in parentheses);

- Hedgerow standards (2023)
- Farmland biodiversity standards (2024)
- Low and no input grassland standard (2024)
- Agroforestry standard (2024)

More detail on the standards is available on the Defra website[67]. The standards are designed to go hand-in-glove with private sector provision of finance; however, it is crucial to address whether payments for carrying out actions via the SFI will preclude farmers from receiving payments from private schemes. As noted above, a key element of carbon emissions trading is additionality, going over and above what already happens.

5 CONCLUSIONS AND NEXT STEPS

Whilst current tools and methodologies used to quantify emissions are imperfect there is no excuse for inaction. Improvement is urgently needed to address the GHG emissions challenge.

There is significant variation in the methods used to calculate GHG emissions and their effect on temperature change. Present estimates suggest that there are between 60 – 80 different calculators which could be used to quantify the emissions from UK livestock. Some of this variation is linked to the perspectives of the owners (sponsors) of some carbon calculators. There is little wonder, all of this is confusing for the lay person to understand.

There is a clear need for a robust framework to accurately capture the net GHG emissions from livestock. There needs to be a meeting of minds on this from both farming and environmental stakeholders. Both parties care for the countryside and wider environment; however, the perfect should not become the enemy of the good. Absolutist views on one side, or purely-production oriented approaches on the other, will not work. A balanced approach is needed. There are different viewpoints on where exactly that desired balance/equilibrium should rest. What is clear is that the worst effects of climate change need to be avoided, whilst feeding a growing global population which could reach 10 billion by 2050. It is clear that has to be achieved by 'doing more with less' and what matters now is real progress, not perfection.

Our conclusions on carbon markets and UK grazing livestock farming are as follows:

- Addressing GHG emissions and other environmental concerns will be a defining factor for UK farming in the coming decades.
- In some cases, 'doing the right thing' environmentally is also good for business as it simply involves more efficient production. There is much work for the industry to do to promote these 'win-wins' to the widest audience. However, this will only get farming so far.
- To get to Net Zero a step-change in practices is likely to be needed, and this is unlikely to happen without some financial incentive for farmers to reduce GHG emissions. Equally, if not more importantly, financial recognition of sequestering actions taken is needed. Many UK farmers are adopting a wait-and-see attitude until there are clear commercial opportunities. Whilst many farmers want to do-the-right-thing, businesses need to be sustainable both environmentally and financially. Often, these two factors are considered separately.
- The new ELM scheme in England will aim to reduce GHG emissions from agriculture. Details of this are now available with a focus on paying for a limited list of actions. It is still not clear how it might interact with market schemes.
- Due to its structure, agriculture is unlikely to be included in the new UK emissions trading scheme any time soon. Any income stream from carbon reduction is therefore likely to come through the offsetting market.
- There are barriers to the development of a carbon (offsetting) market in farming. The key one is the issue of 'permanence' and whether the carbon reduction purchasers are buying will actually be taken out of the climate for the long-term. This is the reason markets are more developed in the forestry sector where woodland planting is a long-term commitment (and can be relatively easily verified).
- Linked to the point above is the lack of clear, independent, verification standards for GHG reduction in UK farming that buyers will feel they can trust. The industry needs a strong set of guidelines on what constitutes "good" carbon offsetting. The forthcoming Integrity Council report is being awaited with interest.
- An agreed methodology (or set of standards) for the calculation of a farm's carbon footprint would be a major step in developing trust in 'farm carbon'. Having a standardised way of calculating carbon accounts in the same way that financial accounts are standardised would be helpful. It might require some industry-wide body (Defra, AHDB etc.) to push this through.
- It is likely to be some years before deep and liquid farm carbon markets develop. In the interim, individual businesses are likely to be the main driver. In the UK, supply-chain businesses (input suppliers, processors, or retailers) will lead as individual farms will need an 'aggregator' to build sufficient scale.
- Finally, whilst concerns associated with GHG emissions are rightly a major focus amongst policymakers, it is also important that progress in this area does not result in severe carbon leakage or environmental degradation in other areas (e.g. water availability, biodiversity etc.). Future policy actions need to take a balanced approach across all these issues.

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