Signpost Conference 2024

21st November 2024

Talbot Hotel, Clonmel

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Foreword

Welcome to the Signpost Conference and General Assembly.

As we approach the final year of the Signpost Programme, this year's General Assembly provides a unique opportunity to reflect on the progress made through the dedication of farmers and partners alike. Today's event brings together a dynamic community of farmers, industry leaders, advisors, and researchers. With a compelling agenda that combines cutting-edge science, inspiring farmer success stories, and actionable advice, we aim to empower attendees to continue building sustainable farming practices.

Irish farmers have already begun to make significant strides in reducing greenhouse gas (GHG) emissions. According to the EPA's most recent report, GHG emissions fell by4.6%, reaching 20.78 $MtCO_2e$ - 37.8% of the nation's total GHG emissions. These improvements align with reduced nitrogen fertiliser sales, increased adoption of protected urea, and greater use of lime and LESS technology. The progress demonstrates that reducing emissions is both feasible and beneficial, bringing additional advantages such as enhanced farm efficiency, improved water quality, richer biodiversity, and stronger profitability. However, achieving these outcomes requires commitment and change.

Key insights from the Signpost Programme highlight the pathway to sustainable farming:

- Farmers are open to adopting new practices when the benefits to their businesses are clear.
- Progress in emissions reductions can be offset by increased farm scale or external factors like weather.
- Long-term solutions often require sustained effort over years.
- Tailored, farm-specific solutions are essential; one size does not fit all.
- Accurate and comprehensive farm data is vital for informed decision-making and progress monitoring.

We extend our gratitude to the Signpost Partners and the Signpost Farmers for their unwavering support and commitment. Their engagement has driven the high adoption rates of critical technologies and practices.

The opening session at this year’s conference features keynote speakers addressing changes in weather trends over the past 60 years and strategies for adapting to future weather patterns. Session 2 highlights progress on Signpost demonstration farms, including an interview with John and Brendan Walsh, dairy farmers from Tipperary, who will share their sustainability journey. Session 3 delves into emerging research on reducing GHG emissions, and the day concludes with an exploration of pathways to achieving climate neutrality.

We hope you find today’s discussions inspiring and empowering as we collectively work towards a more sustainable future in Irish farming.

Frank O'Mara

Prof. Frank O’Mara
Director

Speaker Biographies

Mary Curley,
Met Éireann
Mary Curley joined Met Éireann in 1996. She has worked in the Climate Services Division (formerly known as Climatology and Observations Division) since 2002. Her areas of expertise include quality control, homogenisation, data analyses and data rescue. She has been involved in several International and European projects including the COST Action, Advances in homogenisation methods for climate series (HOME) and the ERA4CS project, Integrated approach for the development across Europe of user-oriented climate indicators for GFCS high-priority sectors (Indecis). Mary was the project leader for producing the most recent 30- year climate averages.

Barry Coonan,
Met Éireann
Barry Coonan joined the Climate Services Division of Met Éireann in 2020 and has been focussing on climate parameter gridding and analysis of extreme weather events. He was involved in developing the long-term climate averages 1991-2020 in the updating of the climate related components of the building standards in Ireland. Currently his team is developing enhanced weather parameter gridding techniques and investigating extreme rainfall in a changing climate.

Dr. Elodie Ruelle
Teagasc
Elodie Ruelle is a senior research officer in Teagasc Moorepark. She is a system modeller and her main model is the Moorepark St. Giles Grass Growth (MoSt GG) model used for on farm grass growth prediction. More recently she has been working on climate adaptation for Irish agriculture.

Dr. Tom O’Dwyer
Teagasc
Tom is Head of the Signpost Programme, with responsibility for leading the Signpost Farms demonstration farms programme. He is involved in a number of EU funded projects, including ClimateFarmDemo (an EU wide network of demonstration farmers), ClimateSmartAdvisors (building the capacity of advisors in climate smart farming) and ClieNFarms (supporting the transition to climate neutral/ climate resilient farming). He delivers the Communications, Innovation and Innovation Support module as part of the UCC Agricultural Science degree programme. Tom joined Teagasc in 1995 as a REPS Advisor, and has held a number of previous roles, including Monitor Farm Specialist, Dairy Specialist, Regional Manager and Head of Dairy Knowledge Transfer.

John & Brendan Walsh

Winners of the Teagasc FBD Environmental Sustainability Awards 2024

John and Brendan Walsh are dairy farming near Ballylooby in County Tipperary. They are operating an efficient and profitable dairy farm, while at the same time both John, Brendan and the rest of the family are passionate about looking after the environment.

Dr. Hazel Costigan

Teagasc

Hazel Costigan is a post-doctoral researcher in Teagasc Moorepark. Having previously working on different calf and heifer rearing strategies, Hazel's research now focuses on evaluating methane reducing feed additives for grazing systems. Her goal is to identify additives that effectively reduce enteric methane emissions and are practical for use with grazing animals.

Dr. Richie Hackett,

Teagasc

Dr. Richie Hackett is a Research Officer in Teagasc, Crops Research Centre, Oak Park, Carlow. is research focuses on applied, field-based studies of crop agronomy under Irish conditions, with particular emphasis on fertiliser nitrogen use on a range of cereal crops. Richie has also carried out research on optimising the agronomy of hybrid rye, agronomic evaluation of cover crops, assessing the impact of fertiliser nitrogen on protein levels in malting barley, studying application strategies for various nitrogen fertilisers in winter wheat and barley, and examining the fertiliser value of organic wastes.

Dr. Paul Crosson,

Teagasc

Dr. Paul Crosson is Enterprise Leader and a Principal Research Scientist with Teagasc at Grange Research Centre where his work involves the economic and environmental assessment of beef production systems. He has collaborated with Bord Bia in the development of a national-scale beef farm carbon audit initiative. His research has supported reviews of the Irish beef breeding indexes carried out by the Irish Cattle Breeding Federation. Key research interests include the evaluation of key profit indicators for beef farming systems, modelling feed costs for pasture-based livestock farming, life cycle assessment modelling, and the analysis of integrating anaerobic digestion and livestock farm systems.

Dr. Giulia Bondi,
Teagasc

Giulia Bondi is a Senior Researcher at Teagasc, specializing in soil carbon sequestration and dynamics. She leads the Soil Deep Sampling Campaign of the Signpost Programme, focusing on carbon sequestration monitoring across various climates, soil types, and agricultural practices in Ireland. Giulia has managed research activities and funds for national and European projects, including the EJP-Soil (European Union's Horizon 2020) project ICONICA. Over the years she has established an international network of collaborators and published extensively in top scientific journals. Currently, her research supports agricultural policies, and she actively disseminates her findings to multiple stakeholders.

Dr. Stuart Green,
Teagasc

Dr Stuart Green Is Senior Research Officer in the Department of Agribusiness and Spatial Analysis in Teagasc . He has a PhD in Earth Observation, EO, and has been a remote sensing specialist in Teagasc for 25 years. His research focus is on the use of EO to support sustainable Agriculture. He has lead projects producing national scale datasets using EO on land cover, land use, habitats and biomass in Ireland.

Dr. Jonathan Herron,
Teagasc

Jonathan Herron is a Researcher Officer in the Livestock Systems Department based in Teagasc's Animal & Grassland Research and Innovation Centre in Fermoy, Co. Cork. Jonathan completed his PhD in 2021 through the Teagasc Walsh Scholarship Programme and University College of Dublin. He is one the lead researchers in the development of the AgNav platform in collaboration with the Irish Cattle Breeding Federation (ICBF) and Bord Bia. He supervises a team of PhD students and post-doctoral researchers in the areas of life cycle assessment, bioeconomic modelling and integrated farming systems.

Weather Trends Over the Past 60 Years

Mary Curley, Ciara Ryan and Barry Coonan

Climate Services Division, Met Éireann, Glasnevin Hill, Dublin 9

Summary

- Ireland was warmer, wetter and sunnier during the 30-year period 1991-2020 than the previous 30-year period 1961-1990.
- Annual mean temperature increased by 0.7°C.
- Annual rainfall increased by 7%
- Annual sunshine duration increased by 4.5%.

Introduction

Climate long-term averages (LTA) or normals are the mean or average values of a climate variable over a standard reference period. The World Meteorological Organisation (WMO) established that the length of the reference period should be 30 years and recommended that the climate averages are updated every 10 years to provide representative reference values for recent climatic conditions.

In accordance with WMO guidelines, Met Éireann recently produced a set of climate averages for the period 1991-2020 for a range of parameters including air temperature, precipitation and sunshine. Annual, seasonal, and monthly average values for the period 1991-2020 were compiled using high-quality data obtained from Met Éireann's observation network. Using the same methodology, 30-year averages for the preceding period from 1961-1990 were also calculated allowing the difference between the two averaging periods to be determined. An outline of the process used to generate the long-term averages for temperature and rainfall is shown in Figure 1 below.

This paper presents an overview of the latest set of climate averages for Ireland as well as an assessment of trends between the two 30-year averaging periods for air temperature, rainfall and sunshine.

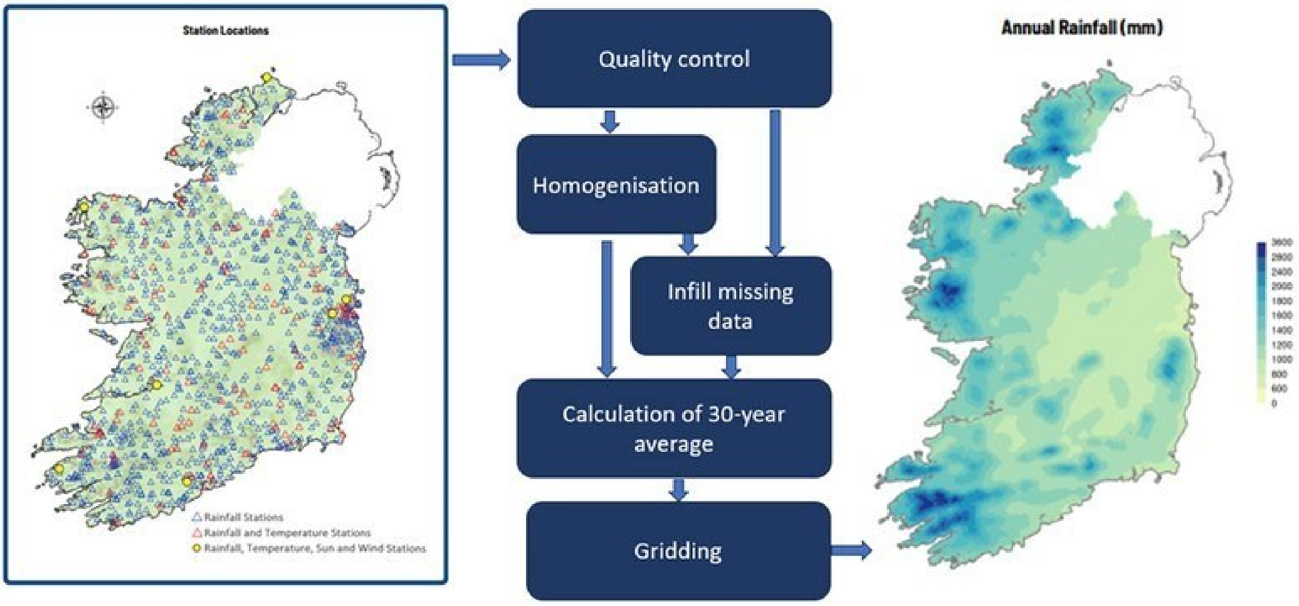


Figure 1. The process used to produce the long-term averages and grids for Ireland

Results

Air Temperature

Long-term average (LTA) annual, seasonal, and monthly maps were generated for mean, maximum and minimum air temperature for the 30-year periods 1991-2020, and 1961-1990 along with difference maps which compare the long-term averages for the two periods. Figure 2 shows an example of the maps produced for annual mean air temperature 1991-2020 and the map of the difference between the two periods.

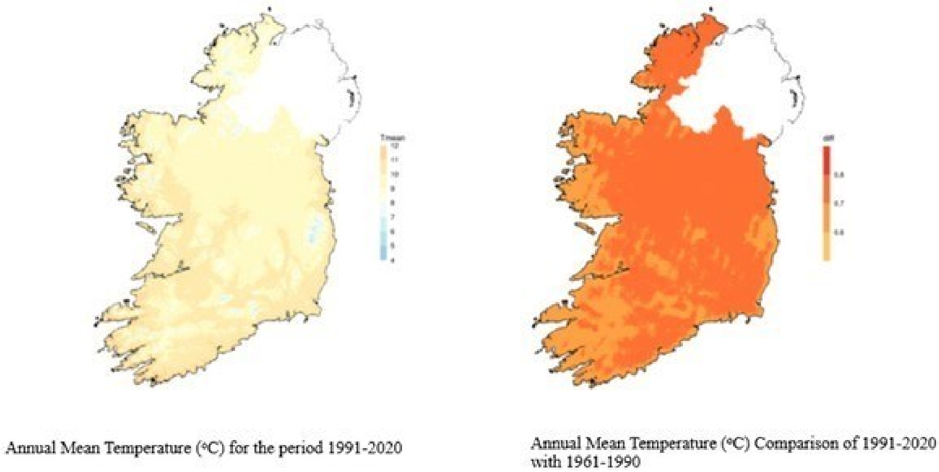


Figure 2. Annual mean air temperature for the period 1991-2020 and differences between the 1991-2020 and 1961-1990 period.

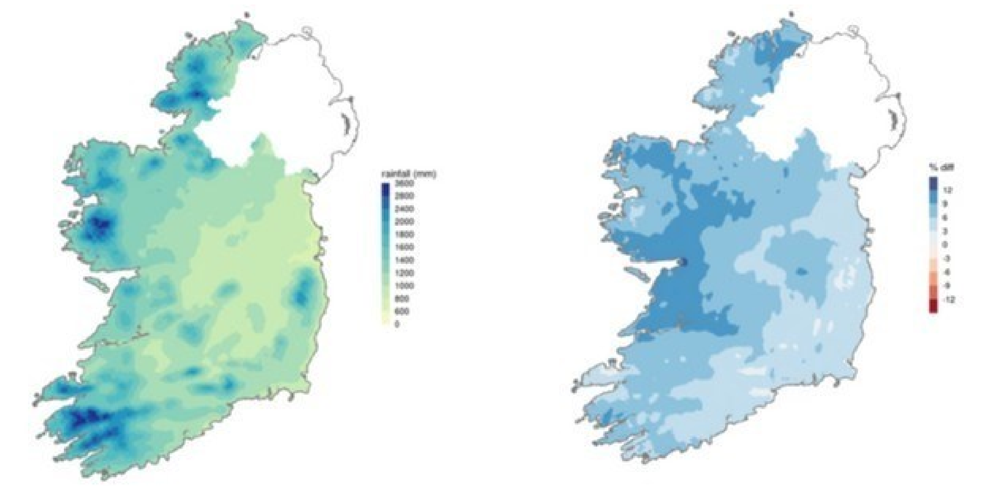
The annual mean, maximum and minimum air temperature for Ireland over the 30-year period 1991-2020 is 9.8°C, 13.4°C and 6.2°C respectively. For all three parameters there is an increase of 0.7°C compared with the 1961-1990 period. An increase is also seen in the 3 parameters in all seasons and months across all regions of Ireland.

Seasonal temperature changes ranged from 0.6 to 0.8°C (mean), 0.6 to 0.9°C (maximum), and 0.5 to 0.8°C (minimum). While all months have recorded an increase in temperature between the recent LTA and the period 1961-1990, the change varies from month to month. For example, October has seen just a 0.2 to 03°C increase across all air temperature measures, but the following month, November, has a 0.8 to 1.0°C increase recorded.

Rainfall

Nationally, annual average rainfall over the period 1991-2020 is approximately 1,288 mm. Highest rainfall amounts are observed in the west of the country, particularly on higher ground. Annual average rainfall ranges from 878 mm in regions along the east coast to 2,045 mm in the southwest mountainous regions. The driest regions are in the east and south of the country, along with parts of the midlands region (Figure 3).

Annual average rainfall has increased by approximately 7% between the periods 1961-1990 and 1991-2020 (Figure 3). Almost all regions have observed an increase in annual average rainfall with the greatest increases seen in the west and north of the country.



Annual Rainfall (mm) for the period 1991-2020

Annual Rainfall (%) comparison of 1991-2020 with 1961-1990

Figure 3. Annual rainfall for the period 1991-2020 and differences between the 1991-2020 and 1961-1990 period.

All seasons show a percentage increase in average rainfall amounts for Ireland between the periods 1961-1990 and 1991-2020 although there are large regional variations with some regions showing a decrease and others an increase in rainfall. On a monthly basis, the greatest difference at 28% is observed in July, with all regions throughout the country observing an increase in average rainfall amounts. March and September are the only months that have observed a decrease in average rainfall amounts for Ireland, in the order of 3% and 6%, respectively. The difference between the two periods for all other months ranges from 0 to 17% but significant regional differences are evident across the country.

Sunshine

Across the twelve stations shown in the map (Figure 4), the mean annual sunshine duration for the period 1991-2020 is 1403.3 hours. In general, stations located near eastern and southern coasts are relatively sunny, while those located near western and northern coasts are relatively dull.

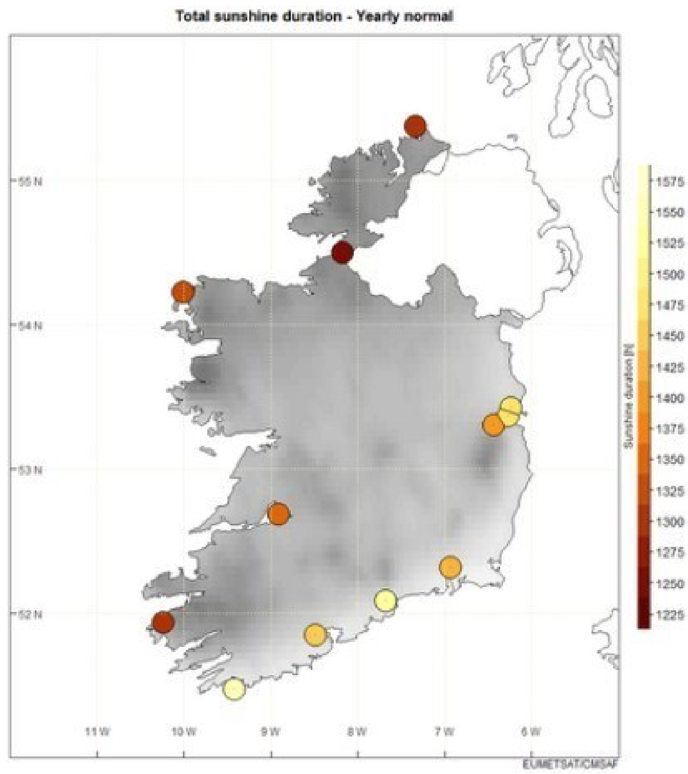


Figure 4. Annual Sunshine Hours 1991-2020.

Compared to the available averages calculated for the period 1961-1990, annual sunshine duration for 1991-2020 has increased by an average of 4.5% or 58.6 hours.

Conclusion

The publication of Ireland's most recent climate averages allows us to assess how Ireland's current climate compares to the previous 30-year period. Ireland's climate is changing, we have warmed by 0.7°C, become 7% wetter and sunnier by 4.5% over the
period 1961-1990 to 1991-2020. We know that the atmosphere is warming and what we are seeing aligns with global trends. The findings in these new 30-year averages are consistent with the results from Met Éireann's TRANSLATE climate projections, which confirms the likelihood of a warmer and wetter climate annually for Ireland, in relation to future potential global warming under different green-house emission scenarios.

Acknowledgements

Information in this paper comes from Met Éireann's research into climate averages (www.met.ie/climate/30-year-averages) and the TRANSLATE climate change projections (www.met.ie/science/translate).

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Future Weather and Adaptation of Farming Practices

Dr. Elodie Ruelle

Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork

Summary

- Weather in Ireland is changing, climate projection are showing a steady increase of temperature across the year, with an increase of winter and spring rainfall.
- While an increase of the recurrence of summer drought is forecasted, the increase of the variability between years will be one of the biggest challenges for Irish farmer in the future.
- For crops, an increase in temperature could lead to new opportunities and increased yield. However, trafficability and increased pest risk are forecasted to be the biggest challenge.
- For grassland, overall annual grass yield is predicted to slowly increase. But the seasonality of the growth will change with an increase in the winter and spring months and a decrease, due to water deficit and increase temperature, in the summer and autumn months, with a big year to year variability.
- Better farm infrastructure, appropriate stocking rate and sufficient good quality forage stocks will be necessary to properly adapt to future climate.

Introduction

For the last decade, Irish research has been focussing on ways to reduce its emission and impact on the environment (mitigation). The change in weather due to climate change is starting to be more visible on farm, as the summer of 2018 or the spring of 2024 are showing. Hence, highlighting the necessity for adaptation strategies to be developed. However, in order to be able to adapt to the future challenges and find relevant adaptation strategies it is important to know what will be the likely impact of future climate on the current systems. This paper will present the likely impact of future climate on the Irish grazing system as well as presenting some of the main challenges and possible solution for the grassland and crops sectors. In this work the data from the TRANSLATE (O'Brien et al, 2024) project from Met Éireann has been used. In a very brief summary, climate projection are showing a steady increase in temperature across the year, with an increase of winter and spring rainfall and a possible decrease of summer rainfall, with higher variability between years.

Future grass growth

Using data from the TRANSLATE project, a modelling exercise has been conducted to predict the impact of climate change on Irish grass growth (Ruelle, 2024). Overall, the prediction for both the 1.5 °C and 3 °C global warming show an increase in annual grass yield for every part of Ireland. However, when looking at the seasonal changes (Figure 1), the story is not as good as most of the increase in grass growth comes from an increase during the winter and spring month. The grass growth is predicted to decrease in the month of July, August and September for the midlands and east coast (the more easterly, the higher the decrease). The trend of change will increase, when going from the 1.5 °C to the 3 °C global warming.

When looking at the variability between years at a specific location (Moorepark), the main change was for the month of April where higher variation was seen (but looking mainly like an increase in growth). For the month of August, where the yearly variability had increased, with many more years with poor grass growth during this summer month. However, this decrease was not statistically significantly showing that the average year will probably be similar to that currently but, the occurrence of a summer similar to 2018 will increase.

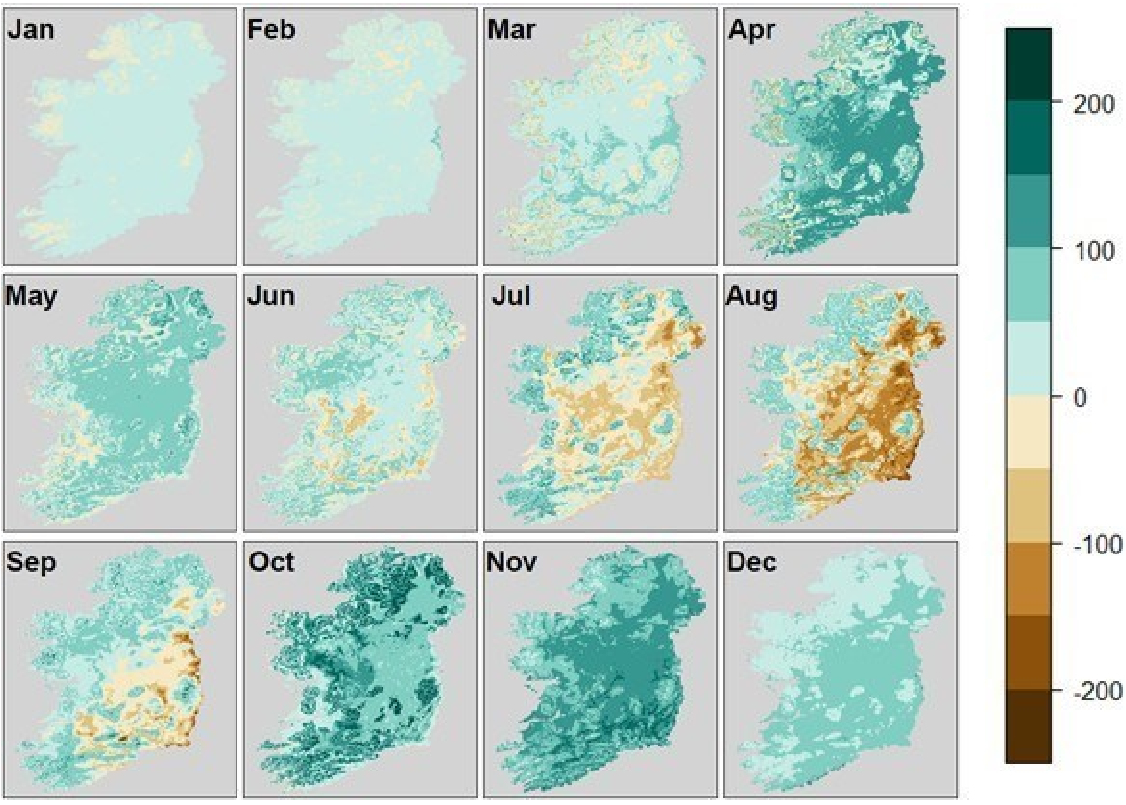

Figure 1: Monthly cumulative grass growth difference between a 1.5 °C warming simulation and the baseline simulation (1976-2005)

Grassland adaptation - What does those forecasted changes means?

While the increase in growth in the winter looks positive, trafficability might be a challenge. It may not be possible to take advantage of the increase in growth in the spring months, through increased grass utilisation, if soil conditions restrict grazing. On-farm grazing infrastructure will have to be improved to ensure good access to paddocks early in the year, especially if the increase of spring growth is also associated with an increase in rainfall. On the other hand, the decrease in growth in the summer, combined with an important increase in the variability during the months of July to September will lead to increased challenges for summer and autumn grass management. This could have repercussions and cause difficulty in creating adequate forage stocks for winter feeding. However the projected increase in growth for the months of October and November could help extend grazing (weather conditions permitting) and reach target closing and opening farm covers. Some extreme years will be associated with very poor or even no growth in some of the summer months. Those years, while rare, will become more frequent in the future. Farmers will need to increase their silage and forage stocks to ensure adequate buffer feed is available during those periods. It will also be important that the forage is of high quality to maintain milk yields.

The switch to more diverse sward or more drought resistant grass could also help in the adaptation to drier summers. The decision support tools such as PastureBase Ireland and grass growth prediction will be an asset to farmers, allowing them to better anticipate the fluctuations and take early action.

However, one of the main factor which will be impacting the resilience of farms is the stocking rate. Having the right number of animals, depending of the grass growth potential of the farm, taking into account management and soil type will be vital. Having too many animals reduce the flexibility of the system.

Crops adaptation

In term of crops, the same modelling exercises is currently ongoing but early results aren't yet available. Nonetheless some hypothesis can be done, in term of yield. The likeliness is that overall yield, especially of winter crops, should increase due to increase in over winter growth due to warmer weather. Also there is the possibility that new cultivars such as soybean and sunflower will be suitable for future Irish climate.

On the negative side, the forecasted increase of rainfall in winter and spring and, the higher variability between years of that rainfall, will make the weeks where sowing and harvesting are possible more limited, because of trafficability. Having a bigger crop diversification pool will help. For example incorporating rye in the rotation. Rye can be planted from mid-September and will increase the window for both planting and harvesting, increasing the flexibility on-farm and so the resilience.

A decision support tool will be developed in the near future to predict farm and field specific crop optimal harvesting and sowing window related to farm location (weather) and soil type based on previous year data. This will help farmers in selecting and planning the best crop rotations to ensure the resilience of the farm. This will also be looked at with a future climate point of view.

With milder winter, there is a forecasted increase in the propagation of pest and diseases. One of the most detrimental viruses is the barley yellow dwarf virus propagated by an aphid. The increase of temperature and especially, winter temperature could be both favourable for the aphid reproduction and survival as well as virus replication within the plant. Research is currently ongoing to predict the best timing of insecticide spraying in the current climate as well as predict the aphid and virus pressure in future climate. The objective will be to create warning messages similar from the blight warning.

Acknowledgements

The author would also like to thank the funding from DAFM (FarmAdapt 2022PSS111 and AgriAdapt 2023RP865) as well as the Teagasc Climate Centre.

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Signpost Farms: Taking Steps to Reduce GHG Emissions

Dr. Tom O'Dwyer

Teagasc, Moorepark Animal & Grassland Research and Innovation Centre, Fermoy, Co. Cork

Introduction

Irish farmers are taking steps to reduce greenhouse gas emissions from their farming activities. Data published by the EPA indicates that GHG emissions declined by 0.7% and 4.6% in 2022 and 2023 respectively, to stand at 20.78 MtCO2e of greenhouse gas (GHG) emissions in 2023, representing 37.8% of total GHG emissions for that year. National figures also indicate reduced sales of fertiliser nitrogen (N) and upward trends in the usage of protected urea, lime and LESS. Reducing greenhouse gas emissions on your farm is possible and achievable. Many of the currently available solutions have other benefits, including increased farm system efficiency, improvements to water quality, enhanced biodiversity and improved profitability. However, to achieve these multiple benefits requires change.

About the Signpost Programme

The Signpost Programme was created to help farmers understand their on-farm options to reduce greenhouse gas emissions, and then to support them in implementing the new practices on their farms.

Listed on below are the practical solutions promoted with the Signpost Farmers, and with all farmers, through our series of "12 Steps" leaflets available here.

These solutions are available to all farmers now. Simultaneously, Teagasc and others are researching solutions that will help farmers continue to reduce emissions and improve farm performance in the future.

Available solutions to reduce GHG emissions

1. Reduce fertiliser N use (through optimising soil pH and soil P and K levels, increasing the proportion of grass/ clover swards)
2. Use NBPT - urea (protected urea) as your source of fertiliser N
3. Manage and make best use of animal slurries and manures
4. Increase and optimise milk and meat production from pasture
5. Use breeding indices to inform better breeding decisions
6. Achieve targets for age at first calving and replacement rate
7. Target earlier finishing of beef cattle and lambs
8. Review your animal health management practices and improve where appropriate
9. Improve hedgerow management and consider planting new hedgerows or trees
10. For tillage farmers, mitigation measures include sowing cover crops, straw incorporation and the use of organic manures (to replace fertiliser N)

Signpost Farmers were identified to act as demonstration farmers. With the support of a dedicated advisor, they were guided to adopt recommended practices on their farms, and to share their experiences with other farmers.

Signpost Farmers' Experience

Earlier this year, the Signpost Team conducted a survey of the Signpost Farmers to measure their climate knowledge, mind-set, attitudes and beliefs. A total of 75 responses were received, representing a 62% response rate.

In one question, farmers were asked to rank their level of agreement with a number of statements both "before" and "after" they joined the Signpost Farms Programme as a demonstration farmer.Their answers indicate that there is an increased awareness amongst the Signpost Farmers of their farm's GHG emissions, and of how their farming activities contribute to their annual GHG emissions. All Signpost Farmers have a plan in place to reduce their farm's GHG emissions, and they also report that they increasingly consider the impact of weather on their future plans.Interestingly, the Signpost Farmers indicate they now realise that they could do more to reduce their GHG emissions, while continuing to place a high importance on maximising farm profit. In another question, respondents indicated that they had either a "reasonable" or "very good" understanding of the actions they can take to reduce their farm's emissions.

Table 1. Signpost Farmers level of agreement with six statements (n = 75, August, 2024)

Statement	**Level of agreement BEFORE (1 – 5)**	**Level of agreement AFTER (1 – 5)**
1. I know the level of GHG emissions generated by my farming activities.	2.42	4.00
2. I understand how my farming activities contribute to GHG emissions.	3.15	4.15
3. I have a clear plan to reduce GHG emissions on my farm.	2.80	4.10
4. I consider the impact of changing weather patterns on my farm.	3.51	4.12
5. I could do more to reduce agricultural GHG emissions.	3.47	3.80
6. I think it is important to make the largest possible profit from my farming activities.	4.09	4.03

The survey also explored both the "ease of use" and the "usefulness" of nine climate mitigation technologies; a summary of the responses is presented in Figures 1 and 2 below.

Farmers reported that using protected urea and maintaining optimum soil pH were easier technologies to adopt and incorporate into their farming system; whereas farmers tended to rank maintaining optimum soil P and K levels, using organic manures, increasing clover content (grassland) / planting legume crops (tillage), and planting trees/ forestry as more difficult technologies to adopt. Approximately one third of the tillage farmer respondents ranked minimal cultivation as "very difficult" (perhaps reflecting a soil type challenge), while all tillage respondents ranked cover/ green crops and straw incorporation as either "easy" or "very easy".

The ranking changed somewhat when respondents were asked to rate the usefulness of the same nine technologies. The usefulness of the first five was indicated by the farmers' responses. It was perhaps a little surprising that 41% of respondents did not recognise the usefulness of planting trees or forestry as a climate mitigation measure. For the three measures more applicable to tillage systems, the tillage farmer respondents recognised the usefulness of the measures, mainly answering "useful" or "very useful".

Finally, 44% of farmer respondents indicated that taking action to reduce climate change will improve their quality of life (just 15% responded that it would reduce their quality of life), with 80% indicating that taking climate action will leave the farm in a better position for the next generation.

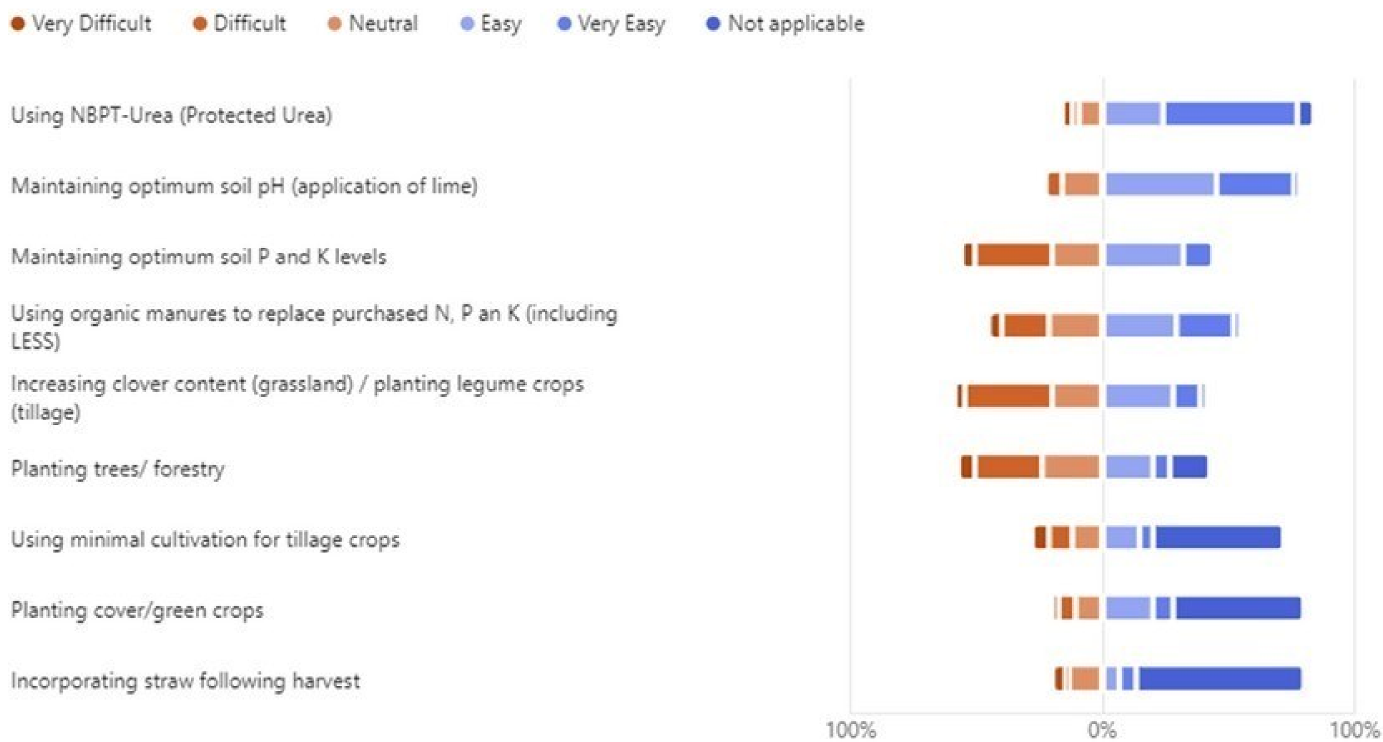

Figure 1: Ease of use of nine climate mitigation measures as ranked by Signpost Farmers (n=75, August 2024)

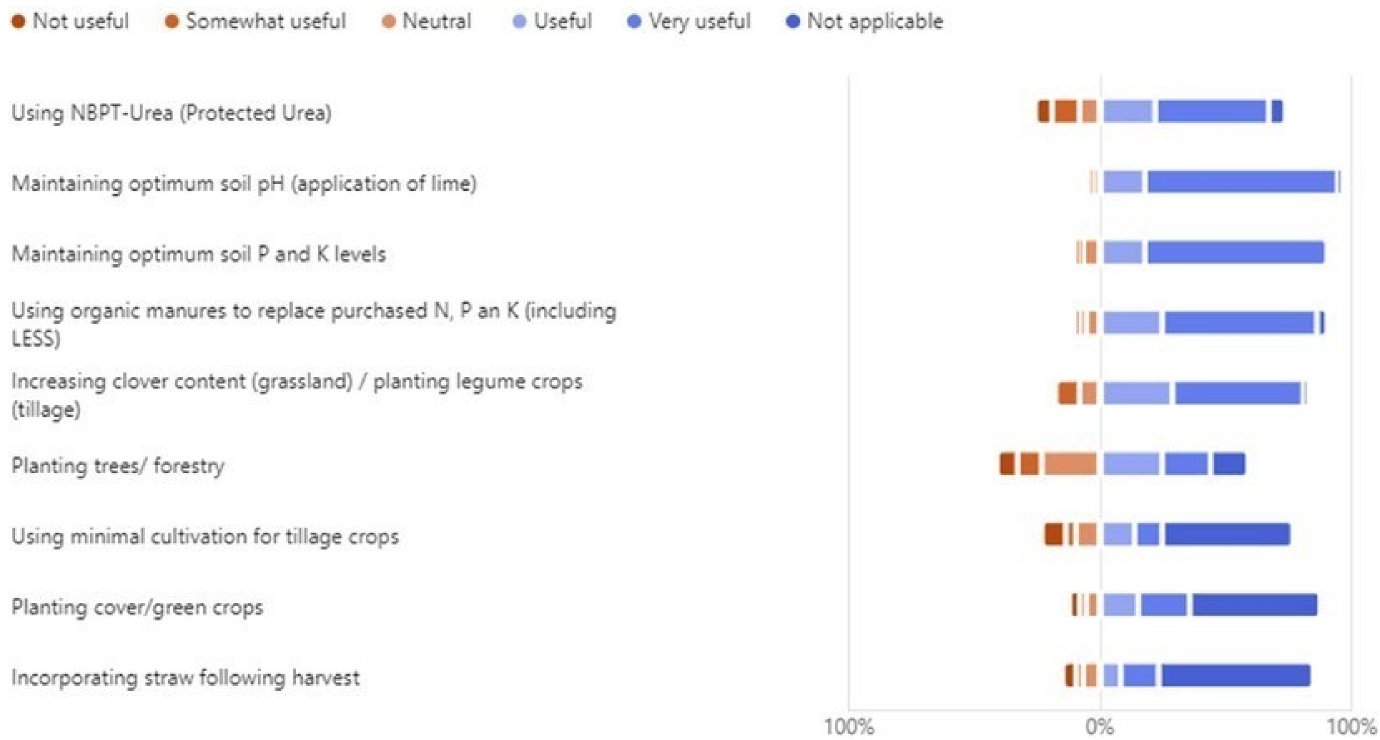

Figure 2. Usefulness of nine climate mitigation measures as ranked by Signpost Farmers (n=75, August 2024)

Adoption of Climate Mitigation Measures by Signpost Farmers

In relation to the adoption of climate mitigation measures on the Signpost Farms, Tables 2 and 3 summarise the progress made in relation to four key climate mitigation measures: the usage of protected urea, lime and low emission slurry spreading (LESS) equipment and the reduction in fertiliser N usage. Data is presented for both Signpost Dairy and Cattle Farms, with figures from the Teagasc National Farm Survey for all dairy farmers and all cattle farmers included for comparison.

The Signpost Dairy and Cattle Farmers are using a higher proportion of protected urea, lime and LESS than all dairy and cattle farmers respectively. While applying higher levels of fertiliser N, the Signpost dairy farmers have reduced their fertiliser N use by a greater proportion than all dairy farmers, while both the Signpost Cattle Farmers and all cattle farmers have reduced fertiliser N usage by a similar proportion.

Table 2. Adoption of four selected climate mitigation measures by dairy Signpost Farmers and all dairy farmers

Climate Mitigation Technology	**Signpost Dairy (n = 42)**	**All Dairy Farmers (NFS)**
Protected Urea (% of total fertiliser N)	44% (2021)	11% (2021)
	51% (2022)	18% (2022)
	67% (2023)	27% (2023)
Fertiliser N Use (kg/ha)	201 (2021)	168 (2021)
	176 (2022)	156 (2022)
	160 (2023)	145 (2023)
Change in Fertiliser N Use (%)	-12% (2022)	-7% (2022)
	-9% (2023)	-7% (2023)
Lime Applied (tonnes/ha)	0.72 (2021)	0.55 (2021)
	0.93 (2022)	0.53 (2022)
	0.75 (2023)	0.43 (2023)
Proportion of Slurry Applied Using LESS (%)	91% (2021)	68% (2021)
	99% (2022)	77% (2022)
	100% (2023)	81% (2023)

Table 2. Adoption of four selected climate mitigation measures by cattle Signpost Farmers and all cattle farmers

Climate Mitigation Technology	Signpost Cattle (n = 30)	All Cattle Farmers (NFS)
Protected Urea (% of total fertiliser N)	20% (2021)	2% (2021)
	44% (2022)	5% (2022)
	53% (2023)	6% (2023)
Fertiliser N Use (kg/ha)	116 (2021)	62 (2021)
	97 (2022)	44 (2022)
	87 (2023)	43 (2023)
Change in Fertiliser N Use (%)	-16% (2022)	-29% (2022)
	-10% (2023)	-2% (2023)
Lime Applied (tonnes/ha)	0.44 (2021)	0.73 (2021)
	0.86 (2022)	0.27 (2022)
	0.64 (2023)	0.29 (2023)
Proportion of Slurry Applied Using LESS (%)	46% (2021)	24% (2021)
	79% (2022)	34% (2022)
	89% (2023)	38% (2023)

In summary, the Signpost Farms programme has made significant progress in raising the awareness of climate change as an issue for Irish farmers, of building the capacity of farmers to understand and interpret their farm's emissions profile and of increasing the usage of recognised climate mitigation measures. Through working with the Signpost Farmers, we have learnt that:

- Farmers are willing to adopt new farming practices, once they are clear on the benefits of such practices to their farm business;
- Gains (reductions in total emissions) can be counterbalanced by increased farm scale, and in some cases factors outside the farmer's control (such as weather);
- Change takes time, some solutions may require a sustained effort over many years;
- One size does not fit all – tailored, farm specific solutions are necessary; and
- Good farm data is necessary both to inform better decisions and to monitor progress made.

Acknowledgements

The author wishes to acknowledge the input of Teagasc colleagues, Brian Moran, Niamh Noone and Caoimhe Duggan in providing data for this paper. The Signpost Programme is a collaborative partnership of farmers, industry and State Agencies, working together for climate action. For further details of the partners, please refer to www.teagasc.ie/signpost.

Putting Technologies into Practice

John & Brendan Walsh

Ballylooby, County Tipperary

John and Brendan Walsh from Ballylooby, County Tipperary were announced as the Teagasc / FBD Environmentally Sustainable Farmer of the Year 2024 at the awards ceremony in County Laois on Tuesday, 1st October.

John and Brendan Walsh from Ballylooby, Co. Tipperary were announced as the overall winners of the inaugural Teagasc/FBD Environmental Sustainability Awards. Pictured were John and Brendan Walsh receiving the award from Dr Laura Burke, Director of the EPA.

The awards, kindly sponsored by FBD, were presented to five enterprise winners: dairy, suckler beef, dairy beef, sheep, and tillage, and to four category winners: reducing greenhouse gas emissions, enhancing biodiversity, improving water quality and improving soil health and carbon sequestration.

John and Brendan Walsh are dairy farming near Ballylooby in County Tipperary. They are operating an efficient and profitable dairy farm, while at the same time both John, Brendan and the rest of the family are passionate about looking after the environment. Significant progress has been made to reduce greenhouse gas emissions on the farm. They have reduced their chemical Nitrogen (N) use by 48% since 2020, and 87% of their chemical Nitrogen is NBPT protected urea. Trees are planted every year on the farm and hedges are allowed to grow up, and out, to maximise their value for biodiversity, but also carbon capture. The Nitrogen surplus on this farm is 91 kilogrammes of N per hectare, compared to the national average of 159 kg N / ha. A low N surplus significantly reduces the risk of nitrate leaching into waterways on the farm.

Speaking at the awards, EPA Director General, Laura Burke, who presented the top Award to the Walshs, said: "I whole-heartedly congratulate all 16 finalists on their achievement. I extend my congratulations in particular to the category and overall winners whose commitment to developing a sustainable future for the agri-sector was so evident to the judges. It is very encouraging to see this group of farmers embrace the environmental challenges facing the sector right now and to see such high uptake of key technologies, including reducing reliance on Nitrogen, the use of protected urea, better management of our hedgerows and greater implementation of actions to protect our water courses."

On behalf of the overall sponsor of the Awards, Michael Berkery, Chairman of FBD Trust said; "These inaugural Teagasc / FBD Environmental Sustainability Awards highlight farmers' commitment to environmental sustainability. We are proud to support these awards which recognise farmers who are making real strides in sustainability. Congratulations to John and Brendan Walsh and indeed to all 16 finalists who are shining examples of environmentally conscious farmers applying best practice on their farms. We wish them continued success."
Professor Frank O'Mara, Director of Teagasc said; "This award is a wonderful celebration of the progress farmers have made, and are making, to improve environmental sustainability on their farms while continuing to produce high quality, nutritious food, in a profitable manner. Congratulations to all finalists and award winners. The agri-sector needs all farmers and all involved in the sector to firmly focus on improving water quality, reducing emissions, and enhancing biodiversity. The 16 finalists in these awards are excellent ambassadors for what is being done on family farms around the country."

The other award winners in the Teagasc / FBD Environmental Sustainability Awards were:

Enterprise winners:

- John and Brendan Walsh - Dairy
- Aidan Maguire, Meath – Dairy Beef
- Shane Keaveney, Roscommon – Suckler Beef
- Brian Nicholson, Kilkenny – Sheep
- Tom Barry, Cork – Tillage

Category Winners:

- Edwin Thompson, Tipperary (Dairy) – Reducing Greenhouse Gas Emissions
- Ken Gill, Offaly (Suckler beef) – Enhancing Biodiversity
- Martin Crowe, Limerick (Dairy) – Improving Water Quality
- James O'Keeffe, Meath (Organic Tillage) – Improving Soil Health and Carbon

Other Finalists:

- Alan and Cheryl Poole, Wexford (Dairy)
- Blatnaid Gallagher, Galway (Sheep)
- Eamon and Donnchadh McCarthy, Waterford (Suckler Beef)
- Shane Fitzgerald, Waterford (Dairy)
- Richard Starrett, Donegal (Dairy)
- John Murphy, Cork (Dairy Beef)
- Michael McGuigan, Meath (Suckler Beef)

Methane Reducing Feed Additives

Hazel Costigan, Laurence Shalloo, William Flynn, Ciara Fitzgibbon, Valentine Glevarec and Ben Lahart

Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Summary

- The methane mitigating feed additive 3-NOP has been evaluated across a range of differing scenarios for Irish conditions
- 3-NOP is most effective in indoor settings when mixed throughout feed using a mixing wagon
- Feeding 3-NOP on commercial farms is possible during the dry period and does not increase labour requirements on-farm
- The Red seaweed (Asparagopsis) yielded a ~24% reduction in enteric methane when pulse fed twice daily during the grazing season
- Further work is required to increase the efficacy of feed additives as well as developing practical solutions for feeding additives during grazing season

Introduction

Enteric methane, which is a by-product of feed digestion, accounts for 63% of agricultural greenhouse gas emissions in Ireland (EPA, 2023). Given that the agricultural sector has a target to reduce its greenhouse gas emissions by 25% by the year 2030, relative to 2018 levels, developing strategies to reduce enteric methane will be crucial to meeting Ireland's agricultural climate targets. Several promising anti-methanogenic feed additives have been identified; however, most of the research to-date has been undertaken in indoor feeding systems, in which animals are housed year round. In these systems, additives can be easily mixed throughout the feed using a mixing wagon so that they are present in every mouthful of feed consumed by the animal and thus actively reduce methane throughout the day, achieving methane reductions of ~30%.

However, in pasture-based dairy systems, grazed grass makes up the majority of an animal's feed intake. Therefore, supplementing animals with feed additives is inherently more difficult in grazing systems, as, at present, the only practical opportunity for doing so is via supplemental feed in the milking parlour twice daily. It is therefore important that feed additives are effective in these scenarios. There is a large research programme underway in Teagasc Moorepark to identify anti-methanogenic feed additives that are effective and practical to use in pasture-based systems.

Research

3-NOP

3-nitrooxypropanol (3-NOP; Bovaer10®; 10% 3-NOP on a carrier) is one of the most consistently effective anti-methanogenic feed additives identified in a review undertaken by Hegarty et al. (2021). Reductions in enteric methane of ~30% have been consistently reported with indoor systems of dairying in which the additive is mixed throughout the basal diet using a mixing wagon (Kebreab et al., 2023). To evaluate the efficacy of 3-NOP in grazing systems, a study was undertaken in Teagasc Moorepark in which 3-NOP was fed to grazing dairy cows twice daily on exit from the milking parlour. The results demonstrated a 28.5% reduction in enteric methane for 3 hours after additive consumption, however, methane output returned to normal thereafter (Costigan et al., 2024).

The short efficacy period of the additive is due to its rapid metabolism in the rumen once ingested, meaning the cumulative reduction in daily enteric methane was only ~5%, highlighting that, in its present form, 3-NOP is unsuited to twice daily feeding during the grazing season.

Future research on feeding 3-NOP in grazing systems should focus on slow release technologies to enhance its efficacy when fed twice daily. However, it should also be highlighted that during the winter housing period, additives such as 3-NOP may be mixed throughout the basal diet.

Research by Lahart et al. (in press) has shown 3-NOP can reduce daily enteric methane by 22% when mixed throughout silage using a mixing wagon and fed to cows during the dry period. As most farmers do not have access to mixing wagons in Ireland, a follow up study was undertaken in which 3-NOP was mixed with dry cow minerals and top-dressed onto grass silage twice daily that was fed to non-lactating dairy cows (Lahart et al., under review); this study reported a reduction in enteric methane of 11%.

A study undertaken in late-lactation in which cows were buffer fed 3-NOP with silage by night, and were out grazing during the day yielded a 13% reduction in enteric methane (Costigan et al., unpublished data). This highlights further opportunities for the application of 3-NOP on farms that have mixing wagons whereby in addition to the 8-week dry period, 3-NOP may be buffer fed in early and late lactation, respectively, if grazing conditions are sub-optimal.

To evaluate the practical application of feeding additives on commercial farms, 3-NOP was fed to ~3,500 dry cows (across 18 Signpost farms) in a pilot study that took place over the winter of 2023/2024. Enteric methane was not measured as part of the pilot study, the 22% reduction achieved in the aforementioned study on dry cows was instead assumed. Focus groups were held with the participating farmers before and after the pilot study to share their experiences of feeding the additive. Each participating farmer's milk processor, together with the Signpost Programme collaborated to fund the purchase of the 3-NOP for their respective farmer. The ultimate objective of the study to show that we, as an industry, are harnessing the technologies available to us to reduce our methane emissions.

Asparagopsis

Asparagopsis is a red seaweed that contains the active ingredient bromoform. It is reported to have promising methane reduction potential (Hegarty et al., 2021), with reductions of between 27% and 67% in TMR feeding systems (Alvarez-Hess et al., 2024). To evaluate its efficacy in pasture-based systems, a trial was undertaken in Teagasc Moorepark in which grazing dairy cows were supplemented with freeze dried Asparagopsis twice daily at morning and evening milking. This trial was the first of its kind in grazing systems, and tested two different dietary inclusion rates of Asparagopsis (20 g/day and 40 g/day, respectively mixed with 2 kg of concentrate). The cows offered the higher inclusion rate of 40 g/day had higher refusals of the Asparagopsis and concentrate mix, therefore, there were similar reductions in daily enteric methane of ~24% across all cows offered the Asparagopsis.

Although milk solids were slightly lower in cows supplemented with Asparagopsis, this is likely due to the high concentrate refusals whereby the cows consumed up to 1 kg less concentrate per day. Milk samples were taken weekly throughout the trial and analysis is ongoing to ensure that there are no residues in the milk produced by the cows consuming the Asparagopsis.

Further work is being conducted to incorporate Asparagopsis within concentrate pellets to reduce feed refusals and improve the practicalities of its supplementation during the grazing season.

Conclusion

At present, 3-NOP has low efficacy when pulse fed to grazing dairy cows in concentrate feed at milking, however, the additive is effective during the winter housing period when it can be mixed throughout the basal diet using a mixing wagon.

Research with the red seaweed Asparagopsis has demonstrated high efficacy in reducing enteric methane when pulse fed twice daily to grazing dairy cows in concentrate during milking. Work is ongoing to improve the practicalities of feeding additives on commercial farms and to evaluate the effect of feed additives on animal performance, milk residues and economics. It is necessary to establish funding models for the use of anti-methanogenic feed additives on pasture-based farms.

Acknowledgements

The authors would like to express their gratitude to the farm staff and students in Moorepark for their care of the animals and for their assistance with data collection during the project. The authors would like to acknowledge the financial support of Science Foundation Ireland (FarmZeroC project (18/FIP/ZE/7558P)) and the Department of Agriculture, Food and the Marine and SFI through (VistaMilk (16/RC/3835)).

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Cover Crops on Irish Tillage Farms

Richie Hackett

Richie Hackett, Teagasc, Crops Research Centre, Oak Park, Carlow

Summary

- Cover crops reduce nitrate leaching
- Covers crops can contribute towards soil carbon sequestration
- Impacts of cover crops on direct GHG emissions is variable
- Reductions in fertiliser N in succeeding crop are difficult to predict
- Benefits of cover crops linked to the amount of biomass produced
- Cover crops can positively impact environmental sustainability on tillage farms but there can be a net economic cost

Introduction

Cover crops are species or mixtures of species grown over the autumn-winter period between two cash crops mainly for the purpose of generating some benefits for the cropping system rather that as cash crops themselves. Generally, they are not harvested, but in some instances may be grazed. Benefits of cover crops can include reduced nutrient loss, improvement of soil organic matter or carbon levels, reduced soil erosion, improved soil structural characteristics, improved biodiversity, reductions in pests and diseases of the following crops, increased nutrient supply to the following crop and yield benefits in the following cash crop. Cover crops also have some potential disadvantages including negative yield effects on the following crops. In addition they introduce additional costs both in terms of their establishment and destruction and careful consideration is required before adopting cover crops to ensure that they do not have a negative effect on profitability.

Currently there is considerable interest in cover crops as a measure to reduce nitrate loss to water and also a means of further improving the greenhouse gas balance of Irish cropping systems. Cover crops are being implemented on the majority of the Teagasc Signpost farms to improve the sustainability of the production systems on those farms. This paper aims to summarise research on cover crops as it relates to improving sustainability in an Irish context.

Cover Crops and N Loss to Water

In terms of nitrate leaching cover crops have been shown to substantially reduce leaching of nitrate in comparison to soil with no vegetative cover. Work at Oak Park found consistent reductions in the concentration of nitrate in the soil solution at 90 cm depth where a cover crop was established in mid to late August in a continuous spring barley rotation, in comparison to where there was no vegetative cover (Premrov et al. 2014). The work also indicated that natural regeneration, largely consisting of volunteer cereal plants where the soil was cultivated after harvest, could also reduce soil solution nitrate concentrations at depth (Figure 1). When the amount of N leached was calculated it was found that, compared to bare soil, a cover crop could reduce N lost by up to 52 kg N/ha and natural regeneration could reduce N lost by up to 21 kg N/ha (Premrov et al, 2014).All this work was carried out on a very leaching prone site (sandy soil overlaying gravel) and the benefits of overwinter vegetation on medium or heavy textured soils, in terms of nitrate leaching, may be more modest. The effects of a cover crop or natural regeneration on leaching, will be dependent on the amount of N accumulated by the cover crop before drainage occurs, which in turn will be linked to the growth or biomass production of the cover crop; the greater the biomass accumulation the greater the N uptake the greater the reduction in N leached.

However, the work clearly demonstrated the positive benefit both a sown cover crop and natural regeneration can have on reducing nitrate loss from Irish cropping systems when established in a timely manner.

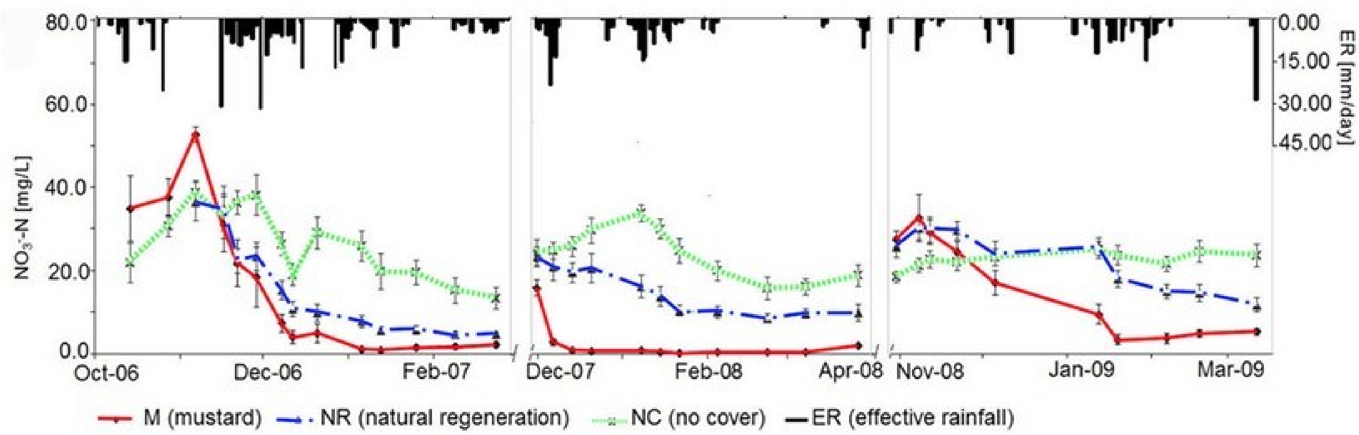

Figure 1. Effect of a cover crop (mustard), in comparison to natural regeneration and bare soil, on soil solution nitrate concentrations over the autumn winter period at 90cm depth (Premrov et al., 2014).

Cover Crops and Greenhouse Gas Emissions/Carbon Footprint

From a greenhouse gas/carbon footprint perspective cover crops, in comparison to soil without overwinter vegetation, can have effects, both positive and negative, through a number of routes, including increased carbon sequestration, reductions in fertiliser N requirements and changes in nitrous oxide emissions. The net effect of cover crops will be dependent on the magnitude of these individual processes.

Carbon Sequestration

The amount of carbon sequestered will be influenced by the amount of biomass accumulated by the cover crop and the degree to which the carbon in this biomass is retained in the soil when it is incorporated. Work at Oak Park has indicated that biomass production of cover crops is typically between 1 and 3 t/ha above ground dry matter, depending on factors such as species and sowing date.

Taking the 3 t DM/ha, assuming that there would be a further 30% present in root biomass and assuming a carbon content in the biomass of 43% would suggest a total carbon input to the soil via plant biomass of 1.68 t C per hectare. If it is then assumed that there is 20% efficiency of retention of that carbon as soil organic carbon (SOC), this would lead to an increase in SOC of 335 kg C per hectare. The actual efficiency of retention will be affected by a range of factors including the type of biomass incorporated (roots tend to show higher retention than aerial part, its C:N ratio and the soil type (clay soils are likely to retain a greater proportion than sandy soils). Assuming a depth of 20 cm and a bulk density of 1.3 g/cm3 this would lead to an increase of ~0.01 percentage points in SOC content per year. Thus, the effects of cover crops on SOC are likely to be relatively small and slow and will require repeated growing of cover crops over time to have a significant effect. This does not mean that agronomic benefits of cover crops require long periods to become evident. While total SOC may be slow to change there will be more rapid changes within different fractions of SOC, particularly in the more labile pools, which can often be more beneficial in agronomic terms than changes total SOC.

Fertiliser N Effects

Fertiliser N can account for over 70% of the carbon footprint of cereal crops in Ireland. Practices which reduce the fertiliser N requirement of cereal crops without leading to substantial increases in direct emissions or without having significant negative effects on grain yield have the potential to reduce the carbon footprint of cereal crops. Cover crops can accumulate substantial amounts of N during the autumn winter period, with amounts of over 100 kg N/ha being recorded in some situations, although amounts of 50-70 kg N/ha for cover crops sown in mid to late August might be more typical. However, when the cover crops are incorporated into the soil (or left on the soil surface after destruction) generally only a small and variable proportion of this N will become available to the succeeding crop such that it can be difficult to give precise recommendations as to the amount that fertiliser N inputs should be reduced by in any given situation. Factors influencing this variability include the quality of the material being incorporated, particularly in terms of its C:N ratio with material with a low C:N ratio (typically greener leafier material) more likely to release a greater proportion of its nitrogen to the subsequent crop. Soil conditions such as soil moisture status and soil temperature will also have a role to play. Research at Oak Park has indicated that the nitrogen benefit of non-leguminous cover crops is often negligible although work with cover crops with a substantial proportion of legumes has indicated that in this situation significant reductions in fertiliser N inputs could be made without compromising yield. Such cover crops have potential therefore to reduce the carbon footprint of the following cereal crop, but only if they do not cause a significant increase in emission of nitrous oxide and if the reduction in fertiliser N inputs can be predicted in advance of fertiliser N application.

Direct Nitrous Oxide (N_2O) Emissions

Nitrous oxide emissions as a result of residue decomposition contribute to the carbon footprint of arable crops. As cover crop biomass is returned to the soil, either by incorporation or left on the surface to decay, there is potential to increase nitrous oxide emissions.There is currently little Irish research on changes in nitrous oxide emission as a result of the introduction of cover crops to arable systems. A summary of a large number of studies from abroad indicated that cover crops didn't significantly change direct nitrous oxide emissions (Abdalla et al., 2019). However individual studies have found increases in N2O emissions as a result of cover crops particularly where a significant proportion of legumes were included in the cover crop mix (e.g. Kandel et al 2018, Olofsson and Ernfors, 2022).

Maximising the Benefits of Cover Crops

The magnitude of many of the benefits of cover crops is dependent on the total amount of biomass produced. In an Irish context the principal factor affecting the amount of biomass produced by a cover crop is its sowing date. Research has shown a significant reduction in biomass production by cover crops as sowing date is delayed from late July until early September (Figure 2). Biomass production and N uptake of crops sown after mid-September is likely to be limited in most years, particularly where drainage begins in early to mid-October, thereby reducing the amount of N available to the cover crop before it has been able to accumulate that N.

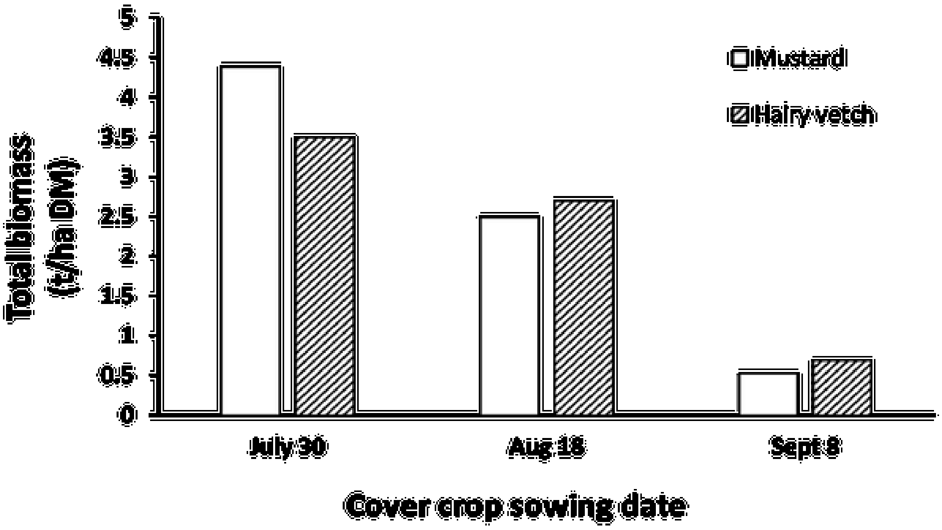

Figure 2. Effect of sowing date on aboveground biomass production by two cover crops at Oak Park, Carlow.

Conclusion

Cover crops can contribute positively to a range of environmental indicators for arable cropping in Ireland. There can also be positive agronomic benefits, although these benefits are not always consistent. For both environmental and agronomic benefits achieving good biomass production by careful species choice and sowing early is desirable. If any additional cost of establishing and destructing cover crops is not matched by increased returns from the cash crop cover crops may not be economically sustainable in the absence of external financial support.

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Reducing Greenhouse Gas Emissions from Agriculture by Finishing Beef Cattle at Earlier Ages

Paul Smith and Paul Crosson

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Summary

- Reducing the finishing age of prime beef cattle has been identified as a key greenhouse gas mitigation measure for the Irish agricultural sector.
- By reducing the finishing age of a beef animal, the total quantity of methane associated with bringing that animal to finish, is reduced.
- Between 2010 to 2022, the average finishing age of prime beef cattle reduced from 27.9 to 25.6 months.
- Challenging weather conditions in 2023, as well as reduction in the number of young bulls being produced, increased average finishing age to 26.1 months.
- Research is ongoing to identify the key factors impeding lifetime live weight performance on beef farms, and assess the barriers to technology adoption of key enabling measures.

Introduction

Reducing the finishing age of prime beef cattle (steers, heifers and young bulls) has been identified as a key greenhouse gas (GHG) mitigation measure for the Irish agricultural sector (Government of Ireland, 2024). The Teagasc Marginal Abatement Cost Curve (MACC; Lanigan et al., 2023), found that a reduction in finishing age by 3 to 3.5 months (from 26 months in 2018 to between 22 and 23 months in 2030), is estimated to reduce annual agricultural emissions by 0.47 to 0.73 Mt CO2 equivalents (eq.). Importantly, earlier finishing of beef cattle, not only has the potential to decrease the quantity of GHG emissions an animal emits over its lifetime, but is also likely to be economically advantageous, by lowering total costs associated with rearing an animal, and thus is a key contributor to on-farm profitability (Taylor et al., 2020; Kearney et al., 2024). However, while a significant reduction in the finishing age of prime beef cattle has been made over the past decade and a half, progress has slowed in more recent years.

In this paper we will firstly, outline the effect of earlier finishing on beef cattle GHG emissions. Following this, an overview of the prime beef cattle performance in both the years before and after the Climate Action Plan will be presented. Finally, some of the on-going research specifically targeted at facilitating an earlier finishing nationally, will be introduced.

Why target earlier finishing for beef cattle?

When cattle ingest feed, especially forages, they produce methane gas as a by-product of the digestive process. The methane produced in this digestive process, which is known as enteric fermentation, accounted for 24% of national GHG emissions in 2023 (EPA, 2024). The amount of methane produced via this process is largely driven by feed intake. Simply put, as an animal's level of feed intake increases, more feed is fermented in the rumen, which increases the supply of energy and protein to the animal, but also elevates the supply of substrates to methanogens (microbes that produce methane), leading to an increased synthesis of methane in the rumen. Based on work conducted by Teagasc Grange, across various different diets and animal types, including intensive finishing rations and pasture based diets, growing beef cattle have been shown to produce 22-27 g of methane for every kg of dry matter intake (DMI). Both rumen size and the voluntary feed intake of an animal increases in order to meet the nutritional demand of an animal as it grows. Thus, at the latter stages of an animal's life, when it is at its heaviest and thus consuming a greater proportion of feed, the quantity of methane an animal produces on daily basis is at highest. As a result, by reducing the finishing age of an animal, the total quantity of methane associated with bringing that animal to finish, is reduced.

Assuming a daily methane output of 230 g/day during the finishing period (Smith et al., 2021), reducing finishing age by one month can reduce emissions by 180 kg of CO_2 eq. per animal. In addition, unlike other technologies such as methane inhibiting feed additives which will likely add to the costs associated with rearing an animal, early finishing tends to be economically beneficial. Using data from commercial suckler-to-beef farms, Taylor et al. (2020), found that reducing finishing age by approximately eight months increased net margin by 22% while reducing total farm GHG emissions by 38%.

Why target earlier finishing for beef cattle?

As seen in Table 1, the annual number of prime beef cattle slaughtered, has maintained relatively stable over the period of 2010 to 2023. However, over this period, the average finishing age of the prime beef cattle population has reduced from 27.9 months in 2010 to 26.1 months in 2023. In particular, a significant reduction in the finishing age of steers has been observed over this period, with an average annual reduction of 5.6, 7.3 and 6.5 days for dairy × dairy, dairy × beef and suckler steers, respectively. Over the same time frame, average carcass weight has changed by -1.3, -0.7 and +0.8 kg per annum, respectively, indicating the potential to reduce finishing age with minimal impact on carcass weight. The increased availability of genetic tools (dairy-beef index, commercial beef value (CBV)) focused on the selection of dairy bred animals with a higher genetic merit for carcass traits, and increased usage of beef genetics, has the potential to mitigate further reductions, if not facilitate a potential increase in carcass weight of steers originating from the dairy herd.

As indicated in Table 1, the average finishing age of beef cattle in 2018 (base year for the Climate Action Plan) was 26 months of age. The mean finishing age of the prime beef cattle population had reduced to 25.6 months by 2022, with a reduction of 12, 10 and 34 days in the finishing age of heifers, young bulls and steers, with minimal impact on carcass weights. However, due to challenging weather conditions in 2023, as well as reduction in the number of young bulls being produced, average finishing age increased in 2023 and is now similar to that in 2018.

Table 1. Overview of the prime beef cattle population size and average finishing age.

Year	Prime cattle finished	Finishing age (months)			
		Average	Steer	Heifer	Young bull
2010	1,181,893	27.9	30.5	26.9	20.1
2018	1,269,359	26.0	27.9	26.0	19.4
2019	1,144,155	26.0	28.2	26.1	19.5
2020	1,318,358	26.3	27.9	26.1	19.5
2021	1,263,018	25.7	27.0	25.6	19.0
2022	1,281,522	25.6	26.8	25.6	19.1
2023	1,191,347	26.1	27.3	26.0	19.1

If the average annual reduction in finishing age over the past five years was re-established, finishing age would reduce to 25.6 months by 2030. Even if the annual decrease in finishing age that was proposed in the Teagasc MACC and the government's Climate Action Plan was achieved, finishing age would be nine weeks greater than that projected due to higher finishing age established in 2023. Therefore, in order to meet the targets that have been set, a substantial annual decline in finishing age over the next six years, will be required.

Ongoing Research

Nationally the mean age at finishing is six months later than achieved on grass-based high-performing commercial and research beef farms. The Teagasc lead Beef-Quest Project, recently funded by the Department of Agriculture, Food and the Marine (DAFM) will undertake a multifaceted approach to identify the key factors impeding lifetime live weight performance on commercial beef farms, and assess the barriers to technology adoption on farm. In collaboration with ICBF and UCD, 200 commercial beef herds have been enrolled in the Beef-Quest Project, as part of a new large-scale on-farm study aimed at determining the key animal nutrition, health and on-farm environmental related factors presently constraining growth performance, and subsequently influencing the finishing age of cattle on Irish farms. Data obtained from the on farm study, will be utilised to determine both the environmental and economic benefits associated with the optimisation of animal nutrition, health and on-farm environment, and subsequently aid the identification of the most effective on farm measures for reducing the finishing age of Irish beef cattle.

In addition to this, research is actively underway at Teagasc Grange, to assess the impact of early life nutrition on the lifetime live weight performance of cattle and the subsequent impact it has on producing a carcass that meets industry specification. This research is particularly pertinent to dairy-bred cattle reared within a grass based production system. For example, in 2023, only 13% of dairy-bred steers finished at under 24 months of age achieved the minimum industry carcass fat cover (2+) and produced a carcass weighing at least 280 kg.

Conclusion

Reducing the average finishing age of the prime beef cattle population is one of the main GHG mitigation strategies for the Irish agricultural sector. While steady progress was made up to 2022, this was reversed in 2023 due to adverse weather conditions. In order to meet finishing age targets, whilst minimising adverse effects on carcass output, a rapid increase in the lifetime live weight gain performance of Irish beef cattle over the next six years is urgently required.

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How Much Soil Carbon is Stored Under the Signpost Farms

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Summary

- Signpost programme and NASCO are vital to progress to robust Measurement, Reporting & Verification (MRV)
- Accurate national baseline of profile soil carbon is essential
- SOC stocks at depth are responsive to management and contribute substantially to the overall carbon stock
- Different soil types have different capacity to sequester carbon

Introduction

Global climate change is one of the most pressing challenges facing our planet, and soil carbon sequestration has emerged as a promising solution to mitigate this challenge. Soil carbon sequestration refers to the process of capturing and storing atmospheric carbon in soils. Soils, especially agricultural soils, have a huge potential to act as carbon sinks, helping to reduce atmospheric CO2 concentrations and mitigate the negative impacts of climate change. Understanding the dynamics of soil carbon (C) sequestration is critical to developing sustainable land management strategies and achieving climate change mitigation goals.

The National Agricultural Soil Carbon Observatory (NASCO) (Murphy et al., 2024) and the Signpost Programme are coherently combining knowledge, infrastructures and tools to establish Irish specific emission factors for soil carbon sequestration for inclusion in Ireland's National Inventory (EPA, 2023). Through these projects, Ireland has invested in the largest infrastructure in Europe to measure and report emissions and calculate C stored in the soil and biomass. The knowledge developed will further our understanding of carbon sinks and sources in Irish agriculture. Furthermore, it will support a transition to more refined emission factors for Tier 2 and Tier 3 approaches within National Inventory Reporting (NIR) under UNFCCC reporting requirements, rather than the current Tier 1 estimates. Integrating datasets will allow us to create a comprehensive carbon budget for Ireland that captures both dynamic fluxes and stable storage. The advanced techniques and tools used will improve our ability to quantify carbon sequestration, informing how soils can act as more effective carbon sinks, contributing to climate change mitigation.

Soil Carbon Sequestration: Insights from the Signpost Programme

The soil campaign from the Signpost Programme effectively addresses spatial variability with standardised and scientifically sound sampling techniques for a more detailed and accurate assessment of Soil Organic Carbon (SOC) stocks as national baseline of soil C in Irish farming systems (Figure 1).

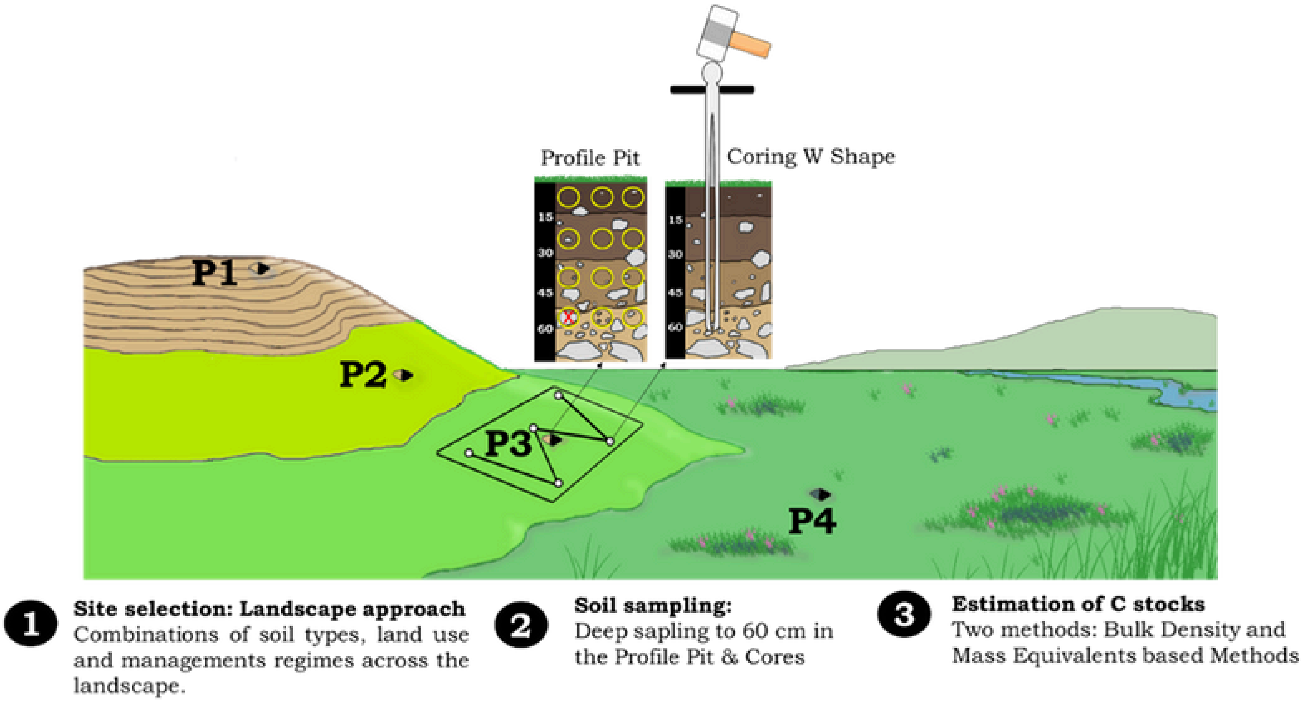

Figure 1: Method scheme for Site selection and sampling within the Signpost Programme

Through a network of participating farms, the Signpost programme collects comprehensive data on soil carbon stocks, greenhouse gas emissions and land management practices. This information is essential to understand the factors that influence carbon dynamics in Irish soils and to develop targeted strategies to maximise carbon sequestration potential.

Quantifying Soil Carbon Stocks: These data serve as a basis for assessing changes in carbon stocks over time in response to different management practices. (Bondi et al., 2024).

Assessing the Influence of Management Practices: The Signpost programme investigates the impact of different management practices, on carbon sequestration. By assessing the performance of different management practices, the programme aims to identify those that enhance carbon sequestration while minimizing greenhouse gas emissions (Bondi et al., 2024).

Developing Measurement, Reporting and Verification (MRV) Systems: The Signpost programme is involved in developing robust MRV systems to monitor and verify changes in SOC stocks. Accurate MRV systems are essential to assessing the effectiveness of carbon sequestration strategies and ensuring transparency and accountability in climate change mitigation efforts (Green et al., 2024).

The Deep Soil Sampling Campaign

In 2023-2024, the Signpost team sampled 67 farms, analysing 268 soil profiles and collecting more than 1000 soil samples. On each farm, four distinct sampling locations were selected at different landscape positions to capture diverse combinations of soil types, agricultural systems, and land management practices (Figure 1). Samples were taken at four soil depths (0-15, 15-30, 30-45, and 45-60 cm).

SOC stocks values for our farms range from 47.66 to 198.71 t ha^{-1} SOC stock up to 60 cm of soil. The results indicate that tillage farms overall exhibit the lowest SOC stocks, with an average of 89.81 t ha^{-1} SOC stock in the 0-60 cm soil profile. The topsoil in tillage farms recorded relatively low SOC stocks levels (34.56 t ha^{-1}) due to continuous tilling and harvesting activities. In contrast, SOC stocks in permanent grasslands were higher, with an average of 96.65 t ha^{-1} recorded within the full soil profile, and 45.69 t ha^{-1} concentrated in the first 15 cm — 32% more than in croplands. This increase can be attributed to the permanent grass cover, which reduces erosion and minimizes carbon loss to the atmosphere. For both systems, the highest carbon sequestration capacity, can be attributed to the Luvisols and Gleysols, associated with high clay content especially at depth (30-60 cm), which helps to protect carbon from microbial breakdown and retains it in the soil for longer periods of time (Torres et al., 2017). In general, SOC stocks are influenced by the interplay of soil types, agricultural systems, and management practices. Furthermore, SOC stocks at depths of 30-60 cm, though often overlooked, contributes meaningfully to total carbon stocks and remains responsive to management interventions.

Implications for Stakeholders

The Signpost Farm programme's findings highlight the significant potential of agricultural soils to act as carbon sinks, contributing to climate change mitigation efforts. Continued research and innovation in this space is crucial to unlocking the full potential of soil carbon sequestration for a more sustainable future. The Signpost programme provides valuable insights into soil carbon sequestration in Irish farming systems that can benefit several stakeholders.

Farmers: Signpost programme results provide farmers with practical information on management practices that can improve carbon sequestration on their farms. By adopting these practices, farmers can store carbon and mitigate the impacts of climate change, improve soil health, and potentially access economic incentives associated with carbon markets.

Policy makers: Signpost data supports the development of evidence-based policies and guidelines related to soil carbon sequestration in agriculture. This information can inform national climate change mitigation strategies, incentive programmes and reporting frameworks.

Industry: Carbon sequestration information generated by the Signpost programme can guide industry in developing innovative technologies, products, and services that support sustainable agricultural practices. This includes the development of soil carbon assessment tools, soil amendments, and management practices that enhance carbon sequestration.

Accurate SOC measurement and monitoring are key for identifying trends and enhancing sequestration strategies. Future research should focus on integrating C datasets to improve Tier 3 modelling for national inventories and decision tools like AgNav. Developing precise soil carbon models that reflect varied soil types, practices, and climates, along with enhancing MRV systems using remote sensing and machine learning, will ensure transparent carbon tracking. Improved soil mapping through high-resolution data will provide more accurate assessments. Additionally, understanding climate change impacts on soil C will guide adaptive management, strengthening Ag Nav's support for sustainable agriculture.

Acknowledgements

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Biodiversity and Stored Carbon

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Two of the goals for signpost participants is to protect and enhance carbon storage and biodiversity on the farm. Biodiversity on the farms is assessed by the quantity and quality of habitats and Carbon is stored on the farm in the soil and in the plants growing on the farm; the biomass. Soil carbon can only be assessed through soil sampling as discussed earlier in this report. Carbon stored in biomass and the distribution of on farm habitats are suitable to be assessed using remote sensing technology.

In the winters of 2022/2023 and 2023/24 a total of 92 signpost farms were surveyed using drone mounted cameras and LIDAR. The colour imagery taken by the drone gives a snapshot of the farm land cover and habitats. The LIDAR is a scanning technology the sends out laser pulses and measures the time it takes for the pulse to be reflected from the surface back to the drone (similar to RADAR), allowing a 3D picture of the farm to be built up of millions of points. This is the reason for flying in the winter, as it is more likely for a laser point to strike the ground beneath a tree, or a hedgerow, helping us get a fuller 3D picture.

The LIDAR points are converted into a Digital Surface Model, or DSM. This DSM is a representation, at very high detail, of the height of the surface of the farm (imagine a blanket thrown over the farm – the DSM is all the lumps and bumps visible). The DSM is combined with the drone images and other images from the national aerial survey. The drone pictures, captured in the winter, do not have as much information as data captured in the summer, so we use these earlier images to help interpretation.

This collection of data is then interpreted by a geospatial specialist to digitise by hand a high resolution biodiversity map. The classes mapped are based on the National Land Cover Map classes but adapted for signpost. The maps give a wall to wall hybrid land cover / habitat map for each block in each signpost farm. There are 45 possible labels with land covers including BUILDINGS, IMPROVED GRASSLAND and CROPS. Habitats include HEATH, SCRUB and WET GRASSLAND. Hedgerows and other woody biomass receive particular attention, with hedgerows split into managed (straight sided, topped), unmanaged (larger, less regular) and treeline (field boundaries largely made up of bushes/trees greater than 10m). Individual trees are also mapped. The habitats as a percentage of the total area are calculated and displayed as a bar chart and as a bar chart and as a total percentage (this is not the same calculation as space for nature). Values range from 3% of the farm to more than 15%.

These maps provide a baseline for the farmer and advisor – they show the structure of the habitat assets on the farm and help direct discussion about where and how to improve. For example showing where a short length of new hedgerow could go that would improve the overall connectivity of the farm habitats whilst also helping potentially to reduce run-off into water curses.

The maps are also used for the calculation of carbon stored in the woody biomass of the farm; hedgerows, woodland, forest, treelines, scrub and solo trees. The habitat maps allow us to extract LIDAR data for all these targets to calculate the biomass present. Each target has to be treated differently. For mature trees (woodland, treelines etc.) a technique known as automatic crown detection is used. Using the LIDARs ability to see through the canopy to the ground a new data set can be created called the Digital Terrain Model, DTM. This is sometimes called the bare earth model as it represents what the ground would look like with all the vegetation stripped away. Taking the values of the DTM away from the DSM, gives us a final product the Digital Canopy Model, DCM. The DCM is a 3D picture of the forests or trees and from this we can identify every individual tree and measure its exact height and width of its crown. With these two measurement we can estimate the biomass and thus the carbon in each tree.

The hedgerows rely on a different approach, created over a number of projects in Teagasc over the last decade. Using the DCM and map we can calculate the exact volume of a hedgerow and using equations developed in Teagasc convert that volume into biomass and thus tonnes of carbon.

It is important to think of volume when assessing how much carbon a hedgerow contains not its length. A short, tightly managed hedgerow will contain much less carbon (maybe as little as a 10th) than the same length of a wider, taller hedgerow that has also trees within it. The signpost farms assessed so far have stored within the woody biomass 100's tons of carbon. But it's important to note that this is carbon stored over the life of the farm-it is not the carbon sequestered annually by the farm biomass.

By the end of the year every farm flown will have a report containing a map and statistics of the farm habitat and carbon. Work has begun within two Teagasc Walsh Scholar PhD projects using this drone data to improve estimates of habitat quality (not just quantity) and to assess how best to reflect the small but important changes that farmers make on the farm that so far are not captured or valued.

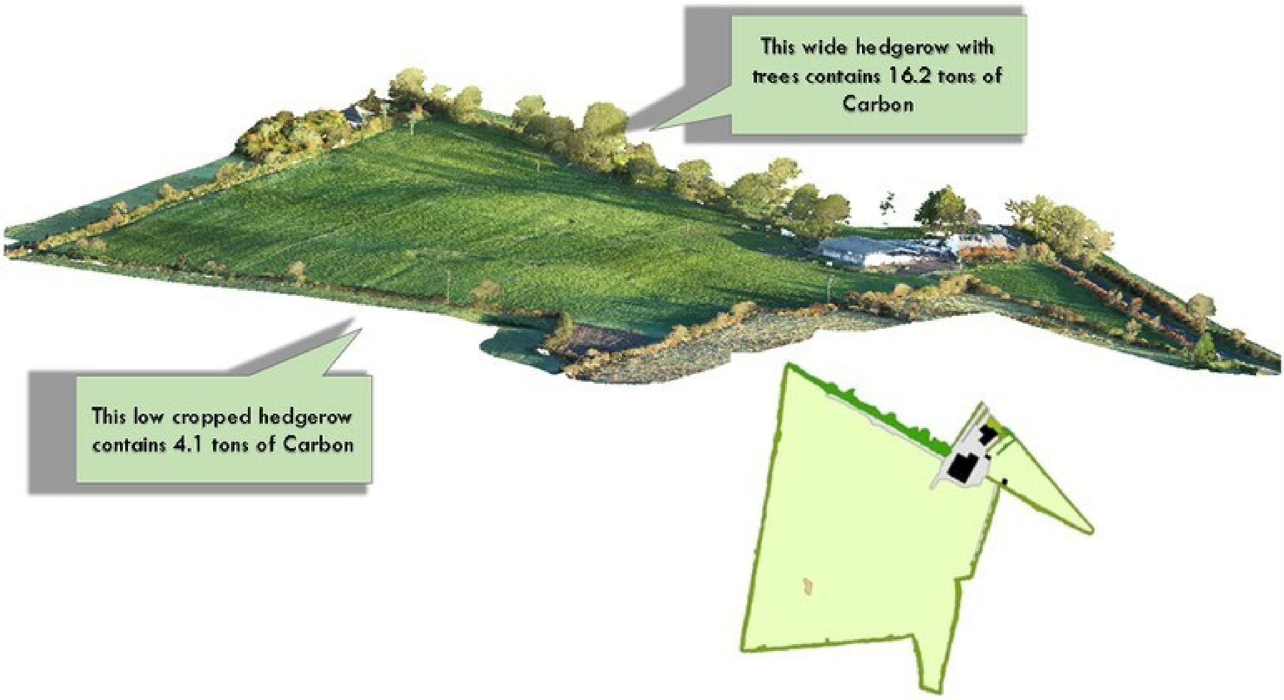

Figure 1. A 3D model of a signpost farm block, with accompanying habitat map. The figure shown is actual above ground carbon estimates for those two hedgerows (both the same length).

Beyond 2030- Pathway to net zero

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Summary

- There is an urgent need for rapid adoption of existing mitigation measures to meet 2030 targets
- Further development of emerging and new mitigation measure is required
- Continue research in improving understanding of factors influence soil carbon storage
- Need for increased afforestation rates and advisory on how forestry can be integrated with other agricultural systems
- Wider discussion on how we treat different GHG emissions and the global/regional food system is needed

Introduction

THE UNFCCC have acknowledge that human activities are causing an increase in average global temperature through the increase in atmospheric concentration of greenhouse gases (GHG). This is affecting climate patterns that can have devastating consequences on lives and the economies. The Green Deal is the EU's growth policy to create a cleaner, healthier and climate neutral Europe by transitioning the way we produce and consume. The EU Green Deal is Europe's contribution to the COP 21 Paris Agreement 2016 that brings all nations into a common cause to strengthen the global response to combatting climate change by keeping a global temperature rise to well below 2 degrees Celsius and to pursue efforts to limit the temperature to 1.5 degrees Celsius above preindustrial level. To achieve this goal the EU Green Deal has committed to reducing EU wide GHG emissions by at least 55% for 2030, with an ultimate goal of becoming the first climate neutral area in the world by 2050. Climate neutrality means the transition to a green economy where GHG emissions from anthropogenic (human) activities are balanced, or exceeded, by the removal of GHGs from the atmosphere, achieving net zero GHG emissions. The EU acknowledges that the transition to a climate neutral economy has challenges and highlights the need for a fair and just transition to include and support people most affected. This paper discusses Ireland's climate commitments up to to 2050, and focuses on its agricultural sector, what progress has been made, the roadmaps available, and what is needed to become a climate neutral economy.

Ireland's climate commitments

Ireland is supporting the EU Green Deal through implementing the Climate Action and Low Carbon Development Act 2021. The Climate Act supports Ireland's commitment to reducing national GHG emissions by 51% by 2030 (relative to 2018 levels), and to achieve a climate neutral economy by 2050. As part of the Climate Act, Ireland are committed to publishing an annual Climate Action Plan for the country. The purpose of the Climate action Plan is to establish roadmap to guide the Irish economy towards to ultimate goal of climate neutrality and will be published annually with the addition of new research and mitigation measures. For the intermediate 2030 climate targets the Irish government has set a 25% GHG reduction target (relative to 2018) for the agricultural sector. Agriculture's target is notably lower that the Electricity (-75%), and Transport (-50%) sectoral GHG reduction targets. This is from the Irish government acknowledging the difficulty in mitigation agricultural GHG emissions in comparison to fossil fuel dominated sectors. For the 2050 climate targets. This is important as it highlights that carbon neutrality is an economy wide target, requiring all economic sectors to work together.

Marginal Abatement Cost Curve 2021-2030

In 2023 the Irish agricultural sector emitted 20.8MT CO2eq, 2.9% lower than the baseline of 2018 (21.4 MT CO2eq), and a 4.6% reduction in comparison to the preceding 2022 production year (EPA, 2024). In fact, Agricultural GHG emissions have been reducing for the past three reporting years with further reduction expected for 2024. In contrast the EPA(2024) have projected LULUCF sector GHG emissions to increase come 2030. Teagasc published a new marginal abatement cost curve (MACC) (Lanigan et al. 2023) for the Agricultural and Land Use, Land Use Change, and Forestry (LULUCF) sectors. The purpose of the MACC is to summarise the science, and evaluate the cost-effectiveness of current technical measures that are available to farmers/landowners to reduce GHG emissions, and increase carbon sequestration and storage. The Teagasc MACC reports that while it is going to be challenging to achieve the Agriculture sectors 2030 target, it was not impossible with projected reduction potentials of 4.9 and 4.1 MT CO2eq for the Agricultural and LULUCF sectors, respectively. These projections are achieved through the rapid and ambitious adoption of measure occurring across the sector.

Towards 2050

The scope of the Teagasc MACC is up to 2030. Post 2030, Irish farmers will need new and improved GHG emission reduction and carbon removal measures to those in the most recent MACC to contribute to the economy wide target of climate neutrality. Promising measures requiring further research include the development of methane (CH4) reducing feed additives for ruminants, and slurry additive. Trials have been conduct on both with promising result to date. Going forward focus needs to be on the practicality of feeding/using additives in Irish systems, the safety of handling and using (i.e. residues) these products, how to bring these products to level, consumer perception, and lastly who is going to pay for the use of these products.

There are also opportunities to further develop well-established measure, breeding being a prime example. Significant resources have been invested into the measurement of enteric fermentation from Irish ruminants. This research will improve our understanding of factors influencing enteric CH4 production, including breeding with future opportunity to select and breed of low emitting ruminants.

Further research is required to improve our understanding of the factors influencing carbon fluxes from agricultural soils. Murphy et al. (2024) and Saunders et al. (2024) have previously highlighted the considerable research effort across Teagasc and the Universities to reduce uncertainties through the refinement of GHG emission factors and carbon sequestration rates for mineral and organic soils. This research will provide soil type specific land-use, land management, and climate emission factors that can be coupled with high-resolution soil maps. Current Irish soil maps are not at a scale that is appropriate for it to be used at field nor farm level. New soil maps are required, utilising more recent soil sampling and geophysical surveys of Irish soils. This information needs to be made available to farmers and advisors, providing field and farm specific soil maps.

The collection of more granular activity data is needed to measure and verify management change at farm level on its journey to climate neutrality. Data integration will be central in this process, compiling existing datasets residing in different locations rather than having to ask farmers again. AgNav, a digital sustainability platform, will provide farmers with information to support decision making on farm to help meet agriculture's climate targets. Over time, new data sources will be included to improve the quality and scope of the assessment and to reduce administrative burden on farmers. Advisory tools/resources such as AgNav should be connected to another to improve the efficiency of advisory service and to ensure there is consistent communication to farmers. Data governance will be key to this process as farmer data is being used.

Historically change has been incremental and not uniform across agricultural systems. Research is needed in determining what drives change around adoption across different cohorts of farms as a one size fits all policy approach is not likely to produce the desired level of adoption of mitigation measures. This research will identify barriers and enable policymakers to tailor a mix of instruments (e.g. incentives, regulation, education & extension) to enhance the uptake of mitigation measures. Take afforestation and water table management measures as examples, both measures are critical if Ireland is to become a climate neutral economy. There is a need for research and confidence building among landowners of the benefits (i.e. carbon capture, biodiversity) of such land uses/managements as a viable option to alternative agricultural systems.

How we treat GHG emissions

The IPCC's 100-year variant of the global warming potential (GWP100) metric has been formally adopted in international climate policy and widely used in standardised Life Cycle Assessment (LCA). The purpose of the GWP100 is to bring all GHGs to a common units, carbon dioxide (CO2) equivalent. When emitted CO2 persists in atmosphere for long period, therefore continued emission will result in the increase of CO2 concentration in the atmosphere. In contrast, when CH4 is emitted form a natural source, natural atmospheric removals limit the increase in atmospheric concentration when emission rate is constant. The GWP100 metric does not distinguish the above behaviour difference of short (CH4) and long-lived (CO2) greenhouse gases in the atmosphere. (Lynch et al, 2020). This is a significant shortcoming of the GWP100, particularly for the livestock sector as CH4 is the dominant greenhouse gas. In response, researchers have been developing alternative methodologies that accounts for the behaviour differences of short and long lives greenhouse gases (Lynch et al. 2020; Shine et al. 2007). Other researchers have called for countries to adopt a split gas approach when setting national targets to achieve climate neutrality by 2050. This approach sets a net zero target for CO2 and nitrous oxide emissions for 2050 and a separate reduction target for CH4 emissions. In preparation for post 2030, discussions at both a national and EU level on how we treat GHG emissions are needed.

Feed/Food competition

An increasingly popular topic is the use of human edible food for animal feed and its impact on food security and resource use. Current livestock systems are engaged in feed-food competition, however this needs to be minimised to meet future food demand, minimise associated environmental impact, and prevent further increase in resource use (i.e. deforestation for agricultural land). Several metrics have been developed to measure the net contribution of livestock to the supply of human digestible protein, such as the edible protein conversion ratio (EPCR) and the land-use ratio (LUR). The EPCR compares the amount of human digestible protein in animal feed over the amount of human digestible protein produced. The LUR goes a step further where it also account for the potential human digestible protein from a crop grown on the land used to produce the livestock feed. In an analysis of the Irish food system Hennessy et al. (2021) calculated that all ruminants provide a positive contribution to global food production when operating on land unsuitable for crop production, however when the crop opportunity cost of land used is accounted for only dairy and sheep have a positive contribution. This raises the question on how and where food should be produced. From a food security and resource use perspective, this would indicate that global ruminant production should occur in regions/countries where land use competition with human edible crop production is minimal. In theory this optimised regional/global food systems approach makes sense, however the economic and social implications of such structural change must be addressed. Furthermore, this regional/global food system approach is at odds at national level climate policy.

Conclusion

There is an urgent need for rapid adoption of existing mitigation measures to ensure the Ireland's Agriculture sectors achieves the intermediate 2030 targets set out in the National Climate Action. To achieve the ultimate climate objective of becoming a climate neutral economy, the sector needs further development of current and new emerging technologies, the integration of afforestation into agricultural systems, improving understanding of factors impact soil carbon, and research in determining drives adoption. Wider discussion is needed around how we treat different GHG emissions and how we produce food.

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