Sustainability in Agriculture

The Science & Evidence

TUESDAY, 5 NOVEMBER 2024

TEAGASC, ASHTOWN
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Teagasc
Agriculture and Food Development Authority

Contents

Foreword

Sustainability is the guiding principle in agri-food systems globally. In Ireland, this means balancing economic viability, environmental stewardship and social equity in order for agriculture to play a central role in the economy and rural livelihoods. Sustainability is at the heart of agricultural policy in Ireland and the European Union, that seeks to feed a growing global population with healthier food in a sustainable way. The vision of the FoodVision 2030 strategy for the Irish agri-food sector is that Ireland will become a world leader in sustainable food systems.

In Ireland, approximately 4.5 million hectares of land is used for food production, representing 76% of our land area. Livestock dominate Irish agriculture, and grassland constitutes about 92% of agricultural land use, far higher than any other country in Europe. This is driven by soil type, climate, relative scale of farms and the relative economics of different enterprises. On average over the three years 2021-2023, the agri-food sector contributes about 6% of Gross Value Added at factor cost to the economy, 8.5% of employment and €16.1 billion exports. As a major driver of rural development, agriculture contributes to the social fabric of rural Ireland and has a complex interaction with the natural environment.

Our reputation for producing high quality, safe food with a low carbon footprint is set against the background of challenges and targets to reduce gaseous emissions, improve water quality and protect and enhance biodiversity. And whilst sustainability is often viewed through an environmental lens, the long-term economic and social viability of our farm systems is equally important. Within the environmental pillar of sustainability, there is often a singular focus on greenhouse gas emissions or the carbon footprint, but we know environmental sustainability is much broader than carbon alone. Environmental sustainability also includes impacts, both positive and negative, on water use and quality, ammonia, biodiversity, and the overall impact on the landscape. Ruminant fill a unique ecological niche by re-cycling or upcycling human-inedible feed into edible foods which has a high nutrient content and nutrient bio availability. Livestock, particularly grass-fed ruminants, play a very important role in maintaining soil carbon and enhancing soil quality through the return of animal manures to soils producing food and feed. These features make livestock an indispensable part of a sustainable food system. Thus the assessment of sustainability of livestock is complex, and bigger than any one indicator and requires analysis across a range of impact indicators across a range of system boundaries.

This conference, titled **Sustainability in Agriculture: *The Science & Evidence*** brings together leading experts to put forward the sustainability credentials in our livestock systems. In our opening session our keynote speakers will set out the global and Irish context of the sustainability of livestock systems. We then explore the nutritional value of the food we produce, the drivers of consumer trends and behaviours and unravel the indicators of environmental economic, and social sustainability in Ireland. A key priority for Teagasc at this point in time is to provide leadership and support to the agri-food sector as it changes and adapts to meet these challenges and in our final session today we will take a look at how we support farmers transitioning to more sustainable practices through our education and training programmes.

The contributions of farmers, industry, policy and consumers in our panel discussion will provide an important reflection on how we can shape the future of sustainability, and I invite you to be part of this critical conversation.

I would like to extend my thanks to the chairpersons, speakers and panellists who have contributed their time and expertise in making this conference happen and my gratitude to Teagasc colleagues for organising this event.

Frank O'Mara

Prof. Frank O’Mara
Director

Speaker Biographies

Dr. Badi Besbes

CHIEF, Sustainable Animal Production, Feed and Genetics Branch of the FAO Animal Production and Health Division

Dr. Badi Besbes has 30 years of experience in the management of animal genetic resources. He holds a Master’s degree in Animal Science and a PhD in Animal Genetics. Before joining FAO in 2006, he worked 14 years in the poultry breeding industry. He also has good experience in supporting inter-governmental policy processes, first with the Intergovernmental Technical Working Group on Animal Genetic Resources, under the Commission on Genetic Resources for Food and Agriculture, and now with the Committee on Agriculture’s Sub-Committee on Livestock, of which he is the Secretary.

Dr. Daire Ó hUallacháin

Principal Research Officer, Teagasc

Dr. Daire Ó hUallacháin is a Principal Research Officer with Teagasc (Environment, Soils and Land-Use Department). Daire has over 20 years’ experience, undertaking research on water quality, farmland ecology and wider agri-environment themes. His applied research focuses on identifying and assessing measures and management practices needed to achieve Biodiversity and Water Quality objectives. These collaborative (national and international) studies cover a range of enterprises and a gradient of farming intensities, from intensive farms through to High Nature Value farming and forestry. His research aims to support policy-makers in making informed decisions and to influence practice amongst wider stakeholders.

Deirdre Ryan

Director of Quality Assurance and Origin Green

Deirdre Ryan is Director of Sustainability and Quality Assurance, (Origin Green) in Bord Bia where she is responsible for the strategic development and management of national quality assurance and sustainability programmes for the Irish food and drink’s sector. Prior to her appointment, Deirdre was Head of Sustainability for Lidl Ireland & Northern Ireland where she led the development and implementation of their first sustainability strategy. Deirdre has also held positions with leading dairy exporter Ornua, Nestle Switzerland, and Metro Group. Deirdre worked as a management consultant and in financial services before moving into the food industry. Deirdre has served as a member of the board of Sport Ireland since 2021.

Dr. Emma Dillon

Economist and Senior Research Officer with the National Farm Survey

As an Economist and Senior Research Officer with the National Farm Survey, Dr. Emma Dillon has a multi-faceted role in terms of survey design, data analysis and reporting of key trends in contemporary Irish agriculture. Primarily through policy modelling at the farm level, research areas of interest include measuring sustainability for policy monitoring and evaluation, and structural change on Irish farms. She has been involved in the development of social sustainability metrics, both internal (to the farmer) and external (for broader society) in the NFS over the past decade. These metrics are now being further developed through the MEASURE and GENFARMS projects, recently funded by the Department of Agriculture, Food and the Marine.

Jane Stout

Vice President of Biodiversity and Climate Action, Trinity College Dublin

Professor Jane Stout is the Vice President for Biodiversity and Climate Action in Trinity College Dublin. Jane is an internationally renowned expert on pollinator and pollination ecology, and a prominent voice for biodiversity and its value. Her research seeks to understand how land management practices, including agriculture and urbanisation, affect ecological processes and the benefits of nature for humans. Jane works across disciplines, and with a broad range of stakeholders in public and private organisations, to improve environmental policy and practice. She leads a large team of researchers in the Plant-Animal Interactions Research group in Botany, in the School of Natural Sciences in Trinity. She is co-founder and former Chair of the Board of Natural Capital Ireland, and co-founder and deputy Chair of the All-Ireland Pollinator Plan.

John Kelly

Principal of Teagasc Ballyhaise Agricultural College

John Kelly has an extensive 23-year career in Teagasc Colleges, beginning his journey at Kildalton and Clonakilty before joining Ballyhaise in 2013. As the leader of Ballyhaise, the only agricultural college in the northern half of Ireland, he has played a vital role in expanding its educational programs and facilities. During his tenure, Ballyhaise has grown from offering seven to eleven programs, now serving over 800 students. Central to his vision is the focus on sustainable agriculture, particularly through a strong partnership with Dundalk Institute of Technology (DkIT) in co-delivering degrees in Sustainable Agriculture. This collaboration underscores Ballyhaise's dedication to addressing the evolving technical and environmental challenges in modern farming. Kelly has also spearheaded significant investments in the college's 220-hectare farm and teaching facilities, which include Ballyhaise House, dairy and beef herds, sheep, and woodlands. These improvements provide students with invaluable hands-on experience in sustainable farming practices, reinforcing the college's standing as a leader in land-based education.

Speaker Biographies contd.

Dr. Jonathan Herron

Research Officer, Livestock Systems, Teagasc

Dr. Jonathan Herron is a Researcher Officer in the Livestock Systems Department of Teagasc Moorepark. He is one the lead researchers in the development of the AgNav sustainability platform in collaboration with ICBF and Bord Bia. He supervises a team of PhD students and post-doctoral researcher in the areas of life cycle assessment, bio economic modelling, and integrated farming systems. He has a number of publications in the area of life cycle assessment and has recently secured funding from the Department of Agriculture Food and the Marine for the continued development of the AgNav platform to expand the scope of the assessment to include all major agricultural systems and environmental impact categories.

Dr. Karl Richards

Senior Principal Research Officer, Teagasc

Dr. Karl Richards is a Senior Principal Researcher Officer at Teagasc. He leads the newly established virtual Teagasc Climate Centre. He led a team of researchers in the area of nitrogen cycling including the impact of management practices on reducing Nitrogen losses (nitrous oxide, nitrate leaching and ammonia). He has published extensively on measures to reduce nitrous oxide and nitrate emissions, including leading the protected urea research that commenced in 2012. Internationally, he has worked on a range of Internationally funded competitive research projects, was a member of the EU Nitrogen Expert panel, a national representative on the Global Research Alliance and has published over 180 scientific papers.

Sinead McCarthy

Research Officer, Teagasc Food Research Centre, Dublin

Dr. Sinéad McCarthy holds a PhD in Public Health Nutrition from University College Cork and is a Senior Research Officer at Teagasc where she is responsible for leading the research programme regarding consumer food behaviours. For more than two decades, Sinéad has been involved in many areas of nutrition research, with a focus on food and health. Sinéad's research career has ranged from human nutritional physiology and public health nutrition, designing and managing national food consumption programmes and consumer behaviour. Sinéad has extensive experience working on a range of National and European funded research projects addressing food choice motivation and health, healthy aging and nutrition for senior consumers and food sustainability. In the area of sustainability, Sinéad is researching sustainable food consumption patterns, sustainable dietary guidelines, as well as additional food sustainability measures such as food waste behaviours and organic food purchasing behaviours. Sinéad has published extensively in peer review journals and widely disseminated her research both national and internationally across a diverse range of audiences from government officials to primary school children! Sinéad contributes to national food policy issues as a committee member the Food Safety Authority of Ireland and was a former board member of Safefood. Sinéad was vice chair of the European Sensory Science Society (2019-2021). Sinéad also currently sits on the EU expert group on general food law and sustainability of food systems.

Trevor Donnellan

Head of the Agricultural Economics and Farm Surveys Department, Teagasc

Trevor Donnellan is an economist and Head of the Agricultural Economics and Farm Surveys Department at Teagasc. His research centres on the economic analysis of agricultural markets, with a particular emphasis on the intersection of agricultural, trade, and environmental policy affecting the agri-food sector, using the well-known FAPRI-Ireland model. Through his work, he aims to inform stakeholders and support evidence-based policymaking. His work also covers short-term market analysis associated with agricultural output, commodity prices and agricultural incomes. Trevor is an author of the National Farm Survey Sustainability Report, which evaluates the economic, environmental, and social sustainability of different farm types in Irish agriculture. He serves as a member of the Climate Change Advisory Council's Carbon Budgets Working Group. With extensive experience on international projects, Trevor has explored various issues surrounding the economics of the agri-food sector at both national and EU level. He also advises the European Commission as an external expert on the medium-term outlook for the EU agricultural sector.

The Sustainability of Ireland’s Livestock Systems

Laurence Shalloo and Jonathan Herron
Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Summary

- Total Irish agricultural greenhouse gas emissions are approaching 2016 levels. (Irelands dairy and beef carbon footprints are one of the lowest in the world, with plans to reduce further through increased productivity and efficiency, adoption of technologies (e.g. protected urea).
- Blue water use on Irish dairy farms is substantially below most other countries in the world due to the abundance of rainfall, low purchased concentrate and lack of irrigation in the production systems.
- Irish dairying and beef production systems are a significant net contributor to the production of human digestible protein. Even when the opportunity potential of land suitable for arable production is accounted, dairy and dairy beef systems remain land use efficient.
- Land use planning and the location of dairy and beef production systems has a dramatic effect on the net human edible food contribution of Irish beef and dairy.

Introduction

Livestock play a vital role in the global food system, but are questioned because of their impact on the environment, particularly on climate change in the case of ruminants. In addition, for some people the direct (e.g. wheat and other primary grains, etc) and indirect (use of arable suitable land for pasture) feeding of human-edible food to livestock is questioned. On the other hand, the role of livestock in upcycling and recycling non-human edible materials into the food chain is well recognised, as is their contribution to soil health through manure recycling and increasing organic matter in the soil. It is important to recognise that in pasture based settings like the Irish example the manure produced by animals is almost exclusively directly recycled by the animal through the grazing process. Approximately 20% of the manure nutrients are produced during the housing period with the remainder returned to pasture directly by the grazing animal and in most cases the slurry produced indoors is also returned to the area used to produce the forage. This paper examines the performance of Irish dairy and beef production with regard to some of these attributes, and makes some international comparisons where possible, before outlining how further improvements can be progressed in the pursuit of increased industry sustainability.

1. Carbon Footprint

Carbon footprints are calculated to estimate the embedded GHG emissions associated with the production of products. Carbon footprints are calculated using life cycle assessment (LCA) models, where agricultural LCAs typically adopt a cradle to farm gate boundary, meaning all GHG emissions along the supply chain up to the farm gate are accounted. This includes GHG emissions associated with the production of farm inputs and the GHG emissions produced on farm. The main sources of GHG emissions within the farm gate are enteric and manure methane, nitrous oxide associated with soils, and carbon dioxide from fuel use, lime use and from urea fertilisers. Upstream (pre farm gate) GHG emissions are largely associated with the production of purchased feeds, electricity, and the consumption of energy for fertiliser production. The functional unit for dairy and beef LCA's are generally fat and protein corrected milk and carcass weight, respectively. Dairy farms are multifunctional, producing both milk and meat. As the processes in producing these co-products are intertwined, LCA methodologies use an allocation technique to distribute GHG emissions between the co products (milk and meat) using a variety of different approaches from economic to biophysical which make comparison across studies difficult.

It is notoriously difficult to compare the carbon footprint of agricultural products from different countries. The difficulty arises due to inconsistent LCA methodologies being applied across studies (e.g. system boundary – where emissions counting starts and stops). To address these inconsistencies international standards and guidelines around LCA methodology have been published. However there will always be inherent differences in LCA methodologies due to structural differences (e.g. data collection, annual vs monthly time step), and different tiers (e.g. country specific emission conversion factors) being used to calculate GHG emissions. Notwithstanding the above, different approaches have been applied to compare carbon footprints. The 2010 EU JRC report (Leip *et al.* 2010) is commonly referenced when comparing the carbon footprint of beef and dairy. In this report Ireland was ranked among the lowest in the EU. However, it is no longer appropriate to reference this study as it is based on activity data from 2002. Alternatively, O'Brien *et al.* (2014) compared Irish pasture-based dairy system with a high-performance United Kingdom (UK) confinement system, and a top-performing US confinement dairy system, and more recently Sorley *et al.* (2024) compared pasture based systems with indoor systems in Western Europe, both studies using consistent LCA methodological approaches and finding pasture based systems to have lower carbon footprints and GHG emissions per hectare than indoor systems. A New Zealand study by Mazzetto *et al.* (2023) took an alternative approach of compiling and comparing "nationally representative" publications to compare studies. This type of approach should be avoided as the comparisons used had different methodologies (even though the authors tried to correct for approaches), the data was from different years and finally there was a wide variety of approaches used to collect representative data. In reality this is the most important issue with the overall approach as there can be huge differences in individual farms and groups of farms in relation to their carbon footprints.

The FAO's Global Livestock Environmental Assessment Model (GLEAM) presents an option for such comparisons where it calculates GHG emissions from livestock systems in different world regions using a consistent LCA methodology. The GLEAM modelling framework puts the Irish dairy carbon footprint at 1.02 kg CO_2eq /kg of milk which was the lowest in all of the comparisons with New Zealand/Australia (1.14), North America (1.30), EU 27 (1.41) and the global average (2.01). Similarly, GLEAM puts the Irish beef carbon footprint among the lowest of global regions at 15.0kg CO_2eq per kg carcass, lower than the average for the EU (15.8), North America (15.9), South America (52.8), and Australia/New Zealand (18.9). While GLEAM is effective in allowing across region comparisons, it's scope makes it difficult to allow country specific emission factors to be used and the use of a generic structure not optimal for every system type. More complex LCA models have subsequently been developed within countries that better reflect their systems, allow the use of country specific emission factors, and better capture within country actions to reduce emissions which can be difficult to account for within the GLEAM structure.

The most recent published carbon footprint of Irish milk is one of the lowest in the world (Herron *et al.,* 2022). The published analysis shows that the average dairy carbon footprint of Irish milk was 0.97 kg CO_2e/kg fat and protein corrected milk yield (FPCM) (Herron *et al.,* 2022) based on average performance data between 2017 and 2019. When this is updated for 2022 data the average carbon footprint drops to 0.94 kg CO_2e/kg FPCM. Recent Irish research on enteric methane emissions from dairy cows while grazing or indoor on grass silage suggest that the current methane conversion factors is over estimating the emissions from dairy cows in Ireland (Lahart *et al.,* 2024a; Lahart *et al.,* 2024b). When these new emission conversion factors are applied, the Irish carbon footprint for dairy reduces to 0.88 kg CO_2e/kg FPCM.

While Ireland's carbon footprint is in a strong position at present, the research target for the dairy industry sees that footprint drop from 0.88 today to 0.63 kg CO_2e/kg FPCM under the future systems identified in the Teagasc Dairy Roadmap 2030 with technologies that are in place today and are being deployed at farm level today. When sequestration is included within this figure based on 1.8t CO_2e/ha/year the carbon footprint becomes much closer to 0.50 kg CO_2e/kg FPCM for the most technically efficient farms. The reduced emissions are achieved through a reduction in fertiliser N use, substitution of CAN based fertilisers with urea based fertilisers, increased productivity from grazed grass with better dairy cow fertility. Lower levels of supplementary feeds while changing the source of the imported feed ingredients to avoid land use change emissions, and finally the inclusion of feed additives both for slurry methane abatement as well as enteric methane abatement during the non-lactating period where animals are indoors and additives can be mixed into the forage based diet through a TMR.

2. Feed/Food competition

There is considerable debate on the use of human edible food to feed animals and its impact on food security. Current livestock systems are engaged in feed-food competition which needs to be minimised to meet futre food demand. Several metrics have been developed to measure the net contribution of livestock to the supply of human digestible protein (HDP), such as the edible protein conversion ratio (EPCR) and the land-use ratio (LUR). The EPCR compares the amount of HDP in animal feed over the amount of HDP in the animal product. The LUR compares the potential HDP from a crop grown on the land used to produce the livestock feed against the HDP in that livestock produce. There is limited research conducted in this area internationally, particularly around pasture based systems. While food production must increase to satisfy global demand for animal based proteins, there is also an increasing need to minimise associated environmental burdens. Thus there is need to move the question on from not only what people should eat but to also where and how should that food be produced to ensure there is balance in the overall debate.

The analysis in Table 1 (Hennessy *et al.,* 2021) shows that there is significant system differences in terms of EPCR and the LUR. For both metrics dairy has the lowest (best) values. In essence, Table 1 shows that Irish dairy is providing a positive contribution to global HDP production, even where the crop opportunity costs of the land (based on suitability of the land for cropping) used for dairy are taken into account (LUR). When higher LUR values (i.e. >1) are taken into account, in conjunction with some of the negative externalities associated with ruminant based agriculture, there is a question of whether it makes sense that animals are fed human edible feed, or should occupy land that could be used to grow crops for food for humans. From a food security and resource use perspective, there is also a question of whether more of the ruminant products globally should originate from regions and countries where ruminants do not compete with land use for human edible crop production, such as from large parts of the Irish land base.

Table 1 Edible Protein Conversion and Land Use Ratio values of Ireland’s ruminant livestock sector.

	Dairy	Dairy Beef	Suckler Beef	Sheep Meat
EPCR	0.18	0.42	0.29	0.21
LUR	0.47	1.08	1.25	0.95

It is clear from Hennessy (2021) that there are substantial differences in the digestibility of foods of different origins. It is common place for the environmental impact of different food types to be compared on a per kg of product or per unit of protein basis. When evaluating one form of food versus another digestibility and nutrient availability must be taken into account. Hennessy *et al.* (2021) showed the digestibility score of one protein source against another can be dramatically different. Depending on the protein source when the digestibility and amino acid profile was taken into account the animal sourced proteins nutritional value increased dramatically relative to plant sourced proteins. Other considerations that need to be included in the overall process are around micro nutrient sources as well as the bioavailability of the nutrients that are offered (Hupertz 2021). There is a need to move to these types of comparisons relative to the required nutrients to ensure that the outcome would include balanced diets as well as more sustainable diets.

3. Water Use

Relatively high rainfall and extremely low water scarcity values means that Ireland has a very low blue water footprint for milk production. A water footprint (WF) measures the amount of water used to produce a product, in this case meat and milk. In general, the WF can be broken into three figures: green, blue and grey. The green WF measures water from precipitation that is stored in the root zone and used to grow the feed consumed by the animals. Blue water is sourced from surface or groundwater and is used in the production process, e.g. animal drinking water or irrigation. Grey water is the soiled water that leaves the system from washings, yards, etc. A analysis across 24 intensively monitored dairy farms has shown that blue water consumption was 6 l water/kg FPCM in Ireland (Murphy *et al.,* 2018). This compares to 110 kg/kg FPCM in the US (Rotz *et al.*, 2024) and 66 L for the Netherlands (De Boer *et al.,* 2013). An Irish study which was completed around the blue water footprint of beef farms showed the average blue water footprint to be 169 l /kg of carcass with only 64 L of that occurring on the farm with the remaining water use being associated with the concentrate production (Murphy *et al.,* 2018). A study of the volumetric water footprint of beef and lamb meat in the United Kingdom (Chatterton *et al.,* 2010) quantified a UK national blue water use of beef at 150 L per kg of carcass.

The differences in blue water use are mainly driven by differences in irrigation across country in conjunction with the blue water use associated with imported feed, coming into the system. Even though Ireland’s blue water use is extremely low it can still be reduced through prompt repair of leaks, recycling plate cooler water and integration of high pressure washers in the washing process. While not directly affecting blue water use, there is scope to introduce rainwater-harvesting systems on farm which would help reduce the energy associated with water pumping.

4. Ammonia Emissions

Ammonia emissions are associated with the acidic deposition onto ecosystems, and the formation of secondary particulate matter. Agriculture accounts for 99.4% of the NH_3 emissions in Ireland with 47.7% of the emissions associated with manure housing and storage, 26.4% with slurry spreading, and, on average, 14.0% and 11.2% with N fertiliser and manure deposition at pasture, respectively. Total NH_3 emissions are above the national ceiling target set as part of the NEC (National Emissions Reduction Directive) since 2016, with a substantial jump in NH_3 emissions in 2018 to 142 thousand tonnes. Teagasc produced a marginal abatement cost curve for NH_3 emissions in 2020 (Buckley *et al.*, 2020). This showed the technologies to reduce ammonia in conjunction with the associated costs. The outcome of that analysis showed that in order to reduce NH3 emissions to meet NEC Targets the sector must adopt Low Emissions Slurry spreading technology, in combination with protected urea and covered slurry stores. Since this time period Ireland has reduced its NH_3 emissions by 9.6% through the adoption of such technologies along with changes in livestock populations. This trend is reflected in the Teagasc NFS Sustainability Report where NH_3 emissions per hectare and per kg product have reduced for both dairy and cattle farms. While this trend is positive, further adoption of measures is required to bring national NH_3 emissions under the emissions ceiling.

Going Forward

There will be increased pressures to focus on both water quality and enhancing the biodiversity status of farms. The most recent analysis of the EPA suggests that water quality status in Ireland is stable but not improving. There is a requirement to reduce nutrient loss to water in order for water quality to improve. Key to this process will be identifying the loss pathways and putting mechanisms in place to reduce the loss. The recently launched Teagasc's Better Farming for Water, 8-Actions for change initiative breaks down measures based on nutrient management, farmyard management and land management. A focus on each of these areas will be central to reduce nutrient loss.

There is increasing interest in biodiversity at farm level. Biodiversity (the variety of plant and animal life in a habitat) is declining globally (IPBES, 2019). There are many causes for this decline, some related to farming. Actions can be put in place to reverse the decline. Key to this process is recognising that there is a problem and identifying actions that could help to reduce the loss. On the average farm in Ireland, approximately 10.0% of the farm area can be described as natural or semi natural; these areas include hedgerows, streams, field margins, etc. On beef farms, the level of enriched space is higher than dairy farms. These levels contrast well with European farms. Typically dairy/beef farmers are not high users of pesticides which can be damaging from a biodiversity perspective.

Conclusion

Irish ruminant agriculture performs well form a sustainability perspective when compared to other countries. However there is scope for further progress to be made across all sustainability metrics. There is a requirement to decouple sustainability impacts from the agricultural systems operated. There are technologies that are being implemented at farm level that allows that progress to be made and there is significant progress being made at research level to deliver on a pipeline of new solutions for the future. International comparisons across most metrics suggest that Irish beef and dairy perform well when compared to other countries. There is a requirement for robust infrastructure to be developed to allow comparisons between countries and systems operated within countries in order to draw conclusion on the sustainability of one system against another for a whole range of metrics. However, regardless of the above comparisons, the agrifood industry needs to focus on improving the environmental performance of their production systems.Future International debate on increasing global sustainability through the diet should also include the location of food production as well as the quality of that food relative to human needs at both a macro and a micro level.

Reference

Buckley C., Krol D., Lanigan G., Donnellan T., Spink J., Hanrahan K., Boland A., Forrestal P., Humphreys J., Murphy P., NiFhlatharta N., O'Brien D., O'Dwyer T., O'Mara F., Richards K., Shalloo L., Wall D., Waters S. (2020). *An Analysis of the Cost of the Abatement of Ammonia Emissions in Irish Agriculture to 2030*.

Chatterton J, Hess T. and Williams A. 2010. *The water footprint of English beef and lamb production*. Retrieved on 12 June 2014 De Boer, I.J.M., Hoving, I.E., Vellinga, T.V., Van de Ven, G.W.J., Leffelaar, P.A., Gerber, P.J., 2013. Assessing environmental impacts associated with freshwater consumption along the life cycle of animal products: the case of Dutch milk production in Noord-Brabant. Int. J. Life Cycle Assess. 18, 193 - 203.

Hennessy DP, Shalloo L, Van Zanten HHE, Schop M, De Boer IJM (2021). *The net contribution of livestock to the supply of human edible protein: the case of Ireland*. The Journal of Agricultural Science 159 (5-6), 463-471.

Herron J., O'Brien D., Shalloo L. (2022). *Life cycle assessment of pasture-based dairy production systems: Current and future performance*. J. Dairy Sci. 105:5849–5869.

Hupertz T. (2021). *Healthy and sustainable diets: providing nutrition, not only Nutrients*. New Zealand Science Review Vol 77 (3–4) 2021.

Lahart B., Shalloo L., Dwan C., Walker N. and Costigan H. (2024). *Evaluating the impact of 3-nitroxypropanol supplementation on enteric methane emissions in pregnant non-lactating dairy cows offered grass silage*. JDS Communications, In Press.

Lahart B., Buckley F., Herron J., Fitzgerald R., Fitzpatrick E., Galvin N. and Shalloo L. (2024). *Evaluating enteric methane emissions within a herd of genetically divergent grazing dairy cows*. J. Dairy Sci. 107:383–397.

Leip, A., F. Weiss, T. Wassenaar, I. Perez, T. Fellmann, P. Loudjani, F. Tubiello, D. Grandgirard, S. Monni, and K. Biala. (2010). *Evaluation of the livestock's sector contribution to the EU greenhouse gas emissions* (GGELS) – Final report. European Commission, Joint Research Centre, Ispra, Ital.

Mazzetto A.M., Falconer S., and Ledgard S. (2022). *Mapping the carbon footprint of milk production from cattle: A systematic review.* J. Dairy Sci. 105:9713–9725.

Murphy E., De Boer I.J.M., van Middelaar C.E., Holden N., Shalloo L., Curran T.P. and Upton J. *Water foot printing of dairy farms in Ireland. (2017)*. Journal of Cleaner Production 140: 547-555.

Murphy E., Curran T.P., Holden N.M., O'Brien D. and Upton J. (2018). *Water footprinting of pasture-based farms; beef and sheep*. Animal 12:5, 1068–1076.

O'Brien, D.; Capper, J. L.; Garnsworthy, P. C.; Grainger, C.; Shalloo, L. (2014). *A case study of the carbon footprint of milk from high-performing confinement and grass-based dairy farms*. Journal of Dairy Science 97: 1835-1851.

Rotz C.A., Beegle D., Bernard J.K., Leytem A., Feyereisen G., Hagevoort R., Harrison J. Aksland G. and Thoma G. (2024). *Fifty years of environmental progress for United States dairy farms*. J. Dairy Sci. 107:3651–3668.

Sorley M., Casey I., Styles D., Merino P., Trindade H., Mulholland M., Resch C., Keatinge R., Le Gall A., O'Brien D., Humphreys J. (2024). *Actors influencing the carbon footprint of milk production on dairy farms with different feeding strategies in western Europe*. Journal of Cleaner Production Volume 435, 5 January 2024, 140104.

Nutritional Adequacy in a Healthy and Sustainable Diet

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Introduction

Food based dietary guidelines (FBDG) have been developed for more than 100 countries worldwide. FBDG identify the type and balance of foods to consume for a healthy diet with adequate nutrients. Despite differences in cultural patterns and food preferences, the basic message in all guidelines remains the same with recommendations for higher consumption of fruit and vegetables and minimum consumption of calorie dense and nutrient poor foods. Therefore, FBDG have been suggested as basis for more sustainable and healthy dietary recommendations (IPCC, 2019). The food pyramid is used in Ireland to communicate these guidelines and was first launched as a visual graphic for healthy eating in 1993. Then, acid rain and air pollution were the environmental concerns of the day whereas now the climatic impact of how food is produced and consumed dominates the environmental discourse. It is estimated that food production and consumption contributes approximately 30% of all greenhouse gas (GHG) emissions in the EU. Hence, the dual challenge now exists to develop healthy eating recommendations in addition to the food pyramid to ensure that both personal and planetary health can be achieved, which is also known as a sustainable diet.

Balancing nutrient content with emissions for both body and planetary health

Is it possible to consume a diet where both healthy eating dietary guidelines can be achieved while also having minimal food related environmental impacts? There is no straight forward solution because not all healthy foods have low carbon footprint, just as not all foods with a low carbon footprint are considered healthy. If consideration is only given to the carbon footprint of foods where by recommendations for a sustainable diet promotes only low carbon foods without consideration of nutritional content, then the likelihood of nutrient inadequacies and unhealthy dietary patterns is high. For example, sweetened carbonated beverages and milk both have the same carbon footprint of approximately 400g of CO_2 per 200mL serving of the beverage. However, milk contains protein, which is an essential nutrient for maintaining and building new muscle and within three hours of it consumption it can be turned into muscle. It also provides one third of our daily calcium requirements for maintenance of health. In the case of the sweetened carbonated beverage, a 200mL glass will provide 86 calories and 21g of sugar, which accounts for two thirds of the daily recommendation along with no other nutrients. It is well established that too much sugar in the diet contributes to weight gain and tooth decay. A similar analysis can be completed for a meat-based meal compared to an equivalent plant based meal. For example one serving of beef based stew will contain more than double the amount of protein, vitamin D, vitamin B12 and zinc compare to an entirely bean/plant based stew. However, the serving of beef stew will have a carbon footprint of 3kg of CO_2, five times higher than that of the plant based dish at 0.6kg CO_2 per serving.

Sustainable dietary patterns

As individuals, we consume a range of foods that constitutes our overall diet and therefore any one individual food change does not result in our diet being more or less healthy or sustainable. A range of foods is generally consumed over a given day and it is this combination and balance of foods that determines the health and sustainability of the diet. A recent Irish study has shown that that those with a cultural food pattern characterised by high consumption of meat, potatoes and vegetables had significantly lower overall dietary greenhouse gas compared to those with the unhealthy pattern who were consuming less meat but had a high consumption of unhealthy foods. Research on dietary related emissions using national food consumption surveys from Ireland, UK, France, Australia have also shown that a sustainable diet which meets requirements for health as well as generating lower emissions can be achieved with the inclusion of meat or dairy products in the diet (Hyland *et al.* 2017).

Nutritional adequacy

In general, plant-based foods have a lower carbon footprint, whereas foods from animal sources are higher, especially from ruminant animals. Therefore, new dietary patterns and guidelines have been proposed such as Eat Lancet, which strictly limits intakes of animal-based foods because of the higher environmental impact. However, foods from animal sources should not be removed as they provide many essential nutrients necessary for good health and therefore are an important part of a healthy diet. A balanced and diverse diet will supply adequate intake of many micronutrients, essential to prevent deficiencies and illness. Removal of an entire food group such as meat can result in inadequate intakes of many essential nutrients. Restrictive diets devoid of animal sourced foods such as vegan diets have been shown to increase the likelihood of nutritional deficiencies (Chouraqui, 2023). A recent review of environmentally friendly diets characterised by low intakes of animal sourced foods resulted in lower micronutrient intakes especially decreased intakes of zinc, calcium, iodine, and vitamins B12, A, and D, increased risk of inadequacies (Leonard *et al.* 2024). These findings are further supported in studies from India where vegetarian diets are frequently the cultural norm. One study showed how the risk for moderately or severe anaemia was much higher for women who did not consume meat fish or eggs (Rammohan, 2012). In the aging community in India, there was a high burden of vitamin D and B12 deficiencies. These nutrients are of particular importance for health aging and with negative consequences for cognition, immunity and frailty if deficiencies occur (Sundarakumar *et al.,* 2021). A review of vegan and vegetarian diets in children suggested that those following these dietary patterns were susceptible to inadequate intakes of certain nutrients as well as high intakes of dietary fibres may further impact bioavailability of nutrients consumed. The risk of malnutrition in these children on restrictive diets is high unless supplementation is also used. These restricted diets especially in younger children requires substantial commitment and planning alongside expert guidance, supplementation to ensure adequate nutrition (Kiely, 2021). Similarly using food intake data from French adult population survey, a modelling study of low meat diets concluded that significant planning and careful consideration would be required to achieve overall nutritional adequacy (Kesse-Guyot *et al.* 2022). Hence, the risk of nutritional inadequacy is high when essential food groups are removed from the diet and few have the essential skills or expertise to ensure adequate intakes from other sources. Throughout the life-course from preconception to pregnancy, infancy to adolescence and then in older years, there are critical growth and development periods, whereby nutrition and adequate nutrient intakes play a crucial role. Careful consideration must be applied to these cohorts of the population when developing sustainable food based dietary guidelines, whereby nutrient adequacy should take precedence over other considerations.

Alignment with dietary guidelines and reduction in greenhouse gas emissions

Current food consumption patterns in Ireland do not align with FBDG. Energy dense and nutrient poor foods from the top of pyramid are being consumed in amounts far exceeding the recommendation of sparingly and no more than twice per week. Currently, average daily consumption of these treats is approximately 690g per day, generating GHG emissions of 1.8kgCO_2/day. Foods from the protein shelf include meat, poultry, fish and legumes. Meat was consumed in excess of recommendations by approximately 70-90g per day. Consumption of foods from the protein shelf generates emissions of approximately 2.8kgCO_2/day. At the bottom of the food pyramid is fruit and vegetables, which is the most important shelf and the foundation on which our diets should be based. The recommendation is to consume at least five portions of fruit and vegetables a day, and ideally seven portions. However, intakes of fruit and vegetables were too low with the majority of people consuming just over two portions per day. The resultant GHG emissions associated with current fruit and vegetable consumption is low at approximately 0.15kgCO_2/day. Consumption of foods from the cereals and dairy shelves align better with the recommended intakes.

Changes to current food consumption, especially fruit and vegetables, meat, and treats, are needed to align with dietary guidelines. Treat consumption should be at least halved. While this would not meet the guidelines in the food pyramid, it would be an achievable reduction with resultant benefits for health and reduced GHG emissions. If treat foods were swapped for three portions of fruit, alongside a modest reduction in meat intake by one portion per day, the healthiness of our diets can be increased, while simultaneously bringing a substantial daily reduction in emissions of 1.6kgCO_2/day. These moderate and achievable changes to the familiar foods we consume would represent a 25% reduction in emissions from current eating patterns. Therefore, a simple rebalance of what we currently consume to align with healthy eating guidelines will meet the dual challenge of personal and planetary health for sustainable diets (Conway & McCarthy 2024).

Recommendations to change our current consumption habits should be evidence based and consider the prevailing cultural food consumption patterns of the population. As was evidenced in the Irish population, a pattern reflecting the cultural consumption of meat, vegetables and potatoes had the lowest carbon footprint and was consumed by at least half of the population. Discretionary foods that have low nutritional quality and should be consumed sparingly and being consumed in high amounts with a resultant high carbon footprint and therefore requires attention from a sustainability perspective. Guidelines developed for sustainability reasons should be holistic in nature, take many parameters into consideration especiallyand prioritise considerations such as health and nutrition, rather than concentrating on one food group or one measure such as emissions. No single food production method or consumption pattern can address the issue of sustainable diets. This will require multi-actor and multi-pronged strategic approaches to produce and consume food in a more sustainable way to achieve the ultimate goal of sustainable food production and consumption for both personal and planetary health.

References

Chouraqui, (2023). *Risk Assessment of Micronutrients Deficiency in Vegetarian or Vegan Children: Not So Obvious*. Nutrients.

Conway & McCarthy (2022). *How sustainable are current dietary guidelines for Ireland–the shape of things to come*. Proceedings of the Nutrition Society.

Hyland *et al. (*2017). *Dietary emissions patterns and their effect on the overall climatic impact of food consumption*. International Journal of Food Science & Technology.

IPCC, (2019). Summary for Policymakers. *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*.

Kesse-Guyot *et al. (*2022). *Nutritionally adequate and environmentally respectful diets are possible for different diet groups: an optimised study from the NutriNet-Santé cohort*. American Journal of Clinical Nutrition.

Kiely, (2021). *Risks and benefits of vegan and vegetarian diets in children*. Proceedings of Nutrition Society.

Leonard *et al.* (2024). *Impact of consuming an environmentally protective diet on micronutrients: A systematic literature review.* American Journal of Clinical Nutrition

Rammohan *et al. (*2011). *Addressing Female Iron-Deficiency Anaemia in India: Is Vegetarianism the Major Obstacle?* ISRN Public Health.

Sundarakumar *et al. (*2021). *Burden of Vitamin D, Vitamin B12 and Folic Acid Deficiencies in an Aging, Rural Indian Community*. Frontiers in Public Health.

Water Quality in Ireland: Status, Trends, Pressures and Policies

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Introduction

Water is a vital natural resource. Healthy aquatic systems deliver multiple ecosystem goods and services, including the provision of drinking water, but also wider ecological and environmental benefits. Abundant, good quality water is thus a fundamental cornerstone of society. In recognition of the importance of healthy aquatic ecosystems, protection and restoration of good water quality is a key goal of sectoral (e.g., Food Vision 2030), national (e.g., Programme for Government), European Union (e.g., Water Framework Directive) and global (e.g., UN Sustainable Development Goals) policies.

The EU Water Framework Directive (WFD) (2000/60/IEC) is the primary piece of legislation aimed at protecting and improving water quality throughout the EU. The WFD stipulates that Member States must achieve at least good status in all waters (both surface water and groundwater) by 2027. Water quality status is determined by a combination of biological (e.g. macro-invertebrates, fish), physio-chemical (e.g. nitrogen, phosphorus) and hydro-morphological (e.g. flow, habitat condition) parameters. Environmental parameters are collected on a temporal resolution ranging from several times annually (e.g. for physio-chemical parameters) to every three years (e.g. biological parameters). Standards and guidelines are set for key nutrients to achieve good water quality status, with a significant focus on phosphorus (<0.035 mg/L of P) and nitrogen (<8 mg/L of NO_3).

Water Quality - Status

Approximately 54% of surface waters in Ireland are achieving satisfactory ecological status (DHLGH, 2024). EPA data (EPA, 2022) highlight that catchments in the west and south of the country have the highest proportion of waterbodies in satisfactory condition. Results at a national scale fall below the objectives of the WFD, which stipulates that all waters must achieve at least good status (i.e. satisfactory condition). At an EU scale, water quality in Ireland compares favourably to our European counterparts, where over half of the surface waters in the EU are of less than satisfactory ecological status (EEA, 2021). Based on data relating to River Basin Management Plan 2 (2010-2015), Ireland lies 7th (of 28 EU countries) when it comes to the proportion of rivers achieving satisfactory ecological status.

With regard to the parameters that contribute to the assessment of ecological status, recent data (EPA, 2024a) indicate that 58% of Irish rivers have satisfactory nitrate concentrations. For comparison with EU counterparts, Ireland is 20th (out of 29 countries) when it comes to the proportion of rivers achieving <2.0mg/L NO^{3-}N (EEA, 2024). Unsatisfactory nitrate concentrations are particularly apparent in the east, south east and south of the country (Figure 1), and are contributing to unsatisfactory concentrations of dissolved inorganic nitrogen in the estuaries and coastal waters of these regions. These trends are persisting, despite a significant reduction (>30% since 2018) in the use of chemical nitrogen.

Seventy-three percent of Irish rivers have satisfactory phosphate concentrations. Rivers in the south east, midlands and east and south display the highest average river phosphate concentrations (Figure 1). Almost all of the assessed estuaries and coastal waters are in satisfactory condition for phosphate (EPA, 2024). For comparison with EU counterparts, Ireland is 6th (out of 25 countries) when it comes to the proportion of rivers achieving <0.05mg/L P[1] (EEA, 2024).

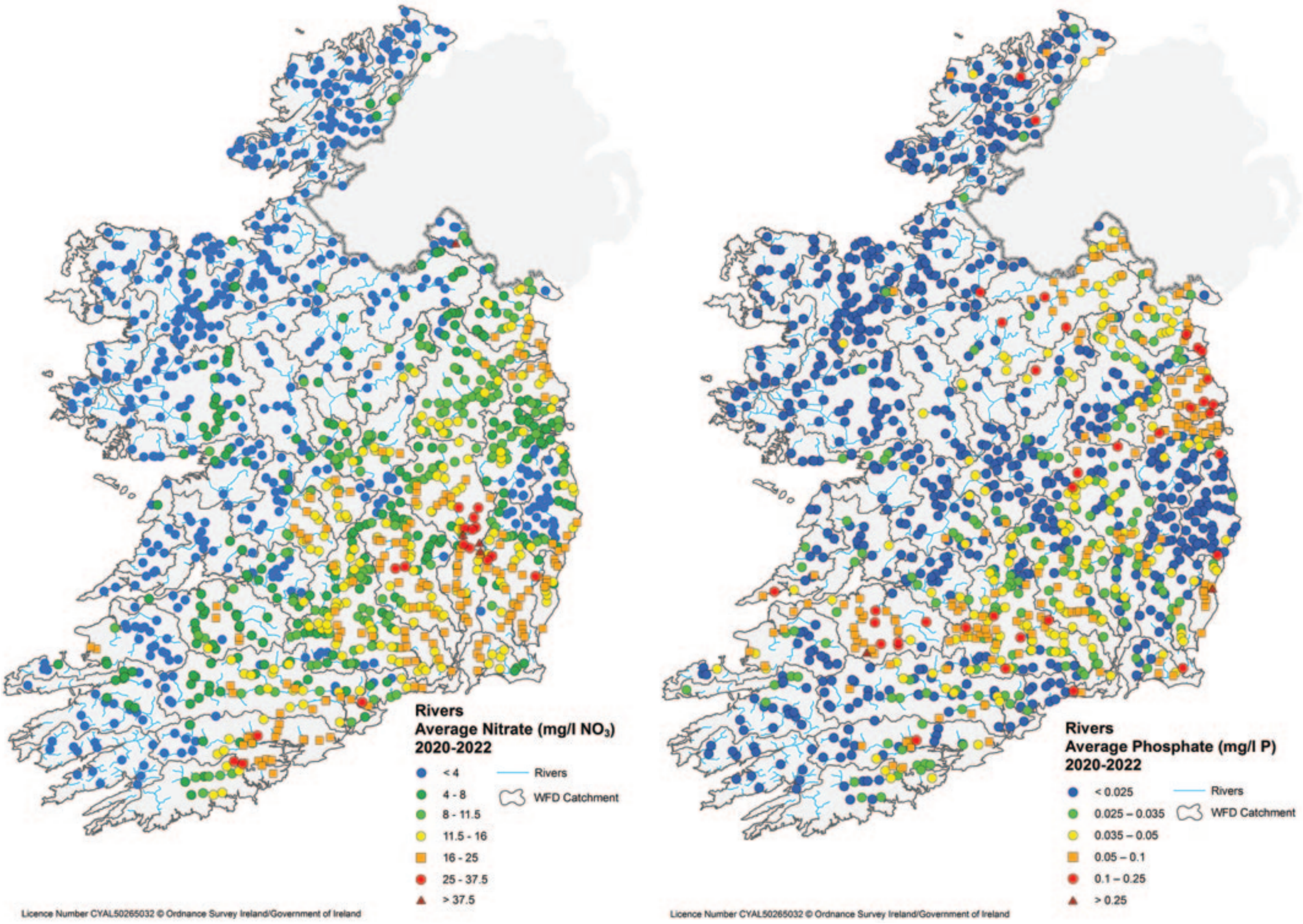

Figure 1 Maps showing water quality status in Ireland giving mean nitrate (left) and phosphate concentrations (right).

[1] This figure is above the thresholds set, but has been used to facilitate inter country comparisons.

Water Quality – Trends

Water quality has declined globally over the last number of decades (IPBES, 2019). In Ireland there has been a modest decline in water quality, from 61% of rivers achieving satisfactory status in 1987-1990, to 55% of rivers achieving satisfactory status in 2020-2023 (EPA, 2024). Of noted concern is the fact that rivers achieving high status have declined from 27% to 16%, with pristine water (i.e. Q5) experiencing the most significant declines. Encouragingly, rivers with poor or bad status have also declined (from 25% to 18%).

Water Quality – Pressures

Agriculture is the dominant land use in Ireland, accounting for almost 70% of the land area. The loss of nutrients (e.g. nitrogen and phosphorus) and sediment from agricultural systems to water has been highlighted as one of the main threats to water quality in Ireland (EPA, 2024) and throughout the EU. Excessive nitrogen and phosphorus can contribute to the eutrophication of surface waters, impacting aquatic species through excessive plant growth and associated fluctuations in oxygen concentrations in water. Sediment can impact the physical quality of aquatic habitats, for example clogging gravels for spawning trout and salmon.

Agricultural sources of nitrogen and phosphorus include animal waste and fertiliser, whilst eroding stream banks, farm tracks and field topsoil are key sources of sediment.

Multiple environmental, climatic and anthropogenic factors can impact the loss of nutrients and sediment for agricultural land. For example, the Agricultural Catchments Programme (ACP) (Mellander *et al.*, 2022) has monitored two intensively-farmed grassland dominated catchments in the south-east and south-west of Ireland since 2009. The Ballycanew catchment in Co. Wexford is poorly-drained and vulnerable to high losses of P during storm events (i.e. P-risky). In contrast, the Timoleague catchment in Co. Cork is well-drained and vulnerable to leaching nitrate (i.e. N-risky). Table 1 clearly indicate that losses vary from year to year and nitrate losses in Timoleague were more than three times greater than losses from Ballycanew. Loss of P were greater in Ballycanew. However, in the 2021 water year the losses of TP from Timoleague were almost as high as from Ballycanew. These observations indicate that N-risky catchments are still vulnerable to generating high P losses particularly if their soils become saturated and generate overland flow and/or fast subsurface flow in the wetter months.

Table 1 Losses of N and P from two grassland-dominated ACP Catchments.

Catchment (Year)	TRP Loss (kg P/ha/year)	TP Loss (kg P/ha/year)	NO3 Loss (kg N/ha/year)
Ballycanew (2020)	0.93	1.72	13.7
Ballycanew (2021)	0.68	1.53	12.2
Timoleague (2020)	0.47	0.76	38.2
Timoleague (2021)	0.82	1.30	50.1

The 3rd River Basin Management Plan has highlighted agriculture as the most common pressure on "at risk" waterbodies, impacting 62% of these waterbodies (DHLGH, 2024). This is an increase on the 53% that was reported in the 2nd River Basin Management Plan. These findings, coupled with the fact that agriculture is the dominant land use in Ireland, highlights the critical role agriculture can play in improving water quality in Ireland.

Improving Water Quality

Protecting the quality of water is the cornerstone of a sustainable farming system. In recognition of this, management prescriptions to protect and improve the water quality in surface and ground-waters have featured prominently in national and international policies for decades. The focus is frequently on the source-pathway-receptor concept. Prescriptions typically aim to either reduce the source of pressure, or break the pathway between source and watercourse. Such measures broadly fall within compulsory (e.g. Good Agricultural and Environmental Condition, Pillar I of the Common Agricultural Policy) and optional (agri-environment measures, Pillar II of the CAP) mitigation measures. The Nitrates Directive (91/676/EEC), aims to protect surface water from pollution by agricultural sources and to promote good farming practice.

Running concurrently with developments in agri-environmental policy, there have been significant advancements in: a) understanding the hydrological and biogeochemical processes that govern the transport of pollutants (e.g. nutrients, sediments, pesticides) to water, b) developing tools to support the targeting of mitigation approaches, and c) implementing multi-actor knowledge transfer programmes.

The Agricultural Catchments Programme: The Agricultural Catchments Programme (ACP) came about in 2008 in order to assess the effectiveness of the implementation of the Nitrates Directive (see above) across six catchments with different soil types, farming practices and climate. A key aspect of each catchment is the collection of high-frequency (sub hourly) monitoring data comprising metrological data, streamflow data and stream chemistry data. This novel approach has enabled the underlying processes that generate and transport nutrients to water to be investigated for over more than a decade. A key finding has been the identification of the influence of climate change on water quality over this period (Mellander and Jordan, 2021). Crucial to the success of the programme has been the active engagement with farmers through an advisory service with an emphasis on knowledge transfer through fostering strong farmer to advisor relationships and dissemination events.

Pollution Impact Potential (PIP) maps: Coupled with enhancing our understanding of hydrological and biogeochemical processes there have been significant developments in mapping approaches to help identify the critical source areas and delivery pathways (throughout the landscape) in relation to pressures on our waterbodies (Thomas *et al.*, 2021). The EPA Pollution Impact Potential (PIP) maps (for Nitrogen (N) and Phosphorus (P)) are a key example of these developments which came about from the findings of the Pathways Project and other research into diffuse pollution.

Agricultural Sustainability Support and Advisory Programme: Coordinated activity at field to catchment scale can result in sustained improvements in water quality, ultimately contributing to national (River Basin) scale objectives. Ensuring active engagement with farmers, industry, community, and government stakeholders throughout this process is crucial to addressing the challenges of water quality.

The targeting of actions at a local level, coupled with the multi-actor approach has been pursued successfully by the Agricultural Sustainability Support and Advisory Programme (ASSAP). The ASSAP is an innovative government-industry collaborative initiative (with support from Ireland's farming organisations) that provides agricultural advice regarding water quality.

Scientists from the Local Authority Water Programme (LAWPRO) assess rivers and streams and engage with ASSAP advisors. ASSAP advisors then work closely with farmers to identify potential issues and recommend mitigation approaches. Over 6,500 farms have been visited to date, with an average of 5.5 issues identified per farm. Key actions implemented by farmers vary depending on the pollutant type. For phosphorus and sediment, management of critical source areas, installation of riparian buffers and fencing of watercourse to exclude cattle have been critical. For nitrogen, actions relating to implementation of a nutrient management plan, and ensuring appropriate application of organic manures, have been widely implemented. Note: Lessons learned from the ASSAP have helped inform the design of the Teagasc Better Farming For Water: 8-Actions for Change campaign (see below).

The latest River Basin Management Plan (DHLGH, 2024) highlighted that where local actions were targeted through the ASSAP, there was a greater net improvement in status of water bodies compared to the national trend.

Building on the success of the ASSAP, a new Farming For Water EIP was launched in 2024. The EIP is a collaboration between Teagasc, LAWPRO and Dairy Industry Ireland. Over the next 3-4 years the Farming For Water EIP will provide €50 million to approximately 15,000 farmers to implement a range of measures designed to help improve water quality.

Better Farming for Water: 8-actions for change: Building on the developments with understanding hydrological and biogeochemical processes; the identification of critical source areas and delivery pathways; and the lessons learned from ASSAP and similar multi-actor approaches (e.g. Duhallow Farming for Blue Dot Catchments EIP). Teagasc has developed the *“Better Farming for Water: 8-Actions for change”* water quality campaign in 2024. The objective of the campaign is to support all farmers to reduce the loads of nitrogen, phosphorous, sediment and pesticides entering the river network from agricultural sources. The 8-Actions for Change focus on nutrient management, farmyard management, and land management, and provide a structured, relatable approach for farmers to effectively engage with improving water quality.

For grassland farmers, priority actions include ensuring that there is sufficient slurry and soiled water storage capacity. Sufficient storage capacity will in turn support activities to ensure that fertiliser and organic manure are applied at appropriate times and under favourable conditions. A key action for livestock farmers is to exclude bovines from all watercourses. This action will reduce phosphorus, sediment and E. coli contributions to water. All farmers can implement mitigation actions such as riparian buffer zones. Riparian buffers help reduce nutrient and sediment inputs, whilst supporting wider ecosystem services (e.g. biodiversity and carbon storage).

Better Farming for Water is a 7-year campaign. The extended duration of the campaign aims to take into account the lag-time that occurs between the implementation of actions, and a response in water quality. Multiple environmental, climatic and anthropogenic factors can influence the lag-time response.

We have never been in a better position to address water quality. Science has enhanced our understanding of the processes that govern the generation and transport of pollutants, and identify potential mitigation actions. Tools have been developed to identify pressures and support the targeting of actions. Multi-actor approaches have demonstrated the steps needed to achieve sustained practice change. Coupled with this there is a heightened awareness and desire amongst all stakeholders, across the wider agri-food industry, to tackle water quality challenges.

References

DHLGH (2024). *Water Action Plan 2024: A River Basin Management Plan for Ireland*. Department of Housing, Local Government and Heritage.

EEA (2021). *Drivers of and pressures arising from selected key water management challenges: A European overview.* European Environment Agency.

EPA (2024a). *Ireland's State of the Environment Report 2024*. EPA 2024.

EPA (2024b). *Water Quality in 2023: An Indicators Report,* EPA 2024. 3.

Mellander, P. E., & Jordan, P. (2021). *Science of the Total Environment,* 787, 147576.

Mellander, P. E., *et al.* (2022). Irish Journal of Agricultural and Food Research, 61(1), 201-217.

Thomas, I., *et al.* (2021). EPA Research Report 396, EPA, Dublin.

IPBES (2019). *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.*

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Balancing Emissions and Sustainability in Irish Agriculture

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1. Introduction

Agricultural production is a major source of both greenhouse gas (GHG) and ammonia emissions. Reducing GHG emissions is crucial to mitigating climate change and keeping global warming below 2 degrees and as close to 1.5 degrees as possible. In addition, reducing ammonia emissions protects air quality, ecosystems, and human health by preventing pollution and acidification of soils and water bodies. Both are vital for ensuring environmental sustainability and long-term public well-being.

There are different ways of expressing the amount of emissions that result from the production of food. The first is the carbon intensity or kg CO_2e kg^{-1} food produced, which is an efficiency metric and is important metric for consumers. The carbon intensity of food, varies considerably for the same food products between countries and is an important metric for the international reputation of Irish food (Shalloo and Herron, 2024). Another option is expressing the total amount of emissions on a hectare or farm basis. While a low carbon intensity is good, it can still result in high levels of emissions per hectare in intensive farming systems producing more food output per hectare. These different ways of expressing emissions can lead to confusion, particularly when seeking to achieve national reduction targets, which focus exclusively on the total emissions generated, as reported in the national inventory, rather than emissions intensity per unit of output.

In Ireland, GHG abatement is guided by the Climate Action and Low Carbon Development (Amendment) Act 2021. It commits to a 51% reduction in GHG emissions by 2030 and achieving climate neutrality by 2050. At the EU level, the European Climate Law enshrines the goal of climate neutrality by 2050 and a 55% reduction in GHG emissions by 2030, both part of the broader European Green Deal. In Ireland, the agricultural sector target for 2030 is a 25% reduction in emissions compared to 2018. The EU have also set a Land-Use, Land-Use Change and Forestry (LULUCF) target for Ireland to reduce emissions by 0.626 MtCO_2e compared to a 2016-2018 reference level.

The objective of this paper is to summarise the current agriculture and LULUCF emission trends, sources of emissions and mitigation potential to meet the Irish and international emissions commitments.

2. Emission trends and sources

Irish agriculture accounts for 38% of national GHG emissions in 2022 (EPA, 2024). The main agricultural GHG emissions sources are methane from enteric fermentation, nitrous oxide from agricultural soils and methane from manure management. Ireland agricultural emissions associated with the production of food are high due to the large amount of dairy and animal protein products that are exported globally. The emissions are dominated by methane produced during digestion and is a difficult gas to reduce without decreasing food production. The main sources and projections of GHG emissions relative to 2018 inclusive of mitigation are shown for Agriculture in Figure 1 and LULUCF in Figure 2.

Agricultural GHG emissions are projected by the EPA to decrease to 18.15 MtCO_2e by 2030 under the *with additional measures* scenario from the Teagasc MACC (Figure 3). However, in its analysis the EPA were unable to model 1.5 MtCO_2e of mitigation in the Teagasc MACC primarily associated with diversification resulting in the reduction of animal numbers.

The LULUCF inventory has been significantly revised since 2018 resulting in major changes in historical emissions and future projections. While emissions from drained grasslands have been revised downward due to changes in the area (Tuohy et al. 2023) and the emission factor there have been increases in Wetland emissions (EPA, 2024). The GHG emissions associated with LULUCF are projected to increase, relative to the 2016-18 baseline of 4.18 MtCO_2e to 4.91 MtCO_2e in 2030 under the additional scenarios projection (Figure 2).

Agriculture accounts for 99.4% of national ammonia emissions, primarily from livestock production (90.4%) and urea fertiliser use (8.9%). Since 2018, emissions have steadily declined to 128.7 kt in 2022, but Ireland failed to meet the 2020 target and has been served with an EU infringement notice. The latest EPA projections, under *with additional measures* (Buckley *et al.* 2020), indicate that Irish NH_3 emissions will decline to 112.6 kt in 2030 and meet the emission reduction target (EPA, 2024).

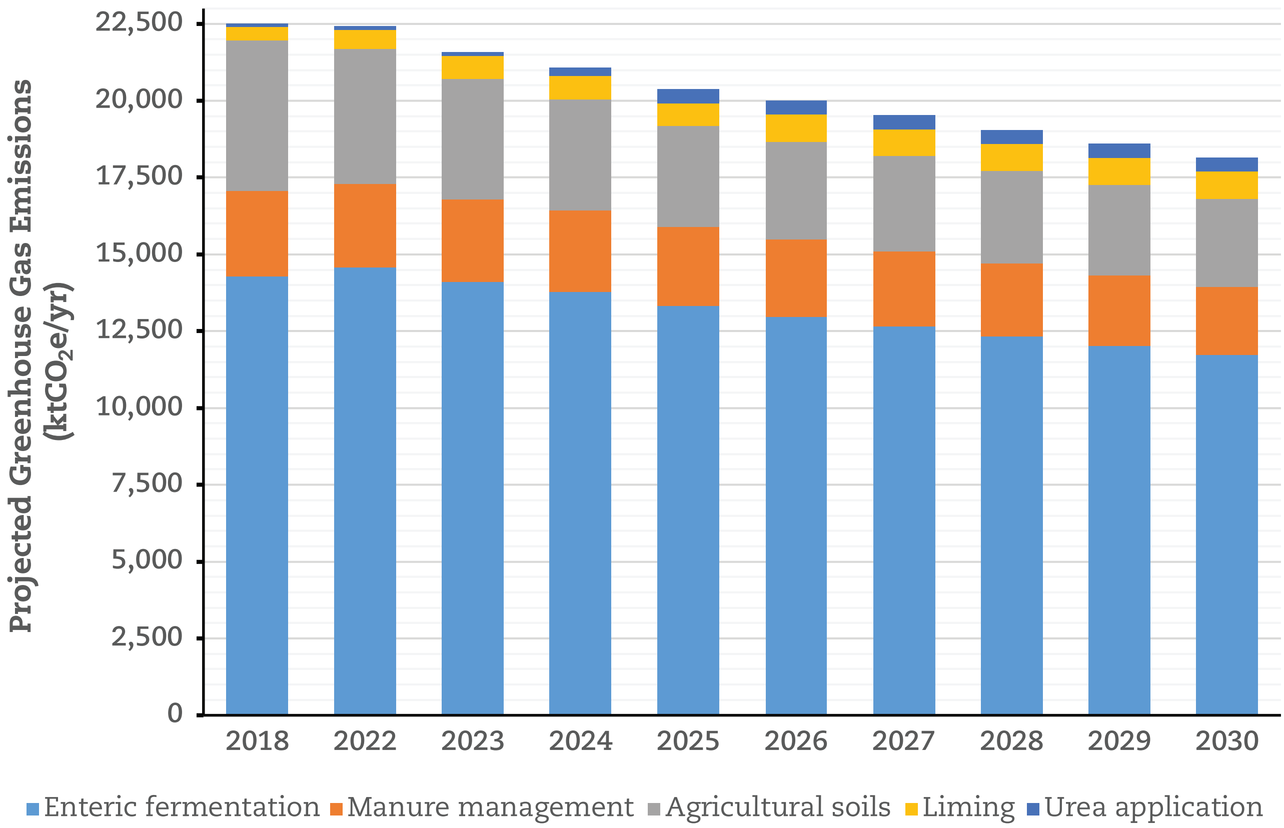

Figure 1 Agricultural GHG emissions in 2018 and 2022 and projected emissions trends (with additional mitigation) from 2023 to 2030 including the source of emissions (Adapted from EPA, 2024).

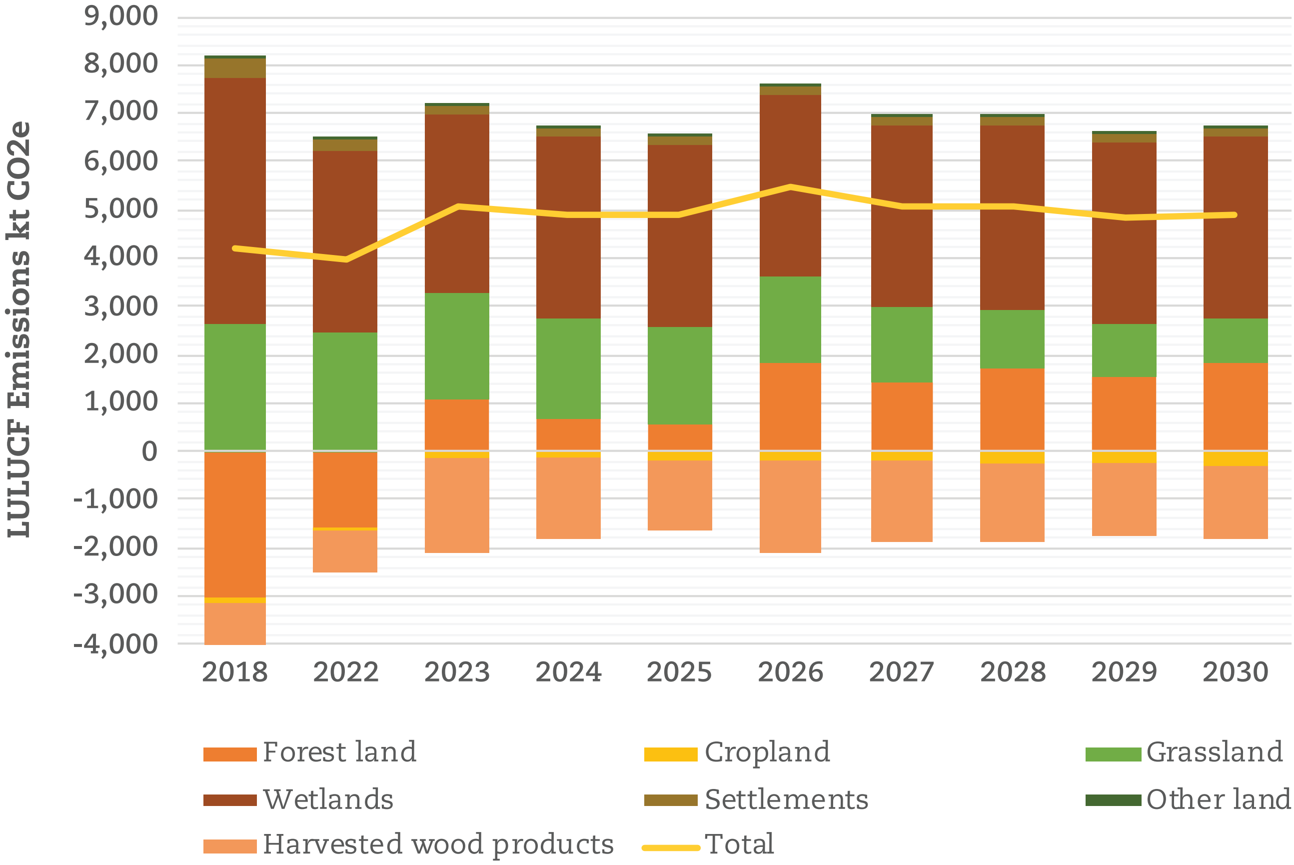

Figure 2 Projected LULUCF emissions in 2018 and 2022 and projected emissions (with additional mitigation) from 2018 to 2030 including the source of emissions (Adapted from EPA, 2024).

3. Emission mitigation

Mitigation is required to reduce gaseous emissions from agriculture and LULUCF. The Teagasc MACC (Buckley *et al.*, 2020; Lanigan *et al.*, 2023) summarises the science on the current technical measures that are available to farmers and other landowners to reduce emissions and increase carbon sinks. The GHG mitigation potential in 2030 is summarised for agriculture (Figure 3) and LULUCF (Figure 4). Both of these MACCs show that there are a large number of technical measures to reduce emissions and the cumulative reductions in 2030 for agriculture was 4.9 $MtCO_2e$ and and 4.1 $MtCO_2e$ for LULUCF. Some of the measures, such as feed additives/ supplements/slurry amendments, are at the advanced research stage, but are costly to implement, requiring incentives for farmer adoption. The MACC analysis highlighted that, under a stable to declining national herd, very ambitious and rapid adoption of measures would be required to meet the 2030 targets.

Currently good progress has been made on the implementation of some of the MACC measures such as reducing chemical fertiliser use, replacing urea and calcium ammonium fertiliser with protected urea and adoption of organic farming. The introduction of the national biomethane strategy and the new Forestry Programme 2023-2027 provide the policy support for these MACC measures and give farmers and land owners with viable diversification options. Reducing enteric methane emissions is progressing through feed additive research and was demonstrated on 18 Signpost farms in winter 2023. Progress on reducing the age of finishing has slowed and requires a whole industry support to achieve the 3 month reduction in finishing age of beef cattle. Further industry and government support is required by farmers to increase the adoption of measures and in particular measures such as methane reducing feed and manure additives that do not have production efficiency benefits and are a cost to farmers.

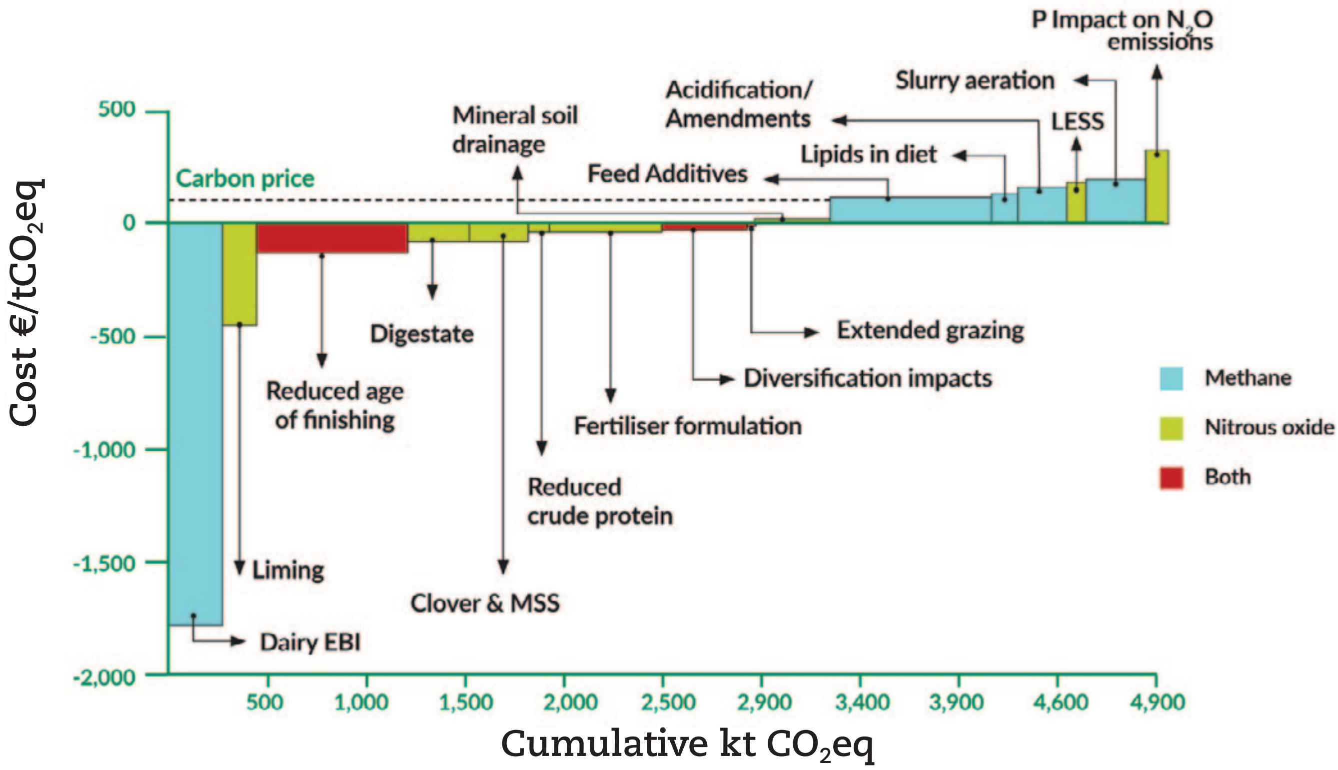

Figure 3 The Agricultural MACC under very ambitious measure adoption (Lanigan *et al.* 2023). The horizontal axis is cumulative carbon reduction and the vertical axis is the measure cost.

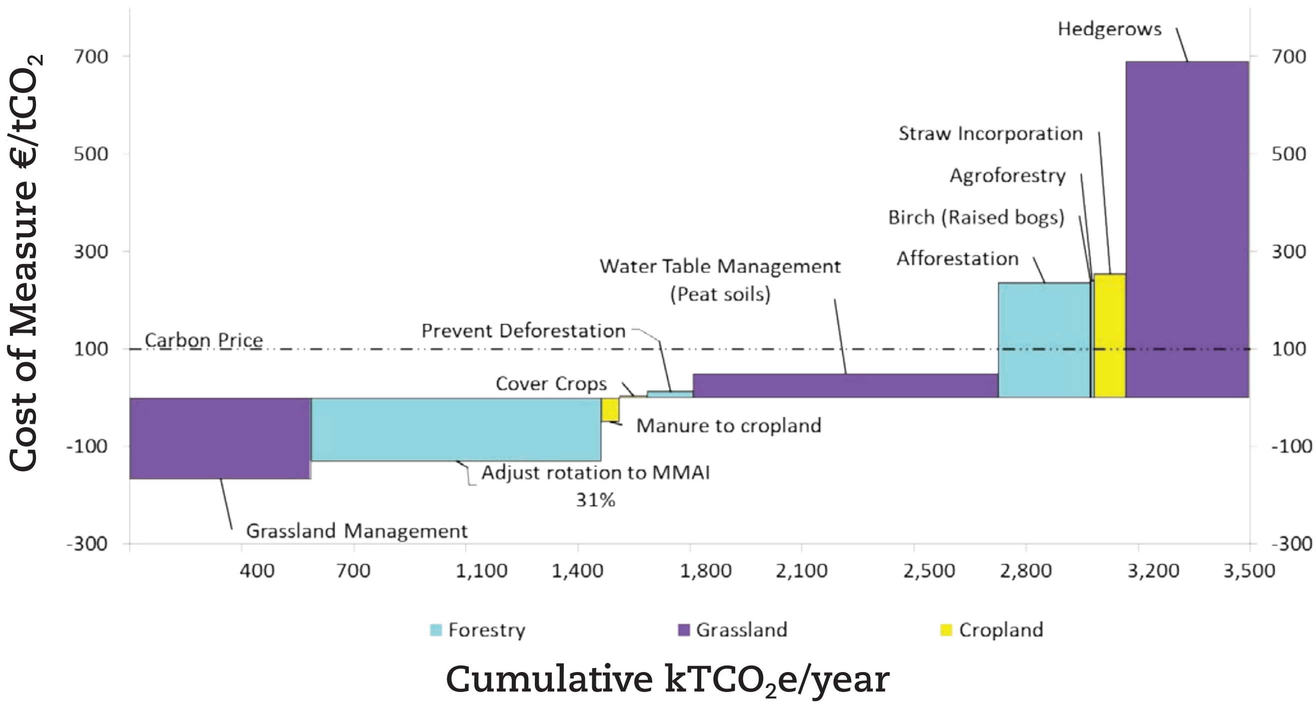

Figure 4 The LULUCF MACC under very ambitious measure adoption (Lanigan *et al.* 2023). The horizontal axis is cumulative carbon reduction and the vertical axis is the measure cost.

The adoption of the MACC mitigation measures results in absolute emissions reductions and it will also reduce the carbon foot print of Irish dairy and meat products. The footprint of Irish food products is low in comparison to other EU countries. There is great potential to reduce the foot print further and contribute to absolute emissions reduction (Herron & Shalloo 2024).

4. Adoption of Mitigation Measures

There is a major industry and Teagasc initiative to promote the adoption of mitigation measures that are highlighted in the Teagasc MACC. The new Signpost advisory and farm demonstration programmes demonstrate best practice and enable farmers to develop their farm sustainability plan using the new sustainability tool AgNAV. These initiatives are a global first and demonstrate the prioritisation that the sector gives to mitigation of gaseous emissions.

The Teagasc MACC 2018 and 2023 have both highlighted that knowledge transfer is important, but will not be able to deliver the changes required on its own. Further policy and financial incentives are required to support farmers and landowners to reduce emissions and transition to meeting the target of climate neutrality 2050. Policy mechanisms led by government, such as regulation or supports, are needed to make adoption more attractive, particularly for measures that cost farmers money and lack production benefits. Private mechanisms/incentives led by the broader agri-food industry such as carbon farming, voluntary production standards or market based incentives are also needed to increase mitigation measure adoption at farm level.

5. Future research needs

Improving current mitigation measures, developing new measures and ensuring their adoption are steps that are urgently needed to reduce GHG emissions from agriculture and LULUCF. Increased focus is required on a. methane-reducing feed and slurry additives for grazed grasslands, b. breeding of low-emission ruminants, c. development of low nitrogen systems, and d. integrating trees into agricultural systems to enhance carbon capture, biodiversity, and water quality. Further research is needed to understand what influences adoption across different farm types, as a one-size-fits-all policy may not suffice. This will help identify barriers and enable policymakers to tailor a mix of incentives, regulations, education, and outreach to boost the adoption of mitigation measures.

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References

Buckley C. *et al.* (2020) *An analysis of the cost of the abatement of ammonia emissions in Irish agriculture to 2030*, Teagasc.

EPA (2024). Ireland's Greenhouse Gas Emissions Projections 2023-2050.

EPA (2024). Ireland's Air Pollutant Emissions 1990-2030

Lanigan G. *et al.* (2023). *MACC 2023: An Updated Analysis of the Greenhouse Gas Abatement Potential of the Irish Agriculture and Land-Use Sectors between 2021 and 2030*. Teagasc.

Shalloo L. and Herron J. (2024). *The Sustainability of Ireland's Livestock Systems, Sustainability in Agriculture Conference*, Teagasc Ashtown.

Tuohy P. *et al.* (2023). *Drainage status of grassland peat soils in Ireland: extent, efficacy and implications for GHG emissions and rewetting efforts.* Journal of Environmental Management, 344, p.118391.

Private and Public Sustainability Mechanisms in Agri-Food Production:

A Comparative Analysis of Ireland & EU Agriculture

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1. Introduction

The European Green Deal (European Commission, 2019), the Farm to Fork Strategy (European Commission, 2020) and the recently published Strategic Dialogue on the Future of EU Agriculture (European Commission, 2024) are just some of the initiatives which aim to shape the future sustainability of EU agriculture. Historically in Ireland and the EU, emphasis was placed on economic and social aspects of agricultural sustainability, but policy objectives have now evolved to give environmental sustainability equal if not greater emphasis than the other two sustainability dimensions.

Faced with the need to meet a host of sustainability objectives, what are the tools that stakeholders across the agri-food sector have available to them? These tools can largely be defined as either government driven **public** mechanisms, such as regulation or financial support, or predominantly industry led **private** initiatives or innovations, such as labelling or certification of a production method to create a point of difference and achieve a product price premium.

This paper examines the public and private mechanisms, which can be harnessed to deliver sustainability, focusing in particular on the commonalities and differences that exist between them. It is in the interest of all stakeholders to better understand the strengths and limitations associated with public and private approaches. This paper argues that a mixed approach, which does not rely exclusively on public or private solutions, may provide the best pathway for progress.

It would be easy to place all of the responsibility for delivering a more sustainable agriculture sector at the farmers' door. However, this would ignore the necessary role of an array of other actors in the food supply chain, from input suppliers all the way through to customers. In considering how improvements in agriculture's sustainability can be delivered, it is therefore critical to understand that the actions of actors across the food chain are important influencers of the end outcome. Actors in the chain will have their own interests and will be motivated first and foremost to act in their own interest. Consequently, they may have different views on how sustainability should be delivered and may disagree on the factors or time scales that are relevant in their decision-making (Garcia-Gonzalez and Eakin 2019; Schoon, B. and Te Grotenhuis, R, 2000).

Recognising heterogeneity in agricultural systems is important in considering sustainability (Grau *et al.* 2013). Recognising how agriculture in Ireland differs from or has similarities with agriculture in other countries is a further important consideration in delivering improvements in the sustainability of Irish agriculture. There may be lessons to be learnt from approaches to enhancing sustainability in other countries, but there could also be drawbacks to replicating approaches in Ireland that are used elsewhere. This paper examines the initiative used in Ireland and a number of neighbouring countries.

In pursuit of a more sustainable agri-food sector, defining an end objective is important. i.e. maintaining Ireland's capacity to produce food, while recognising the need to do so in a way that balances economic viability, environmental stewardship and social equity over the long term. All dimensions of sustainability are important (Harwood, 2020).

2. Sustainability Mechanisms

In economics, the choice between private and public can be thought of as a choice between markets and governments. Wolf (1993) argues that the market is more efficient and more innovative, but can be a blunt mechanism which fails to take account of equity. By contrast, Wolf argues, government mechanisms offer the public a voice in shaping policy and its impact, but argues such mechanisms have flaws in terms of unwieldy bureaucracy and the potential for favouritism. Similarly, sustainability mechanisms can be considered as either private or public and can be evaluated in a like manner.

2.1 Sustainable dietary patterns

The key characteristic of private sustainability mechanisms are that they generally have minimal or no government involvement in their creation or operation. Instead, private initiatives are driven by industry or non-governmental bodies (NGOs). In agri-food production, private sustainability initiatives can be broadly categorised as follows:

- **Product Certification:** where producers must achieve particular quality criteria – a familiar example is Origin Green
- **Corporate Sustainability Initiatives:** where an individual business sets quantifiable sustainability targets and requires its suppliers to do likewise. Sometimes this may include public reporting of associated sustainability metrics.
- **Voluntary Standards:** where independent measurement, certification and labelling are available to interested parties – an example would be the UK Carbon Trust

The key advantage of private initiatives is that they **can be set up** and can evolve **relatively easily.** Private initiatives do not require legislation and therefore can be developed and can evolve, while avoiding the red tape and time delays typically associated with the delivery or amendment of legislation required for some public initiatives. Furthermore, **private initiatives can evolve** in response to changing market circumstances. In a competitive food production system, players should seek out opportunities to differentiate their business from competitors. Becoming more sustainable is one way to do this. Finally, private sustainability initiatives can be self-financing (not reliant on the taxpayer for support), in the sense that consumers may be willing to pay more for products with desirable sustainability attributes.

On the flip side, private initiatives also have drawbacks. Given that they are not grounded in legislation, they are **someway optional in nature.** This can mean that some actors adopt them and others do not. So private initiatives to deliver improvements may not achieve the blanket coverage that is possible when legislation is applied across the board. The public can also view private sustainability initiatives suspiciously, since they may **lack independent oversight** to verify any claims made regarding their impact. Finally, since sustainability claims can be used to attract new customers, there is the **temptation to turn a quick buck,** which could lead to revision and reinterpretation of sustainability objectives or a narrow focus on a particular aspect of sustainability purely to attract new business – sometimes described as 'greenwashing'. Alternatively, if customers appear to lose interest in a particular sustainability attribute, it may be de-prioritised by other actors in the chain and the momentum for change is then lost.

Private initiatives have been criticised for a number of other reasons. Lambin and Thorlackson (2018) point to the diverse range of standards, which can lead to competition between them. They say that certain stakeholders may be included or excluded in their creation. They suggest that the lack of coordination between standards may ultimately force the public sector to step in to provide a form of governance.

2.2 Public Sustainabilities Mechanisms in Agri-food

As their name suggests, public sustainability mechanisms are led by government and typically involve policies or supports aimed at achieving compliance with a national or international policy objective. In agri-food production, public sustainability initiatives can be broadly categorised as follows:

- **Legislation:** Regulation encompassing particular sustainability goals with which actors in the sector **must comply.**
- **Financial Incentivisation:** This can be in the form of a subsidy or a support payment to reduce costs or enhance profitability, with the aim of persuading actors in the sector to behave in a way that could enhance sustainability.
- **Financial Support for Research:** where national or international funding mechanisms are used to improve sustainability through the development of new technology to either enhance income, reduce environmental impacts or to satisfy particular social objectives.

In contrast to the voluntary nature of private mechanisms, mandatory public sustainability mechanisms can be designed to have **blanket coverage** and apply to all actors. Given that they are often motivated by compliance with future targets, public sustainability mechanisms tend to have **long-term objectives,** which are less likely to dissolve with the passage of time. Finally, the hand of government can be used to enforce public mechanisms, to ensure compliance and hence their effectiveness.

On the flip side, the requirement for legislation in the case of government regulations or financial supports mean that implementation of public initiatives can only move at a pace determined by the political system. A change of government or changing government priorities can have an impact on the progression of legislation, while lobbying by interested parties can affect the nature, pace and scope of legislation (Patashnik, 2023). In addition, public mechanisms place a burden on the exchequer to cover the cost of financial supports or the cost of ensuring regulatory compliance. Finally, legislation, when either poorly drafted or implemented, can be perceived as unfair, while poorly designed incentivisation mechanisms can appear unattractive to those they are aimed and may fail in their objectives (Weersink *et al.,* 1998). The design of effective and efficient public sustainability mechanisms can be difficult, complicated and slow, if there is a need to take account of a range of diverse circumstances in order to avoid harsh outcomes or unintended consequences.

3. Public and Private Mechanisms: Shared Interests and Competing Interests among Stakeholders

In a prescient paper, Christy (1996) notes an increasingly tendency for policy questions to become interrelated, creating a requirement for multi-disciplinary analyses. He further notes that as agriculture becomes a smaller part of the economy, environmental and social concerns relating to agriculture will increasingly influence it.

Given the range of actors in the agri-food chain, understanding the perspectives and interests of stakeholder is critical to the design of effective sustainability interventions. Farmers, the food industry, policy makers and consumers may have interests that coincide or differ and which may promote or hamper the delivery of a more sustainable agri-food system (Saviolidis *et al.,* 2020).

Shared interests: The achievement of sustainability improvements in the agri-food system is aided by the fact that all stakeholders can perceive the **necessity to improve sustainability** over the long term (Saviolidis *et al.,* 2020). Equally, all should recognise that **improving sustainability costs money.** For example, given the current precarious financial position of many farmers, it is not realistic to imagine that they could absorb the cost of delivering significant improvements in environmental sustainability, without compromising their capacity to produce food and their economic sustainability. All stakeholders should agree on the need for the **development and deployment of new technologies** to enhance sustainability.

Competing interests: By contrast, there are areas of diverging stakeholder interests also. There will be a tendency for policy makers to favour **rigid regulation, good governance** and an **accountability** framework to demonstrate outcomes in return for exchequer spending. This will create tensions with farmers and food processors focused on **practical considerations** that in their view may require a degree of **flexibility** and **"common sense"** in regulatory design, implementation and enforcement. There may be differing perspectives also between policy makers and farmers when it comes to the **speed of delivery** of some sustainability outcomes. While taking a **long-term perspective,** policy makers will also be keen to see evidence of short-term progress, particularly with the urgency now attached to aspects of environmental sustainability. Farmers will point to the fact that it takes time to effect change and that the delivery of improved environmental sustainability cannot come at the expenses of their short-term economic and social sustainability. They will emphasise that their **survival in the short-term** is a requirement to allow them **deliver in the long-term.** Tait and Morris (2020) provide a detailed discussion of the tension between models of sustainability that are ecologically focussed and those that adopt a wider definition of sustainability.

4. Sustainability: Some Important Characteristics of Irish Agriculture

While the Irish agri-food sector is subject to the same broad policy framework that can be found in other EU Member States, this does not mean that the sector in Ireland faces all of the same challenges found elsewhere in the EU. A few important factors, which characterise Irish agriculture, are detailed below.

Environment: Climate, soil characteristics, tradition and policy have combined to deliver the agriculture sector which now operates in Ireland. Ireland's low population density gives it a natural food export capacity. This food export capacity is concentrated in bovine agriculture, a significant greenhouse gas emissions source, which is now the subject of intense policy focus. Water quality and biodiversity loss are other key concerns associated with bovine agriculture.

Economic: While some parts of Irish agriculture have a strong track record in innovation and technology adoption, other parts do not. Only some elements of Irish agriculture are in a strong financial position. While bovine agriculture dominates in Ireland, there are deep contrasts between dairy farming, which is generally highly profitable, and beef farming, which in general is not. While parts of Irish agriculture can be characterised as intensive, much of Irish agriculture is extensive. A significant share of farming in Ireland is part time and made feasible by off-farm employment. The export focus of Irish agriculture means that the main customers for Irish food are located in other countries. It is difficult to see how Irish consumers' preferences can significantly influence the sustainability of Irish agriculture, which means that in the Irish case, mechanisms other than domestic consumer demands need to be relied upon to influence the sector.

Social: Ireland's history has created a strong attachment to land and as a result land ownership changes very slowly. The age profile of farmers is high. The strength of the wider economy, a high level of educational attainment in farming families, declining farm family size and low farm incomes, are among the factors impeding generational renewal.

Considering these factors in the design of an effective strategy to address sustainability is critical.

5. Comparative Analysis: Ireland vs. Europe

5.1 Ireland

Public Mechanisms: Irish agriculture faces challenges across the environmental, economic and social dimensions. In Ireland, much of the effort with respect to sustainability improvement in the past reflected the economic and socially focused objectives of the CAP. Support payments primarily addressed the issue of economic sustainability, essentially tackling low farm incomes. More recently, reflecting evolving CAP and other policy priorities, there has been a widening of the focus of policy to include environmental concerns (eco schemes, organics). Several explicit quantifiable targets now exist requiring actions to address environmental sustainability, (GHGs, ammonia, nitrates/water quality) but there are no such quantitative targets with respect to economic and social sustainability.

Private Mechanisms: The best known of these is Origin Green, which, while voluntary in nature, is regulated by Bord Bia through its assessment system. A feature of Origin Green is that it aims to secure a price premium and largely has an orientation toward markets outside of Ireland. This is perhaps unsurprising given the remit of Bord Bia and the export capacity in some of the main agricultural sectors in Ireland. Some Irish supermarkets pursue local sourcing from suppliers via local farming partnerships. Some sell imperfect fruit and vegetables, which previously would have been diverted to food waste. Some supermarkets also have a commitment to a net zero supply chain.

5.2 Beyond Ireland

Beyond Ireland, other countries in Europe also use a mix of public and private sustainability initiatives. Their deployment in Ireland is not radically different to how they are used elsewhere in Europe. However, the mix of approaches used in countries across Europe and the areas of emphasis are not uniform.

UNITED KINGDOM

Public Mechanisms: Having left the EU, the UK has signalled a preference for performance based environmental payments to deliver environmental public goods and a more sustainable agricultural system, particularly in England (Grant and Greer, 2023). There is also a new emphasis on innovation and productivity improvement in agriculture. It is not yet clear how the recent change in government in the UK might affect this planned policy shift. Right now, it looks set to continue. It would represent a major change from the CAP style system. There have been tensions between UK farmers and the UK government, with respect to food imports into the UK. Farmers argue that they are subject to unfair competition from lower priced imports produced with fewer regulatory requirements, implying they are less sustainable.

Private Mechanism: UK supermarkets are a powerful force shaping UK agriculture, setting standards to which suppliers must comply. UK produced foods sell at a premium to imported foods, but there are tensions between farmers and supermarkets regarding lower priced imported products. A major point of difference between agriculture in Ireland and the UK is that the UK is a substantial net food importer. This means that UK farmers are largely producing food for domestic UK consumers. This in turn means that UK consumers and UK supermarkets can exert a significant influence on the sustainability of food production in the UK. Initiatives focus on a range of sustainability objectives, such as animal welfare, waste reduction and the support of sustainable farming practices. The Red Tractor label is used by retailers to signal high animal welfare and environmental standards. Some supermarkets also use carbon labelling. Supermarket commitments to a net zero supply chains are also a feature.

FRANCE

Public Mechanisms: Farmers are encouraged to adopt practices that are supportive of biodiversity, reductions in pesticide use, better soil health and lower greenhouse gas emissions. There is a specific target for an increased area of organic farming, with associated financial support. Legislation has been enacted to promote fairer pricing for farmers. Short supply chains and direct selling are also encouraged, as are reductions in food waste. There are also policies to support agro-forestry and the protection of pollinators. Public-Private partnerships are used to boost research capacity.

Private Mechanism: Supermarkets operate a range of local and organic sourcing mechanisms. There are also supermarket initiatives to reduce food waste and to sell imperfect fruit and vegetables. Farmer partnerships and support for organic conversion is also provided through specific contracts with farmers. Organic and Eco labels are also used to influence consumer choices. Labelling is used to signify products produced with environmentally friendly farming practices. Supermarkets are also focused on carbon reduction along the food chain and reduced chemical input usage.

GERMANY

Public Mechanisms: As in other countries, there is government support in Germany for local production and direct selling. A target has been set for growth in the area of organic agriculture. Financial support is provided for organic farmers. Integrated Pest Management is promoted as a means to reduce pesticide use. Regulations exist to reduce fertiliser usage in support of better water quality. A GHG reduction target has been set for the agriculture sector. There is an initiative to improve soil health and animal welfare standards. Financial support for research has targeted precision agriculture and climate resilient crops. The production of renewable energy is also seen as an important contribution which farmers can make to deliver a more sustainable economy.

Private Mechanism: There is a wide range of initiatives in Germany, such as the promotion of local and regional products by supermarkets. Organic and biodynamic products are prominent on some supermarket shelves. Contracts are available to farmers who adopt organic or sustainable farming practices. Eco labelling and organic certification are commonplace.

THE NETHERLANDS

Public Mechanisms: The Netherlands has had a difficult experience in the last few years in implementing public sustainability mechanisms. Dutch agriculture, like Irish agriculture has a very substantial export capacity. However, significant environmental concerns have emerged in the Netherlands. The previous Dutch government aspired to a more circular agriculture sector to better manage nutrient use. Reducing nitrogen emissions was made a priority and this has been controversial, since it required a reduction in animal numbers. Government support has been provided to deliver technical solutions to reduce greenhouse gas emissions. A more recent change in government was in part motivated by demands from farmers for a reversal of some of these policies.

Private Mechanism: Some supermarkets emphasise the sourcing of local and organic products from Dutch farmers. Partnerships with farmers who use sustainable production techniques are also used. There are also initiatives to support farmers who farm in a way that is supportive of biodiversity. Fair pricing initiatives focus on rewarding farmers financially.

6. Conclusion

As Wolf (1993) highlights, the choice between public and private is a complex one and should not be seen as binary. He highlights the pros and cons of public and private interventions to deliver outcomes. It is not necessary to rely exclusively on public or private sustainability initiatives. Both have strengths and weakness and, depending on the circumstances, they may substitute or complement each other (van der Ven and Barmes, 2023).

Looking at the countries included in this analysis, there are greater similarities in terms of public sustainability mechanisms since the associated sustainability objectives derive from policy objectives that largely originates at EU or global level. Private initiatives by their nature are more country-specific, given that they are established at business or NGO level. Looking across Europe, the identified priorities in terms of agricultural sustainability objectives also exhibit differences and this can possibly be attributed to the prioritisation of particular sustainability objectives in each country's agriculture sector.

Society needs to consider the pros and cons of public and private initiatives in making decisions about how to deliver sustainability improvements. Achieving such improvements requires buy in from stakeholders along the supply chain, which may require compromise where interests conflict. Specific contextual factors relating to agriculture in Ireland should be considered in making choices about the suitability of various interventions. The fact that most of the consumers of Irish food products are in export markets is an important distinction between Ireland and neighbouring countries.

The current prominence of the agri-food sector's environmental sustainability in public discourse is understandable, but stakeholders should not lose sight of the importance of economic and social sustainability objectives, if a balance across all three strands of sustainability is to be achieved.

References

Christy, R.D., (1996). *Markets or government? Balancing imperfect and complementary alternatives*. American Journal of Agricultural Economics, 78(5), pp.1145-1156.

European Commission (2019). *Communication from the Commission to the European Parliament, the European Council, the Council, The European Economic and Social Committee and the Committee of the Regions*. The European Green Deal. Brussels, 11.12.2019 COM(2019) 640 final.

European Commission (2020). *Communication from the Commission to the European Parliament, the European Council, the Council, The European Economic and Social Committee and the Committee of the Regions A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system* Brussels, 20.5.2020 COM (2020) 381 final.

European Commission (2024). *A shared prospect for farming and food in Europe: final report of the Strategic Dialogue on the future of EU agriculture*. https://agriculture.ec.europa.eu/document/download/171329ff-0f50-4fa5-946f-aea11032172e_en?filename=strategic-dialogue-report-2024_en.pdf .

Garcia-Gonzalez, J. and Eakin, H., (2019). *What can be: stakeholder perspectives for a sustainable food system*. Journal of Agriculture, Food Systems, and Community Development, 8(4), pp.61-82.

Grau, R., Kuemmerle, T. and Macchi, L., (2013). *Beyond 'land sparing versus land sharing': environmental heterogeneity, globalization and the balance between agricultural production and nature conservation*. Current Opinion in Environmental Sustainability, 5(5), pp.477-483.

Grant, W and Greer, A., (2023). *How has UK agricultural policy changed since Brexit?* (Accessed: 12 October 2024).

Harwood, R.R., (2020). *A history of sustainable agriculture. In Sustainable agricultural systems* (pp. 3-19). CRC Press.

Lambin, E.F. and Thorlakson, T., (2018). *Sustainability standards: Interactions between private actors, civil society, and governments*. Annual Review of Environment and Resources, 43(1), pp.369-393.

Patashnik, E., (2003). *After the public interest prevails: The political sustainability of policy reform*. Governance, 16(2), pp.203-234.

Saviolidis, N.M., Olafsdottir, G., Nicolau, M., Samoggia, A., Huber, E., Brimont, L., Gorton, M., von Berlepsch, D., Sigurdardottir, H., Del Prete, M. and Fedato, C., (202). *Stakeholder perceptions of policy tools in support of sustainable food consumption in Europe: policy implications*. Sustainability, 12(17), p.7161.

Schoon, B. and Te Grotenhuis, R., (2000). *Values of farmers, sustainability and agricultural policy*. Journal of Agricultural and Environmental Ethics, 12, pp.17-27.

Tait, J. and Morris, D., (2000). *Sustainable development of agricultural systems: competing objectives and critical limits*. Futures, 32(3-4), pp.247-260.

van der Ven, H. and Barmes, D., (2023). *The uneasy marriage of private standards and public policies for sustainable commodity governance*. Business Strategy and the Environment, 32(8), pp.5161-5173.

Weersink, A., Livernois, J., Shogren, J.F. and Shortle, J.S., (1998). *Economic instruments and environmental policy in agriculture*. Canadian Public Policy/Analyse de Politiques, pp.309-327.

Wolf Jr, C., (1993). *Markets or governments: Choosing between imperfect alternatives*. Mit Press.

People Power: Incorporating the Social Dimension in Assessing Farm Sustainability

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Introduction

The growing recognition of sustainability's holistic nature is increasingly reflected in EU policy. In terms of agriculture, this is evident in the multidimensional objectives (economic, environmental and social) of the CAP (2023-27) and the broad ambitions of the European Green Deal and Farm to Fork Strategy. Similarly, the recently published Strategic Dialogue on the Future of EU agriculture reinforces the importance of creating socially responsible, economically profitable, and environmentally sustainable agri-food systems. However, less attention to date has been given to the social dimension of sustainability. Globally, the UN Sustainable Development Goals (SDGs) have been pivotal in accentuating social sustainability, underscoring the importance of human well-being, equity, and social inclusion in sustainable development and shaping policies, frameworks, and innovations across sectors, including agriculture.

Social sustainability, at its core, revolves around addressing the needs of individuals and society in both present and future contexts. Balaman (2018) describes it as *"specifying and managing both positive and negative impacts of systems, processes, organisations, and activities on people and social life."* For agriculture, this includes both internal factors such as farmer health, working conditions, and well-being, and external elements with implications for broader society such as animal welfare, generational renewal and rural viability. Insights on such matters can help us understand the social and institutional context to citizen actions, the broader economic and political incentives, and the limitations and possibilities for behavioural and other change. Such an understanding of the sustainability (and resilience) of agriculture is all the more critical in the context of a *'just transition'* for farm families. Enhanced reporting requirements[1] and social conditionality[2] within the CAP, as well as more broadly the new *Corporate Sustainability Reporting Directive,*[3] require greater accountability and transparency in how social factors are managed within agricultural systems, recognising that environmental and economic sustainability cannot be fully achieved without addressing social issues.

[1] Common monitoring and evaluation framework.
[2] Social conditionality in the CAP links farm subsidies to labour standards, ensuring that farms meet certain social conditions such as providing fair wages and safe working conditions.
[3] Corporate sustainability reporting.

In agriculture, social sustainability measurement is critical for the design of appropriate policies to support the well-being of rural communities, promote equitable resource distribution, and maintain social cohesion in the face of ongoing challenges. The recent pilot project investigating the conversion of the EU Farm Accountancy Data Network (FADN) to the Farm Sustainability Data Network (FSDN)[4] highlighted four broad focus areas for social sustainability measurement, namely: the social attractiveness of the farm sector, social inclusion, education, training and advice and other aspects including a range of factors that may impact the social conditions of farmers such as internet access, living conditions and access to public transport. Likewise, the DAFM Irish Food Vision 2030[5] places an emphasis on social issues such as generational renewal, gender balance, diversity, education and training, health and safety, mental health and wellbeing and broader rural development.

Current state of the art, and of the nation

There is now an emerging literature in social sustainability measurement in agriculture, within which it is broadly acknowledged it is less developed relative to economic and environmental dimensions. Several papers highlight the limitations posed by data availability (Lebacq *et al.*, 2012; Latruffe *et al.* 2016). Robling *et al.* (2023) identifies particular gaps in measuring work-life balance, isolation, and animal welfare and calls for improved data collection systems and co-ordinated efforts to develop more comprehensive, accurate, and accessible datasets for sustainability assessments. Likewise, Latruffe *et al.* (2016) provide a review of sustainability metrics in agriculture and call for the development of new indicators, particularly for social themes and innovation. Lebacq *et al.* (2012) further suggests that the selection of indicators should involve stakeholder participation to address the interactions between the environmental, economic, and social dimensions.

A suite of farm-level sustainability indicators across economic, environmental and social dimensions have been under development in an Irish context through the NFS for over a decade (Dillon *et. al.* 2016). In addition to the socio-demographic data reported annually through the Teagasc NFS[6] and Sustainability[7] reports, a series of special surveys have been undertaken in recent years to report a broad range of issues relating to social sustainability. Expanding on the internal and external classification of social sustainability, and following consultation with stakeholders, Brennan *et al.* (2020), using data from the NFS categorises social sustainability into dimensions reflecting farmer, animal and community wellbeing, and identifies relevant indicators for each dimension. Farmer wellbeing incorporates elements relating to quality of life (i.e. working hours, stress etc.), animal wellbeing consolidates herd level welfare data, while community wellbeing examines indicators measuring multifunctionality, service accessibility and heritage and culture (including generational renewal). Furthermore, Brennan *et al.* (2022a) combine self-reported stressors and statistical analysis to identify the prevalence of farm related stress and describe the attributes of those impacted. Findings corroborate the literature identifying poor weather, workload, and financial pressures as key stressors, as well as the increased probability of dairy farmers experiencing stress compared to operators of other farm systems. These findings demonstrate that occupational stressors impacting farmer wellbeing are multi-faceted, influenced by both internal and external pressures, and vary by enterprise type and demographic factors. The findings highlight variance in the levels of stress reported by farmers by age and farm system, and consequently, the need to develop targeted supports that take consideration of differences within the population of farmers and farm enterprises.

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[4] Conversion to a Farm Sustainability Data Network (FSDN).
[5] Food Vision 2030 – A World Leader in Sustainable Food Systems.
[6] Teagasc National Farm Survey 2023.
[7] Teagasc National Farm Survey - 2022 Sustainability Report.

The broad and diverse nature of social sustainability poses a particular challenge in its assessment, as does its subjective and sometimes sensitive nature. Asai and Antón (2024) provides a comprehensive overview of the current state of the art in integrating social sustainability in agricultural assessment, based on experiences from several OECD countries, including Ireland. It highlights how progress has been made through the incorporation of social questions into farm-level surveys and sectoral data collection initiatives and provides a framework for analysing social issues in agriculture by focusing on well-being at the individual, community, and societal levels. This includes factors such as income, job quality, safety, health, education, and social connections. It also identifies significant data gaps that hinder comprehensive analysis of social issues in agriculture and contends that improved data collection systems could enable better-targeted interventions to address issues of concern.

With reference to existing international frameworks, such as the OECD Better Life Index[8] and the Eurostat Quality of Life Indicators,[9] Brennan *et al*. (2022b) developed a Farmer Sustainability Index (FSI) in an Irish context, drawing from NFS socio-demographic and economic variables from 2018. The composite index is designed to measure social sustainability on farms by focusing on three dimensions: *farm business continuity*, *community and social connections, and farmer comfort and quality of life,* as detailed in Figure 1.

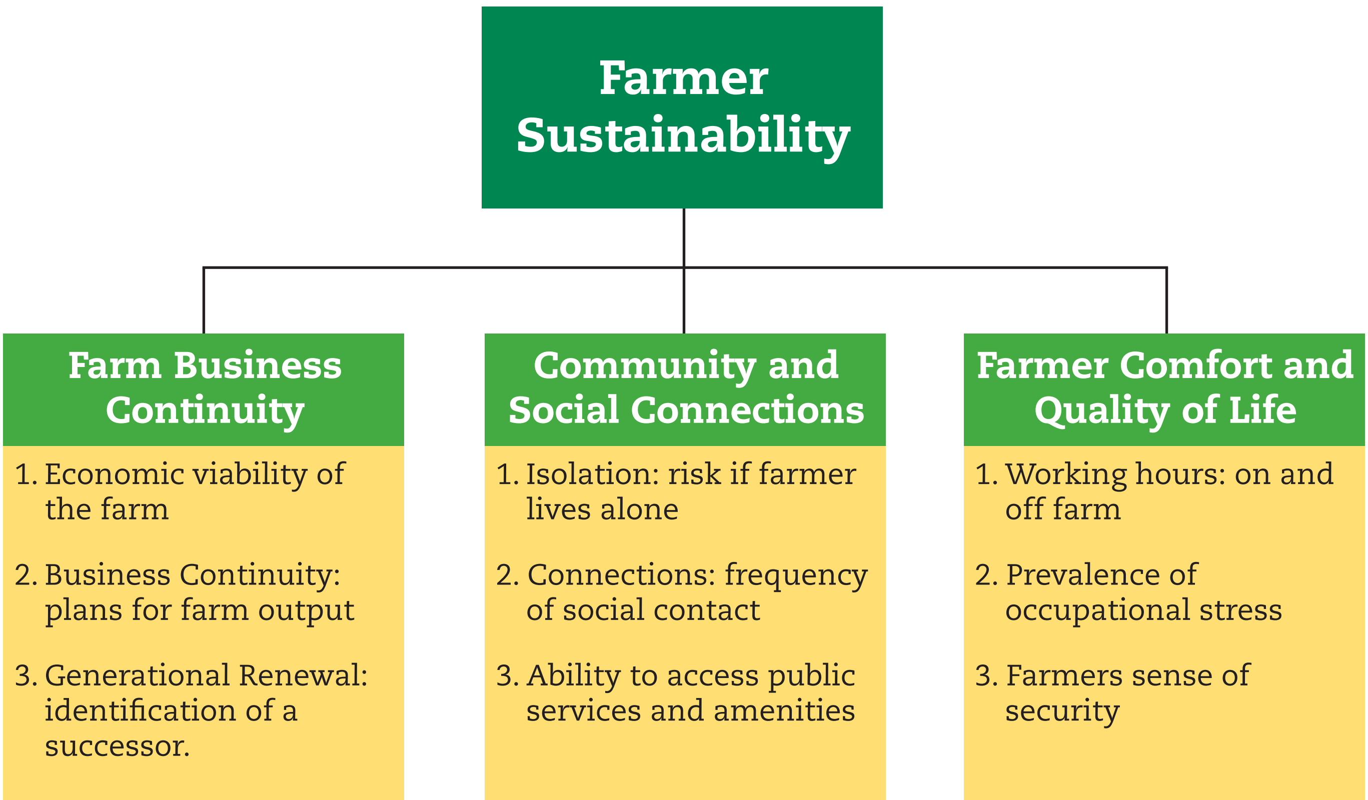

Figure 1 Farmer Sustainability Composite Index. Source: Adapted from Brennan *et al.* (2022b).

8 OECD Better Life Index.
9 Eurostat Quality of life indicators.

Data analysis indicates that farmers, particularly those in the cattle and sheep sectors, as well as those aged over 60 years, face significant social sustainability challenges. The research highlights how social isolation, economic vulnerability, and mental health concerns disproportionately affect older farmers and those in regions with poorer infrastructure. However, the paper also raises the context specific nature of sustainability assessment and, for example, the inherent trade-offs across dimensions e.g. between economic sustainability on the one hand, and social sustainability on the other. That is to say that dairy farms performed well in terms of economic viability but that dairy farmers themselves suffered proportionately more from stress and poor work-life balance due to their workload. In contrast, sheep farmers scored better on work-life balance but displayed greater levels of economic vulnerability. Regional differences were also evident, with farmers in the South-West and Border regions facing lower social sustainability scores due to poor access to services and economic vulnerability.

The study emphasises the growing recognition that without addressing social sustainability, broader sustainability goals in agriculture may remain incomplete. Integrating these social indicators into agricultural policy frameworks, is crucial to enhancing the wellbeing of farmers and ensuring the long-term viability of rural areas. Furthermore, Brennan *et al.* (2022b) draws on Vallance *et al.'s* (2011) trifold conceptualisation of social sustainability and, specifically, the concept of maintenance sustainability that *'speaks to the traditions, practices, preferences and places people would like to see maintained (sustained).'* Other recent papers exploring farmer mental health and wellbeing in an Irish context include Hammersley *et al.* (2022, 2023), Russell *et al.* (2023) and Rose *et al.* (2024).

Social data insights from the National Farm Survey

Selected sociodemographic data from the NFS, relating to the farm holder and household are published on an annual basis. This provides insights into age profile, marital status, household composition, incidence of off-farm employment, hours worked (on and off farm) and agricultural education. Over the past decade, this has reflected the ageing farmer profile and the increased proportion of farm households in receipt of off-farm income. Supplementary data relating to social issues of concern have also been collected through the NFS over the past decade, including data on farmer health and safety, ICT use and access to services e.g. banking and health. A brief description of data collected with regard to generational renewal, farmer wellbeing and social engagement are provided here.

Generational renewal

Data from the 2020 Irish Census of Agriculture indicated that almost 33% of farm holders were aged more than 65 years, up from 23% in 1991. Conversely, only 7% were aged less than 35 years, down from 13% over the same period. As such, there is growing concern around the issue of delayed succession and generational renewal on farms. Although some qualitative insights on the drivers and barriers to farm transfer have been garnered through research such as Conway *et al.* (2017) and Leonard *et al.* (2020), there existed a lack of quantitative data on farm holder intentions with regard to succession. This provided the motivation for the collection of such data through the NFS. Data from the 2023 NFS indicates that on average, 6 in 10 farmers aged over 60 have identified a successor, with some variation by farm system (Figure 2 *(next page)*). Across all farm types, a decline in the proportion of farmers with an identified successor is evident when compared to 2018 when the data was previously collected. Further data analysis by Loughrey *et al.* (forthcoming) concludes that factors impacting farm succession across systems are nuanced, and that economic, demographic, and social dimensions need to be considered in the design of targeted interventions to support generational renewal.

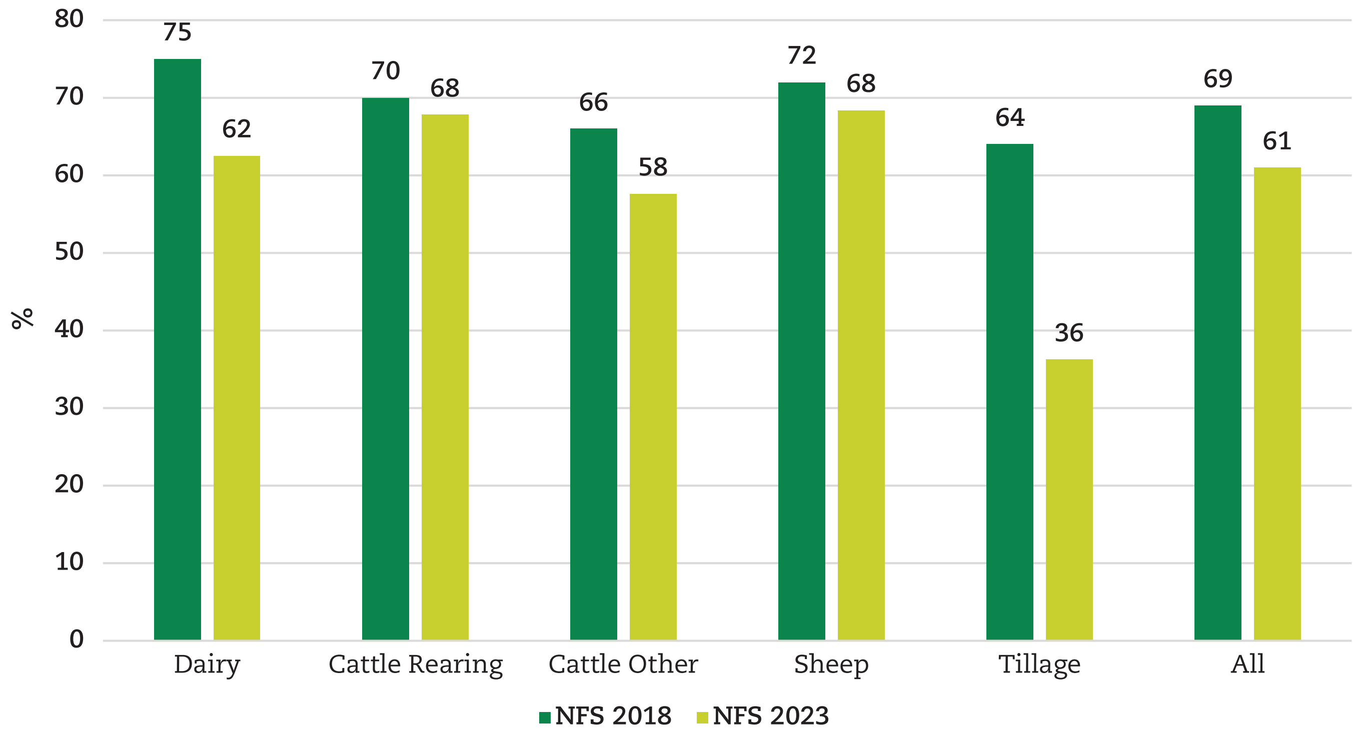

Figure 2 Proportion of farms with identified successor (farmers aged >60 years). Source: Teagasc National Farm Survey.

Data from the NFS Small Farms Report 2022[10] further indicates that a lower proportion of small (cattle and sheep) farm operators have identified a successor, at just 56% on average. The challenge of delayed succession is further illustrated in Figure 3 which illustrates the length of time that the average farm holder has been in place as the main farm operator, across both the core NFS and on small farms.[11] The data indicates that almost three-quarters of farm holders have had managerial control of their farms for more than 20 years. The proportion was somewhat lower on small farms at 58%.

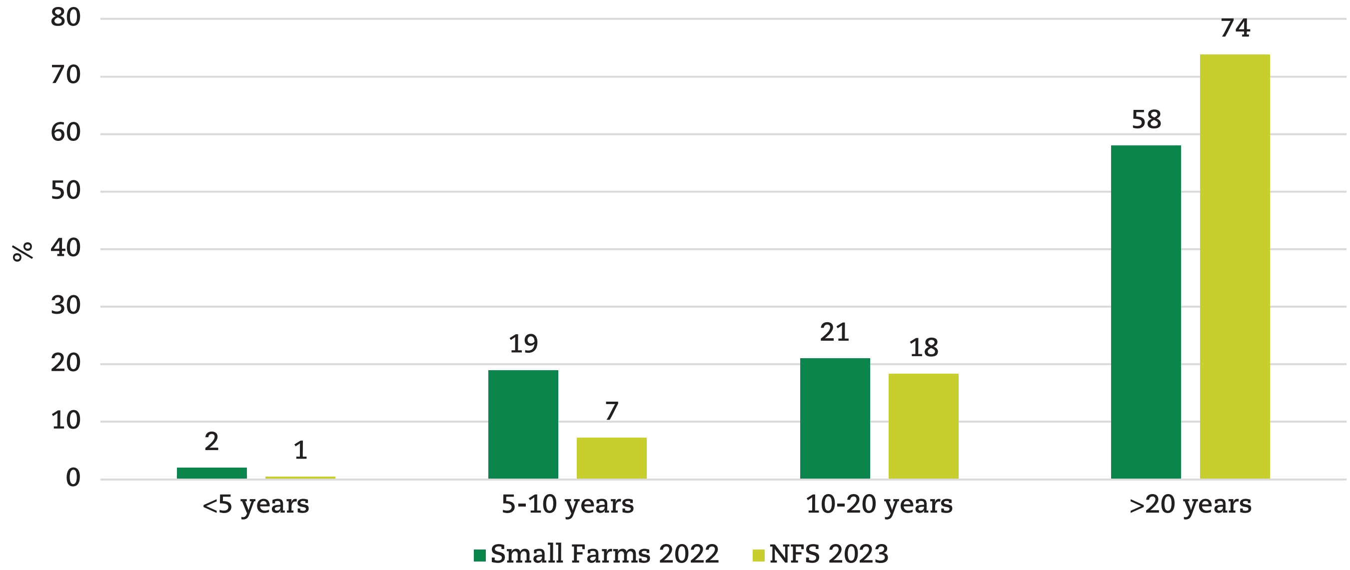

Figure 3 Farm holder duration as main operator. Source: Teagasc National Farm Survey.

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[10] Teagasc National Farm Survey Small Farms Report 2022.

[11] Farms included in the annual NFS sample have a standard output above €8,000 and are representative of approximately 85,000 farms annually. Small farms have a standard output below this threshold and data is collected on a periodic basis. Such farms are representative of approximately 48,000 farms in Ireland.

Farmer Wellbeing

The increased recognition of the need for appropriate provisions around farmer mental health and wellbeing allowed for the collection of additional data on the incidence of stress on farms through the NFS in the past number of years. Figure 4 illustrates that almost 4 in 10 farmers reported experiencing stress relating to their farm business over the period 2017 to 2021. Across farm systems, the prevalence of stress was highest on dairy farms with more than 1 in 2 dairy farmers indicating that running their farm business was a source of stress. This compares to between 1 in 4 and 1 in 3 across other systems.

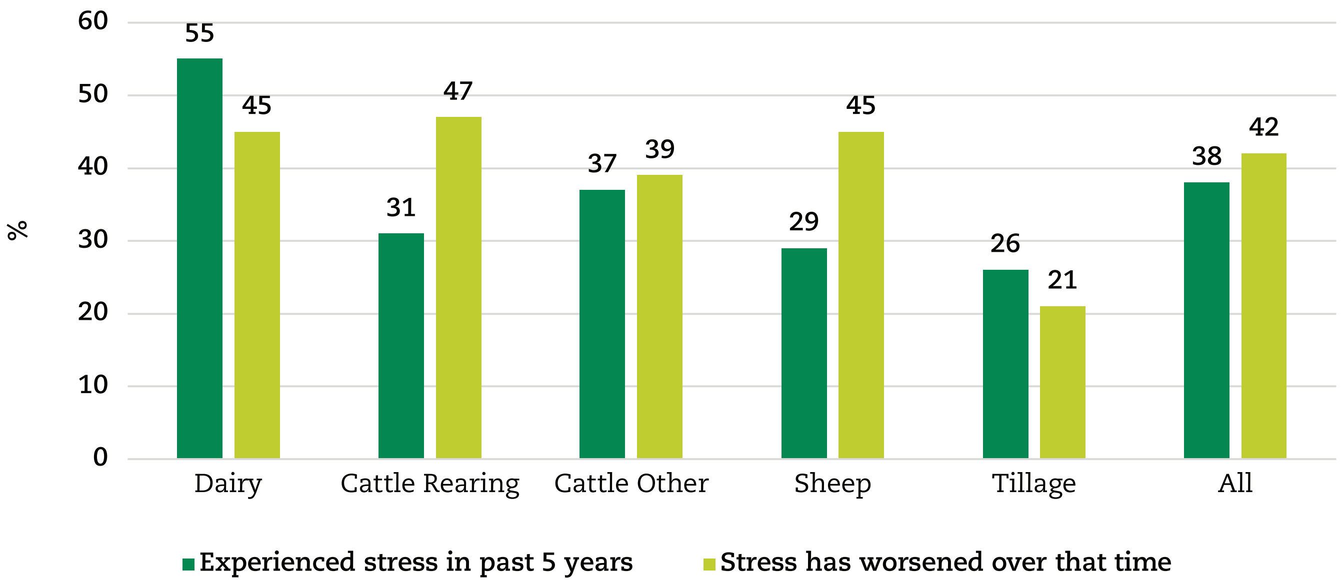

Figure 4 Prevalence of farm business related stress 2021. Source: Teagasc National Farm Survey.

All farmers reported a significant deterioration in their stress levels over recent years. Identified farm stressors include weather, workload and financial concerns. See Brennan *et al.* (2022a) for an in depth examination.

Social Engagement

Data insights on farmer social contact in recent years (Figure 5 *(opposite)*) illustrate the impact of Covid-19 in reducing daily interaction with people outside of their household. This was the case across all farm systems, and on Sheep farms in particular, the proportion going from almost three quarters in 2018 to just over half in 2021. The older age profile of those farmers serves as some explanation. Tillage farmers were less impacted, on average. As a consequence an increase in the proportion of farmers with less social contact across farm systems was evident.

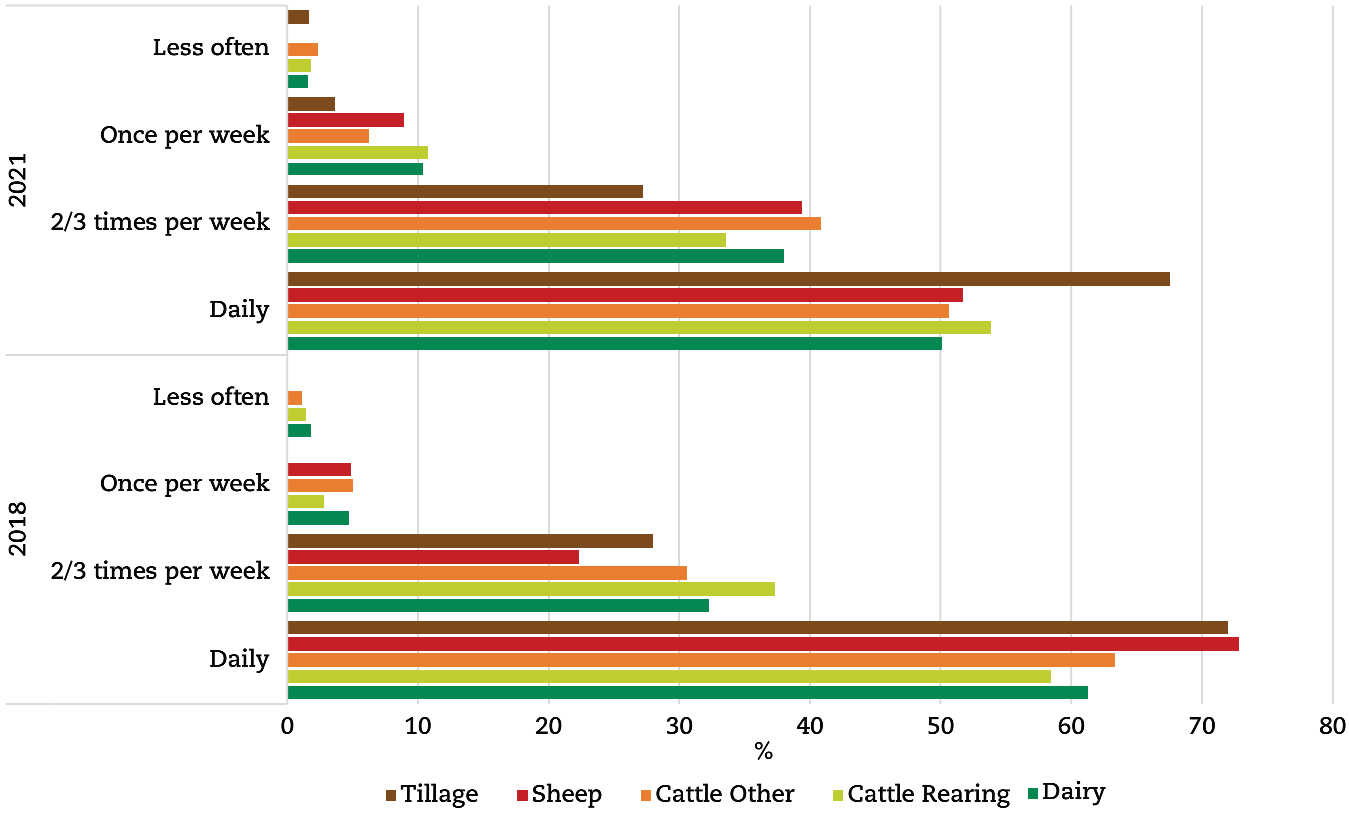

Figure 5 Frequency of farmer social contact outside of household, % by farm system 2018 & 2021. Source: Teagasc National Farm Survey.

Conclusion

Policy monitoring and evaluation requires harmonised multidimensional indicators to gauge progress towards specific sustainability targets. A guiding principle of the recent Strategic Dialogue on the Future of Agriculture is that economic, environmental, and social sustainability can reinforce each other. The delivery of a more holistic assessment of farm level sustainability, with improved social metrics will facilitate the design of more targeted policy interventions and allow for the achievement of a wider range of sustainability goals.

Given the broad spectrum of social sustainability, the collection of relevant data for integration into farm level sustainability assessments is challenging, complex and costly. Particular difficulties include the burden of collecting broad ranging data every year, and the potential sensitivities around the discussion of certain personal or family issues. Resource requirements are high due to the nature of data collection in some instances (e.g. one-to one engagement with farmers) or the sheer volume of data required (e.g. to collect accurate representative data on antibiotic use on farms). In the context of the NFS, a core component of the newly DAFM funded MEASURE[12] and GENFARMS[13] projects will build upon the progress made in the design of sustainability indicators through the NFS. This will involve stakeholder engagement and knowledge exchange in the co-design of suitable new survey instruments, for social and environmental metrics in particular. In addition, in an attempt to ease the data collection burden, efficiencies should be made, where possible, through the use of existing digital datasets. For example, in time, the possibility of utilising available administrative data through the antibiotics register would be very valuable.

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[12] MEASURE (Modelling Estimates for Agricultural Sustainability Using Real Evidence).
[13] GENFARMS (Gender and Generational Factors in Agricultural Resource Management for Sustainability).

References

Asai, M. and J. Antón (2024). "*Social issues in agriculture in rural areas*", OECD Food, Agriculture and Fisheries Papers, No. 212, OECD Publishing, Paris, https://doi.org/10.1787/fec15b38-en.

Balaman, S.Y. (2018). *Decision-Making for Biomass-Based Production Chains: The Basic Concepts and Methodologies*. Academic Press, 2018.

Brennan, M., Hennessy, T. and Dillon, E. (2020). *Towards a better measurement of the social sustainability of Irish agriculture*. Int. J. Sustainable Development: 23:3/4. https://doi.org/10.1504/IJSD.2020.115229 .

Brennan, M., Hennessy, T., Meredith, D. and Dillon, E. (2022a). *Weather, Workload and Money: Determining and Evaluating Sources of Stress for Farmers in Ireland*. Journal of Agromedicine, 27:2. https://10.1080/1059924X.2021.1988020 .

Brennan, M., Hennessy, T. Dillon, E. and Meredith, D. (2022b). *Putting social into agricultural sustainability: Integrating assessments of quality of life and wellbeing into farm sustainability indicators*. Sociologia Ruralis https://doi.org/10.1111/soru.12417 .

Conway, S.F., McDonagh, J., Farrell, M. and Kinsella, A. (2017). *Uncovering obstacles: The exercise of symbolic power in the complex arena of intergenerational family farm transfer*. Journal of Rural Studies 54:60-75. https://doi.org/10.1016/j.jrurstud.2017.06.007.

Dillon, E.J., Hennessy, T., Buckley, C., Donnellan, T., Hanrahan, K., Moran, B. and Ryan, M. (2016). *‘Measuring progress in agricultural sustainability to support policy-making’*. International Journal of Agricultural Sustainability, Vol. 14, No. 1, pp.31–44. https://doi.org/10.1080/14735903.2015.1012413

Hammersley, C., Meredith, D., Richardson, N., Carroll, P. and McNamara, J. (2023). *Mental health, societal expectations and changes to the governance of farming: Reshaping what it means to be a ‘man’ and ‘good farmer’ in rural Ireland*. Sociologia Ruralis, 63(S1), 57–81. https://doi.org/10.1111/soru.12411

Hammersley, C., Richardson, N., Meredith, D., Carroll, P., and McNamara, J. G. (2022). *Supporting farmer wellbeing: exploring a potential role for advisors*. The Journal of Agricultural Education and Extension, 29(4), 511–538. https://doi.org/10.1080/1389224X.2022.2082498 .

Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., Ryan, M. and Uthes, S., 2016. *Measurement of sustainability in agriculture: a review of indicators*. Studies in Agricultural Economics, 118(3), pp.123-130. https://doi.org/10.7896/j.1624ff .

Lebacq, T., Baret, P.V. and Stilmant, D., 2013. *Sustainability indicators for livestock farming. A review.* Agronomy for sustainable development, 33, pp.311-327. https://doi.org/10.1007/s13593-012-0121-x

Leonard, B., Farrell, M., Mahon, M., Kinsella, A. and O'Donoghue, C. (2020). *Risky (farm) business: Perceptions of economic risk in farm succession and inheritance*. Journal of Rural Studies, 75:57-69. https://doi.org/10.1016/j.jrurstud.2019.12.007.

Loughrey, J., Shin, M., Dillon, E. Kinsella, A. (forthcoming). *Generational Renewal and Farm Succession: Insights from Ireland*. Eurochoices.

Robling, H., Hatab, A.A., Säll, S. and Hansson, H. (2023). *Measuring sustainability at farm level – A critical view on data and indicators*. Environmental and Sustainability Indicators, 18. https://doi.org/10.1016/j.indic.2023.100258.

Rose, D.C., Bradley, F., O’Connor, D., Hall, J., Morrison, R., Mulkerrins, M., Nye, C. and Russell, T. (2024). *The mental wellbeing of young farmers in Ireland and the UK: driving factors, help-seeking, and support*. Scottish Geographical Journal, 140(1-2), pp.155-175. https://doi.org/10.1080/14702541.2023.2274004.

Strategic Dialogue on the Future of EU Agriculture (2024). Available at: https://ec.europa.eu/commission/presscorner/detail/en/ip_24_4528.

Russell, T., Markey, A., Stapleton, A. and McHugh, L. (2022). Dying to farm: developing a suicide prevention intervention for farmers in Ireland. https://www.hse.ie/eng/services/list/4/mental-health-services/connecting-for-life/publications/grant-scheme-paper-11.pdf

Vallance, S., Perkins, H.C. & Dixon, J.E. (2011). *What is social sustainability? A clarification of concepts*. Geoforum, 42, 342–348. https://doi.org/10.1016/j.geoforum.2011.01.002.

Driving Change Through Education

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Introduction

Sustainability has long been a core principle of Irish agriculture, and the educational philosophy in Teagasc is deeply connected to the institutions it works within. Both the advisory services and colleges, which play key roles in training and education, trace their origins to the establishment of the Department of Agriculture and Technical Instruction for Ireland (DATI) in 1899. This was made possible by the Agriculture and Technical Instruction (Ireland) Act of 1899. These reforms aimed to improve Ireland's social and economic sustainability, particularly in rural areas. The creation of this Department was driven by the recognition that agriculture, central to the Irish economy, needed modernisation, and that technical education could provide the skills necessary for both industrial and agricultural progress.

The DATI was responsible for promoting agricultural improvement and fostering technical education, particularly in rural areas. The functions of the DATI included:

- **Providing advice and support to farmers, promoting better farming practices.**
- **Developing technical schools and agricultural colleges.**
- **Offering grants and subsidies for research and innovation in agriculture.**
- **Establishing experimental farms to trial new agricultural methods.**

It made important strides in agricultural education, providing a foundation for the modernisation of Irish farming. The establishment of rural technical schools, agricultural colleges with experimental farms, and improved farm management techniques helped to boost agricultural productivity. The department also worked to improve the quality of livestock, dairy production, and crop yields, laying the groundwork for agricultural sustainability. It also helped introduce the idea that technical education is crucial for industrial and economic development, a principle that continues to inform Irish education policy to this day.

For more than 125 years, educational programmes and initiatives have played a crucial role in promoting economically sustainable farming practices. In recent decades, although this economic focus has persisted, the focus on environmental sustainability within educational courses and programmes has evolved and Teagasc has adapted to be able to equip farmers with the knowledge and resources they need to effectively tackle environmental challenges.

The Need for Change in Farming Practices for Environmental Sustainability in Ireland

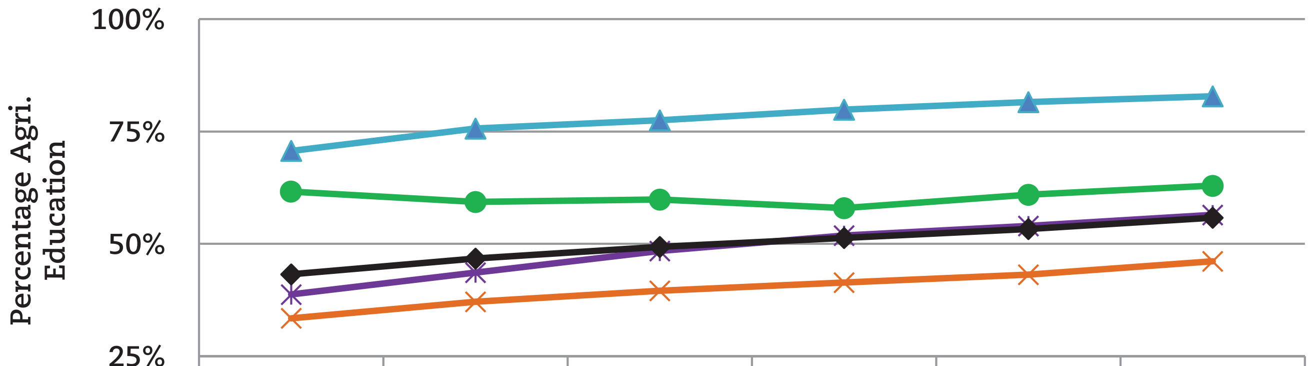
The need for change in farming practices to achieve environmental sustainability in Ireland has become increasingly urgent as the nation grapples with the effects of climate change and biodiversity loss. While traditional farming methods are integral to Ireland’s agricultural heritage, there is an increasing understanding that they may also potentially create risks to soil health, water quality, and increased greenhouse gas emissions (Teagasc, 2020). The adoption of more sustainable practices can enhance soil health, reduce chemical inputs, and promote biodiversity (Department of Agriculture, Food and the Marine, 2022). By embracing these innovative methods, Irish farmers can not only contribute to the preservation of the country’s rich natural landscape but also ensure the long-term viability of the agricultural sector, aligning with national and EU sustainability goals (European Commission, 2021).

Education as the Driver of Sustainable Change

In the European Union (EU), more than 50% of farm managers have no formal agricultural training (Eurostat, 2013). Similarly, in the USA, less than 6% of farmers have received formal agricultural training (Data USA, 2019).

Ireland has a notably high participation rate in agricultural education compared to other countries (Angioloni, 2024). This success can be traced back to the 1899 Act and the proactive role of the Department of Agriculture in enhancing educational access. Additionally, EU policies and national taxation strategies aimed at fostering generational renewal—including an educational component—have played a crucial role. In terms of rural development, generational renewal goes beyond simply reducing the average age of farmers in the EU; it also emphasises the importance of empowering a new generation of skilled young farmers who can utilise technology to improve sustainable farming practices throughout Europe (European Network of Rural Development, 2024).

The Teagasc National Farm Survey (NFS) tracks educational attainment annually, revealing trends among farmers. As shown in Figure 1, the proportion of farmers who have received some form of agricultural education rose from 44% in 2017 to 53% in 2022. Notably, dairy farmers exhibit significantly higher levels of formal agricultural education compared to farmers in other sectors.



	2015-2017	2016-2018	2017-2019	2018-2020	2019-2021	2020-2022
Dairy	71%	76%	77%	80%	82%	83%
Cattle	33%	37%	40%	41%	43%	46%
Sheep	39%	44%	48%	52%	54%	56%
Tillage	62%	59%	60%	58%	61%	63%
All Farms	43%	47%	49%	51%	53%	56%

Figure 1 Formal Agricultural Education: The percentage of all farmers who have received some form of agricultural education presented as 3 year rolling average 2017-2022 (average per system). Source: Teagasc National Farm Survey Sustainability Report 2022.

Teagasc, as the leading research and advisory body in agriculture, plays a crucial role in delivering agricultural education by integrating cutting-edge research with practical, on-the-ground expertise. This synergy ensures that educational programmes are grounded in the latest scientific findings and technological advancements, equipping students and farmers with the knowledge and skills necessary to address current challenges in the sector. By collaborating with industry stakeholders and incorporating real-world applications into their curriculum, Teagasc fosters a learning environment that is both relevant and responsive to the evolving needs of agriculture. Furthermore, the latest Teagasc strategy initiative, 'Teagasc Together' encourages its extensive network of advisors and researchers to give continuous feedback and suggested improvement, ensuring that educational initiatives remain effective and aligned with best practices in sustainable farming and land management.

Case Studies: Real-World Impact of Educational Initiatives

Incorporating pasture management into the curriculum

In recent years, pasture management has evolved significantly. The development of digital measurement tools and technology has greatly enhanced how pasture is managed. PastureBase Ireland is an online platform designed to help farmers manage their grasslands more effectively. It focuses particularly on pasture measurement and management, aiming to optimise grass production for livestock and ensure it is utilised efficiently.

In addition to the use of this technology, Teagasc started extensive farm wide trials of white clover inclusion on the Teagasc Clonakilty Agricultural College farm in 2012. This quickly demonstrated that incorporating clover into pasture systems offers numerous sustainable benefits that enhance soil health, improve forage quality, and support biodiversity. Clover is a nitrogen-fixing legume, which means it can naturally enrich the soil with nitrogen, reducing the need for synthetic fertilisers.

In educational institutions, significant changes, such as those mentioned relating to pasture management, usually occur gradually. First, the need for change must be identified before being incorporate into the next scheduled curriculum review, which can take a number of years to come around. However, at Teagasc, the close integration with research and the ability to update module content provide an opportunity to implement changes more quickly and demonstrate the latest research first-hand to learners. For example, Teagasc have already introduced pasture development in our Level 5 course through the Grass Production module. In the Level 6 Grassland Management module, Teagasc are further advancing sustainability concepts, focusing on decision-making and the inclusion of clover in grassland management practices.

Sustainable Farming in the Environment (Level 6) module

Economic sustainability has always been a fundamental aspect of our educational programmes. Farm production efficiency plays a crucial role in driving economic sustainability. In turn, these efficiencies contribute to the overall sustainability of the farm. With this in mind, all of our production and soil modules incorporate environmental sustainability. To further highlight the importance of environmental sustainability within our programmes, we have introduced a new "*Sustainable Farming in the Environment*" module at Level 6, aimed at learners in the second-year of their full-time programme.

The environment module specifically focuses on sustainable farming practices, environmental regulations, and protecting natural resources. In summary the module covers:

1) **Sustainable Farming Practices**
   - **Soil Health:** Understanding soil composition, fertility management, and conservation techniques.
   - **Nutrient Management:** Efficient use of fertilisers, crop rotation, and organic farming to reduce environmental impacts.
   - **Waste Management:** Handling farm waste responsibly, including recycling and reducing hazardous waste.
2) **Environmental Regulations**
   - **Irish and EU Policies:** Overview of relevant environmental laws and policies affecting farming in Ireland, such as the Nitrates Directive and the Common Agricultural Policy (CAP).
   - **Cross-Compliance Requirements:** Ensuring that farming practices meet environmental standards, including biodiversity preservation and water quality protection.
3) **Climate Action in Agriculture**
   - **Greenhouse Gas Emissions:** Impact of farming on climate change and strategies to reduce carbon footprints.
   - **Carbon Sequestration:** Methods of capturing and storing carbon, including tree planting and soil management.
4) **Water and Land Management**
   - **Water Quality Protection:** Reducing runoff and pollutants entering watercourses through good farm management practices.
   - **Biodiversity:** Encouraging biodiversity on farms, such as hedgerows, wildlife corridors, and native species planting.
5) **Practical Applications**
   - **Farm Audits:** Conducting environmental audits on farms to assess impact and improve sustainability.
   - **Agri-Environment Schemes:** Participation in government-supported schemes like past schemes such as GLAS (Green, Low-Carbon, Agri-Environment Scheme) or REPS (Rural Environment Protection Scheme) or the current Agri-Climate Rural Environment Scheme (ACRES).

This module is essential for modern farmers in Ireland, ensuring they can balance productivity with environmental stewardship, aligning with national and EU sustainability goals.

Overcoming Barriers to Educational Change in Farming

Although we can adaptively implement changes and solutions to enhance farm sustainability, challenges still persist. While Teagasc remains the primary provider of vocational education in agriculture, it is no longer the only one. In recent years, Education and Training Boards (ETBs) and private educational institutions have also begun offering agricultural education at both Level 5 and Level 6 providing additional opportunities for farmers to acquire “Trained Farmer” qualifications. Given Teagasc's emphasis on the significance of environmental sustainability in agriculture and its leadership in emerging technologies within this field, it is important that the research information available through Teagasc is used to influence the curriculum and learning outcomes provided by other institutions as well as by Teagasc programmes. Existing collaborations in place with a number of providers, including Higher Education Institutes that utilise Teagasc and private Agricultural Colleges for programme delivery is an important example of this collaboration.

Conclusion

Agricultural education in Ireland has evolved since the establishment of the Department of Agriculture and Technical Instruction (DATI) in 1899, which aimed to modernise farming practices and enhance the socio-economic conditions of rural areas. As Ireland grapples with climate change and biodiversity loss, there is an increasing and urgent need to shift towards more sustainable farming methods.

Education is pivotal in facilitating this transition, with Teagasc at the forefront, integrating cutting-edge research and technology into its training programmes. The introduction of initiatives such as improved pasture management techniques and the new “Sustainable Farming in the Environment” module underscores the commitment to environmental stewardship in agricultural education.

In addition to these advancements, new opportunities are emerging through new educational providers, such as Education and Training Boards (ETBs) and private institutions. To ensure that sustainable practices are effectively incorporated into all agricultural training, there is an important role for Teagasc to continue to support the curriculum and learning outcomes offered by these emerging institutions. This ongoing effort is vital for aligning Ireland’s agricultural practices with national and EU sustainability goals.

Information Sources

Data USA (2019). *Data USA: Agriculture: Agriculture Degree Recipients*. Accessed 10 October2022. https://datausa.io/.610 S. ANGIOLONI ET AL.

Department of Agriculture, Food and the Marine. (2022). *Sustainable Agriculture*.

European Commission. (2021). *Farm to Fork Strategy*.

Teagasc. (2020). https://www.teagasc.ie/media/website/publications/2019/TResearch_Winter2019_AgriAndClimateChange_Web.pdf

Teagasc. (2022) https://www.teagasc.ie/media/website/publications/2022/Teagasc-Climate-Action-Strategy-2022-2030-web.pdf

Teagasc. (2022) Teagasc National Farm Survey Sustainability Report 2022, Retrieved from
https://www.teagasc.ie/media/website/publications/2023/SustainabilityReport2022.pdf

Europa 2024 Generational Renewal.

Angioloni, S. (2024) *“Eliciting farmers’ preferences towards agriculture education in Northern Ireland”*.

The Journal of Agricultural Education and Extension, *Competence for Rural Innovation and Transformation,* Volume 30, - Issue 4.

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