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Collaborating on Climate:
Bioeconomy & Sustainable Agriculture Research & Innovation across the UK and Ireland

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March 2022

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Foreword from the British Ambassador to Ireland

We all know the world is at a tipping point. The Glasgow Climate Pact agreed at COP26 will succeed in keeping 1.5 degrees of global warming within reach only if the international community comes together to deliver the urgent action that is needed to tackle the climate emergency. We owe it to future generations and people on the frontline of climate change today to accelerate ambition, and all sectors of society will need to play their part.

Agriculture is crucial as the sector that feeds us, supports many jobs and rural communities, and that can sustain the biodiversity essential to the delicately balanced ecosystems on our planet.

At COP26, countries from across the world set out their commitment to transform agriculture and food systems through policy reforms, research and innovation to reduce emissions and protect nature, whilst securing food and jobs. This needs to be done through a fair and just transition that protects the livelihoods and food security of millions of people worldwide.

These are shared concerns and interests across both UK and Ireland, given the similarities in our agricultural practices and the economic and cultural significance of the sector to both our countries. I see the challenge of transition also as a common opportunity – to protect our natural environment and to embrace innovations that will allow us to farm and eat sustainably into the future. The UK and Ireland can be leaders in making this transition, and there is much that we can learn from each other as we do so.

I am grateful to the team at BiOrbic, Bioeconomy SFI Research Centre, for engaging with key stakeholders and sharing in this report their recommendations for future UK and Ireland sustainable agriculture cooperation.

I would also like to thank the policymakers, researchers and practitioners who were interviewed and took part in the *"Agricultural innovation for people, nature and climate"* workshop hosted by British Embassy Dublin ahead of COP26. Notably participants from Innovate UK, the Department for Environment, Farming and Rural Affairs (DEFRA), universities and associations who travelled from the UK to join us last October and to meet their Irish counterparts.

The UK and Irish governments are committed to supporting sustainable agriculture and there is regular policy dialogue between our respective agriculture and environment departments. We were fortunate to have DEFRA Permanent Secretary Tamara Finkelstein and the Department of Agriculture, Food and the Marine (DAFM) Secretary General Brendan Gleeson share their valuable insights with workshop participants.

We at the British Embassy see great potential to work more together as the UK and Ireland each take steps to meet our net zero targets. In the UK's pathway to net zero, we committed that 75% of farmers in England will be engaged in low carbon farming practices by 2030, rising to 85% by 2035. Ireland has also set very ambitious goals. Both countries have deservedly excellent reputations globally for agricultural research and innovation and there is a long and fruitful history of collaboration between UK and Ireland-based researchers. This report from BiOrbic serves to highlight some of this cooperation and we look forward to continued collaboration with contributors and others in taking forward its recommendations.

Paul Johnston

British Ambassador to Ireland

Executive Summary

BiOrbic, Bioeconomy SFI Research Centre, was commissioned by British Embassy Dublin to produce this report to support ongoing engagement on research and innovation in sustainable agriculture across and between the UK and Ireland.

Today's society and global economy rely on agriculture to provide food, feed, and natural resource management while also supporting jobs and rural communities. Agriculture is a key pillar of the bioeconomy, together with forestry and the marine. The first farmers were the founding fathers and mothers of the bioeconomy and a sustainable bioeconomy is not possible without sustainable agriculture.

The most significant environmental challenge facing our planet and our biological resources is climate change and the agriculture sector has a crucial role to play. Agriculture is one of the primary sources of greenhouse gas (GHG) emissions in the UK and Ireland, with contributions of 10%[1] and 35%[2] of the totals, respectively. Farmers have always been protectors of the land and with more recent knowledge of ways in which they can further contribute to sustainable and environmentally friendly on-farm practices, there is a lot of good work already underway across both islands. Nevertheless, it is generally accepted that most of the carbon footprint from agricultural produce resides at farm level and not in processing facilities. It is therefore imperative to further strengthen work with farmers and land managers to support them in reducing the carbon footprint of every piece of farmland across these islands.

It is critical that our governments and society continue to recognise and fully value the importance of agriculture to both the UK and Irish economies. As we work to mitigate the negative impacts of climate change, both the UK and Ireland are committed to working with stakeholders to support vibrant and resilient agriculture sectors. This sector can enhance animal welfare, biodiversity, and the environment to help meet the ambitious climate resilient and climate neutral targets by 2050 required by legislation and laid out in pathways to net zero (see Ireland: Climate Action Plan[3] and UK: Net Zero Strategy[4]).

In addition to climate mitigation, preparedness for climate change impact must also be factored into national plans. Climate mitigation and adaption go hand in hand with one slowing and potentially reversing climate change, while the other prepares society for shocks due to climate change. Agriculture must become a source of carbon sequestration and reduce its contribution to overall GHG emissions, but it must also

1 Agri-climate report 2021 - GOV.UK (www.gov.uk)

2 Environmental Protection Agency report, 2019

3 gov.ie - Climate Action Plan 2021 (www.gov.ie)

4 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf

change to ensure that food production systems are resilient to climate change. This resilience can be achieved by restoring and enhancing biodiversity, diversifying production, and improving air and water quality.

To enable sustainable agriculture to thrive, we must engage with and empower farmers with the tools, support and knowledge to also prosper. We must provide data to increase farmers' knowledge and understanding of the farm's carbon footprint and its natural capital. We must deploy mitigation strategies to bring the right players together across research disciplines, to provide the evidence. This work will create a pathway to better agriculture where vibrant farming communities are properly rewarded for their production from and protection of, agricultural land.

Knowledge transfer and exchange is critical. It is particularly important that optimised transfer processes are embedded within the research environment, including the incorporation of co-creation and the inclusion of multi-actors relevant for the size, scope, and nature of projects. The UK and Ireland have a rich history of working closely across a number of domains of agricultural research and innovation from animal health to crop science. Agri-food policymakers have also been developing, improving and aligning their respective national agri-food innovation approaches and policy instruments to target investments in agri-food related science and technology. There is close engagement between farmers and practitioners across these islands, and active engagement with the objectives behind sustainable agriculture. All of this provides a basis from which to encourage greater cooperation.

This report highlights examples of existing research and innovation (R&I) activity on sustainable agriculture and seeks to identify key opportunities for future collaboration. It provides an overview of Centres of Excellence working across different areas of agriculture and a snapshot of Ireland and UK projects. Together these give a flavour of the ongoing work on both islands that will contribute to the development of climate neutral farming of the future.

Focus areas of sustainable agriculture within a sustainable bioeconomy covered in the report are:

Natural Capital: This section considers how viewing nature as capital can act as a means of framing the full extent of a country's natural resources. It also considers the advantages of Natural Capital Accounting and ongoing policy and research work in the UK and Ireland around the promotion of the Natural Capital concept and valuing carbon sequestration.

Soil Health and Crops: This section centres on the recognition of soil as a critical resource. It looks at potential measures for improving soil health, including improved soil and crop management, soil analysis and land mapping. It also examines links with carbon farming, current and future land management and payment schemes, Nitrogen-use efficiency, crop science, peatlands and organic production.

Agricultural Emissions: This section looks at research into agricultural greenhouse gas emissions (GHG) abatement.

Animal Health: This section is divided into three subsections considering:

- **Livestock Efficiencies** and the importance of feed composition, enhanced breeding, better management and housing and improved herd health;

» The issue of **Antimicrobial Resistance**, potential causes and forthcoming legislative change; and

» **Pig Health**, with a focus on ongoing research projects in this area.

Agritech Innovation: This section focuses on the potential for Precision Agriculture to support management decisions and improve the efficiency, productivity, quality, profitability and sustainability of agricultural production. It also explores the farm machinery of the future, and the potential for the deployment of robotics and other technologies in the agricultural context.

BiOrbic views farmers as the first bioeconomists and critical agents for sustainable agriculture and a section of the report is dedicated to proposals for building their capacity and engagement.

We propose that the development of a sustainable bioeconomy and sustainable agriculture in the UK and Ireland can be significantly strengthened through a focus on the key areas of:

- **Research and Innovation:** The generation of new knowledge and solutions, also focused at a farm level and on farmer-centric solutions.
- **Education and Engagement:** Multi-actor engagement, across research, producers, consumers, citizens and young people to support the uptake of solutions.
- **Investment:** De-risking the scale up of solutions and demonstrating medium and large-scale solutions through infrastructure investments, including leveraging private investment.

This report contains details of current relationships, ongoing projects and initiatives, and suggests potential areas for future work. We also propose four recommended actions to provide the basis for closer cooperation across the two islands:

1. **Place farmers at the centre of agricultural innovation**

   » Farmer-centric cooperation: Look at ways to maximise opportunities for farmer, forester and mariner engagement and experience sharing. Focus on implementation where researchers engage with and support practitioners and help them to address the gaps in knowledge that will allow leading edge sustainable practices uptake.

   » Strengthen and improve join-up of demonstration scale farmer networks: Create opportunities for farmers to build connected demonstration scale networks for knowledge, best practise implementation and exchange.

2. **Identify shared outcomes and objectives**

   » Shared Research and Innovation Vision workshops: Workshops to look at common areas of interest for R&I work and projects that could have joint future benefits

   » Identify shared technology goals

   » Identify opportunities to align research programmes and enhance partnership opportunities

3. **Improve alignment of research agendas and strengthen collaborative opportunity**

   » More effective use of existing shared research funding models: Look at opportunities for joint schemes under the Horizon Europe Framework and other viable routes to build upon ongoing significant partnership work

   » Strengthen research and innovation collaboration mechanisms: Enable informal and formal research and innovation collaboration in the areas of bioeconomy and sustainable agriculture

4. **Explore opportunities to share research and innovation infrastructure in the bioeconomy including sustainable agriculture**

Addressing the challenges facing our climate will require coordinated and sustained efforts across the globe. To lead in this regard, UK and Ireland can build on their existing individual and joint efforts in research and innovation for sustainable agriculture - a central pillar of a thriving bioeconomy - to reach solutions faster and more effectively. Despite and because of the common challenges, there is an opportunity to achieve globally significant outcomes by working together.

"BiOrbic is delighted to be working with our colleagues from across Ireland and the UK to identify areas of common interest and collaboration opportunities in sustainable agriculture and the bioeconomy. The impacts of climate change are not confined to national borders. We face a global challenge and working in partnership is critical. The first farmers were the founders of the bioeconomy. Agriculture is a critical pillar of a biobased society. To enable sustainable agriculture to thrive, we must engage with and empower the farmer with the tools, supports and knowledge to also thrive."

Professor Kevin O'Connor
Director of BiOrbic, Bioeconomy SFI Research Centre.

Introduction

The UK and Ireland have a rich history of working closely across a number of common projects, whether that be in animal health or crop science. Relationships have flourished and common aspirations have benefited from the joined-up thinking when applied at the right moment. Agri-food policymakers in both countries have, over time, been developing, improving and aligning the national agri-food innovation approach and its policy instruments to target investments in agri-food related science and technology in order to maximise their economic impacts. Across the UK, sustainable agriculture plans have been published such as 'The Path to Sustainable Farming: An Agricultural Transition Plan 2021 to 2024'[5] in England, and Ireland have adopted 'Ag Climatise[6]' – a roadmap of 29 actions aimed at a climate neutral farming model to be reached by 2050. Both documents set out the pathway to providing stakeholders with a framework to support climate change commitments.

The actions outlined in these plans seek to help all involved stakeholders and outline what needs to happen and by when. Multiple objectives running in harmony and tandem are essential from the farmer, producer, consumer, and governments to make critical progress.

As we enter a new phase, post-Brexit, the future prosperity of the bioeconomy relies on research and innovation, and the demonstration and deployment of new technologies to enable more sustainable agricultural practices. This will help to address climate change with farming at the heart of the solution.

The UK and Ireland have both published strategies that set out mirrored visions for agriculture sectors; anchored on the production of healthy food for consumption, where farms can be profitable and economically sustainable, and where the agriculture and land use sectors play a key role in contributing significantly to environmental goals by reducing emissions, developing renewable energy systems and protecting our biodiversity[7][8]. The EU Farm to Fork Strategy[9] is at the centre of the European Green Deal[10] and aims

5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/954283/agricultural-transition-plan.pdf

6 https://www.gov.ie/en/consultation/b65e3-public-consultation-on-ag-climatise-a-national-climate-air-roadmap-for-the-agriculture-sector-to-2030-and-beyond/

7 https://www.gov.uk/government/publications/the-future-for-food-farming-and-the-environment-policy-statement-2020

8 https://www.gov.ie/en/publication/c73a3-food-vision-2030-a-world-leader-in-sustainable-food-systems/

9 https://ec.europa.eu/food/farm2fork_en

10 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

to make food systems fair, healthy, and environmentally friendly. It sets concrete targets such as halving the use of pesticides, reducing fertilizers by at least 20%, increasing agricultural land under organic farming to 25% and lowering antimicrobials used for farmed animals by 50%.

Expanding scope to include climate targets and sustainable development goals (SDGs) etc. means that policymakers increasingly need to use multiple policy framings. This also means engagement with a wider set of stakeholders to achieve the diverse policy outcomes needed and that citizens are now demanding from their investments in innovation. As such, the focus of agri-food innovation policy in the UK and the EU has broadened significantly to examine these grand challenges. Given the scale, further collaboration would support not only innovation for economic growth, but also the understanding of the key challenges for agriculture. This collaboration can support Ireland, the UK and devolved nations to develop a coherent vision of what a future sustainable food system could look like.

More rapid and equitable diffusion of science and technologies will be needed if sustainable development is to be achieved in practice and within the timeframes set out in the respective plans, all the while ensuring ethical, legal, economic, policy and social issues are addressed. In addition, matters such as a just transition to address the speed and new ways of working associated with scientific, technological and social change need to be considered. Further work is needed on policy frameworks that grant equal weight to sustainable development in decision-making, placing justice and inclusion at the core.

Innovation systems within the UK and Ireland include: research performing organisations, agritech centres, technology gateways; state-funded and public-private institutes and bodies; higher education institutions; education policies to support the absorptive capacities of firms; policies that focus on entrepreneurship; support for high growth innovative firms; policies to support the commercialisation of research carried out in higher education institutions; policies and programmes to support knowledge transfer; advisory services (or extension services) and cooperation; and more recently in cluster policies to stimulate private-private collaboration between firms and develop regional enterprise and economic development.

With all this infrastructure in place, there are significant opportunities to coordinate and achieve shared goals.

This report sets out to highlight existing linkages between the various actors in the system, as well as identifying opportunities to enhance future partnership opportunities. For the purposes of the report, a series of interviews were conducted to get an overview view of key ongoing work in this area. Contributions were sought from academia, government departments, accelerator hubs, research performing organisations and agri-business support organisations. Then in October 2021, the British Embassy Dublin hosted a workshop entitled *'Agricultural Innovation for people, nature and climate - opportunities for the UK and Ireland to work together in support of COP26 goals'*[11] that brought together leading stakeholders from the UK and Ireland to further discuss the focus areas for cooperation.

11 https://www.youtube.com/watch?v=XErEp-9b1zY

The Bioeconomy and Sustainable Agriculture

A sustainable system must be long-lasting and have no negative impact on the environment or natural resources such as soil, water, air, and crops, to ensure future generations can provide sufficient, safe food for their communities.

The bioeconomy is the sustainable use of renewable biological resources and industry technologies, to produce bio-based products and services for societal, environmental, and economic gain now and in the future. The bioeconomy uses renewable biological resources sourced sustainably from land and sea such as crops, forestry, fisheries, aquaculture, micro-organisms and converts these resources and their processing by-products into value added bio-based products including, but not limited to proteins, feed, fertilizers, plastics, and energy.

Sustainable agriculture is a cornerstone of the bioeconomy and includes the production of food that is healthy, humane, and fair for every element of the food chain, from the farm, the animal, the farmer, and the consumer. It is a way of life rather than a regulated industry. Sustainable agriculture depends on healthy soils, healthy animals, reducing emissions, thriving biodiversity and placing the farmer at the centre of the solution.

The three main pillars of a sustainable system are: environmental health, economic profitability, and social and economic equity. A robust bioeconomy needs to protect and enhance our natural resources and adopt new technology and methods to futureproof long term sustainable development. The challenges for sustainable agriculture include the growing global population, demand for food production; less available land, water, and energy resources; together with the numerous effects of climate change and commitments to significantly reduce greenhouse gas (GHG) emissions.

Biodiversity and the climate crisis are linked - to have clear policies and targets we need sufficient results-based evidence to show what is working and where the gaps are. Climate neutral farming or net-zero farming can be a consequence and contributor to much of the above themes and practices. Across both islands, transitions are underway with pathways to support farmers while protecting and enhancing the environment. The economic and social consequences for farming communities and wider society are intertwined. With a coherent and collaborative approach to specific areas, Ireland and the UK can reach their goals faster.

A common objective on both islands has been to link bioeconomy driven priorities into wider government strategies and policy areas, so that it is embedded in the thinking and planning of actions over the next 5 to 10 years and beyond. At policy level, the UK has published a new Innovation Strategy to support innovation in places, sectors, and businesses across the UK[12].

12 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009577/uk-innovation-strategy.pdf

Contributors detailed ways the bioeconomy sector might be supported that included:

- Joining up clusters of the bioeconomy (research hubs, infrastructures to enable the bioeconomy, locating relevant resources domestically for bioeconomy actors and international relations building for bioeconomy development).
- Ensuring a pipeline of skills (including academic and corporate/commercial side, i.e., a wide skill set is needed to make this a success) – to ensure this is an attractive area to enter.
- Regulation – making sure the right regulations are in place so that businesses can succeed – understanding what businesses need.
- Ensuring the right 'translational infrastructure' is in place – to support scale-up challenges.
- Addressing public perception – communicating the bioeconomy, ensuring consumers understand what the bioeconomy is and generating 'consumer-pull' for bio-based products and new industrial and production systems and solutions.

The Irish government launched a 'National Policy Statement on the Bioeconomy[13]' in 2018, which sets out a vision, common principles, strategic objectives, and a framework for implementation for the development of the bioeconomy, harnessing Ireland's natural resources and competitive advantage. The Bioeconomy Implementation Group, co-chaired by the Department of Agriculture, Food and the Marine and the Department of the Environment, Climate and Communications, is mandated to advance actions and challenges identified in the National Policy Statement to further develop the Bioeconomy in Ireland. The National Bioeconomy Forum was established in 2020 as part of Bioeconomy Ireland week to provide a voice for a broad range of stakeholders, including industry, community groups, NGOs and relevant state bodies to support the development of the bioeconomy.

There was a common thread in contributions that the mechanism of EU funding such as Interreg projects, ERA-NETs and Joint Programming Initiatives (JPIs) were all welcome sources of structured collaboration. There was a consensus across the islands that any initiative to capture this momentum and relationships built through joint projects is very desirable. It is seen by many UK contributors as essential to maintain EU links and activity with Irish partners; indeed, the direct link to Irish research and innovation sources and hubs is seen as a key enabler for advancing common research goals across the UK. Contributors suggested it would be of use to look at opportunities for multi-actor approaches (similar to EU project constructions) across the regions and models like the EIP-AGRI operational groups could be a means to initiate common areas of interest and work. For reference, the EIP-AGRI operational groups are intended to bring together multiple actors such as farmers, researchers, advisers, businesses, environmental groups, consumer interest groups or other NGOs to advance innovation in the agricultural and forestry sectors.

Contributors suggested that while mechanisms for collaboration are to be welcomed and encouraged, there does need to be an acknowledgement of differences where they exist also, in terms of production systems whether that be animal or plant/crop-based systems.

13 https://www.gov.ie/en/publication/c1e596-national-policy-statement-on-the-bioeconomy/

Focus Areas in Sustainable Agriculture

This section will deal with some of the main focus areas of sustainable agriculture within a sustainable bioeconomy. These include: i) Natural Capital, ii) Soil Health and Crops, iii) Animal Health, iv) Agricultural Emissions and v) Agritech Innovation

It also seeks to present what existing and planned activities across the two countries, including stakeholders who are active in those areas currently and incorporates input from *'Agricultural Innovation for people, nature and climate'* workshop participants.

Focus Area 1: Natural Capital

Natural Capital frames the full extent of a country's natural resources. Natural Capital includes our natural infrastructures, our peat bogs, woodlands, forests and coastal assets – these all have a size, location and quality. The bigger a natural asset is and the larger its location, the better its function and its capacity to provide for variant species, and more species allows for increased biodiversity.

Natural Capital Accounting allows for an integrated cost benefit analysis of these resources. If we can properly account for these they can be added to the value of our natural resources, by attributing a proper value.

Any form of diversity, be it in nature or business, allows for resilience, versatility, growth and sustainability. Society, in general, has not been engaging with nature to promote diversity. Overwhelming demand has put enormous strain on the entire system. Several ecosystems are in a delicate state of existence, some on the brink of collapse, which would have enormous and costly global effects.

According to the Dasgupta Review on the Economics of Biodiversity[14], change is required if sustainability is to be achieved and should be focussed on three pillars

- Ensure our demands do not exceed supply.
- Change our measures of economic success to include sustainability.
- Systemic and institution changes are required.

Governments have taken steps, but not yet enough, to counterbalance the damage done by exploitive industries. Recently, the 26th Conference of the Parties to the UN Framework Convention on Climate Change (COP26) and the 15th Conference of the Parties to the Convention on Biological Diversity (COP15) have agreed global actions for a new aggressive approach to nature protection and ecosystem restoration. Change is possible as evidenced by many

14 Final Report - The Economics of Biodiversity: The Dasgupta Review - GOV.UK (www.gov.uk)

sustainable projects in motion in both the UK and Ireland but there is more to do that could be supported through common tools and methods.

As a starting point, it is necessary to look at how we value our natural capital. How do we measure and value the quality and quantity of our natural resources; our air, water, soil, biodiversity and human capital – our natural capital.

The most pressing issue is the balance between improving and protecting our natural capital and biodiversity and maintaining the rural communities and their economic requirements – it must make sense to farmers and producers. Policy is required to develop business models, incentives and regulations to measure, implement and account for this capital.

In England, government has completed a Natural Ecosystem Assessment which included an assessment of soil, water, and habitats. This then provides direction on where to improve, how best or better to manage the resources and identify the gaps and potential economic opportunities for development. In addition, new guidance on natural capital assessment has been issues in the form of ENCA – "Ensuring a Natural Capital Approach"[15]. In 2016, Wales introduced the Environment Act, the main aims of which are to enable Wales' resources to be managed in a more proactive, sustainable and joined-up way and to establish the legislative framework[16] necessary to tackle climate change. Additionally, in 2013 Natural Resources Wales was formed which is a Welsh Government sponsored body who among other responsibilities for managing Wales' natural resources published a state of Natural Resources Report[17] for Wales, the most recent was published in 2019. The UK also established the Natural Capital Committee in 2011 and are quite advanced with their agenda.

Collaboration on the execution of these plans with targeted implementation and more active engagement with farmers, agencies and policy makers would be of value to both countries. Currently, researchers in Trinity College Dublin and Teagasc work with institutes such as SRUC and the James Hutton Institute on common projects, including EU projects.

In Ireland, Natural Capital Ireland is a not-for-profit organisation leading the conversation for adoption of natural capital concepts in public policy and corporate strategy. Its goal is to value, protect and restore Ireland's natural capital and ecosystem services by informing the public and private sector and assist in the establishment of a national natural capital accounting standard. One of its activities is the Irish Natural Capital Accounting for Sustainable Environments (INCASE) project, working with four Irish universities and ecosystem experts, IDEEA Group, to apply a UN standard for Natural Capital Accounting known as SEEA. Natural Capital Accounts integrate economic and environmental themes and provide an evidence base for investments in rural development. These accounts will assist policy makers, landowners and managers to make better informed decisions.

15 Enabling a Natural Capital Approach (ENCA) - GOV.UK (www.gov.uk)

16 https://gov.wales/environment-climate-change-planning-strategy

17 https://naturalresources.wales/evidence-and-data/research-and-reports/state-of-natural-resources-report-sonarr-for-wales-2020/?lang=en

Interviewees noted that a common mechanism or framework, worked on in a joint way, would speed up efforts to properly assess the optimum ways to measure and manage natural capital in both countries. While bilateral and individual relationships between Irish and UK researchers are already underway, there is no common ambition or framework under which to work, saving time and cost. While a sound basis exists, this is an area which could benefit from some joint structured approaches and sharing of knowledge and expertise.

Workshop participants suggested further cooperation on:

- Common and interoperable approaches to Natural Capital Accounting
- Funding models to incentivise private investment in natural capital; aligned regulation and standards for carbon markets
- Data sharing and standardisation; replication of practice in other sectors (e.g., animal and plant health)
- Ensuring increased value for farmers in income or efficiency e.g., improved knowledge and insight; monetising food and farming data; price premium from environmental quality standards; payments for carbon sequestration, biodiversity and landscape recovery
- Demonstration and peer-to-peer learning with behavioural change focus as farmers diversify; share examples where there has been mutual economic, environmental and social benefit

"The workshop today was just brilliant, all the work being done really reassures me. I am a community co-ordinator in the Dingle Hub. We are rolling out a project called Dingle Peninsula 2030, working with 36 farmers, supported with funding from IFA, Kerry Agri, Teagasc and Horizon Europe. We interviewed some of the farmers recently and the social factors of the project were really valuable; we need to stop talking negatively about farming, especially to the younger generation. Farmers want to do something, to be involved in improving farming. Every farmer we are working with is happy to be involved in sustainable agriculture projects. I'm really reassured after today that we share the same values and ambitions for change."

Tom Fitzgerald
Community Engagement Co-ordinator, Dingle Hub Ireland.

Focus Area 2: Soil Health and Crops

Sustainable farming and natural capital accounting recognise the importance of the soil as a critical vital resource, its inherent value, and the key role it plays in food production, animal welfare and the environment. Soil health and management is a delicate balancing act. Optimum fertility, microbial health and proper cultivation are essential for the success of quality harvesting and sustainable agriculture. Key recommendations for the improvement of soil include:

- Improved soil and crop management for better fertility and yields
- Soil analysis for better fertility and improved resource efficiency
- Land mapping – understanding the terrain, drainage, and areas of risk.
- Microbial balance – ensuring an optimum bacterial composition that complements soil health
- Biodiversity - cross farming and holistic land grazing
- Increasing soil carbon sequestration
- Diversifying species on the farm - 10% of farm area to be dedicated to high quality habitats. This includes soil as multi-species swards which have deeper roots and can improve soil aeration and structure

Carbon farming refers to the farm-level management of carbon pools and is aligned with the objective of mitigating against

climate change. Result-based carbon farming schemes require that a direct and explicit link is established between the results delivered (e.g., GHG emissions avoided, or CO2 sequestered) and the payments made to the land manager. These schemes offer opportunities to better incentivise farmers to undertake climate-friendly actions. There may be an opportunity for the UK and Ireland to share experience on pilot schemes where the farmer is paid for sequestering carbon. Additional research in support could focus on improved baseline measurements, monitoring strategies, modelling tools, and frameworks under which robust science-based carbon trading could take place.

90% of the carbon footprint comes from the farm. Whether farming for ethanol or milk it starts with the soil. If the carbon can be managed at farm level it can have a significant impact and efficiencies in soil, animal health and biodiversity will lead to a reduction in emissions.

In Ireland, the Department of Agriculture, Food and the Marine is investing in the establishment of a National Agricultural Soil Carbon Observatory. Through this investment, Teagasc, on behalf of the Department, will commence intensive monitoring of carbon emissions and removals across a range of Irish soils, putting Ireland at the forefront internationally in terms of understanding, supporting, and rewarding farmers for practices that build carbon on their farm. This initiative will allow Ireland to:

- Better quantify and model soil carbon emissions and sinks from agricultural land,
- Enable mitigation measures to increase carbon sequestration to be included in the national inventory,
- Participate in the EU ICOS (Integrated Carbon Observation System) network
- Enable Ireland to benefit from the 2018 EU Effort Sharing Regulation

Rothamsted in the UK, is working to develop a carbon model that can be verified and calibrated to suit conditions under consideration in due course. Measurement of carbon in peatland in is an example of another area where collaboration could work well.

Within Teagasc, the Soil and Environmental Microbiology Research Group focuses on microbial adaptation, soil microbiome, nutrient recycling, mediating greenhouse gas emissions, plant-soil-microbial interactions, environmental enteropathogens and soil persistent E.coli. In the UK, both Harper Adams and Bangor University are also working on soil microbiome and soil sensor projects (see UK project mapping section below).

Land Management and Payment Schemes

In 2021, the practice of direct payments to UK farmers will begin to reduce. At the same time, the government wish to support improving how existing schemes and regulations operate. In England, schemes that reward farmers and land managers for producing public goods will replace current direct payments to farmers as it seeks to reward the delivery of environmental benefits. The future schemes will include:

- Sustainable Farming Incentive
- Local Nature Recovery scheme
- Landscape Recovery scheme

The schemes will collectively deliver environmental benefits including:

- Clean air
- Clean and plentiful water
- Thriving plants and wildlife
- Protection from environmental hazards
- Beauty, heritage, and engagement with the environment
- Reduction of and adaptation to climate change

This will be achieved, in the initial stages from 2021 to the end of 2023 by running tests and trials, and a national pilot before the full roll-out of the scheme in 2024.

"Devenish relies on our farming customers, so in 2013 we invested in a sustainability team to try to ensure our knowledge toolbox is shared and transferred to farmers. We need to articulate the journey we are going on. We have the same challenges so can help each other and work together across the United Kingdom and Ireland to ensure we all learn from each other."

John Gilliland
Director of Global Agriculture and Sustainability, Devenish Nutrition.

In Ireland, the transition to the new Common Agricultural Policy eco-schemes lies ahead. Current schemes such as the Green Low-Carbon Agri-Environment Scheme (GLAS) established in 2015, will be phased out and the mechanics of what they will be replaced with is currently under preparation. As both countries need to face these transitions, there may be an opportunity here to assess together the best approaches to take and take inspiration from different initiatives and attempts to bring farmers along on this new phase of sustainable agricultural practices. Farmer engagement will be key here and as demonstrated below, there is much work to do to convince farmers and implement the overall policy goals. In a recent survey[18] of UK farmers, findings included:

- 64% expect the change from direct payments to payment for public goods under ELMS to result in lower farm profitability.
- 76% said they were concerned the payments will be insufficient.
- 57% said they were concerned administration will be poor.
- 44% said they were concerned that ELMS will not deliver the prescribed environmental benefits.

18 Survey by Strutt & Parker and the Country Land and Business Association - https://www.fwi.co.uk/news/farm-policy/what-farmers-are-thinking-about-the-elm-scheme

Nitrogen

The EU Green Deal and Farm to Fork strategies are seeking a reduction of up to 20% in fertilizer usage by 2030. In the UK, new guidance developed by the UK Centre for Ecology and Hydrology (UKCEH) and adopted by the United Nations Economic Commission for Europe (UNECE) in December 2020 will give governments and farmers evidence proving the need to reduce nitrogen losses. The guidance includes 76 detailed measures for reducing agriculturally based emissions of ammonia, nitrogen oxides, nitrous oxide to air, plus nitrate and other leaching to water[19].

Nitrogen use efficiency (NUE) is of increasing importance in assessing the sustainability credentials of farming operations. NUE as defined by Teagasc is a calculation that quantifies how efficiently nitrogen that comes into a farm in the form of fertilizer, slurry or feed - exits the farm in the form of milk or meat. It is calculated as a percentage. Current National Farm Survey Sustainability reports put Irish dairy farms at 25% in terms of their ability to recover N from their N imports. That is, of the N imported onto a farm in the form of fertilizer and feed amongst other things, 25% of it is recovered in the form of milk sales or sales of cattle either live or to slaughter. This leaves room for improvement with an industry target of 35% being the figure set for farmers to achieve in the coming years.

Achieving this will indicate improved sustainability of farming systems in three ways.

- Improved usage of N inputs (fertilizer, feed) will save farmers money on input costs (financial sustainability)
- It will benefit water quality as improved nitrogen usage will reduce the risk of nitrogen losses to water (environmental sustainability)
- Reduced fertilizer usage will also reduce ammonia emissions thus improving air quality (environmental sustainability)

Rothamsted Research and Teagasc are both working on nitrogen research and at ways of reducing its use and what the optimum replacement methods and tools are. At EU level, Ireland is benefitting from the so-called Nitrates Derogation currently – but the end is in sight for this and research and development work which can support a change of practice and impacts will benefit agriculture and the environment overall.

Crop Science

Ireland and the UK have similar temperate climates. Throughout this report, there are references to crop research and efforts to tackle diseases in crops, improving their ability to combat disease. Researchers are also looking at crop diversification to identify new sources of nutrients and to diversify national outputs to feed the growing global population and to support a shift to sustainable diets. Diversification of crops will also serve to deal with the effects of climate change (i.e. flooding, drought, high winds). There is a common interest in sharing information, research and monitoring of crop production systems and science on both islands – synergies could be tapped into further. For example the UK has a long established crop breeding platform comprising four independent but interlinked Genetic Improvement Networks[20], focusing

19 https://www.ceh.ac.uk/sites/default/files/UK-CEH-Annual-Review-2020-2.pdf

20 Genetic Improvement Networks | AHDB

on Wheat, Oilseed Rape, Vegetable and Pulse crops. The networks bring together genetic materials from seedbanks and diversity collections to identify beneficial traits for crop quality, resource efficiency, sustainability, and resilience. These networks are coordinated by researchers at Rothamsted, the John Innes Centre, Warwick University and the University of York.

Peatlands

Ireland's National Peatland Strategy published in 2016 is the Government's guide to peatlands management and conservation with 25 key principles and 32 actions across sectors and themes including climate change, research, energy, water quality and agriculture. In 2019, €131,000 in funding was provided to 13 initiatives under the Peatlands Community Engagement Scheme.
In Ireland, of the Department of Culture, Heritage and the Gaeltacht's Budget allocation for 2020, €5 million has been allocated for an accelerated programme of peatland restoration. With this funding, it is intended to restore over 1,800 hectares of protected raised bog on up to 9 sites to continue up to 2024[21].

Peatland covers around 3 million hectares in the UK. Reducing GHGs from peatlands is key to the UK's ambition of reaching net zero emissions by 2050.

In England, a new Peat Action Plan is part of the Department of the Environment, Food and Rural Affairs' 25 Year Environment Plan. This includes £50m for peat restoration to 2025 under the Nature for Climate Fund.

Most of the UK's peat is located in Scotland, the Scottish Government has been funding peatland restoration schemes for several years as part of its National Peatland Plan. This includes Scottish Natural Heritage's Peatland Action initiative which has restored 19,000 hectares since 2012. In 2019, the Scottish Government announced a total of £14m of funding[22] to repair and restore peatlands. The Welsh and Northern Ireland governments have also backed peatland restoration schemes. The Welsh Government launched a national peatlands action programme[23]. Another example of where collaboration in research would benefit both countries could be the 'measurement of below the ground biomass' – this needs to still be done and could be a joint project in the future.

21 https://www.npws.ie/sites/default/files/files/national_peatlands_strategy_progress_report_2018_and_2019_english.pdf

22 https://www.bbc.com/news/uk-scotland-highlands-islands-48744548

23 https://gov.wales/welsh-government-launches-national-peatlands-action-programme-help-lock-carbon-and-reinvigorate

Organic Production

The EU has a set of guidelines for seeds, aquaculture, wine, livestock and the food chain which means that all organic products in the EU must follow strict rules. Although there has been a considerable increase in organic farming, results vary greatly between member states.

The total of certified area under organic production is on the rise across Europe, and in 2019 was counted at 13.8 million hectares. Both Ireland and the UK had shares of less than 6% compared to Austria, Estonia and Sweden which had the highest area of organic production with over 20%[24].

To promote organic production in Ireland, the Organic Farming Scheme was reopened in 2021. Under DAFM's Rural Development Programme, farmers could qualify for €220 per hectare during the conversion period and up to €170 per hectare once full organic status has been achieved. In addition, priority will be given to young farmers entering the Organic Farming Scheme.
The Economics of Organic Farming project aims to highlight the factors affecting the profitability of organic farming and how government policies affect the organic sector and public policy goals with improved data collection and analysis[25].

Workshop participants suggested further cooperation on:

- Raising the profile of soil science and soil health with policy or statement to emphasise its importance
- Promoting a more holistic approach and partnership funding across the nations (Ireland, England, Wales, Scotland & NI)
- Working together on research and knowledge exchange; synergies and comparable agricultural conditions but need formal structures for collaboration to bring together work happening in silos
- Transparency to understand our baseline and where farmers are on the journey to encourage agricultural innovation and behaviour change
- Working with farmers to improve understanding of emotional/ psychological journey of change and transition; better reflect this in the policy narrative

24 https://ec.europa.eu/eurostat/statistics-explained/index.php/Organic_farming_statistics#Organic_production

25 https://www.gov.uk/government/collections/organic-farming

Focus Area 3: Agricultural Emissions

Ireland's largest Greenhouse Gas (GHG) contribution comes from the agriculture sector, accounting for 35% of all emissions – while this has to be taken in the context of a low industrial sector, it is urgent now for Ireland to deal with agricultural emissions. The requirement to reduce ammonia emissions is urgent, both in terms of compliance with the National Emissions Ceilings Directive (NECD), and as a principal loss pathway for agricultural nitrogen (N).

In September 2020, Teagasc published a new marginal abatement cost curve (MACC) for ammonia emissions to 2030. The publication called 'An Analysis of the Cost of the Abatement of Ammonia Emissions in Irish Agriculture to 2030' seeks to quantify the ammonia mitigation potential under likely uptake pathways. This is essential for Ireland as agricultural ammonia emissions are projected to increase by 9% (without any mitigation) by 2030 relative to 2005 levels.

Improvement of N efficiency is a key focus for improving farm efficiency and sustainability as well as reducing the ammonia, nitrate and greenhouse gas (GHG) footprint of agriculture. This work 'represents an assessment of best available techniques, based on scientific, peer-reviewed research carried out by Teagasc and associated national and international research partners'.

Agriculture constitutes around 10% of UK GHG emissions, but 88% of ammonia emissions. In the UK, the Inventory of Ammonia Emissions from UK Agriculture[26] sets out an assessment of emissions from agriculture including the impact of mitigation steps to tackle their reduction.
Further to this, results will shortly be published from the "Delivering clean growth through sustainable intensification" project by Scotland's Rural College (SRUC)[27], which has developed a revised MACC for GHG mitigation measures in agriculture and engaged stakeholders to develop feasible mitigation pathways to 2050. There is an opportunity to collaborate on such activities to learn from each other and implement the best and most effective practices at farm level on both islands.

Contributors suggested that better activity relating to data-measurement is necessary and this needs to be able to scale eventually also – this needs to be taken into account when data-measurement activity is being designed. There is a need to 'work on the methane yield per cow' and on the methane production potential of manure and slurry.

The UK and Ireland have a strong history of collaboration on agricultural emissions research, including informal networking, data exchange, development of common field protocols and joint funding and participation in collaborative R&D calls, particularly via the Horizon 2020 ERAnet programme. In this context, representatives from both Teagasc and SRUC stated that there was good cooperation in these areas to date (including with the Roslin Institute at the University of Edinburgh) – there are activities involving sharing of data, invited speakers to national events, joint advisory groups, joint publications and even joint PhD students.

26 https://naei.beis.gov.uk/reports/reports?report_id=1018

27 https://pure.sruc.ac.uk/en/projects/delivering-clean-growth-through-sustainable-intensification

Workshop participants suggested further cooperation on:

- Capturing activity data on emissions, such as methane yield per cow; sharing data on slurry emissions across the UK and Ireland would really help deepen our knowledge in this area.
- Building better models for carbon sequestration; potential learning from the UK's Rothamsted Carbon model.
- Peatland emissions – Northern Ireland researchers are just starting out on this work, so could learn from the research already undertaken in Ireland.
- Genomics / genetics research; work together on breeding programmes that aim to lower emissions from animals.
- Root system measurements to understand the level of carbon capture.
- Funding - Ireland would benefit from funding support for large demonstration projects; Scotland do this well, so could share lessons and knowledge.
- Ensuring that research is translated into practice for the benefit of farmers and the climate; drivers to incentivise change include policy, a roadmap and industry.

"Rome is burning – we don't have time to duplicate research and data, we need to act. There are huge synergies in innovation between the UK and Ireland, from soil carbon, artificial intelligence and everything in-between. We have experience of researchers from the UK and Ireland working together in the past – for example the greenhouse gas project, however, what was missing was funding for the last piece of work to integrate the research into practice. We can look at all regions across the UK and Ireland from Scotland to Kent to Dingle and we should work together to build a critical mass. We should consider joint funding calls from both SFI and UKRI to work together across the UK and Ireland to solve these issues together."

Dr Karl Richards
Principal Research Officer and Head of the Environment Soils and Land-Use department, Teagasc Johnstown Castle.

Focus Area 4: Animal Health

Livestock Efficiencies

Livestock production is of significant economic value to both economies, but also presents significant externalities. For example, cattle are the most significant source of both ammonia and methane emissions in the UK. Enhanced production efficiencies can reduce these burdens significantly. Improved feed composition, enhanced breeding, better management and housing and improved herd health can ensure 'farm to fork' high quality of meat and efficient herd management.

In the UK and Ireland there is a strong track record in animal health research and established links are active. Livestock management and genetics is a key strength in and there are a number of R&D projects on the implication of nutrition and livestock feed on GHG emissions. Nottingham University, Queens University Belfast and Teagasc are all active in these areas. In Northern Ireland, at Queen's University Belfast, there is ongoing work relating to animal microbiome research while in Wales there is work ongoing around Parasitology (a branch of biology dealing with parasites and parasitism especially among animals) using FAGE technology. In addition, IBERS are working on a 'PreciseAg' project[28] dealing with livestock performance. In Ireland, there is the Anti-Parasitic Action Plan which is currently in development. This is a multi-strand, multi-agency, multi-objective plan to address anti-parasitic resistance issues. Much of his work is contributing to wider international partnership through the Livestock Research Group of the Global Research Alliance.

28 https://www.aber.ac.uk/en/ibers/research-and-enterprise/research/research-groups/animal-systems/preciseag/

Basic and applied genomics research on animal health can make significant contributions to mitigation of greenhouse gas (GHG) emissions from livestock production in the UK and Ireland. In particular, tackling the burden of infectious disease (e.g., tuberculosis, Johne's disease, liver fluke, mastitis, bovine viral diarrhoea, brucellosis etc.) to reduce animal wastage and increase productivity.

Biosecurity

The UK and Ireland have significant expertise and resources for basic and applied genomics research in livestock and pathogens. There are exciting opportunities for collaboration, particularly if joint funding opportunities become available through DEFRA-DAFM or UKRI/BBSRC-SFI links etc.

The full gamut of genomics and functional genomics technologies should be leveraged to understand more about host-pathogen interaction and disease pathogenesis. These include high-density genetic information that can be obtained from single-nucleotide polymorphism (SNP) genotyping arrays, whole-genome sequence (WGS) data, and imputed WGS data. It also includes a wide range of functional genomics data types that capture information about genome regulation and its impact on phenotypic outcomes (the Genome to Phenome paradigm) in both the host and pathogen.

The Functional Annotation of Animal Genome project (FAANG)[29] is a major global initiative in this area; UK and Irish researchers are active participants in these efforts (e.g., Roslin Institute, SRUC, Teagasc, and UCD). Research in this area will help develop biomarkers/biosignatures of infection and disease in biological fluids (e.g., blood, urine, milk), and provide information useful for genome-enabled breeding and genome editing for disease resistance, and development of novel pharmaceutical interventions and vaccines.

High-throughput sequencing (HTS) can be used for rapid cost-effective sequencing of livestock pathogen genomes (c.f., SARS-Cov-2 genome sequencing during the current COVID-19 pandemic). This genome sequence information is a powerful tool for genetic epidemiology and surveillance. For example, it can be used to identify new sources of infection, emerging livestock pathogens due to climate change and movement of insect vectors, human activities that may be contributing to disease outbreaks (e.g., animal movements), and identify strain genome variation that impacts transmissibility, virulence, and pathogenicity. Genome sequencing has become so cheap and easily applied that it is now possible to routinely sequence even relatively large bacterial genomes from very large numbers of easily collected biological samples.

Pathogen genome sequence information is a key requirement for the development of RNA- and DNA-based vaccines that can be rapidly deployed to protect against existing and emerging pathogens that that can impact UK and Irish livestock populations (c.f., SARS-Cov-2 genome sequence data for rapid development of mRNA vaccines etc.).

Contributors suggested that common programmes to ensure there is a constant funnel of experienced researchers, with a particular focus on PhD researchers would be useful. These programmes could act as catalysts for relationship building for the future would be extremely useful. Contributors also suggested that they want to see more

29 www.faang.org

opportunities to share what is happening – sharing outcomes and then complementing each other rather than duplicating research and work undertaken elsewhere. In short:

- Use and share outcomes and deployment on farm
- Hold large events based around this theme – with 500 people sharing results as an example
- Next generation solutions to be presented – these solutions are what people are now interested in and need to be understanding

An issue that was raised is the impending shortage of farm vets which is emerging. This is particularly the case for large animals. It would be useful to understand how technology can support farmers and vets of the future to help their work and 'do more with less' in terms of human labour input and available resources.

Finally, Animal Health Ireland (AHI) manages the compulsory National Eradication Programme to tackle the BVD virus in cattle. The virus is the cause of an important viral disease of cattle that is estimated to cost Irish farmers around €102M each year. AHI is also working closely with the Irish Cattle Breeding Federation on development of a genetics database that would make results accessible for breeding and herd resilience, particularly in the case of resistance to liver fluke, which would have a knock-on effect of improving the economics of the herd.

Antimicrobial Resistance

Antimicrobial Resistance (AMR) is a natural resistance that evolves within an organism (bacteria, viruses, fungi and parasites) after misuse or continued exposure to medicines and it no longer responds to them making them ineffective for disease control. The majority of antimicrobials in animal production are used to treat sick animals, prevent disease spread and to promote faster animal growth. Antibiotics and fungicides are sprayed on agricultural crops. Global use is hard to determine due to lack of regulations and data collection.

The increased use of antibiotics in agriculture not only contributes to poor animal gut health but also to higher levels of antibiotic resistance in humans. The impact of antibiotic use extends further than the farm. Waste from the animals containing undigested microbes seep into the soil and water and effectively are re-introduced to the food chain for both animals and humans. Water contamination is possible not just from the farm waste but also from pharmaceutical manufacturer sites.

Both Ireland[30] and the UK[31] have established long term plans to reduce antibiotic use and make improvements to animal husbandry and welfare to mitigate future and recurring need. In the UK reductions in the use of antibiotics in livestock farming have been made and in some cases in pig and poultry farming have ended routine use.

30 http://amr.ie/agriculture/

31 https://www.gov.uk/government/publications/uk-5-year-action-plan-for-antimicrobial-resistance-2019-to-2024

A 2020 report[32] from the European Centre for Disease Prevention and Control reported that Ireland's antimicrobial consumption in the community is higher than the European average. Over 60% of sales concern oral antimicrobials, with a substantial proportion attributed to the pig sector. Separately, the recent ERANET JPI-AMR-Action Call on One Health Interventions to Prevent or Reduce the Development and Transmission of Antimicrobial Resistance (HARISSA)[33] to understand antibiotic resistance development and transmission and to develop interventions in various geographic and socio-economic settings. Factors include consumption of antibiotics, prescribing practices, agricultural practices, pharmaceutical manufacturing, sewage/effluent management and treatment.

In the EU the New Veterinary Regulation (NVR)[34] comes into effect on 28 January 2022 for all member states. It is in relation to veterinary medicinal products and their prescription and usage which will make blanket herd treatments illegal and only allow for targeted prescriptions with shorter validity timeframes to address resistance issues. Persistent use of medicines going into our immediate environment is a matter of environmental, animal and human concern.

The legislation is intended to:

- Harmonise the internal EU market for veterinary medicinal products
- Reduce the administrative burden on companies and regulatory authorities
- Enhance availability of veterinary medicinal products
- Stimulate innovation of new and existing medicines
- Strengthen the EU response to fight antimicrobial resistance.

Pig Health

There are a number of research projects underway through Teagasc and the JPI-AMR initiative relating to pig health which could link in well with UK researchers. In monogastric research, there is still room for more collaboration between Ireland and the UK. While UK partners such as Newcastle University and the University of Reading were involved in the 'PROHEALTH' project[35] in the past, which developed an understanding of the multi-factorial dimension of animal pathologies linked to the intensification of production; antimicrobial resistance research and the development of infeed therapeutic medication is an area of attention for Northern Irish, Irish and English researchers. In addition, research on the effects of therapeutic zinc oxide (ZnO) on the pig microbiome and immune system are ongoing in Teagasc alongside looking at strategies to facilitate ZnO withdrawal (due to the future zinc oxide ban in pig feeds).

32 https://www.ecdc.europa.eu/en/publications-data/country-visit-ireland-discuss-policies-relating-anti-microbial-resistance

33 https://www.gov.ie/en/publication/06699-eranet-jpiamr-action-co-fund-call-on-one-health-interventions-to-prevent-or-reduce-the-development-and-transmission-of-antimicrobial-resistance-harissa/

34 http://www.hpra.ie/homepage/veterinary/regulatory-information/implementation-of-the-new-veterinary-regulation-(regulation-2019-6)

35 https://cordis.europa.eu/project/id/613574/reporting

Animal Health Ireland are progressing on their second year of the Pig Health Programme and are still building the key elements of this. Although there is more extensive pig production in England there are still common production systems between Ireland and England.

Pig tail docking is still a concern particularly in countries with intensive production. The Agriculture and Horticulture Development Board (AHDB) has undertaken a risk assessment guidance report for England and contributors suggested that a different approach will be required for Ireland.

Workshop participants suggested further cooperation on:

- mRNA vaccines in the animal population
- Early ill health detection
- Eradication of BVD; Ireland has a compulsory scheme and is close to eradication
- JOHNES disease control strategy; strengthen work on biomarkers and with UK genome specialists
- Technology for diagnostics
- Climate change adaptation; potential for new and dormant diseases becoming more widespread due to warmer climate and heat stress; also buildings and animal housing adaptations for changing conditions
- Biosecurity; halting the spread of disease (not only TB); genomics for strain diversity surveillance and understanding likely pathogenic impact of different strains

Focus Area 5: Agritech Innovation

Precision Agriculture

Precision Agriculture (PA) is defined as a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production. It seeks to use new technologies to increase crop yields and profitability while lowering the levels of traditional inputs needed to grow crops (land, water, fertilizer, herbicides and insecticides). One example is GPS devices on tractors, which allow farmers to plant crops in more efficient patterns and proceed from point A to point B with more precision, saving time and fuel. Precision agriculture also has the potential to enhance nitrogen use efficiency (fertilisers) so they are added in the right amounts, in the right places and at the right time.

University College Dublin and Origin Enterprises Ltd (an Irish agribusiness with significant operations in the UK) established a dedicated digital, precision agriculture and crop science collaborative research partnership (CONSUS) which is looking at the creation of scalable, dynamic and integrated crop models which incorporate consistent and real-time data driven and data analytical approaches that optimise sustainable crop performance through enabling enhanced predictive intelligence capabilities at field level.

The UK has established a network of Agri-Tech centres to accelerate the development and implementation of innovative technologies in Agriculture.

This includes:

- AgriEpiCentre – dedicated to incubating and enabling innovative technology in the agritech sector
- Agri-metrics - has created a Data Marketplace, enabling organisations to share and monetise their data
- Crop Health and Protection (CHAP) - Act as a catalyst for change bringing together researchers' industry and government to accelerate the identification, development and adoption of innovative agritech solutions in crop production
- CIEL - World-leading livestock research alliance bringing new technologies and processes to livestock food production

Other notable centres of excellence for agricultural engineering and innovation include Harper Adams and Lincoln University.

Harper Adams (HA) are looking at the economics of PA and new business models for the bioeconomy. For real advancements with the bioeconomy, changes to the economic models are critical. HA have linked in with economic professors to measure the real value adds and break-even points even on a small farm holding. There is still a question if autonomous machinery will be affordable, or what type of machinery is best deployed to make farms more cost effective.

There needs to be further work done on the business of bringing new equipment to market and the cost of producing, maintaining, and continually developing new engineering tools and then how they can be leased, hired, or bought by the farmer.

To make farming sustainable, farms have to be economical regardless of the machinery

developed, data collected, or legislation. HA has a team dedicated to reviewing the full spectrum involved and working with their own 'Exemplar Farm' site on everything from how farming industry will have to change, how the food processing and retail industry are connected and what the consumer wants. The scope effectively examines the entire supply chain and where the farmer fits in that chain and how things can evolve with an economically viable sustainable model. This will allow the university and farm manager to trial new ideas and systems and see what works and what is economical.

All key stakeholders must be on board from the farmers, banks, policy makers, machinery producers, governments, and consumers. Every element is interconnected. Whatever processes or recommendation are made must be simple for people to understand and for us to calculate effective remedies.

However, there is the potential within the next 2-3 years for increased EU funding and projects focused on precision farming to assist farmers to fund the purchase of new equipment. One challenge for Ireland may be that applying precision farming techniques to larger farms is much easier than to small holdings to record and measure impacts.

Future Machinery

Although a relatively minor component of agricultural GHG emissions, farm machinery may be significantly easier to decarbonise than the complex biological systems. Therefore, an exploration of alternative technologies to reduce energy and fuel use in agriculture is of interest. For example, smaller electrically powered machines, that are battery operated or have an alternative fuel source that do not emit CO2 could be a step forward in the challenge to reduce emissions.

In the UK, the Harpers Adams (HA) University is working on 'Hands Free Farm' and 'Hands Free Hectare' projects. These projects were designed as publicity vehicles and have highlighted some of the key elements for change within the industry. For example, machinery and tractor design has not changed over many decades. Harper Adams maintains that the entire ecosystem of the farm needs to be reviewed with a focus on new implements that are less costly for the farmer and perform well from an environmental point of view, to match emerging machine innovations. HA has been to the Irish National Ploughing championships over a number of years and more recently in 2019 to demonstrate some of their emerging technologies in this vein.

HA are part of a consortium working with the Agritech Centre of Excellence at Munster Technological University to develop innovative engineering education in Ireland - REEdI[36]. This includes more hands-on work, online delivery, use of virtual reality and augmented reality learning tools.

It is a partnership with CONFIRM Smart Manufacturing SFI Research Centre, IMaR Technology Gateway, AgriTech Centre of Excellence (ACE), LERO Software Development SFI Research Centre – to allow innovations in research to be embedded in undergraduate programmes. HA is working in the areas of engineering, and work-based placement models. The project offers agile and innovative learning options from school leavers to upskilling industry professionals and mature students to enable them navigate future challenges and disruptive technologies faced by the manufacturing sector.

Robotics

Robotics can ease the workload of the farmer of the future - advanced technology that is already demonstrating improvements for the farmer with the likes of robotic milking and harvesting, laser weeding, and other energy management projects are becoming more popular. HA is working on projects in these areas together with commercial entities and these are close to being ready for commercialisation within 2-3 years.

HA is also working with Aston University in Birmingham to develop sector sensors to use their expertise in photonics funded from a mix of EU and UK funding. One of these projects in motion is a collaboration with an SME company, on a major project in East Anglia using a sensor system to look into the soil to map and measures the size of potatoes in the field and to map the yield. This totally non-invasive technology will give the farmer significant advantages to maximise optimum harvesting.

University of Reading is leading the 'Robot Highways' project - the largest known global demonstration of robotics and autonomous technologies on a farm. The robots will assist farmers by carrying out essential, energy intensive physical farm processes such as picking and packing fruit and treating crops to reduce critical pests and diseases.

36 https://reedi.ie/about-reedi/

LiDAR – Light Detection and Ranging

LiDAR technology uses small drones equipped with mirror-based laser scanners to map and create a 3-D representation of the target area.

This is being increasingly used by the agriculture industry due to the many benefits it provides. It can capture the smallest details and helps to track deforestation and agriculture patterns.

The data obtained provides vital information that allows the farmer to better understand the natural resources, soil constituents and risk areas to provide increased efficiencies, improved crop management and more precise agriculture methods.

Typical applications of LiDAR technology in the agriculture sector include analysis of terrain, yield rates, crop scouting and seed dispersions, planning, mapping under the forest canopy, and more.

"There's great collaboration potential for researchers, policy makers and industry, following this joint workshop, for both the UK and Ireland to work closer together and develop solutions to solve climate change."

Ian Cox,
Innovation Lead, Agri-Tech Centres, Innovate UK / UKRI

Workshop participants suggested further cooperation on:

- Feed innovation to reduce emissions from ruminants such as insect-based diets; heat treatment of grains to improve protein quality; use of algae/seaweed, which could also be gene-edited in time to include pharmaceutical properties.
- Building design and engineering innovations to capture methane when animals are indoors
- Precision agriculture including sensors, virtual fencing, use of autonomous equipment or drones, which could allow more sustainable/efficient management of land, crops and animals.
- Nutrient and soil management supported by UK capabilities in earth observation and Ireland nationwide soil samples collected by DAFM to provide farmers with nutrient maps and advice.

Farmers: Critical Agents for Sustainable Agriculture and the first Bioeconomists

Farmers are essential change agents and champions in this climate crisis. They need to be motivated and convinced of the efficacy of any new innovative techniques. Farmers don't need more work. They need supports in the form of automation – reducing workload, supporting data interpretation and recommended actions and a community of peer support and best practice from which they can draw. New farming and livestock management processes need to be adopted by those in direct contact and control of the environment.

A new breed of ambitious and motivated farmers are emerging who want to contribute to the climate cause, for the benefit of their own business longevity, community enhancement and sustainability goals. Through the UK's Food, Farming and Countryside Commission, the 'Farming Smarter' report[37] highlighted that many farmers across the UK are adopting agro ecological practices and that economic benefits are beginning to emerge. Farmers need to be involved in the co-creation of new solutions. They also need to see the environmental and financial sense to shifting their current practices on the farm. The basic questions of adding value to the farm business while protecting and enhancing the environment need to be met.
One example of the diffusion of interesting insights on sustainability among farmers is in the Farm Ambassador Programme[38] which has arisen from the Dingle Peninsula 2030 project. This project has been showcased by the UN as a living laboratory. The development of sustainable agriculture as a theme emerged through a series of Farmers Fora. The Dingle Peninsula 2030 team has initiated a pilot Farm Ambassador Programme, using soil and water monitors to ensure that the impact from the spreading of fertilizers is minimised; delivering community meetings on the Peninsula to give residents an opportunity to voice their concerns and priorities on sustainability, and improving sustainable transport links.

Extension Services for Engagement, Knowledge Transfer and Implementation

In both countries, different actors have been working with farmers to encourage engagement and uptake of advances in science, research and innovation. In the UK, these engagement mechanisms, such as 'BioVale', 'Farming connect'[39] and SRUC are in the form of 'extension services', often commercially run services for farmers and

37 https://ffcc.co.uk/news-and-press/farming-smarter-launch

38 https://dinglepeninsula2030.com/projects/agriculture/farm-ambassador/

39 https://businesswales.gov.wales/farmingconnect

advice may be influenced by commercial goals; in Ireland, Teagasc, farmer organisations, agritech companies and BiOrbic all engage with farmers to provide advice, peer-to-peer learning, pilot schemes and support mechanisms. For example, the Teagasc Signpost programme is a multi-annual campaign to lead climate action by all Irish farmers.[40]

In England, the Agriculture and Horticulture Development board undertake pre-competitive research to underpin productivity growth in the agricultural sector, and trial innovative technologies and practices. Their research and knowledge exchange activities are augmented with a demonstration network of strategic and monitor farms. Other important brokers of information include the AgriFood Knowledge Transfer Network (KTN), the Farmer Led Innovation Network and the British On Farm Innovation Network (BOFIN).

Knowledge transfer and exchange is critical. It is particularly important that optimised transfer processes are embedded within the research environment, including the incorporation of co-creation and the inclusion of multi actors relevant for the size, scope and nature of projects.

Some examples across Ireland and the UK include:

- BiOrbic Farm Zero C project
- Young Farmers Groups – networks and conversation that lead to embracing smart tech and processes (Macra na Feirme, Teagasc)
- Training - in biodiversity, technology, and farm management to increase efficiencies (Ireland: Signpost Farms, UK: Farm lets)
- Networking – connecting farmers not only to each other, but to support agencies, researchers and emerging projects.
- International shared learning from those doing it now (EU, UK, USA and NZ)

Farmer Networks

Farmers need to be supported at a number of levels, not just with clear guidelines and legislation to meet stringent subsidy criteria but also how to commercially manage their farms while embracing new or pilot biodiversity, bioeconomy or any form of sustainable farming projects. This must stem from national and local government support, education with peer groups, connections to industries and co-ops with links to bioeconomy research projects and funding opportunities. Both Teagasc in Ireland and the environmental land management schemes in the UK have thriving farmer networks, which can be further supported and engaged with to build out direct supports to farmers.

Business Models

From the various interviews conducted, it was apparent that a shift in thinking about the economic consequences of changing farming practices and potential land use changes is needed. Farmers can be better engaged when the financial costs and revenue of these transitions are clearly set out. Farmers need to see and understand the bigger picture in terms of the business model that flows from these sustainable practices – while they actively protect and enhance the environments with which they work.

40 https://www.teagasc.ie/environment/climate-change--air-quality/signpost-programme/

"This 'theory into practice' challenge we're talking about here in farming has been around for thousands of years, and it requires careful thought. Embedding innovation is about having great ideas, yes, and, critically, turning them into practice. The apparently mundane activity of turning ideas into action is where we need to focus. This means choosing and funding research designs that are more accessible to farmers, to pay them for their participation in research projects, and to focus on ways that help embed change across the sector."

Sue Pritchard,
CEO Food, Farming and Countryside Commission.

From the research undertaken, there is a gap in the research and demonstration projects of the concrete business models that will enshrine these new approaches. BiOrbic in Ireland and the Harper Adams University (UK) are both acutely aware of these challenges and is committed to working on the economic aspects associated with the technological and biological advances a sustainable bioeconomy and a sustainable agriculture sector present. There is a need to understand future business models, to include natural capital accounting approaches, incorporate bonus schemes, CAP eco-schemes (IRL) and/or 'payments for public good'. The Food, Farming and Countryside Commission (FFCC) in the UK proposes establishment of an Agroecology Development Bank to help accelerate the transition to sustainable food and farming systems 'towards approaches that enhance environmental services, restore natural capital, contribute to a low carbon transition, and produce healthy food whilst supporting rural livelihoods' [41]. As both countries transition, this is an area of potential collaboration – a shared journey which could assist both to get to the most effective solutions and business models faster.

Technology

Automated systems and machinery in agriculture have helped to revolutionise the industry. They have been necessary due to the growth of the global population, farming industry and demand for public consumption, especially in the past two decades. Challenges remain in both countries to have these technological advancements transfer onto farm operations. Enhancing skills and putting solutions into the inventory of tools, machines and datasets for farmers to draw from is essential if the research and innovation efforts are to have the impact they are planned for. With agritech centres in both countries and many technology-based projects underway, further collaboration is needed to ensure these innovations reach farms and at the right cost.

Farm Buildings and Infrastructure

As we invest in machinery and equipment, and there is a strong focus on technology and processes to make the farm more efficient and better monitored, an aspect that can be overlooked is the issue of farm buildings of the future – these need to be looked at in the context of the 21st century environment – the way that they are powered, the capability of these buildings, internet connectivity, - they need to be self-sufficient, e.g. using renewable technologies and energy to power them. Low carbon buildings for farm and rural areas is a topic that requires further focus within the context of sustainable agriculture.

41 https://ffcc.co.uk/what-we-do/agroecology-development-bank

Key Areas for Development

The development of a sustainable bioeconomy and sustainable agriculture in Ireland and the UK can be significantly strengthened through a focus on three key areas – i) Research & Innovation, ii) Education & Engagement, and iii) Investment.

Research and Innovation

Research and innovation is critical to generating new knowledge, know-how and solutions.

Research must not only focus on macro level solutions but also consider farm level and farmer-centric solutions. As more multi-actor approaches are taken when considering research projects and scope for innovation, the farmer will be able to play a key role to inform these efforts.

Education and Engagement

Education and engagement are critical to the co-creation process to ensure solutions are user (farmer) centric. A move to nature-based solutions and environmentally focused business models must be demonstrably viable and practical for farmers. The agricultural sector, both primary producers and agri-businesses who benefit from their outputs must be engaged to demonstrate their role so that new thinking, direction and involvement can be actioned urgently.

In particular engagement from the research and innovation community with farmers and producers is critical and will support new technologies to process the raw materials and new knowledge that can help to bring about changes in farming practices, cooperation amongst farmers and between farmers and industry to open up new value chains. By working in partnership with industry and biomass producers in the agri-food and marine sectors a resource efficient approach to sustainable integrated production of food and non-food products can be fostered.

More outreach and engagement activities will support the scale up of solutions that research and innovation can demonstrate. Multi actor engagement centred on the climate crisis, what innovation has been made and how the adoption of new processes and technology are having a real and tangible impact must be expanded. This not only includes researchers, producers and industry but also wider society including consumers, citizen and young people.

Investment

To support all the outlined activities, research and ideas that are emerging, investment is essential. Without appropriate funding or support for grass roots assistance to shared research and innovation, the Paris Agreement commitments simply cannot be met (locally or globally). While fundamental and applied

research needs to continue to be supported in both countries, investment is needed in demonstrating the solutions that are coming from this research. An opportunity for joint investment programmes in research also exists. De-risking the scale up of solutions and demonstrating medium and large-scale solutions through infrastructure investments is needed to leverage private investment. This will speed up the uptake of technology and best practices among farmers and land managers. This requirement is applicable in both countries beyond Brexit and beyond the highly competitive and oversubscribed EU funding routes.

Recommended Actions

This report contains details of current relationships, ongoing projects and initiatives. The following recommendations from BiOrbic are intended to set a course for future collaboration in research and innovation across the two islands. The will, expertise and ideas are there to reap timely rewards for the climate crisis we face and the opportunities for sustainable agriculture.

1. Place farmers at the centre of agricultural innovation

Farmer-centric cooperation

Cooperation between Ireland and the UK should look at ways to maximise opportunities for farmer, forester and mariner engagement and experience sharing There should be a focus on implementation where researchers engage with and support practitioners and help them to address the gaps in knowledge that will allow leading edge sustainable practices uptake. Contributors suggested that it is necessary to connect with farmers at their level, understand where they are on their journey and support the in the emotional/ psychological journey of change and transition to these new farming practices. The policy narrative around this approach needs to be changed also to reflect this.

Strengthen and improve join-up of demonstration scale farmer networks

Create opportunities for farmers to build connected demonstration scale networks for knowledge, best practise implementation and exchange.

While this will build on existing schemes and initiatives, wherever new sustainable practices are incorporated inside the farm gate and these prove successful, it is necessary to harness the success and practical experience of peers for the farming community to learn from. Such opportunities should form part of just transition initiatives and KPIs that support farmers to engage and transform their agricultural practices using outputs of R&I. This will help to transfer knowledge from R&I to the practical implementation on farm.

2. Identify shared outcomes and objectives

Shared Research and Innovation Vision workshops

Workshops would seek to look at common areas of interest for R&I work and projects that could have joint benefits for both countries in the future. For example, the *"Agricultural innovation for people, nature and climate"* workshop that took place in October 2021 looked at the focus areas of this report and insights from some of the participants are shared throughout.

Sharing the understanding of these areas and defining those initiatives that can benefit from a joint approach can make the best use of resources and get to results in a more efficient way. Formalisation of the outputs from the workshops can be a catalyst for future cooperation and development of a framework for joint efforts and practical supports to the R&I work on both islands. Drawing on this framework, policy makers, decision-makers and researchers can use their existing networks to define and work on common projects. The workshops can also be a catalyst for more joined up thinking, new approaches to UK/Ireland collaborations in this field and will enable a more structured network of relevant contacts to be established and grow over time.

Identify shared technology goals

Build upon the outcomes of joint R&I workshops to identify shared technology goals and improve partnership working in these areas. This will draw upon existing work and activities, aiming to use the most up to date farmer engagement and available technology to further drive innovation for sustainable agriculture.

Identify opportunities to align research programmes and enhance partnership opportunities for sustainable agriculture

Identify opportunities for joint programming and greater alignment of research programmes to enhance collaboration and partnership working. This includes consideration of opportunities for more effective use of existing bilateral or multilateral funding mechanisms, including through the Horizon Europe framework programme, and the Global Research Alliance (medium term).

3. Improve alignment of research agendas and strengthen collaborative opportunity

Strengthen research and innovation collaboration mechanisms

Strengthen and create structures and mechanisms to enable informal and formal research and innovation collaboration in the areas of bioeconomy and sustainable agriculture. Structures may include existing groups where both countries are active but where a joint approach is not (always) prepared together. Arising from the formalisation of the joint R&I understanding, it would become a practical and embedded step to coordinate and collaborate where possible on identified shared goals and pathways for their achievement.

On the informal side, there is a need to continue to harness the existing relationships built up over years, to widen the network and bring young researchers and relevant interlocutors in. Harnessing the power and investment in this relationship building, will provide an on-going and fruitful source of information and collaboration in the future.

More effective use of shared research funding models

Look at opportunities for joint schemes under the Horizon Europe Framework for specific areas of interest as sets of building blocks to achieve the medium- and long-term visions, in order to build upon significant partnership work already ongoing under the H2020 ERAnet programmes.

Other viable routes to align interests and enhance joint working include the EU Joint Programming Initiative on Agriculture, Food Security and Climate Change (JPI FACCE)

and the Global Research Alliance on Agricultural Greenhouse Gases.

There may also be other models already existing such as the EPSRC and Science Foundation Ireland (SFI) joint funding of research partnership or others to be created which would simplify a joint approach and which could reap benefits for researchers and innovators. Contributors suggested looking at a more formal and holistic partnership which would help attract funding for areas of common interest due to the nature of UK and Ireland farming systems. These joint schemes can then be part of a longer pathway to achieving common goals in this area.

4. Explore opportunities to share research and innovation infrastructure in the bioeconomy including sustainable agriculture

As both countries are investing in various research projects and infrastructure, there may be opportunities to benefit from each other's resources. A pathway to gain a full understanding of the available resources on both islands will be useful so that actors involved in this R&I can identify suitable and timely resources. This will also help to identify gaps which can then be addressed in a comprehensive way.

Below is a non-exhaustive list of the practical supports which could serve to help the implementation of the recommendations. These ideas are presented as a means to achieve the above objectives and can serve as initial starting points for future collaboration efforts.

- Targeted funding calls (joint calls like the current DAFM/NI model (North-South council agreement) or SFI and EPSRC Centres for Doctoral Research programmes and Centres for Research Training.
- Exchange of personnel, shared expertise
- Twin demonstrators
- Twin living labs (e.g., carbon farming schemes, natural capital projects)
- Twin farmers' networks showcasing best practices with business models
- Joint appointments (of academia) on specific topics of common interest
- Programme partnerships in research and innovation
- Bring Investment communities together
- Clear pathways and mechanisms for cross country public and private investment in research and innovation.

Potential Areas for Future Work

Identify innovative processing technologies and products of common interest that use agricultural resources.

A regular contact between the UK and Ireland research and innovation bodies could seek to identify novel approaches with regard to processing technologies innovation as well as outputs and products of common interest, arising from agricultural resources. This sharing of progress and areas of interest could stimulate further cooperation and sharing of research to help each player get to solutions more efficiently and build on each other's work.

Identify barriers and enablers to financing the bioeconomy from a range of stakeholder perspectives

Both countries face challenges in terms of financing bioeconomy solutions. Due to the early stage of research, development and demonstration across the area, identifying financing partners and removing barriers to accessing finance could be a shared objective. This joint approach to identify and hopefully, remove barriers through information and education of relevant players could bring results for the financing of projects earlier. Learning from each other's experience, may provide insights and useful information for the achievement of financing on projects, technologies and business cases.

Explore new business models for future farms

Explore new business models for future farms drawing on R&I achieving sustainability targets and what future farm incomes look like and contain.

This includes future farm business models, with sustainable agriculture practices more embedded in the daily operation of the farm. More work is needed on the future farm revenue streams, the value placed on the public good being provided by the farm and the fair return for primary producers for work done inside the farm gate, including sustainability measures. The economics and metrics of what future farms will produce and protect need to be evaluated and valued in keeping with natural capital accounting and product value.

Intellectual capital management

In Ireland, there is a wider range of expertise across the areas mentioned in this report – however, it does not have a critical mass which would allow those skills/expertise to be embedded in the daily operation of farms. On the other hand, in the UK, there is a critical mass, and the challenge lies in the ability to bring cohesion across skill sets and on both islands.

Future joint vision/horizon scanning

Below is a list of areas identified by contributors that could benefit from a shared vision to steer efforts across mutually beneficial research and innovation in the future. Each of these topics could be the focus of specific initiatives which would benefit the bioeconomy and sustainable agriculture thinking and implementation on both islands.

- Climate neutral farms of the future
- Natural capital and eco-systems services in the bioeconomy
- Circular integrated sustainable food and non-food production systems
- Dairy innovation alignment
- Farm infrastructure of the future (farm buildings, measurement technologies, embedding technology in the future farm, natural capital metrics)
- Sustainable protein strategy

Wider focus on Forestry and Marine bioeconomy pillars

This report does not deal with the forestry and marine pillars of the bioeconomy in detail but contributors to the report were keen to include ongoing and fruitful collaborations in these pillars wherever it interacted with agricultural resources and processing.

With solid foundations in each pillar there are opportunities to continue to build links and share ambition and expertise for the development of the bioeconomy in both countries.

Forestry: Afforestation is increasing on both islands. The UK has a target to plant 27000 ha with forestry per year from 2020 to 2030. Over 11% of Ireland is under forest and the Government target 17% forest cover by 2030 equivalent to one million hectares of forest. For this to happen, government investment in these schemes needs to be clear and the financial commitment to reward farmers who change the land use for parts of their farm needs to be robust. Again, the business model behind this needs to be convincing for farmers and clearly demonstrate the positive impact for the bioeconomy and climate change commitments. This report does not cover forestry in detail but as some agricultural land may be used for agro-silvestral feed for animals and land may be used for bio-economy purposes, there is a clear link with sustainable agriculture.

Rothamsted Research have a strong track record on SRC Willow and are active in the research and development of renewable bioenergy sources from crops. Ireland (MTU) and the UK colleagues at Bangor University Biocomposite research centre are currently collaborating on the 'BioWill' Interreg project – which looks at utilising all fractions of Willow feedstock to produce high to medium based Bio-Chemicals/Materials, Renewable Energy in the form of Bio Methane production and Natural Fertilizers. Aberystwyth University continue to develop Miscanthus as a biomass crop for UK growing conditions as part of the MISCOMAR Plus ERAnet collaboration. Recently Cranfield University has been considering the potential of novel biomass crops such as Sida hermaphrodita (cup plant).

Marine: Similarly, Bangor University's Biocomposite research centre is collaborating with Irish commercial research partners such as BioAtlantis on an Interreg project, BioNaspa, in discovering and developing new biomolecules from biomass available in the European-Atlantic region (seaweeds, microalgae, marine plants, weeds) to control key crop diseases or stimulate crops grown in the regions, mitigating the effects of environmental stress and reducing the fertilizer footprint.

Northern Ireland & Ireland Collaboration

The North South Ministerial Council (NSMC) was established under the Belfast/ Good Friday Agreement (1998), to develop consultation, co-operation and action within the island of Ireland.

The Agriculture Sectoral meeting of the NSMC met last on the 18 November 2020 and discussed the agreed areas of co-operation: animal and plant health; EU funding; CAP issues; and rural development. Ministers noted that Department of Agriculture, Environment and Rural Affairs in NI (DAERA), the Department of Agriculture, Food and the Marine (DAFM) and the Department of Rural and Community Development (DRCD) in Ireland will hold a workshop to review the work programme in the Agriculture Sector, and that an update paper will be brought to the next Agriculture Sectoral meeting.

There is existing cooperation on the 'All-Ireland Chalara Control Strategy' by officials from DAFM and DAERA in response to ongoing scientific and surveillance evidence and the research being undertaken to develop a population of Irish planting stock tolerant to the Chalara Ash Dieback disease. Work is also underway on a joint approach to the continued sharing of science and diagnostic capability and in the regulation of the use of pesticides. This framework provides a good basis for work in these areas and the recommendations set out below need to be seen in light of these ongoing collaborations while avoiding overlaps.

The Shared Island Initiative was announced by Department of the Taoiseach in October 2020 and a series of events recently marked the first-year anniversary.[42] The Irish Government has put in place a €500m budget for collaborative projects between North and Southern Ireland that support the commitments and objectives of the Good Friday Agreement which includes commitments to North-South cooperation on several areas including the environment. The initiative is focused on three areas:

- building a Shared Island
- fostering constructive and inclusive dialogue
- commissioning research

With objectives to:

- strengthen the social, economic and political links on the island
- promotion of an all-island approach to strategic challenges faced by North and Southern Ireland
- deliver on the commitment of the Share Island in the Programme for Government

42 https://www.gov.ie/en/press-release/bf062-taoiseach-marks-one-year-of-shared-island-initiative/

An event in February 2021 brought over 100 thought leaders together to discuss opportunities for cooperation on climate policies and in particular, biodiversity and the importance of cross border community engagement between Ireland, the Northern Ireland Executive and the UK Government. Then in December came the launch of the 'Collaboration on Climate and Biodiversity: Shared Island as a Catalyst for Renewed Ambition & Action' report by the National Economic & Social Council (NESC) to discuss cooperation on climate change and biodiversity loss as integrated and urgent shared challenges. [43]

One of the joint biodiversity projects already in motion is supported by the National Parks and Wildlife Service and the Northern Ireland Environment Agency; the National Biodiversity Data Centre (NBDC) that has created an online database that allows for sightings of invasive species.

Cross border funding institutes such as Interreg have proven beneficial for biodiversity projects, best practice examples, and connecting key players. However, previous mutual alignment is now at risk, as Northern Ireland moves to create more of its own policies post Brexit.

There are differences on both sides of the border on how agriculture policy has been designed and implemented, results-based methods are advanced in Ireland and a tier-based system is advanced in Northern Ireland. Lessons and knowledge are to be gained from both.

There is a key need to address a lack of baseline data, detailed maps and coordinated surveys; especially in Ireland where the data is fragmented. Better and more consistent monitoring and tracking systems are required to see how our ecosystems are functioning and how best to assist them. Volunteer data gathering is currently predominant on many schemes. There is a potential to increase these volunteer networks to achieve greater engagement, knowledge sharing, awareness and increase the scope of the datasets.

All-Island Climate and Biodiversity Research Network (AICBRN)

This major initiative brings together leading research centres across the whole island of Ireland to tackle the climate and biodiversity emergency where a trans-national approach is essential.

Researchers from all the centres across the network have come together to work with national, regional and local governments, communities and industry to effectively deliver solutions to climate, biodiversity and social challenges caused by global warming.

"The ambition of the AICBRN is to develop a large-scale research and innovation initiative to improve public good policy and management decisions, underpin business and enterprise strategies and strengthen societal capacity to address the climate and biodiversity emergencies."[44]

43 156_shared_island_cbd.pdf (nesc.ie)

44 https://www.aicbrn.net/

UK & Ireland Mapping: Centres of Excellence

The following section sets out an overview of the Centres of Excellence working across different areas of agriculture of relevance to this report. This list is by no means exhaustive but seeks to provide a relevant overview of the ongoing work across the different nations.

England

The UK has a number of **Centres of Excellence** dealing with different topics such as livestock, crops and innovation.

The Agri-Tech Centres[45] are collaborations between the UK Government, Research and Businesses to drive innovation, productivity, and sustainability across the agri-food sector. The four Agri-Tech centres are:

- Agri-EPI – Agricultural Engineering Precision Innovation
- Agrimetrics – Data analysis tools
- CHAP – Crop Health and Protection
- CIEL – Centre for Innovation Excellence in Livestock

Agricultural Engineering Precision Innovation (Agri-EPI)

This was established with the vision to drive growth, innovation and support farmers and the agri-food business to become more sustainable and profitable by providing commercially viable solutions with precision technologies, robotics and autonomous solutions. The centre offers a range of business, project and grant management supports including technical expertise, key industry relationships and business incubators.

Agrimetrics

Launched in 2015, it is a centre for agriculture innovation using data science to aid the development of a highly intelligent, productive, efficient, and resilient system. Working with businesses and universities to engage with stakeholders to enable a better understanding of the needs of farmers, food manufacturers, retailers, consumers and environment through data tools and analytics. Founding partners include Rothamsted Research, the University of Reading, the National Institute of Agriculture Botany (NIAB) and Scotland's Rural College (SRUC).

Crop Health and Protection (CHAP)

CHAP brings leading scientists, advisors, innovators, businesses and farmers together on the challenges they uniquely and

45 https://www.agritechcentres.com/

collectively face to develop sustainable crop systems. Working with industry and research stakeholders their mission is to promote viable technology solutions to increase crop production and quality.

Centre for Innovation Excellence in Livestock (CIEL)

CIEL works with 12 of the UK's leading livestock research institutions and industry partners across the food chain to bring new technology to livestock food production. CIEL provides collaboration and expertise working with researchers and industry partners to identify supply chain solutions and assist with access to the £70m of capital investment that has been made available for R&D.

BioVale

Supporting the Yorkshire and Humber region, BioVale is a non-profit company associated with University of York promoting the circular bioeconomy. Their aim is to establish the region as a world-leading centre for bioeconomy innovation focussing on raw materials and low carbon agriculture to stimulate growth and support the sustainable goals while engaging with key policy makers and influencers. They have 600 members and provide:

- Networking, dialogue and partnerships among researchers, innovators and supply chains.
- Support an entrepreneurial ecosystem for bio-based products, processes and services.
- Promotion of the region as a place for bio-based business and R&D.

Support – for new business creation in the bioeconomy, with assistance on funding, contacts, market discovery, research access, promotion, and locating specialist facilities.

Entrepreneurship – helping develop and commercialise start-ups, introductions to researchers, funders and investors in the region and Europe through European bioeconomy clusters[46] 3Bi in Germany, Netherlands, and France. Co-founded by BioVale, 3Bi is a strategic European partnership to facilitate research, innovation and commercial collaboration among members in Europe.

International Connections – organising trade missions, and as members of the Bio-based Industries Consortium (BIC) representing UK SMEs and promoting the UK bioeconomy.

Centre for Ecology and Hydrology

The Centre for Ecology and Hydrology is an independent not-for-profit research institute for environmental science in water, land, and air. Their 500 scientists provide key data and insights to researchers, governments and businesses on topics ranging from molecular biology to global climate modelling. With many cross-border partnerships in place, they are a strategic delivery partner for the National Environment Research Council, part of UK Research and Innovation.

Food and Environment Research Agency (Fera Science)

Fera Science's origins in delivering world-class science began over 100 years ago as

46 3Bi — BioVale

the Institute for Plant Pathology services. Fera continues to address some of today's biggest challenges, including coping with the impact of global population growth and the need to make efficient sustainable use of natural resources. Fera is a national and international centre of excellence for interdisciplinary investigation and problem solving across plant and bee health, crop protection, sustainable agriculture, food and feed quality and chemical safety in the environment.

John Innes Centre

The John Innes Centre is an independent, international centre of excellence in plant science, genetics and microbiology. Their work addresses global challenges using knowledge of plants and microbes to answer fundamental questions, as well as having a significant impact on industrial biotechnology, society and global development.

National Institute of Agricultural Botany (NIAB)

Founded in 1919, and with a longstanding international reputation for expertise in plant varieties and seeds. NIAB's scientific capabilities span the crop improvement pipeline; from underpinning research required to develop higher yielding more climate resilient crops through to the extensive trials data, agronomy expertise and advice needed to ensure these advances are transferred effectively onto farm.

NIAB is at the forefront of the application of genetics, physiology, soil science, precision agronomy and data science to improve the yield, efficiency and resilience of crop production across the arable, forage and horticulture sectors.

University of Reading

Located at the University's Shinfield Farm and established in 1992, the Centre for Dairy Research (CEDAR) is a unique, state-of-the-art scientific facility for applied and strategic large animal research, including studies concerning milk composition and human health, dairy cow nutrition, and the environmental impacts of meat and milk production. Research capabilities of CEDAR include capacity of individually feeding up to 200 cows fed different diets in a commercial environment, and digestion and metabolism facilities that enable more detailed studies.

Rothamsted Research

Rothamsted Research is a non-profit research centre focussing on the sustainable intensification of arable and grazing-livestock systems in the UK and globally. They are supported by funding from the Biotechnology and Biological Sciences Research Council (BBSRC) and other sources. Working in partnerships with institutions and research centres in over 50 countries it provides data and software tools to the global scientific community. Their two flagship projects, Omega-3 Camelina Development and Integrated Systems Lab complement their five Institute Strategic Programmes (ISPs):

- Designing Future Wheat
- Tailoring Plant Metabolism
- Smart Crop Protection
- Soil to Nutrition
- Achieving Sustainable Agricultural Systems

Demonstration Farms

Rothamsted Farms in Harpenden is the home of 'Classical' agriculture experiments and runs a number of mostly arable farms that run studies on grazing systems, field conditions, biomass production, and livestock methods. Their researchers run 120 experiments on average each year.

Farms in the group are located in Woburn, Bedfordshire, Suffolk, and Devon and they have amassed a significant amount of data over 100 years of agri-systems research. Ireland's agri-catchments programmes[47] and dataset is not as extensive but is growing having been in place since 2008.

Harper Adams University

Harper Adams University is a specialist university concentrating on the development of food production, processing, animal sciences, engineering, land management and sustainable business. Its research centre's work covers crops, soil and water, precision farming and technology, animal nutrition, pest management, agri-tech, fresh produce research, drought mitigation and sustainable energy systems; as well as informing decision-makers and industry.

University of Lincoln

The Lincoln Institute for Agri-Food Technology (LIAT) based at the University's Riseholme Campus is home to a working farm with specialist research facilities. LIAT's multi-disciplinary team brings together sector-leading expertise in a diverse range of areas such as artificial intelligence, robotics, engineering, crop science, environmental sustainability, food manufacturing, product development and supply chains.

University of Nottingham

Nottingham has an international reputation for work in the areas of animal reproduction, development and production, with research covering major livestock species with focus on the biological basis of feed efficiency and sustainability in ruminant and non-ruminant systems.

47 https://www.acpmet.ie/

Scotland

Industrial Biotechnology Innovation Centre (IBioIC)

Established in 2014 and based in Glasgow, IBioIC –is a networking and support organisation connecting industry, academia and governments to bring biotechnology processes and products to the global market to fulfil the Scottish National Plan for Industrial Biotechnology[48] to grow the sector to a £900 million turnover by 2025.

With its extensive network of over 120 member organisations, it offers scale-up facilities, talent development, research and industry partner connections, funding support, and promotion of Scotland's unique assets.

Industrial biotechnology uses plant-based and waste products to create materials, chemicals and energy, moving away from the reliance on fossil fuels. Industry members include medical biotechnological companies working on protein production to those developing solutions in biomanufacturing using agriculture, marine and forestry derived feedstocks.

Zero Waste Scotland

Zero Waste Scotland is a non-government organisation committed to becoming a pioneer of the Circular Economy and the promotion of responsible use of products and resources. Four-fifths of Scotland's carbon footprint comes from the heat and energy to grow, make, process, transport and provide products and materials.

Their aim is to encourage responsible consumption, responsible production and to maximise the value from waste – all while efficiently harnessing and respecting the limits of their natural resources. Their work includes municipal programmes, school education programmes on food waste, energy saving, and recycling.

Scotland's Rural College (SRUC)

Scotland's Rural College is a higher education, consulting and research institution focused on rural, environmental, and land-based business and advisory services. Their courses include Applied Biology for best land use practices for climate change, biodiversity and food security. Their mission is to partner locally and globally to develop a natural economy fuelled by responsible use, creating prosperity and scaled through innovative management.

SRUC are considering biorefining diversification options that highlight the farming sector as a solution to other issues e.g., plastic alternatives produced from cow dung. The objective is to assist the rural communities and businesses and ensure commercial benefits remain local.

Aside from business and public sector consulting, research is carried out on animal welfare and crops, low carbon farming and increased efficiencies through innovation and technology. Under the topic of sustainability, SRUC covers biodiversity consultancy, water and air quality, climate change and Agrecalc – a leading resource efficiency and greenhouse gas emissions calculator developed by SRUC and SAC Consulting.

Agrecalc has over 3,000 users across the UK. It is a management tool for farmers allowing them to identify and monitor high emission impact areas. With this the farmer

48 https://www.sdi.co.uk/media/1673/national-plan-for-ib-2019-pdf.pdf

and industries can determine the best mitigation practices, to reduce emissions, increase efficiencies and provide key data for policy makers.

James Hutton Institute

The James Hutton Institute is a networked organisation that operates from multiple sites, including two in Scotland, Aberdeen and Dundee. Their research in crops, soils and land use contributes to the understanding of key global issues, such as food, energy and environmental security, and developing and promoting effective technological and management solutions.

With more than 500 scientists it is one of the Scottish Government's main providers of environmental, crop and food science. The Institute brought together the former Macaulay Land Use Research Institute and the Scottish Crop Research Institute on 1 April 2011.

Dairy Innovation Centre

Although Scottish agriculture is mainly focused on fish farming (salmon), there are 850 dairy farms in Scotland and 90% of the dairy farm income comes from the sale of milk.

There is a new Borderlands Growth project being finalised between Scotland and England covering counties north of the Scottish English border and a significant area south of the border to include Cumbria. This £8 million joint capital funded project will focus on developing a Dairy Innovation Centre and demonstrates both governments commitment to the economic development of the area. The Centre will be based at the Crichton Royal Farm, Dumfries, Scotland.

Wales

University of Bangor

The university is committed to being known as 'The Sustainable University' through its teaching, research and public engagement. They established The Sustainability Lab to lead on all aspects of sustainability within the University. Their excellent research strengths include sustainable use, conservation, agricultural landscape and the value chain of renewable materials and bio-based chemical products, amongst others. Major collaborative projects include the BEACON Biorefinery Centre of Excellence[49] and Bluefish[50] (Building Resilience into Blue Growth in the Irish and Celtic Seas Fisheries and Aquaculture) and it is also one of the four locations for the UK Centre for Ecology and Hydrology[51] (Bangor, Edinburgh, Lancaster and Wallingford).

Institute of Biological, Environmental and Rural Sciences (IBERS)

This is a research and teaching centre in Aberystwyth University. It is the home of the National Plant Phenomics Centre and the BEACON Centre of Excellent for Biorefining – a partnership with Aberystwyth, Bangor, Swansea Universities, and the University of South Wales. Over 300 members of staff are providing research on food security, bioenergy and sustainability, working with industrial partners and developing innovative solutions to mitigate climate change impact and plant and animal diseases and deliver renewable energy, food and water security.

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49 http://beaconwales.org/
50 http://bluefishproject.com/
51 https://www.ceh.ac.uk/

Aberystwyth Innovation and Enterprise Campus (Aber Innovation)

This is a £40.5m innovation campus with expertise in the technology, agritech, food and drink sectors. Working with industries to develop new products and processes and is co-located with other projects including:

- BEACON Biorefinery Centre of Excellence – supporting the transition to a low-carbon economy.
- Future Foods Project – working with commercial food and drink manufacturers on R&D projects to develop healthy, marketable products.
- National Plant Phenomics Centre – addressing how genetics and the environment interact.
- VetHub1 - £4.2m European Regional Development Fund (ERDF) backed project providing animal health and biosecure facilities.
- BioInnovation Wales – connecting research and decision makers with the bio-based technology industry.
- CIEL – one of the UK's 4 centres of excellence working across all farmed animal systems.
- Geographical Data and Earth Observation for Monitoring GEOM – helping Welsh organisations to benefit from spatial intelligence technology within the agriculture, energy, environment and infrastructure sectors.

Wales is prominent in waste recovery, municipal waste management but not as advanced on bio-based waste management. There are good links between Wales and South East region of Ireland due to proximity and similarities on supports, projects and previous commercial collaborations – but not as many on agriculture initiatives.

Wales has a comprehensive network of demonstration farms[52]. Since 2015, the demonstration Network farmers, supported by sector specific industry experts, have been trialling and implementing more efficient and profitable ways of managing their businesses. These farmers have been selected for their progressive approach and ambition to operate at peak performance levels.

52 https://businesswales.gov.wales/farmingconnect/our-farms

Northern Ireland

Queens University Belfast

The University is active across a number of areas relating to sustainable agriculture including food security, animal health and animal disease. It has a strong history of collaborating on EU projects. The University looks to tackle cross-disciplinary research priorities, by the formation of Global Research Institutes in areas where it has "a critical mass of world-class research to take on major societal challenges". The University's research priorities are underpinned by four Global Research Institutes focusing on: health sciences; peace, security and justice; global food security; and future technologies. These maps strongly across future EU priorities, supporting Sustainable Development Goals, tackling climate change and boosting competitiveness and growth.

Agri-Food Biosciences Institute (AFBI)

AFBI is a multi-disciplinary organisation with 650 staff involved in high technology research and development, diagnostic and analytical testing for the Department of Agriculture, Environment and Rural Affairs (DAERA) and other Government departments, public bodies and commercial companies in Northern Ireland, and further afield.

Its 3 main areas of work are:

- Natural and marine environment
- Animal, plant and human health and welfare
- Sustainable livestock production

AFBI already has a number of collaborations ongoing (and from the past) in the areas of agri-food, animal health and livestock production. The Department of Agriculture, Food and the Marine (DAFM) in the Republic of Ireland also closely cooperate with both AFBI and the DAERA on areas of mutual interest including joint funding opportunities.

AgriSearch

AgriSearch was formed in 1997 to provide a mechanism through which beef, dairy and sheep farmers could have direct involvement in production orientated research. Funds contributed to AgriSearch are used to commission research into the improvement and development of beef, sheep and dairy farming.

AgriSearch's guiding principal is to provide practical benefit for primary producers to reduce costs, improve performance, drive innovation and improve welfare.

Beacon Farm Network

Established in 2021, the Beacon Farm Network is AgriSearch's new flagship project to build a structured, intentional and semi-permanent farm network in Northern Ireland. The Network aims to gather evidence for research into sustainable livestock farming systems that deliver for people, planet and profit. The network currently consists of farms from across the province, covering the full range of ruminant farming systems.

Ireland

BiOrbic

BiOrbic[53], Bioeconomy SFI Research Centre is Ireland's national bioeconomy research centre and includes over 100 researchers from across Irish universities and research performing organisations, focused on addressing challenges and delivering solutions for the development of a sustainable circular bioeconomy. BiOrbic researchers work closely with farmers and producers, industry, policymakers, consumers and citizens to deliver the Centre's mission to enable a vibrant sustainable circular bioeconomy through research excellence, innovation and the development of future bioeconomy leaders for the benefit of Ireland, Europe and beyond.

Established in 2017 BiOrbic's founding partner institutions include University College Dublin, Trinity College, Dublin, Teagasc, National University of Ireland, Galway and University of Limerick. The Centre has three key research pillars in sustainability, selective separation, and conversion.

Farm Zero C is a flagship BiOrbic project to establish the world's first carbon neutral Dairy Farm – a collaboration between BiOrbic and Carbery and others to address the challenges of carbon neutral farming.

BiOrbic has 5 strategic priorities:

- Responsible and excellent research, invention, and innovation for the bioeconomy
- Local application of research to address global challenges
- Inclusive collaboration at local, national and global level
- Create future leaders for the bioeconomy
- Engage, inspire and involve the public and societal partners

The Circular Bioeconomy Research Group based in the south-west of Ireland is a partner of the BiOrbic and is composed of:

Circular Bioeconomy Cluster South West

The cluster[54] aims to builds upon the current strengths of the Technology Gateways of Shannon ABC (Applied Biotechnology Centre); IMaR Research Centre and other research organisations which Munster Technological University (MTU) has a relationship with. Recently launched in March 2021, funded by Enterprise Ireland, the cluster will focus on two themes, Marine and Waste-to-Value which are strongly embedded in Cork and Kerry. Combining a network of stakeholder groups including small and medium enterprises, industry, educational institutes, government, and investors it will develop a vision, strategy and action plan for the next two years. The initiative will also have an industry led steering committee.

University College Dublin (UCD) School of Agriculture and Food Science

UCD School of Agriculture and Food Science[55] research programme is comprised of 63 Principal Investigators, 163 graduate students and 47 contract research staff on

53 https://biorbic.com/

54 https://cbcsw.ie/

55 www.ucd.ie/agfood

four key areas of Production Agriculture, Agribusiness and Rural Development, Agri-Environment and Sustainable Resource Management, Food Science and Nutrition. It is the only academic institution in Ireland with a dedicated School of Agriculture and Food Science. It delivers education and research on the complete food chain from farm production to processing and ultimately the consumer from its UCD Belfield campus and its research farm.

The UCD Lyons Research Farm runs undergraduate and postgraduate courses as well as professional development options for agri-food professionals. The 220-hectare teaching and research facility focussed on beef, crops, dairy, equine, sheep and pigs is operated by the College of Health and Agriculture Sciences within University College Dublin. This €2.3m partnership between academia and industry looks to investigate innovative models of milk production, genetics, nutrition, and herd health management. The farm will also examine novel grass-based production systems suited to an Irish environment.

The UCD farm also includes the AgTech and Bioeconomy Innovation Hub which aims to bring together Ireland's wider AgTech community and help with the launching and scaling of AgTech companies by providing access to on-farm research collaboration opportunities, as well as a location to test and trial their products and services in a real-world environment.

VistaMilk SFI Research Centre

VistaMilk SFI Research Centre is a collaboration between Agri-Food and information communications technology (ICT) research institutes, funded by Science Foundation Ireland (SFI) and the Department of Agriculture Food and the Marine (DAFM). It is hosted by Teagasc. Its aim is to lead the Agri-Food sector with innovation and enhanced sustainability throughout the dairy supply chain. Its research covers soil nutrition and sustainable pasture management, animal nutrition and fertility, dairy processes and products, and advanced data analytics, communications, sensors and systems integration.

University College Cork (UCC)

The School of Biological, Earth and Environmental Studies (BEES) at UCC and working in collaboration with Teagasc, offer a new Agriculture Science Degree which supports graduates moving into the agri-food industry, translating research to help deliver skills and innovation to the sector. BEES mission is to advance research in three main areas:

a. Healthy environment (geology, biodiversity, water and habitats)

b. Sustainably produced high quality food (crops, aquaculture and fisheries)

c. Sustainable energy and resources (hydrocarbons, renewables, raw materials and crops)

BioConnect Regional Cluster

BioConnect Regional Cluster based in Monaghan established a centre of excellence for the provision of cutting-edge research and services to the regional cluster and promote bioeconomy opportunities. The Innovation Centre is made up of a consortium of 6 local businesses, public bodies and 7 academic partners. Industry-led, it provides facilities to enable the commercialisation of innovative high value biotechnology products.

Irish Bioeconomy Foundation (IBF)

The Irish Bioeconomy Foundation is Ireland's national bioeconomy association and innovation cluster. The IBF was founded in 2017 to promote the conversion of Ireland's natural land and sea resources to high value products for the development of a sustainable competitive bioeconomy that creates local development. The IBF works closely with BiOrbic and other key stakeholders to form an Irish bioeconomy innovation ecosystem.

Its 455-hectare location in Co Tipperary is a converted mining site and includes an €80m infrastructure including roads, electrical substation, wind turbines, weigh bridges, water, and buildings.

Services are provided under 5 headings: Design and Scale-up – consulting and evaluation services to support access to pilot plants in Europe and Ireland.

1. Private Finance – fundraising within IBF networks and extra-EU investors (EIIS, VISA scheme) and leveraging Irish banking fund supports.

2. Public Funding – support in pre-competitive innovation public funding sourcing.

3. Promotion and Outreach – positioning and promotion of products, processes and brand.

4. Advocacy – Insights and trend spotting within the Irish and European regulatory and policy making environment.

Teagasc

Teagasc, Agriculture and Food Development Authority is the Irish national body providing integrated research, advisory and training services to the agriculture and food industry and rural communities. They offer research and training, with their Signpost Series webinars on the science and advice underpinning Farm Sustainability in Ireland and a number of Demonstration Farms.

Through research and knowledge transfer on over 300 annual projects carried out by 500 staff it actively collaborates with international partners. Its mission is to support science-based innovation in the agri-food sector and bioeconomy to provide profitability, competitiveness and sustainability under four areas,

- Animal and Grassland Research and Innovation,
- Crops, Environment and Land Use
- Food
- Rural Economy and Development

Teagasc currently has a number of Demonstration Farms working on joint programmes with commercial farmers to test and demonstrate best practice in animal breeding, grassland management, animal health and financial management.

- Better Farm Beef Challenge – 22 farmers participating select from a list of mandatory and optional challenges to tackle over four years of the programme. Challenges include, soil fertility, mixed grazing, farm safety, herd health, green farming, quality assurance, grass and farm financing.

- Derrypatrick, Grange, Co Meath – the project aims to explore new ideas and system comparisons during the animal lifecycle, using a herd of 100 suckler cows in a finishing system of 65 ha. Measurements to be detailed during the project include live weight and body condition, intake of grazed grass and conserved forage, fertility, milk yield, calving interval and slaughter and carcass traits.

- Newford, Athenry Co Galway – Teagasc and Dawn Meats supported by McDonald's and The Irish Farmers Journal have established a standalone suckler herd. The herd is run on a fully commercial basis and demonstrates the potential of a moderately large suckler farm to generate viable income when operated at the highest level of best practice and technical efficiency.

- Green Acres Calf to Beef Programme – 14 farms nationwide participating with the aim to achieve a net margin of €500/ha (excluding premia). The programme focusses on calf rearing, animal health, grassland management, soil fertility, financial management and farm planning.

AgriTech Centre of Excellence

The ACE centre at MTU is a public-private partnership and Ireland's first and only augmented, virtual and mixed reality learning space with custom-built software and technology. It provides engaging and immersive training scenarios to experience physical space and products through a virtual environment be it for workshops, conferences, design thinking or remote collaborations.

Munster Technological University

Munster Technological University Kerry (MTU) is the National Centre for Agricultural Engineering and it has developed an E-Learning Development Unit (EDSU) and has developed online/ blended learning programmes. It is also the first UNESCO Chair research centre. MTU hosts the Intelligent Mechatronics and RFID (IMaR) Technology Gateway and Shannon Applied Biotechnology Centre (Shannon ABC).

UK & Ireland Mapping: Projects

The following provides a snapshot of some of the ongoing projects in both Ireland and the UK which will contribute to moving agricultural practices to a more sustainable footing. These are drawn from bioeconomy and agriculture perspectives. They provide a flavour of the ongoing work in both islands to contribute to the solutions for climate neutral farming of the future.

Ireland

Farm Zero C

Farm Zero C Project[56] – BiOrbic, Bioeconomy SFI Research Centre flagship project to establish the world's first Climate Neutral (CN) Dairy Farm – a collaboration between BiOrbic and Carbery and others to address the challenges of CN farming looking at the following areas:

- Renewable Energy
- Soil and Grassland
- Animal Diet and Breeding
- Biodiversity
- Life Cycle Analysis
- Partners: BiOrbic, Carbery, VistaMilk, UCD, Teagasc, Indigo, TCD, AFBI, Tralee IT, Wageningen UR

AgriChemWhey

Agri Chem Whey is seeking to build an integrated industrial-scale biorefinery for the conversion of dairy by-products to high value and cost competitive, sustainable lactic acid. This can be used to create bio-based products for growing global markets including biodegradable plastics, bio-based fertilizer, and other minerals. The refinery and its technology will provide the dairy and wider industries with greater efficiencies from these bio resources, less waste, more products and integration of food and non-food material production.

Biorefinery Glas

This project began in 2019 and is an EIP project funded by DAFM and run in collaboration with Carbery, Grassa!, Barryroe Co-op, Munster Technological University and UCD. It is Ireland's first grass biorefinery projects and one of Europe's first small scale biorefinery demonstration models.

The project aims to improve the nitrogen efficiency of Irish grassland by 40% using a protein optimisation process which separates the proteins in the grass resulting in less emissions produced by the cow and other animal feedstocks being created.

56 Farm Zero C – BiOrbic, Bioeconomy SFI Research Centre.

The refinery process generates four by-products:

- Fibre cake – a dry silage
- Protein – suitable for pigs and poultry
- Phos – a prebiotic
- Grass whey - fertilizer

In its recent presentation of results, Biorefinery Glas findings were:

- Biorefining can improve the resource efficiency of Irish grass providing diversification opportunities and feed independence.
- All 4 co-product streams compared well with incumbent products and offer key opportunities for emission displacement.
- Integration between biorefining and bioenergy can be a win-win.
- Bioeconomy can be delivered economically at small scale with 3 products.
- Farmers and primary producers can and should play a more central role in bioeconomy value chains.

Farmland Pollinators

The National Biodiversity Data Centre's project 'Protecting Farmland Pollinators' is a five-year research project funded under the European Innovation Partnership (EIP) and co-funded by the European Union and Department of Agriculture, Food and Marine. Pollinators are important to farmers to ensure continued biodiversity. In Ireland, one third of our 99 bee species are threatened with extinction. The project aims to develop and test a whole-farm pollinator scoring system and identify which practices benefit pollinators.

HeartLand: One Health from Soil to Society

Health, Environment, Agriculture, Rural development, Training network for Land Management

The HeartLand[57] project has been developed to train a new generation of creative, entrepreneurial and innovative PhD graduates. Investigating how to create economically and environmentally sustainable livestock products of enhanced nutritional value through pasture-based production systems.

HeartLand will explore and integrate the relationships between soil, sward, animal, farm management, environment and ultimately human health. The HeartLand project has recruited 5 PhD candidates to develop their projects in the domains of:

- soil biology
- grassland sciences and sward composition
- animal nutrition and performance
- farming systems and modelling
- environmental sciences.

Partners: This European Industrial Doctorate (EID) programme is being undertaken at the Devenish Lands at Dowth and will

57 Heartland (heartlandproject.eu)

connect Devenish to cutting-edge scientific knowledge from Wageningen University, University College Dublin and University of Gloucestershire while maximising the impact of the programme by working closely with Bord Bia and the European Food Information Council.

UK

SOIL Projects

Harper Adams, England and the Biocomposites Centre at Bangor University, Wales are working on soil sensor projects – looking at the soil biome. In particular, Bangor's research farm is testing early warning systems to measure nitrogen content in the soil and to give precision-based information to the farmer for proactive and optimum soil management. Improving nitrogen efficiency is a key focus for improving farm efficiency overall. The research also focuses on pesticide reduction and replacement of herbicides.

Robotics Project

Harper Adams is also working in the area of Poultry Robotics – RoboChick - in use for both Broilers and Egg Layers. The advantages seen here is that the robot moves the birds which improves their fitness. It can remove dead birds. By removing the dead birds from the houses, this reduces ammonia production and has the effect of also reducing the growing cycle by 1-2 days, which gives a marked improvement in production efficiency and better use of feed and facilities.

The project team is a consortium that includes the Royal Veterinary College, Harper Adams University, commercial farming business Applied Poultry and robotics manufacturer Ross Robotics. The project seeks to build a device that can monitor birds without any disturbances while ensuring movement, increased feed conversion (allowing smaller birds to get feed and water) thus presenting fewer rejected birds (18.7%)[58]

Dairy Innovation

The new £8m investment in a Dairy Innovation centre in Scotland has within its' scope to assist the dairy farming industry, from farm to processing on the use of technology to add more value and improve efficiencies including the carbon footprint.

SRUC will use their farms to demonstrate not only the 'easy wins' that can be immediately implemented but also some of the more challenging initiatives. The centre aims to develop, implement, and provide information for sustainable breeding and management systems for dairy cows. Critical to their focus is to improve the health and welfare of the UK dairy herds and measuring the environmental impact of different systems, and considering carbon footprint, biodiversity, and soil health in dairy production.

Detailed data recording of the animals allows for a diverse range of add-on monitoring projects – from lameness detection through to proxies for feed efficiency and methane emissions.

58 https://www.poultryworld.net/Home/General/2019/5/Robotics-revolution-happening-now-425378E/

Digital Dairy Project

A recent digital dairy project was awarded £50,000 in seed-corn funding by UK Research and Innovation under the Strength in Places Fund[59]. By using digital communications and advanced manufacturing, wholesalers, retailers, and consumers will have accurate product tracing. The project aims to establish South-West Scotland and Cumbria as the leading region for high-value sustainable dairy processing while creating jobs and boosting the local economy.

Global Research Alliance

The Global Research Alliance on Agricultural Greenhouse Gases brings countries together to find ways to grow more food without increasing greenhouse gas emissions, linking research efforts and expertise across sub sectors of paddy rice, cropping, livestock and integrative agricultural projects. Members work to promote synergies, knowledge sharing and capability among scientists and other practitioners. GRA also identifies Flagship Projects for collaboration that are specific, time-bound and approved by the GRA Council and led by GRA community experts. Their four integrative networks focus on:

- Farm and Regional Scale Integration
- Inventories and NDC
- Circular Food Systems
- Soil Carbon Sequestration

Both countries have involvement in this alliance, and it could be used as a common place to express aligned research priorities while also providing a more formalised framework from where to build projects.

59 https://www.ukri.org/our-work/our-main-funds/strength-in-places-fund/

ANNEX: Sustainable Agriculture Innovation Workshop Participants

26 october 2021, RDS, Dublin, Ireland

Organisation	Role
British Embassy Dublin	British Ambassador to Ireland
British Embassy Dublin	Counsellor
Department for Environment, Food and Rural Affairs (DEFRA), UK	Permanent Secretary
Department for Agriculture, Food and the Marine (DAFM), Ireland	Secretary General
Innovate UK	Innovation Lead, Agri-Tech Centres
BiOrbic, Bioeconomy SFI Research Centre, Ireland	Director
BiOrbic, Bioeconomy SFI Research Centre, Ireland	Executive Director
Department for Environment, Food and Rural Affairs (DEFRA), UK	Head of Soil and Contaminated Land
Department for Environment, Food and Rural Affairs (DEFRA), UK	Senior Policy Advisers
Department for Environment, Food and Rural Affairs (DEFRA), UK	EU MS Diplomacy & Relations Team

Organisation	Role
Department for Environment, Food and Rural Affairs (DEFRA) UK	Head of Innovation, Innovation, Productivity and Science
Harper Adams University, UK	Head of Engineering Department
Food, Farming & Countryside Commission, UK	CEO
Newcastle University, UK	Duke of Northumberland Professor of Rural Economy
University of Nottingham, UK	Professor of Dairy Science, Faculty of Science
University of Reading, UK	Professor of Animal and Dairy Science
Centre for Innovation Excellence in Livestock, UK	CEO
AgriMetrics, UK	Chief Scientific Officer
Agri EPI Centre, Roslin, Scotland	CEO

Organisation	Role
SRUC, UK	Ruminant Nutrition and Production Systems and Head of SRUC's Dairy
National Institute of Agricultural Botany, UK	Director of Commercialisation
Agri Food & Biosciences Institute, Northern Ireland, UK	Director of Sustainable Agri-Food Sciences Division
Department of Agriculture, Environment and Rural Affairs (DAERA) Northern Ireland, UK	Head of Environmental Policy
Department of Agriculture, Food and the Marine (DAFM), Ireland	Chief Agricultural Inspector, Research and Climate Division.
Department of Agriculture, Food and the Marine (DAFM), Ireland	Agricultural Inspector, Economics and Planning Unit
Department of Agriculture, Food and the Marine (DAFM) Ireland	Agricultural Inspector, Climate Change and Bioenergy Division
Teagasc, Agriculture and Food Development Authority, Ireland	Beef Enterprise Leader
Teagasc, Agriculture and Food Development Authority, Ireland	Head of the Environmental, Soils and Land Use Research Dept

Organisation	Role
Teagasc, Agriculture and Food Development Authority, Ireland	Head of Agri-Food Business and Spatial Analysis Research Dept
Teagasc, Agriculture and Food Development Authority, Ireland	Research Officer, Agricultural Emissions
Vistamilk, Teagasc	VistaMilk IP and Business Development Manager
University College Dublin	Professor for Bioeconomy and Business
University College Dublin	Associate Dean for Research Innovation and Impact
British Irish Chamber of Commerce	Director of Policy
Eur Digital Village	EU Funding Consultant
BiOrbic, Bioeconomy SFI Research Centre, Ireland	Industry Engagement Manager
BiOrbic, Bioeconomy SFI Research Centre, Ireland	Communications Manager
British Embassy Dublin	Science & Innovation Officer
British Embassy Dublin	Economic & Prosperity Second Secretary

ANNEX: Glossary

Bioeconomy
Bioeconomy can be defined as those parts of the economy that use renewable biological resources from land and sea – such as crops, forests, fish, animals and micro-organisms – to produce food, materials and energy.

Biorefinery
Biorefining takes biomass feedstock and generates additional high value by-products from agricultural waste or non-food plants which would otherwise contribute to CO2 emissions. These converted by-products create new revenue streams for farmers and reduces the CO2 emissions.

Carbon Neutrality
Having a balance between CO2 emissions and carbon absorbed from the atmosphere. Removing CO2 from the atmosphere and storing it is known as carbon sequestration. Increased carbon sequestration will be essential if we are to counterbalance the greenhouse gas emissions.

Circular Economy
Circular economy is easily defined as a system as make, use, and remake where the value of the products and systems are maximised and waste is minimised, reducing costs, generating new revenue streams and contributing to climate change initiatives.

Natural Capital
Natural Capital is the stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to provide benefits to people.

Precision Farming
The term precision farming refers to a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. New technologies enable farmers to manage their fields based on the spatial variability of variables such as the availability of nutrients and expected crop yield. To a much greater extent than before, plant protection is guided by the pressure to avoid damage and economic efficiency. The precision farming method involves measures of small-scale soil cultivation, sowing, fertilization, application of pesticides and other operations.

Precision farming serves economic and ecological improvements:

- Reduction of resources (seed, fertilizer, pesticides, fuel)
- Reduction of machine and work hours
- Improvement of crop yield and crop quality
- Minimization of environmental impact
- Complete documentation of the production process

Carbon Farming
Carbon Farming is a new way of farming to sequestrate carbon in the soil. Carbon that otherwise ends up as CO2 in our atmosphere, causing climate change. There are many ways to do this: from small adjustments on farm level - like applying fertilizers rich in carbon, reduced or no-tillage, or planting cover crops - to changes in the entire farming system - like enriched crop rotation or agroforestry.