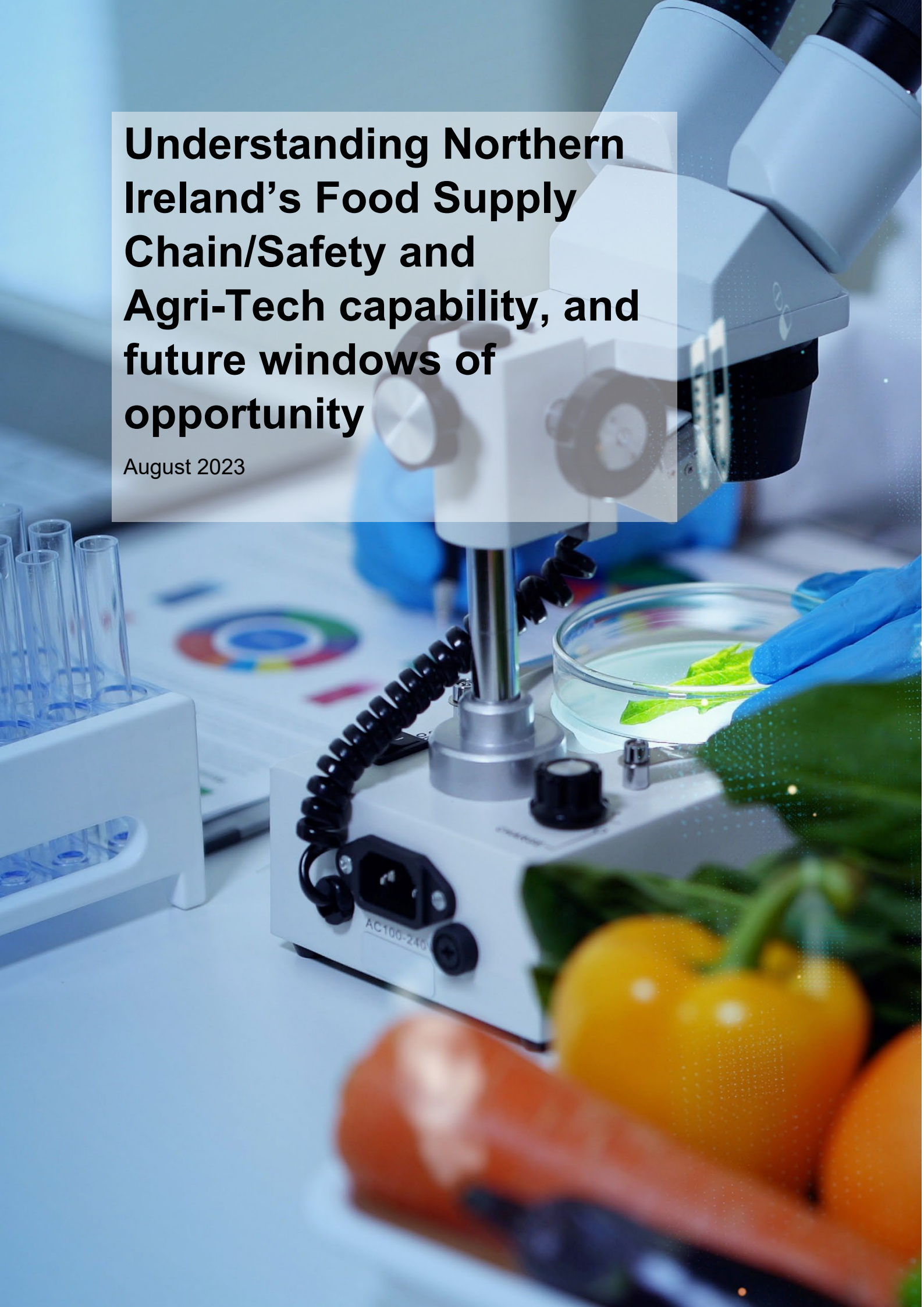

Understanding Northern Ireland's Food Supply Chain/Safety and Agri-Tech capability, and future windows of opportunity

August 2023

About this report

Commissioned by

Researched and produced by

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Glossary

ABiC - Agri Bio Innovation Centre	FSCS - Food Supply Chain/Safety
AFBI - The Agri-Food & Biosciences Institute	GII - Global Innovation Centre
AMIC - Advanced Manufacturing Innovation Centre	IGFS - The Institute for Global Food Safety
APHIS - Animal and Plant Health Inspection Service	IUNA - Irish Universities Nutrition Alliance
B2B - Business-to-Business	NI - Northern Ireland
B2C - Business-to-Consumer	NZ - New Zealand
CAFRE - College of Agriculture, Food and Rural Enterprise	PLC - Programmable logic controller
CCC - Climate Change Committee	QUB - Queen's University Belfast
CFDD - Centre for Food and Drug Discovery	RAPIC - Robotics, Automation and Packaging Innovation Centre
Cobot - Collaborative robot	RoI - Republic of Ireland
DAERA - Department of Agriculture, Environment and Rural Affairs	SCADA - Supervisory Control and Data Acquisition
DAFM - Department of Agriculture, Food and Marine (of Ireland)	S&M - Sales and marketing
DfE - Department for the Economy	UCD - University College of Dublin
DE - Department of Education	UU - Ulster University
ESG - Environmental, social, and governance	

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Executive Summary

The Department for the Economy's (DfE) 10X Economic vision outlines a transformative plan for the economy of Northern Ireland (NI). The publication sets out a long-term ambition for a more innovative, inclusive, and sustainable economy. The goal is for NI to be one of the top performing small advanced economies in the world.

The 10X Economic vision identifies several priority sectors where NI has the potential to be world class, the Agri-Tech sector is one of these priority sectors. NI has well-established primary agriculture and food and drink sectors, which play an important role in the economy. These sectors enable the production of high-quality food and drink products, much of which is exported to Great Britain, Ireland and beyond.

Food Supply Chain/Safety (FSCS) and Agri-Tech solutions offer an opportunity to support the growth, efficiency and environmental sustainability of the primary agriculture, food and drink sectors. In addition, growing NI's FSCS and Agri-Tech capabilities as a sector presents an opportunity to drive the region's economy forward.

Within this context, DfE commissioned KPMG to prepare this research report. The report aims to facilitate a broader understanding of Northern Ireland's FSCS and Agri-Tech capability, and future windows of opportunity. The objectives of this report are to:

- Identify the specific FSCS technologies, within NI's Agri-tech sector, where NI has current or future world class competitive advantage
- Identify NI's research strengths in terms of FSCS technologies and the level of alignment with areas where NI has world leading capability. Identify the levels of knowledge transfer/commercialisation and alignment of these strengths with the needs of NI's Agri-Tech sector
- Analyse and map NI's industrial and research strengths in FSCS technologies against national and international windows of opportunity, including horizon scanning and opportunities from NI's City and Growth Deals
- Evaluate and score the FSCS technology strengths against these opportunities to identify a prioritised set of ‘‘winning" innovative and cutting edge FSCS technologies
- Develop an economic profile of the NI Agri-Tech sector in terms of size (e.g., GVA, employment, average salary), scope (e.g., occupations, specialisms, and applications across the economy), and composition (e.g., business size, overseas owned vs. indigenous, regional spread)
- Analyse the enablers/policy levers required to capitalise on these opportunities, grow trade and exports and support adoption / diffusion of these innovative FSCS technologies across the NI Agri-Tech sector
- Identify the top five challenges to be addressed to enable NI's FSCS technologies and Agri-Tech sector to be world leading over the next 10 years
- Provide a list of key recommendations for government and businesses, framed over the short to medium and longer term, to maximise the windows of opportunity identified and propose metrics to measure success.

This report is structured into seven sections:

- Section 1 provides background to the project and defines Agri-Tech
- Section 2 provides an appraisal of the FSCS and Agri-Tech landscape, considering the sector definition, sector technologies, research strengths, application of technologies in NI and the funding landscape
- Section 3 provides an economic profile for the sector, based on the sector definition outlined in section 2. This includes a market sizing, outline of our methodology and assumptions, as well as findings and implications
- Section 4 provides international benchmarking, considering Australia, Ireland, Israel, the Netherlands, and New Zealand. This section highlights global trends and key lessons for NI
- Section 5 provides a SWOT analysis for the sector, including the underlying approach. Key challenges and opportunities are highlighted
- Section 6 outlines our methodology and assumptions for ranking Agri-Tech and FSCS technologies, the ranking results, and the associated implications for NI
- Section 7 presents the conclusions, recommendations, and proposes metrics for measuring the success of implementing the recommendations.

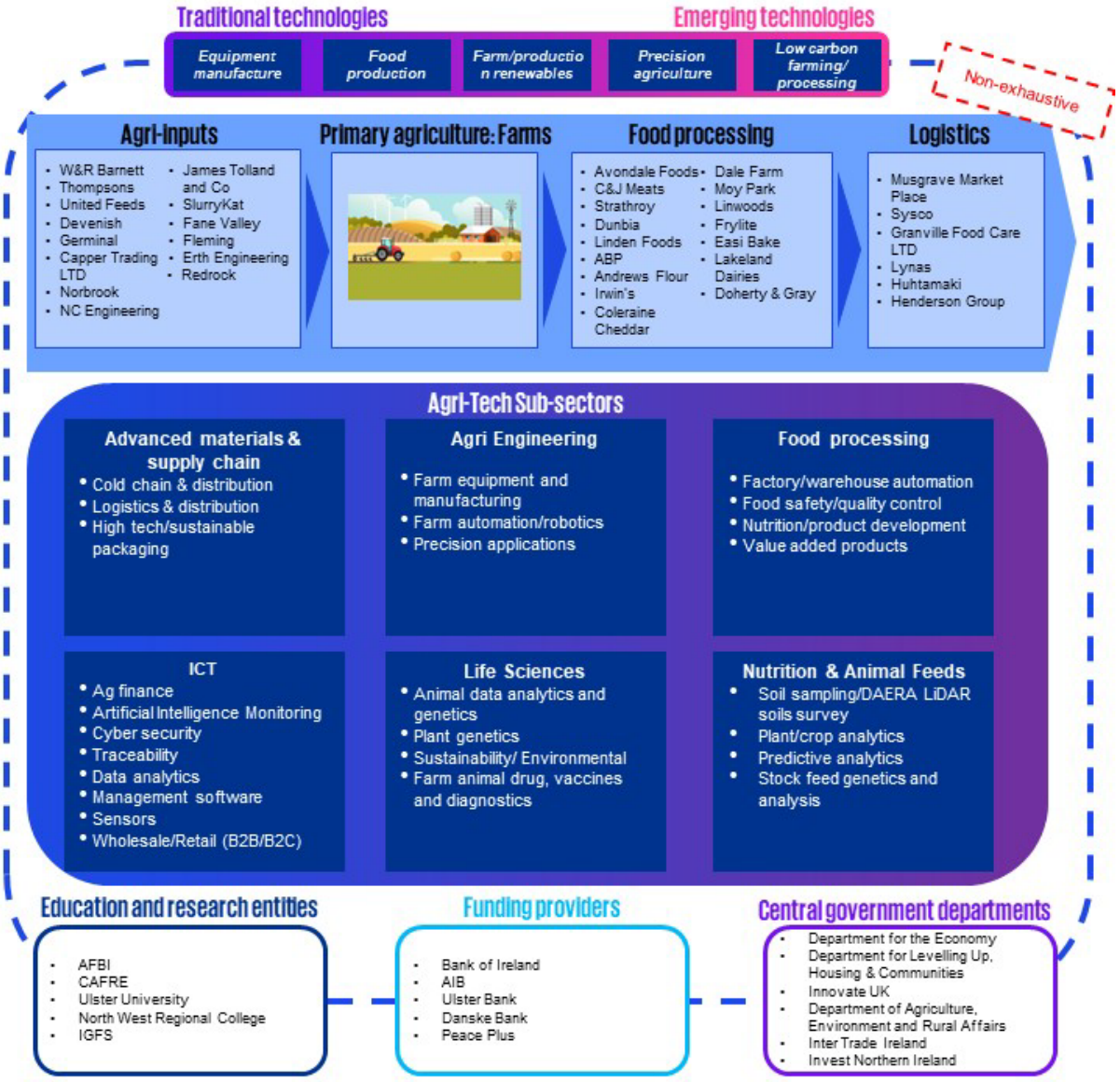
NI has had highly innovative and successful businesses producing goods and services for the Agri-Food supply chain for decades and, as the need for innovation across the supply chain has increased, the number of companies has increased to a small but growing sector in the NI economy with clear opportunities for innovative growth in the future. However, there is no single or standardised definition of Agri-Tech. Note that different countries use a number of variations for how each defines the sector.

Agri-Tech definition

For the purposes of this report, the “Agri-Tech sector” is defined as consisting of the businesses providing Agri-Tech related solutions (products and services) to a range of end users across six Agri-Tech sub-sectors. The Agri-Tech sub-sectors include advanced materials and supply chain, agri-engineering, food processing, information and communications technology (ICT), life sciences, and nutrition and animal feeds. Agri-Tech is considered with a wide lens to include technologies that range from traditional/current solutions to emerging/novel solutions. NI’s Agri-Tech sector is a component in a wider ecosystem (illustrated in Figure ES.1), that includes Agri-Tech businesses, end users of Agri-Tech solutions and organisations that support the sector.

A non-exhaustive illustrative summary of NI’s Agri-Tech ecosystem is provided below.

Figure ES - 1: NI's Agri-Tech ecosystem



Key aspects and categories of the ecosystem include:

- Technologies in the sector range from traditional/current solutions to emerging/novel solutions
- End users of Agri-Tech solutions are spread across the value chain, ranging from producers of agricultural inputs, primary agriculture (farms), food processors and logistics
- Agri-Tech solutions are categorised into specific sub-sectors, based on the type of solution in question. The sub-sectors were identified by considering the existing sector classifications used by Invest NI and through input from stakeholder consultations
- These sub-sectors include nutrition and animal feeds, information and communications technology (ICT), life sciences, agri-engineering, food processing, and advanced materials and supply chain. Sector technologies are described in more detail in section 2.4
- Organisations that support the sector fall into three categories: education and research entities, funding providers, and central government departments

The FSCS and Agri-Tech landscape

The Agri-Tech sector consists of the businesses providing Agri-Tech related solutions (products and services) to various end users including FSCS technologies, for example, technologies serving the farming, food and drink, processing, logistics, cold chain, retail, and safety components of the broader value chain. For the purposes of this study, the Agri-Tech sector is split into six sub-sectors:

- Advanced materials & supply chain technologies
- Agri-engineering
- Food processing technologies
- ICT
- Life Sciences
- Nutrition & animal feeds.

Specific technologies are considered as part of each sub-sector, and these have been ranked by the degree to which NI has current and/or future world class competitive advantage.

Ranking technologies

A Multi-Criteria Analysis (MCA) was used to rank technologies where NI has a competitive advantage The starting point for the MCA was to shortlist technologies and to identify the most impactful NI technologies to be considered for analysis. This was achieved through an industry survey and stakeholder consultations. The technologies, from highest to lowest rank, are:

Table ES - 1: MCA Results

Technology ranking	Technologies
1	Food safety / quality control
	Food nutrition / product development[1]
3	Animal data analytics & genetics
	Sustainability / Environment
5	Logistics & distribution
6	Data analytics
	Traceability
8	Crop / feedstock genetics and analytics
9	Farm equipment & manufacturing thereof
10	Cold chain management
11	Factory / warehouse automation

[1] Note: this refers to human food rather than animal

Research strengths and windows of opportunity
Northern Ireland's Agri-Tech research strengths primarily flow from the work of a number of key education and research entities, including Queen`s University Belfast, Ulster University, the Agri-Food & Biosciences Institute (AFBI), and the College of Agriculture, Food and Rural Enterprise (CAFRE). Each of these entities plays a valuable role in supporting the development of NI's Agri-Tech sector.

Considering the number of academic staff, position in world and UK university rankings, research citations, industry income and research, as well as the types of research conducted by research institutes, NI has research strengths in the following areas:

- Sustainability & environmental
- Genetics
- Traceability
- Food packaging
- Farm data
- Robotics
- Food integrity & security
- Nutrition
- New product development (primarily food products)
- Value added products (primarily food products)

Local and international windows of opportunity are considered for the shortlisted/top technologies and mapped against NI's research strengths. The local (NI) windows of opportunity include technology solutions that can increase yield, efficiency, profitability, sustainability, reliability, and quality or adding any other kind of value.

Global windows of opportunity include the provision of technologies that can increase efficiency in the growing agri-food sub-sectors of middle- and low-income countries, including India and China. Similarly, with an expected focus on increasing productivity and an increase in poultry meat production, Sub-Saharan Africa, and Near East and North Africa present an opportunity for solutions that increase productivity as well as technologies applicable to the poultry sector. On a policy level, with regional policies on sustainability set to become more stringent, North America and Western Europe show potential for technologies that support sustainability and animal welfare.

Economic profile
As outlined in the definition, Agri-Tech is considered with a wide lens to include technologies that range from traditional/current solutions to emerging/novel solutions. The sector plays a key role in improving productivity for both primary agriculture and the processing sector.

An economic profile of the sector is constructed, using a survey of 54 NI Agri-Tech businesses as the starting point. Using publicly available information, a list of 97 Agri-tech businesses was compiled and considered as an indication of the total number of active Agri-tech businesses.
To account for businesses not included on the list, a sensitivity of 10% was assumed, giving a total of 107 businesses. Accordingly, the total number of businesses currently active in the sector is assumed to range between 97 (lower estimate) and 107 (upper estimate). These are spread across areas including advanced materials and supply chain technologies, agri-engineering, food processing technologies, information and communication technologies (ICT), life sciences, nutrition and animal feeds. Based on the available data and our assumptions, the sector accounts for up to £813 million in annual revenue and up to 4,380 full time employees.

International learnings
Several jurisdictions are considered as international case studies of the Agri-Tech sector. These include Australia, Israel, New Zealand, Ireland, the Netherlands, and the United Kingdom (excluding NI).

Case studies of these jurisdictions are used to identify key lessons for NI, several of which are set out below:

- The Australian Government has allocated funding for specific programmes within the Agri-Tech sector, identifying opportunities which could support multiple farms. This highlights the importance of funding support. Australia has lots of start-ups, driving innovation across the sector. Supporting start-ups can grow the NI Agri-Tech ecosystem
- Israel has developed Agri-Tech to provide food stability in a challenging agricultural environment with unfavourable growing conditions. Lessons could be learned for a similarly challenging environment in NI. Israel has more than 500 Agri-Food Tech start-ups, which are supported by accelerators and incubators. Accelerators and incubators can support NI Agri-Tech start-ups, providing an environment for testing new products and developing ideas
- New Zealand is a world leading exporter of quality food with a history of innovation across the primary sector. The Government has published an Agri-Tech Sector Transformation Plan (2020) which provides a clear outline and plan for the sector. Development of a NI plan for the sector can set out a clear path to grow the sector
- The Irish Agri-Tech sector has a strong backing from the state, including funding, accelerator programmes and industry bodies. This organisational structure allows for collaboration, funding applications and a wider international reach. Funding, accelerator programmes and industry bodies can support the NI Agri-Tech sector
- The Netherland's agri-food sector is innovative at adopting new technologies at scale. The Netherlands hosts 15/20 of the largest global agri-food players' major research and development centres. Promoting technology adoption can help to grow the NI Agri-Tech sector
- The UK Government encourages innovation in the Agri-Tech sector through funding, developing centres of excellence and supporting research. A clear action plan sets out a pathway for the UK to become a world-leader in Agri-Tech. NI could develop a similar approach through using centres of excellence and targeted funding for innovation
- Several of the international technology examples are based on technologies that are easily adopted and can be linked to a farmer's / processer's phone. This means the technologies are easier to implement without equipment or need for significant capital investment. This can include the use of generative AI and the likes of ChatGPT to use publicly available data on weather, soil monitoring, application rates, and current events to provide insight to farmers/producers

Seven global Agri-Tech trends were identified, each of which has relevance in a NI context and is applicable to the NI Agri-Tech sector:

1 **Efficiency:** There is a focus on increasing efficiency to make inputs go further, creating a market opportunity for technologies that can automate processes, eliminate waste and save time. For example, automation technologies (e.g., PLCs, SCADA systems, temperature control) and human replacement technology (e.g., optical scanners rejecting unsuitable food)
2 **Environmental sustainability:** There is increased awareness of, and policy focus on, reducing the agri-food sector's environmental footprint. This creates a market opportunity for technologies that can reduce emissions, such as anaerobic digestion technology and methanogenesis inhibiting ruminant feed additives
3 **New product development/value added products:** There is an increasing focus on developing novel/value added products and developing waste streams for both the primary agriculture and the food processing industry, linked to trend one and two above. Examples include the use of technologies to create nitrate free bacon
4 **Novel meat products:** Evolving consumer preferences[2] are providing a space for the sector to create alternative protein sources such as plant-based meat and lab-grown meat products. This is linked to the broader sustainability focus, mentioned in trend 1
5 **Data systems:** The collection, processing, use and ownership/custodianship of data is a challenge for the wider adoption of smart data/data analytics and the interoperability of technology solutions. This is also a constraint in the NI context
6 **Skills and training:** A lack of relevant skills and technical training is generally a constraint in the sector. In particular, a lack of candidates with Science, Technology, Engineering and Maths (STEM) qualifications. In NI, more students need to be attracted to study STEM subjects across all levels, and current employees need to be upskilled. Career initiatives could help to attract STEM candidates into food and drink processing, and Agri-Tech businesses. Developing and attracting a pipeline of STEM talent is needed to address this challenge
7 **Funding and capital investment:** In terms of technology adoption, access to capital funding for investment is a constraint for the food processing sector. During consultations, stakeholders have strongly indicated that expanded capital grants, especially for large businesses, could help to support the adoption of Agri-Tech within NI.

[2] Note that consumer preferences are not static and continue to evolve. In addition to price, purchasing decisions are driven by factors such as culture, taste, health, and environmental concerns, including concerns over animal welfare and meat consumption. Alternative dairy products have gained more appeal with mainstream consumers, while alternative meat products (especially lab-grown meat) still have some way to go to garner a similar appeal with mainstream consumers.

Challenges and opportunities

Through stakeholder consultations and an industry survey, a number of key challenges and opportunities for the NI Agri-Tech sector have been identified:

- The top five challenges include high competition with international products; labour, skills and training; inflation/increase in cost of doing business; improving productivity/adoption of smart data and a lack of environmental and sustainability data/metrics
- Key opportunities include collaboration between agri-food, health, life sciences, and advance engineering sectors; establishing data systems for the agri-food sector; encouraging new value-added product development and the development waste streams; exploring export opportunities for food safety/quality control technologies[3]; and technologies contributing to lower carbon emissions and climate change mitigation.

Recommendations

Considering the key challenges facing the sector, **the top five recommendations** include the following:

1 Promote technology adoption
2 Expand and better signpost the support available
3 Address skills shortages
4 Develop an Agri-Tech sectoral plan
5 Support the development of environmental and sustainability metrics

The overall recommendations, including the top five, are grouped into three themes and are summarised in the tables below.

[3] The Institute for Global Food Safety (IGFS) at Queen's University Belfast has a research strength in food safety and can collaborate with NI Agri-Tech businesses to explore export opportunities.

Table ES - 2: Summary of recommendations: Theme 1

Recommendation	Actions	Lead	Partners	Timescale
Theme 1: Technology, research strengths and windows of opportunity				
Technology adoption Note: consider the technologies that the local farming and processing sectors need to adopt, even if there is a need to buy in from outside NI	• Increase the adoption of Agri-Tech solutions within NI's primary agriculture and processing sectors • DAERA to consider inviting local Agri-Tech businesses to their knowledge transfer events, where possible • Increase technology adoption for food and drink processors by introducing a capital scheme to promote the 10x triple bottom line of Innovation, Environmental Sustainability, Inclusion plus improving productivity and the adoption of digitalisation/data analytics	• DAERA lead, DfE, Invest NI, primary production, and processing sectors • Invest NI to lead with input from DfE	• Industry bodies, Agri-Tech businesses, Sustainability Body[4]	• Short to medium-term
Grow the NI Agri-Tech sector's global footprint	• Grow the NI Agri-Tech sector's global footprint by focusing on the international windows of opportunity for these technologies	• Lead by Invest NI, industry bodies, and Agri-Tech businesses	• DAERA, DfE, industry bodies, Sustainability Body	• Medium to long-term
Expand and better signpost the support available Note: This would generate benefits for Agri-Tech businesses and end users	• Government entities should expand and better signpost the support available for primary producers and food and drink processors. This would generate benefits to both AT businesses and the primary producer and processor end users	• For primary producers: DAERA lead • For food and drink processors: Invest NI lead with input from DAERA	• Industry bodies, Agri-Tech businesses	• Short to medium-term

[4] Sustainability Body has a role to play in supporting the adoption of technologies that improve sustainability and to collaborate in the adoption/promotion of industry data and data interoperability.

Table ES - 2: Summary of recommendations: Theme 1 (continued)

Recommendation	Actions	Lead	Partners	Timescale
Theme 1: Technology, research strengths and windows of opportunity				
Support the commercialisation of research: Note: to create further alignment between research and industry needs, increasing commercialisation of research	• Review the R&D process between universities and companies, and facilitate industry engagement • Establish innovation hubs, incubators, and accelerator programs to enable start-ups and established businesses to get involved in the R&D process. Use the proposed Mid South West Growth Deal Agri-Tech centre as a starting point	• Overall research and commercialisation: NI Diamond, universities and industry • Incubators and accelerator programs: Lead by Invest NI, industry bodies and proposed Agri-Tech centre	• Industry bodies, AFBI, DfE, DAERA and Invest NI	• Medium to long-term

Table ES - 3: Summary of recommendations: Theme 2

Recommendation	Actions	Lead	Partners	Timescale
Theme 2: International learnings				
Develop an Agri-Tech sectoral plan	• Develop an Agri-Tech sectoral plan to set out a clear path to promote the growth of Agri-Tech businesses in NI	• DfE lead, with input from Invest NI, industry bodies, DAERA, AFBI	• Invest NI, industry bodies, DAERA, AFBI	• Medium-term
Foster Agri-Tech sector collaboration	• Develop key Agri-Tech initiatives that can foster collaboration within the NI Agri-Tech ecosystem and promote technology adoption • Foster international collaboration with industry bodies in other jurisdictions to facilitate knowledge sharing	• Within NI: Universities, industry associations/bodies and Agri-Tech businesses • International: Industry associations/bodies with support from Invest NI	• Invest NI, DAERA, DfE	• Medium to long-term

Table ES - 4: Summary of recommendations: Theme 3

Recommendation	Actions	Lead	Partners	Timescale
Theme 3: Challenges and opportunities				
Address skills shortages	• Increase the level of skills in the sector through graduate, postgraduate, further education, and apprenticeship courses. Additionally, increase skills of existing employees through training and upskilling initiatives • Focus on STEM areas (science, technology, engineering, and mathematics). Schools can help in increasing the promotion and attractiveness of STEM subjects. This can follow through to support a greater uptake of STEM subjects when students go on to Further or Higher Education • Provide promotional activities to attract students on courses and promote careers in the sector • This could also include initiatives such as bursaries, marketing events, international student exchange programs and student internship programmes)	• DAERA, UU, QUB, FE Colleges, DfE Careers Service and Industry	• Department of Education (DE), Industry bodies, Agri-Tech businesses	• Medium-term
Increase productivity and the adoption of smart data practices	• Government to continue to promote the use of smart data to improve productivity and efficiency • Expand capital grants, especially for large businesses, to support the adoption of Agri-Tech products and services • Promote interoperability of data across the supply chain	• For primary producers: DAERA • For food and drink processors: Invest NI • For interoperability of data: DAERA lead with input by the Sustainability Body and Industry	• DfE, industry bodies, Agri-Tech businesses, Sustainability Body DAERA and universities	• Medium to long-term
Support the development of environmental and sustainability metrics	• Adopt a coordinated approach to develop and establish environmental and sustainability metrics across the agri-food value chain	• NI Diamond[5], DAERA, DfE, AFBI, Sustainability Body	• Industry bodies, Agri-Tech businesses, universities, retailers	• Medium to long-term

[5] The proposed NI Diamond will identify research gaps and prioritise research needs for the wider Agri-Food sector with representation from Industry, Academia, civic society, and Government.

Table ES - 4: Summary of recommendations: Theme 3 (continued)

Recommendation	Actions	Lead	Partners	Timescale
Theme 3. Challenges and opportunities (continued)				
Foster collaboration with other sectors	• Foster collaboration between Agri-Tech businesses and University research departments in other disciplines to assist with innovation or new product development	• Industry bodies and universities	• DfE, Invest NI	• Medium to long-term
Establish data systems for the agri-food sector	• Establish data systems for the agri-food sector: for the collection, processing, storing and interoperability of data	• DAERA, DfE, Invest NI, Sustainability Body	• Industry bodies, retailers	• Medium to long-term
Support the development of technologies that can contribute to climate change mitigation	• Develop and support technologies contributing to lower carbon emissions and climate change mitigation • Align these efforts with the Green Growth Strategy, NI Energy Strategy and the draft Circular Economy Strategy	• Universities, DAERA, DfE, Invest NI, NI Diamond	• AFBI, DAERA, Sustainability Body	• Medium to long-term

There is no single solution that can ensure the successful development of the NI Agri-Tech sector. Success requires that a range of actions, focusing on policy change and collaboration between government, businesses, and industry bodies, be implemented.

Metrics to measure the success of actions, that should ultimately support the growth and development of the sector, could include the following:

- Increase in the number of Agri-Tech start-ups
- Increase in employment or sectoral employment in the Agri-Tech sector
- Increase in Agri-Tech sector revenue
- Export intensity
- The number of networking events and collaboration projects between government departments and industry bodies

Note that because each country defines their Agri-Tech sector differently, there is limited comparable Agri-Tech data available. This is likely to improve as the sector becomes better defined over time, and more research and analysis is undertaken within other countries.

1 Introduction

This section provides an overall background on the rationale and objectives for this research study. This section considers the local and international policy context, defines Agri-Tech for the purposes of this report, provides an overview of local and international literature, and sets out the structure of this report.

1.1 Project background

The Department for the Economy's (DfE) 10X Economic vision outlines a transformative plan for the economy of Northern Ireland (NI). The publication sets out a long-term ambition for a more innovative, inclusive, and sustainable economy. The goal is for NI to be one of the top performing small advanced economies in the world, with benefits for all the people of NI, to be realised by:

- Focusing on innovation in areas where NI has strengths
- Ensuring economic growth is innovation led, inclusive and sustainable
- Focusing on the core technologies and clusters where NI can be a global leader within the next decade.

The 10X Economic vision set out a list of 8 technologies where NI is already, or can be, globally competitive: Food Supply Chain/Safety (FSCS); Digital Transactions/ID authentication; Zero carbontech, transport, energy and agrifood; advanced composites; robotics; software engineering and artificial intelligence; cybersecurity; virtual production. In addition, the 10X Economic vision identifies a number of priority sectors where NI has the potential to be world class: Agri-Tech; Life and Health Sciences; Advanced Manufacturing and Engineering; Fintech / Financial Services; Software (including cyber); Screen Industries; Low Carbon.

NI has well-established primary agriculture and food and drink sectors, which play an important role in the economy. These sectors enable the production of high-quality food and drink products, much of which is exported to GB, Ireland and beyond.

Within this context, FSCS and Agri-Tech solutions offer an opportunity to support the growth, efficiency and environmental sustainability of the primary agriculture and food and drink sectors. In addition, growing NI's FSCS and Agri-Tech capabilities as a sector presents an opportunity to drive the region's economy forward. The objectives of this report are to:

- Identify the specific FSCS technologies within NI's Agri-tech sector where NI has current or future world class competitive advantage
- Identify NI's research strengths in terms of FSCS technologies and the level of alignment with areas where NI has world leading capability. Identify the levels of knowledge transfer / commercialisation and alignment of these strengths with the needs of NI's Agri-Tech sector
- Analyse and map NI's industrial and research strengths in FSCS technologies against national and international windows of opportunity, including horizon scanning and opportunities from NI's City and Growth Deals
- Evaluate and score the FSCS technology strengths against these opportunities to identify a prioritised set of ‘‘winning" innovative and cutting edge FSCS technologies
- Develop an economic profile of the NI Agri-Tech sector in terms of size (e.g., GVA, employment, average salary), scope (e.g., occupations, specialisms and applications across the economy), and composition (e.g., business size, overseas owned vs. indigenous, regional spread)
- Analyse the enablers/policy levers required to capitalise on these opportunities, grow trade and exports and support adoption / diffusion of these innovative FSCS technologies across the NI Agri-Tech sector

- Identify the top five challenges to be addressed to enable NI's FSCS technologies and Agri-Tech sector to be world leading over the next 10 years
- Provide a list of key recommendations for government and businesses, framed over the short to medium and longer term, in order to maximise the windows of opportunity identified and propose metrics to measure success.

1.2 Policy context

DfE recently published the *10X Vision – Next Steps for Implementation*. This document reports on findings from consultation on the 10X Economic vision, published in 2021, and updates priorities for delivering on this vision. Reflecting the responses received through consultation, the Department will prioritise three key issues:

- Triple Bottom Line – delivering the 10X Economic vision will require a clear focus on three core priorities: innovation, inclusion, and sustainability
- Focus – in order to achieve the 10X Economic vision and transform the economy, resources will be focused on maximising NI's areas of competitive advantage and using the resources within NI to the best effect possible to deliver on the triple bottom line
- Scale – transformation of our economy will require NI to be ambitious and deliver on a scale which it has never achieved before.

The 10X Economic vision is a mind-set which is focused and ambitious. Its objective is to have a decade of transformative development to improve the current state of the economy and make it as competitive as possible, focusing on areas where there are already strengths in NI. The aim is to see a tenfold increase in innovation while also achieving a fairer distribution of opportunities for people to participate in and benefit from economic growth. Seeing a positive impact on NI's economic, societal and environmental wellbeing is central to the plan.

10X identified technologies within FSCS in which NI potentially has a world class competitive advantage, while also identifying Agri-Tech as one of the priority clusters/sectors which could be both an early adopter and beneficiary.

Seven priority sectors were identified in the 10X Economic vision as key areas of growth:

1 Agri-Tech (incl. food-tech)
2 Life and Health Sciences
3 Advanced Manufacturing and Engineering
4 Fintech/Financial Services
5 Software (incl. cyber)
6 Screen Industries
7 Low Carbon.

The 10X Economic vision defines Agri-Tech and FSCS technologies as:
"*The application of innovation and enabling technologies to build competitive advantage and transition to net zero across the primary and secondary processing sectors, including genomics, traceability of food, advanced packaging, plant and animal health specialisms, and the application of AI to new agricultural methods*".

DfE's specific focus relates to the Agri-Food processing sector, with policy responsibility for farm producers under the remit of the Department for Agriculture, Environment and Rural Affairs (DAERA). As well as those companies processing food and drink, this research study also considers Agri-Tech businesses that are developing new and innovative software / technical / machinery solutions.

The 10X Economic vision definition of Agri-Tech is used as a starting point and expanded upon to set the context and parameters for this report.

1.3 Defining Agri-Tech

NI has had highly innovative and successful businesses producing goods and services for the Agri-Food supply chain for decades and, as the need for innovation across the supply chain has increased, the number of companies has increased to a small but growing sector in the NI economy with clear opportunities for innovative growth in the future. However, there is no single or standardised definition of Agri-Tech[6], with different countries using a number of variations for how each defines the sector. Section 4 provides case studies of Agri-Tech in the following jurisdictions: Australia, Israel, New Zealand, Ireland, the Netherlands, and the United Kingdom (excluding NI). Table 1-1 illustrates selected examples of how these countries define Agri-Tech.

Table 1-1: International definitions of Agri-Tech

Countries	Agri-Tech Definitions
Australia[7]	**Definition:** "Agritech is a standalone sector which applies technology to the Agri-Food supply chain, and contemporaneously crosses over into energy, water, sustainability, environment, climate, industry and emissions reduction."
New Zealand[8]	**Definition:** "The agritech sector refers to manufacturing, biotech and digital-based technology companies that are creating product, service, IP and value chain solutions for the agriculture, horticulture, aquaculture, apiculture, and fishing sectors, with the aim of improving yield, efficiency, profitability, sustainability, reliability, quality or adding any other kind of value. Forestry and wood processing is excluded."

[6] Nor a standard naming convention, for example Agri-Tech and agritech.
[7] Australia Agritech: What is Agritech? – Ausagritech (Australian Agritech Association)
[8] Growing innovative industries in New Zealand: Agritech industry transformation plan, (Ministry of Business, Innovation and Employment).

Table 1-1 (Continued)

Countries	Agri-Tech Definitions
UK[9]	**Definition:** The "agritech" sector is defined as the technology solutions that cover the following key areas: • **Plant sub-sectors**: including plant genetic improvement, plant health: plant production, plant protection, crop storage and silage (including post-harvest storage and on-farm waste and biomass for non-food uses) • **Animal sub-sectors**: Including animal genetic improvement, animal nutrition, animal health and welfare • **Information and communications technology (ICT) systems and decision support:** to support production planning, scheduling; input use efficiency (e.g., irrigation scheduling) • **Environmental and physical sub-sectors:** including Soil/ substrate management, environmental interactions, harvest, and early-stage processing (harvest technologies, post-harvest cleaning, postharvest storage), and on-farm waste (AD and other waste treatment plants) and biomass for non-food uses. • **Engineering and precision farming:** including machinery (cultivation, crop and grass health (drilling, spraying, fertiliser application), tractors, harvesters, pickers, post-harvest transport and cleaning), robotics and autonomous devices, sensor technology (handheld, fixed and remote including animal welfare and monitoring) • **Infrastructure**: Accounts for buildings (including glasshouses, livestock production buildings), heating and cooling systems, storage of crop and animal products in ambient, controlled atmosphere, cold stores and freezing plants, irrigation/ water management storage and distribution systems, dirty water systems, lighting (intensive livestock and glasshouse crops); 'vertical' and enclosed farming systems

Other case study jurisdictions (Ireland, Israel and the Netherlands) do not have specific definitions, but they highlight certain aspects of Agri-Tech:

- **Ireland**[10]**:** while there is no *formal* definition of Agri-Tech in Government, the country's leading trade association defines it as the field that spans stakeholders including farmers, industry, government, research, finance, environmental groups, farming groups and skills training, and involves innovation and the dissemination of technology onto farms
- **Israel**[11]: Israel uses the term ag-tech is relation to innovative growing technologies that aim to maximise fresh food yields using resources in smarter, greener ways, as well as sophisticated equipment and IT systems that help to accelerate learning in order to optimise farm, post-harvest, food processing, storage and retail operations
- **Netherlands**[12]: In the Netherlands, areas of focus for Agri-Tech include services and technologies that improve agricultural efficiency, sustainability, and energy efficiency, amongst others. Example technologies include advanced farm management software, vertical farming tools, direct-to-consumer delivery apps and services including lab-grown and plant-based meat

[9] Agri-Tech Industrial Strategy: Evaluation Scoping Study and Baseline, (Department for Business Innovation & Skills).
[10] AgTech Ireland
[11] Israel Agricultural Technology & innovations Hub
[12] Best locations: Is the Netherlands a good place for agritech?

Taking account of these definitions, some commonalities suggests that the Agri-Tech sector:

- Applies technology to the Agri-Food supply chain
- Refers to manufacturing, biotech and digital-based technology companies
- Excludes forestry and wood processing
- Provides solutions across sub-sector areas, such as to plant, animal, ICT, environmental, engineering and infrastructure sub-sectors.

Globally, businesses operating in this sector are focused on:

- Creating products, developing IP & value chain solutions, and providing services, for the agriculture, horticulture, aquaculture, apiculture, and fishing sectors
- Improving yield, efficiency, profitability, sustainability, reliability, quality or adding any other kind of value.

Agri-Tech definition:
For the purposes of this report, the "Agri-Tech sector" is defined as consisting of the businesses providing Agri-Tech related solutions (products and services) to a range of end users across six Agri-Tech sub-sectors. The Agri-Tech sub-sectors include advanced materials and supply chain, agri-engineering, food processing, information and communications technology (ICT), life sciences, and nutrition and animal feeds. Agri-Tech is considered with a wide lens to include technologies that range from traditional/current solutions to emerging/novel solutions. NI's Agri-Tech sector is a component in a wider ecosystem (illustrated in Figure 1.1), that includes Agri-Tech businesses, end users of Agri-Tech solutions and organisations that support the sector.

This definition should be considered within the following context:

- The **"Agri-Tech sector"** consists of both **Agri-Tech** and **"partial Agri-Tech"** businesses. The focus here is on Agri-tech businesses that are already in the market/trading
- These businesses can be purely focused on Agri-Tech as their core business or may be primarily involved in other areas within the agrifood/food and drink value chain, with only a minority of its revenue derived from Agri-Tech related revenues, hereafter referred to as "partial Agri-Tech" businesses
- Partial Agri-Tech business may also produce innovative technology solutions for other sectors, such as construction, materials handling, and manufacturing. This portion of their business is not considered as part of the Agri-Tech sector, only the Agri-Tech related portion of the business is considered to be a part of the Agri-Tech sector
- **Agri-Tech solutions** (products and services) can include FSCS technologies, for example, technologies serving the farming, food and drink, processing, logistics, cold chain, retail, and safety components of the broader value chain. Hereafter, we simply refer to it as Agri-Tech or Agri-Tech solutions
- The food and drink processing sector is a core component in the Agri-Tech ecosystem. Food and drink processors can adopt Agri-Tech solutions to enhance efficiency, profitability, and sustainability, ultimately, supporting economic growth and increasing productivity within NI
- Overall, Agri-Tech solutions are focused on improving yield, efficiency, profitability, sustainability, reliability, quality or adding any other kind of value
- Technology solutions are categorised into specific sub-sectors, based on the type of solution in question. For example, animal health, ICT or Agri-engineering

This definition corresponds to international examples, by focusing on:

- The application of technology to the Agri-Food supply chain, including the food and drink processing sector

- The businesses providing Agri-Tech related solutions (products and services) to various end users
- Technology solutions that aim to improve yield, efficiency, profitability, sustainability, reliability, quality or adding any other kind of value
- Technology solutions that cover various sub-sectors.

An overview of NI's Agri-Tech ecosystem, examples of specific technology solutions and sub-sectors is provided in Figure 1-1: NI's Agri-Tech ecosystem below.

Figure 1-1: NI's Agri-Tech ecosystem

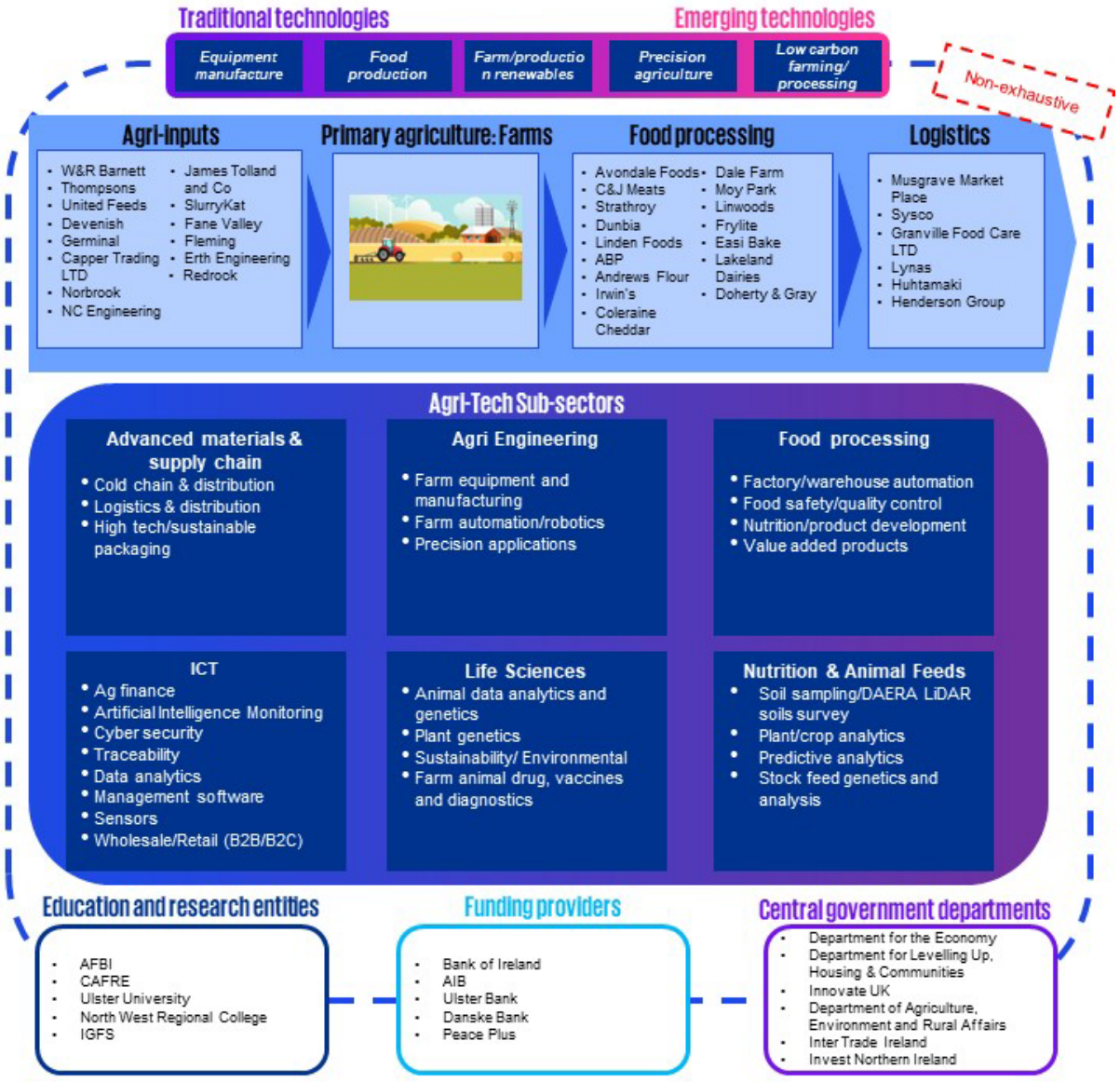


Figure 1-1 provides a non-exhaustive illustrative summary of NI's Agri-Tech ecosystem. Key aspects of the ecosystem include:

- Technologies in the sector range from traditional/current solutions to emerging/novel solutions
- End users of Agri-Tech solutions are spread across the value chain, ranging from producers of agricultural inputs, primary agriculture (farms), food processors and logistics

- Agri-Tech solutions are categorised into specific sub-sectors, based on the type of solution in question. The sub-sectors were identified by considering the existing sector classifications used by Invest NI and through input from stakeholder consultations
- These sub-sectors include nutrition and animal feeds, information and communications technology (ICT), life sciences, agri-engineering, food processing, and advanced materials and supply chain. Sector technologies are described in more detail in section 2-2
- Organisations that support the sector fall into three categories: education and research entities, funding providers, and central government departments

Education and research
Whilst playing an important role in the wider ecosystem, universities, training and research centres that provide training and R&D to the Agri-Tech sector are regarded as distinct from the "Agri-Tech sector". However, research leading to the commercialisation of a technology and a subsequent spin out / creation of an Agri-Tech business would qualify as Agri-Tech and this would be considered when it enters into the market or starts operating. See later analysis in section 2.5 Research strengths.

Government
Government departments/organisations play a key role in the creation of a supportive commercial operating environment through policy and government supports. End users of Agri-Tech products and services include farmers (primary agriculture) and food and drink processors (processing sector). Primary agriculture falls under DAERA's policy remit, while food and drink processors, and Agri-Tech/partial Agri-Tech businesses fall under DfE's and Invest NI's remit.

As Agri-Tech relates to the broader Agri-Food sector, DfE and DAERA both have a role and involvement with the teaching and research institutions (universities, FE colleges, training and research centres). DAERA's College of Agriculture, Food and Rural Enterprise (CAFRE) delivers specialist higher and further education, apprenticeships, training and knowledge transfer activities for the farming and food and drink processing sectors. Likewise, DAERA's scientific arm's length body, the Agri-Food and Biosciences Institute (AFBI), supports the Agri-Food sector through its research, diagnostic, compliance testing and advisory services across agriculture, animal health, food safety, environment, and biosciences.

Given the scale of NI's agri-food sector, there is a clear degree of policy overlap relating to the Agri-Tech sector, the end-users of Agri-Tech solutions, and players in the ecosystem.

1.4 Local context

A review of the existing NI-focused literature and research provides context to the local landscape and highlights gaps and learnings that are applicable to the Agri-Tech sector. Collaboration, innovation, sustainability, and the use of smart data have already been identified as key areas, and now need policy action. This literature is summarised in Table 1-2 below.

Table 1-2: Northern Ireland literature review

Report	Key recommendations	Gaps and learnings
 **Independent Strategic Review of the Northern Ireland Agri-food Sector** (2021) **Author:** Sir Peter Kendall, (ISRAF), commissioned by DfE and DAERA	Recommendations made across 11 themes: 1. Embrace the smart use of data and the opportunities it creates 2. Create a NI Diamond to deliver green growth with ministers outlining a vision and encouraging a collaborative model 3. Demonstrate sustainability through a new Sustainability Body 4. Be ambitious on net zero 5. Aim high on environmental scorecard 6. Boost investment by large food businesses 7. Focus on trading arrangements beyond GB 8. Tackle skills and labour supply issues 9. Innovate 10. Design an agricultural policy that drives change 11. Entice talent and entrepreneurship	• Each theme outlines recommendations and actions to make strategic advances in the sector a reality • Themes 1, 2, 3, 4, 6, 8, 9 and 10 are of particular relevance to this report recommending that DAERA, DfE and the NI Diamond should work with the Agri-Food and Agri-Tech sectors to identify innovation opportunities and provide support schemes for the sector to avail of • DAERA to design a 'made for Northern Ireland' agricultural policy with a greater focus on measuring and reporting and have a skills development element
 **AMIC Tech Roadmap** (2022) **Author:** IfM Engage	A 10-year strategic technology roadmap for the Advanced Manufacturing Innovation Centre (AMIC). Recommendations include: • AMIC to consider acting as a capability enhancement facilitator with an integrated approach and a role in promoting strengths and competitive position • Accelerate the delivery phase of AMIC and confirm capability requirements (map capabilities & horizon scanning for tech trends) • AMIC to consider Implement early projects (digital manufacturing workshop, scope requirements for increased 'digital twin' capability)	• 6 themes were identified as priorities from AMIC with manufacturing decarbonisation (a global issue) and food and drink processing (gap in innovation capability) identified as the two themes presenting a greater scale of challenge needing significant investment

Table 1-2: (Continued)

Report	Key recommendations	Gaps and learnings
 **Draft Green Growth Strategy** (2021) **Author:** Northern Ireland Executive	The Green Growth Strategy outlines that radical change is required to achieve Green Growth ambitions. Innovation is required across many sectors including how food is sourced to improve carbon efficiency with an opportunity for Northern Ireland to lead the way. It outlines 10 commitments including 'Investing in Green Growth' by proactively maximising funding and investment opportunities to promote innovation, skills, research and technology.	• Executive Ministers will lead the way and make changes to how budgets are spent, recognising the significant long-term investment required • The commitments most relevant to this report are 'Embedding Green Growth' and 'Investing in Green' through investment in innovation, technologies and skills
 **Collaborating on Climate** (2022) **Author:** BiOrbic, Bioeconomy SFI Research Centre, commissioned by British Embassy Dublin	Not only production but processing facilities must also change to ensure that food production systems are resilient to climate change. Aimed at farmers, Governments must empower farmers with the tools to prosper with knowledge transfer across the UK & Ireland critical. 1 Place farmers at the centre of agricultural innovation 2 Identify shared outcomes and objectives 3 Improve alignment of research and strengthen collaborations 4 Provide opportunities to share research and innovation infrastructure	The report also identified potential areas for future work, including: • Identify innovative processing technologies through contact between the UK and Ireland • Explore new business models for farms (drawing on R&I and achieving targets)
 **Agriculture Strategy** (2022) **Author:** Birnie Consultancy for Armagh City, Banbridge and Craigavon Borough (ABC) Council	The strategy outlines 10 practical and achievable recommendations where the council can make a positive impact, including: • Develop a plan to facilitate skills development in agriculture and agri-business • Facilitate structural upgrading • Further studies in sectors related to agriculture industry • Agri-food development	• The recommendations are focused on areas the council can help, not specifically agricultural businesses • The broad implementation plan divides the delivery of recommendations into immediate, short-term and medium-term actions

1.5 International context

A review of the international literature provides context to the international landscape. International examples point to a need for a focus on ecosystem development, research institutes, supply chain complexities and circular economy ambitions. This literature is summarised in Table 1-3 below.

Table 1.3: International literature review

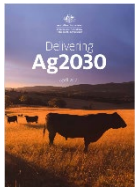
Report	Key recommendations	Gaps and learnings
 **Agri-Tech Industry Transformation Plan** (2020) **Author:** Ministry of Business, Innovation & Employment, New Zealand Government	Actions to accelerate the Agri-Tech sector's growth include: • High impact projects which have the opportunity to have significant impact in a short period of time such as development of a Horticultural Robotics Institute, creation of a specialist Agri-Tech venture capital fund • Ecosystem development which contains actions to grow the Agri-Tech industry across six workstreams including prototyping technology, international research collaboration and maximize global funding links	• The document contains detailed lists of actions required to make the Agri-Tech sector more productive, sustainable and inclusive and outlines actions that are currently in progress
 **Delivering Ag2030** (2022) **Author:** Department of Agriculture, Water and the Environment, Australian Government	• The government will be committing $600m budget to agriculture in 2022-23 across 7 themes: Trade and exports, Biosecurity, Stewardship, Supply chains, Water and infrastructure, Innovation and Research, and Human capital. In supply chains, they will continue to progress the Modern Manufacturing Strategy including building scale in onshore processing and packaging capability and encourage the adoption of smart technologies	• Supply chains and trade relationships are increasingly more complex, and the sectors need to be able to adapt quickly and be proactive

Table 1-3 (Continued)

Report	Key recommendations	Gaps and learnings
 **Plan of action** 2019 **Author:** Ministry of Agriculture, Nature and Food Quality of the Netherlands	The Vision on Circular Agriculture sets out ambitions for the Netherlands to be a global leader in circular agriculture by 2030. Policy efforts include: • Promote precision agriculture and farm innovations • Support short supply chains • Create more possibilities for experimentation	The Government has specific requirements to achieve their objectives: • A commitment to knowledge and innovation • Strong international market position and capacity to innovate • Favourable legislation and regulation

1.6 Report layout

The remainder of this report consists of seven sections, structured as follows:

- Section 2 provides an appraisal of the FSCS and Agri-Tech landscape, considering the sector definition, sector technologies, research strengths, application of technologies in NI and the funding landscape
- Section 3 provides an economic profile for the sector, based on the sector definition outlined in section 2. This includes a market sizing, outline of our methodology and assumptions, as well as findings and implications
- Section 4 provides international benchmarking, considering Australia, Ireland, Israel, the Netherlands, and New Zealand. This section highlights global trends and key lessons for NI
- Section 5 provides a SWOT analysis for the sector, including the underlying approach. Key challenges and opportunities are highlighted
- Section 6 outlines our methodology and assumptions for ranking Agri-Tech and FSCS technologies, the ranking results, and the associated implications for NI
- Section 7 presents the conclusions, recommendations, and proposes metrics for measuring the success of implementing the recommendations.

2 Appraisal of the FSCS and Agri-Tech landscape

This section builds on the Agri-Tech definition and ecosystem analysis outlined in section 1, through an overview of the three key components in the Agri-Food value chain, the types of technologies considered and how these relate to or are connected with the wider ecosystem. In addition, this section reviews NI's research strengths and technologies in use currently, as well as the funding landscape.

2.1 Sector overview

As defined in section 1.3, for the purposes of this research study, the "Agri-Tech sector" consists of the businesses providing Agri-Tech related solutions (products and services) to various end users. The technology solutions these businesses provide are intrinsically linked throughout the value chain. There are three key components in the value chain: primary agriculture, food and drink processing and retail.

Primary agriculture

Primary agriculture covers a range of agricultural sub-sectors all of which can benefit from the use of Agri-Tech and FSCS technologies. There are opportunities for the public sector to support adoption through initiatives that create awareness of technology solutions, the benefits of adopting technology, and by providing training support that can aid technology adoption. The College of Agriculture, Food and Rural Enterprise (CAFRE) already plays an important role towards this end. This support is critical as the sector is comprised of a large number of small-scale farms and the age profile of farmers is older than the wider workforce in the economy, which may reduce the adoption of new technologies.

Co-operatives can also take part in and support such initiatives, by members working together to pool resources. The Agri-Food sector's planned Sustainability Body can be a part of this collaboration, to help facilitate the adoption of technologies aimed at increasing environmental sustainability.

Food and drink processing

This is likely the key market for Agri-Tech and FSCS technologies in NI. Windows of opportunity are discussed in more detail in sections 2.6.

The sector has a growing need for automation and efficiency improvements, as well as the scale for the technology to make a material impact over a reasonable timeframe. Focusing on productivity also requires that processors enhance their data collection and processing capabilities to support efforts to increase efficiency through automation. At the smaller end of the scale, basic data collection needs to improve, while the larger players should be priority for application of more advanced productivity/automation technologies. Similar to the case of primary agriculture, CAFRE plays an important role in encouraging the uptake of new technologies by food and drink processing businesses.

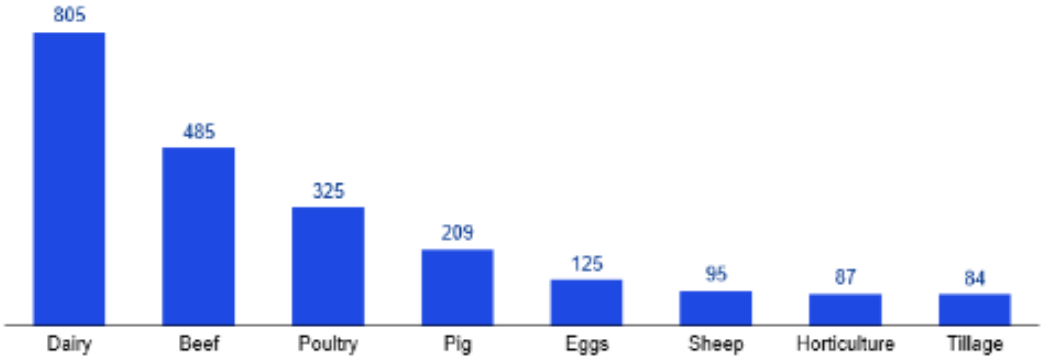
Retail
The retail sector has a strong influence on the value chain and has the relative market strength to put in place requirements on suppliers to meet specific standards. These standards can arise from consumer preferences or legislative/policy considerations.

The Agri-Food sector's initiative to establish a Sustainability Body, which will work across all agricultural sectors with the involvement of processors, is a positive initiative. This can build on DAERA's work to establish a data platform for the sector. The Sustainability Body will help to demonstrate the sustainability credentials of NI's food, improvements in sustainability over time, and can support the promotion of NI's food products. NI's Agri-Tech businesses can collaborate with the Sustainability Body to help facilitate the adoption of technologies aimed at increasing environmental sustainability e.g., Anaerobic Digestion technology, biogas, Lidar/multispectral scanning, pollution monitoring sensors, methanogenesis inhibiting ruminant feed additives, soil carbon sequestration, renewables.

2.2 Agri-food sector overview
The dynamics within the primary agriculture, food and drink processing and retail sectors have a direct influence in shaping the domestic market environment for the Agri-Tech sector. These dynamics are discussed below.

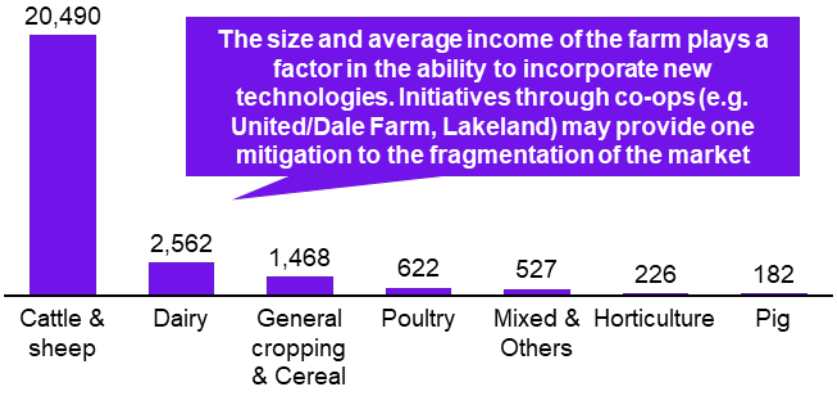
2.2.1 Primary agriculture
Through stakeholder consultations, a key theme that emerged was that NI's primary agriculture sector is fragmented and hence scaling existing technology solutions is a challenge. Sales and marketing/implementation support for Agri-Tech businesses can potentially support adoption. Sub-sector output for the primary agriculture sector is shown in Figure 2-1 and the number of farms by sub-sector is shown in Figure 2-2, both below.

Figure 2-1: Primary agriculture sector output by sub-sector,
2021, £m, Total £2,215m[13]



[13] Sources: DAERA: Statistical Review NI Agriculture (2021). ISRAF: Independent Strategic Review of the Northern Ireland Agri-Food Sector (2022).

Figure 2-2: Number of farms by sub-sector, 2021, *Total 26,077*[14]



NI's primary agriculture sector accounts for 2.5% of total employment, spread over 26,077 active farm businesses. Total farm income in 2021 was 54% greater than that of the total farm income in 2011 (adjusted for inflation)[6]. Stakeholders consulted over the course of this research study emphasised that efficiency improvements through innovation and technology have played a large role in this increase.

Indigenous Agri-Tech solutions applicable to primary agriculture include Cattle Eye, an AI-enabled farm safety and autonomous livestock video monitoring system. Feedback from stakeholders consulted as part of this research project indicates that sales and implementation skills are a barrier to higher Agri-Tech technologies adoption rates.

Accordingly, there is scope to enhance the adoption/use of technology through marketing/implementation support for Agri-Tech businesses. This can include marketing training support for Agri-Tech businesses, as well as wider initiatives that create awareness of technology solutions, the benefits of adopting technology, and technical training support for end users in getting the most value out of their technology purchase. By supporting greater adoption/use of technology, a greater number of Agri-Tech start-ups can scale, mirroring the successes of key players such as Devenish, Crop Safe, CattleEye, SlurryKat, and UNITAS.

However, the scale of cattle and sheep, general cropping and cereal farms – ~89% tend to be very small in size (less than 1 FTE)[6] – creates challenges when implementing new technologies across these sub-sectors, due to prohibitively high set up costs relative to farm size. However, as 41% of dairy farms are large in size, and 35% of poultry farms are medium or large, these sub-sectors have greater relative potential to see returns from new technologies. Where co-operative structures exist, this may further facilitate the roll-out/adoption of technology solutions.

[14] DAERA: Statistical Review NI Agriculture (2021)

2.2.2 Food and drink processing

The food and drink processing sector accounted for more than 39% of total manufacturing sales and accounted for over 25,000 jobs in 2020. Beef and sheep meat, milk and milk products, and poultry are the largest sub-sectors, collectively accounting for ~63% of the food and drink sector turnover.[15]

Given the scale of the food processing sector, the application of new technologies in this sector has the potential to create the largest absolute efficiency savings and/or productivity improvements of all sectors considered. Agri-food's Gross Value Added by sub-sector (2020) is summarised in Figure 2-3, and examples of key Agri-Food processors are provided in Figure 2-4.

Figure 2-3: Agri-food Gross Value Added by sub-sector, *2020 £m (Total £1,088m)* [16]

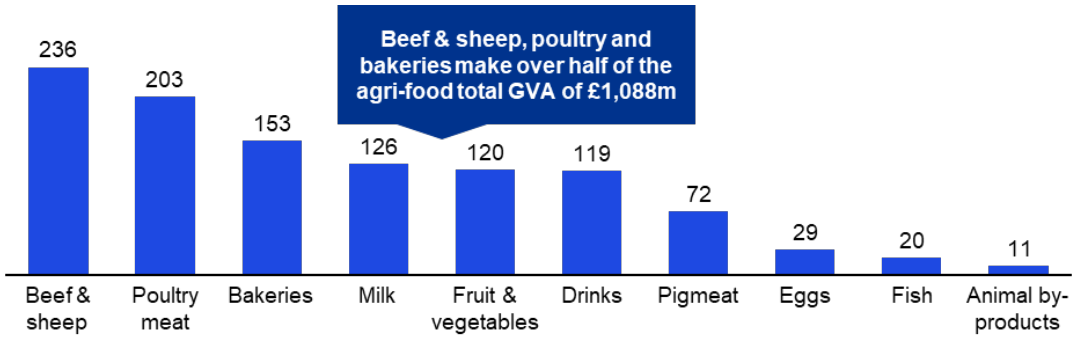


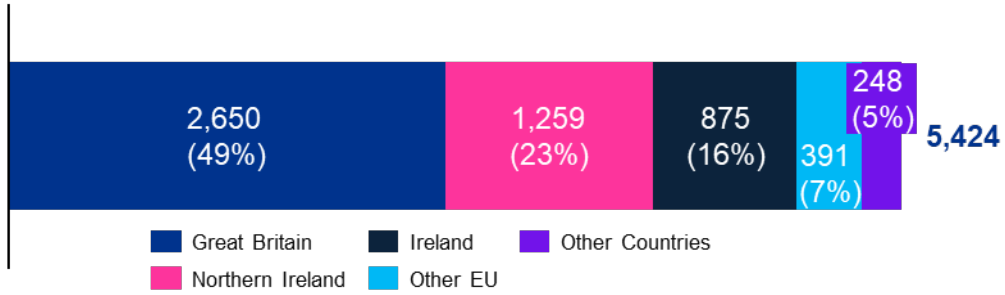
Figure 2-4: Key Agri-Food Processors in NI[16]

The food and drink sector accounts for a large share of NI's total external sales, and under a quarter of NI-produced food and drink is consumed within NI. Figure 2-5 below shows that NI's two main trading partners are Great Britain, with £2,650m of external sales (49% of total) and Ireland with an export value of £875 (16% of total).

[15] DAERA: Northern Ireland Food and Drinks Processing Report (2020).

[16] DAERA: Northern Ireland Food and Drinks Processing Report (2020), ISRAF: Independent Strategic Review of the Northern Ireland Agri-Food Sector (2022).

Figure 2-5: Food and drink processors' total sales by country of destination, *2020 £m*[16]



NI has a history of lower productivity compared to the rest of the UK. A contributing factor is the relative lack of scale and sector FDI (compared with GB), and subsequent lack of capital investment in technology. Stakeholders note that low margins curtail commercial funding and available publicly funded capital grant support funding for this investment is limited. Stakeholders note that many agri-food processing factories are unprepared for emerging technological concepts such as the 'Internet of Things' with approximately 50% of businesses completely dependent on manual data collection, indicating a clear need for the adoption of basic data collection and analysis. The relatively low productivity can potentially be improved through the application of existing technology and innovation solutions.

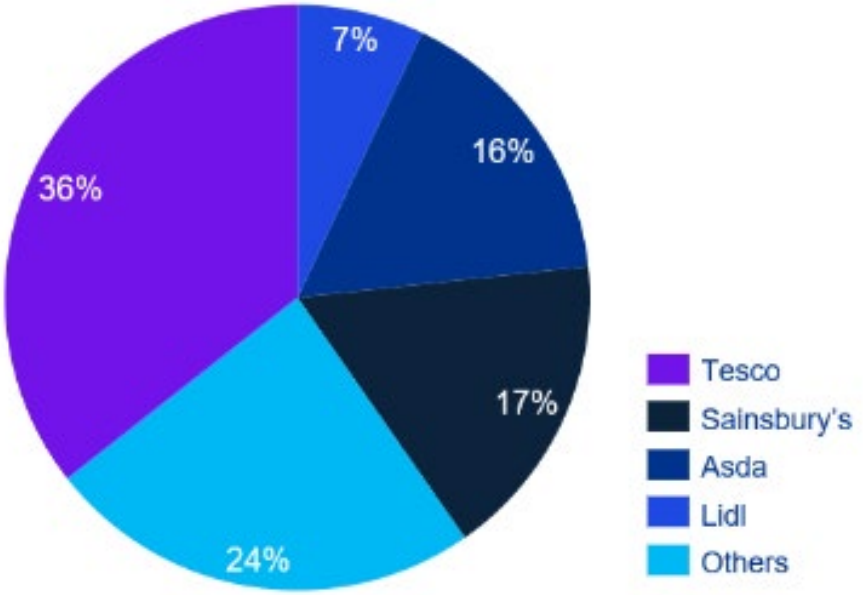
Policy focus should prioritise improving the baseline of basic data, and application of leading automation/productivity technologies in the larger players. This corresponds with theme 1 of the Independent Strategic Review of the Northern Ireland Agri-food Sector, calling for uptake in the smart use of data and the opportunities it creates.
Examples of automation/productivity technologies include generic automation technologies (Programmable logic controllers - PLCs, Supervisory Control and Data Acquisition - SCADA systems, temperature control), automatic food packaging.

2.2.3 Retail

The retail sector is a key component in connecting the agri-food sector to consumers. The sector forms a major link back to the primary and processing sector, in particular by sharing market and consumer feedback, such as trends in consumer preferences. The GVA of the Food and Drink Industry in NI is £1.54bn, out of which Wholesale and Retail Trade is around £420m[17]. Grocery retailers are placing a heavy focus on traceability technologies and their involvement should be sought for major initiatives.

[17] DAERA: Northern Ireland Food and Drinks Processing Report (2020).

Figure 2-6: Total Grocery Market Share in NI, 2022[18]



Retail NI has launched a new Supply Chain Forum that aims to connect and to promote trading opportunities with local producers, manufacturers and suppliers among its independent retail and wholesale members. Tesco, Sainsbury's and ASDA hold a significant market share in the Grocery market in NI; these businesses' buying power over a more fragmented supply chain means their buy-in and potential leadership of key drives around traceability (and therefore data) is critical.

Collaboration with the retail sector, to ensure alignment across the agri-food value chain, can help to address industry data gaps and support data interoperability. In terms of environmental, social, and governance (ESG) considerations, the retail sector has set out targets for the sector itself and for its suppliers. Initiatives to modernise NI's processors and primary sector should take account of ESG (and associated traceability) in procurement, using the relative concentration of the retail sector to standardise requirements around the basics of data collection. Example of retailer's sustainability goals include:

- Tesco aims to be carbon-neutral by 2035 and deliver its goal to be net zero from farm to fork by 2050; It reduced its electricity demand across the estate by almost 25% since 2015
- Sainsbury's recently pledged to spend £1bn to become a carbon-neutral business by 2035 – 10 years ahead of government's target; It reduced absolute greenhouse gas emissions from its own operations by 44.5% in 2022 compared to the previous year[19].

NI also has a strong packaging and cold chain sub-sector, with businesses such as Huhtamaki and Granville playing a key role in delivering high standards of quality and compliance. Technologies in the retail distribution space play a critical role in improving the efficiencies of the sector. These technologies include sensor technology, data handling, and quality monitoring.

[18] Kantar: Total Take Home Grocery - Northern Ireland Consumer Spend (2022).
[19] https://www.about.sainsburys.co.uk/sustainability/better-for-the-planet/carbon

2.3 Policy landscape

A number of key policies play a role in the development of the Agri-Tech sector in NI, including policies from NI, UK Government and internationally. A review of these policies highlights the following actions as key considerations:

1 Steps that create an environment with fair competition within the sector and the provision of permitted economic aid where and when necessary to encourage innovation, development, and modernisation
2 Identify shared targets and goals for climate action with alignment on innovative approaches across the industry for a shared approach to objectives and best practices
3 Encourage private sector R&D and increase the focus on skills and training within the industry to enhance operational efficiency

These policies have been summarised in Table 2-1 below.

Table 2-1: Overview of current Agri-Food and Agri-Tech policies[20]

Regional focus	Policies	Key themes
Local	• Armagh City, Banbridge & Craigavon Borough Council: Agriculture Strategy	• Develop a plan to facilitate skills development • Develop an Agriculture Centre for advice, training, demonstration and research • Agri-food development
Northern Ireland	• 10X Economic Vision • Independent strategic review of the Northern Ireland agri-food sector • Future agricultural policy proposals for Northern Ireland	• Innovation through R&D programmes • Increasing of fair competition • Modernisation of technologies currently in use
United Kingdom	• Countryside Stewardship. • The Environmental Land Management (ELM) • Farming Equipment and Technology Fund (FETF)	• Investing in technology, equipment and innovation • Financial support for farmers around the country • Offering grants for items to increase productivity
International	• Agri-Tech Industry Transformation Plan (New Zealand) • The He Waka Eke Noa – Primary Sector Climate Action Partnership • EU Common Agricultural Policy	• Reduction of agricultural greenhouse gas (GHG) • Climate change action • To protect food and health quality

A common theme across these policies is a focus on sustainability and climate change. In addition, underlying themes to be noted also include increasing productivity and the potential for the smart use of data across the agri-food sector. These represent a key area driving the potential use for and development of technology solutions that can reduce the agri-food sector's environmental footprint.

In June 2019, the UK passed legislation requiring the UK government to reduce national carbon emissions to net zero by 2050. In response, the Climate Change Committee (CCC) recommended a series of sectoral targets and budgets for the UK, including Northern

[20] Respective polices plans.

Ireland. As part of its recommendations, in December 2020 the CCC recommended at least an 82% reduction in NI's sector-wide carbon emissions by 2050, compared to 1990 levels.

The Climate Change Act (Northern Ireland) 2022 "*sets a target of an at least 100% reduction in net zero greenhouse gas (GHG) emissions by 2050 (i.e., net zero emissions by 2050) for Northern Ireland compared to baseline, along with interim targets including an at least 48% reduction in net emissions by 2030. DAERA must also, by June 2024, review and potentially set updated 2030 and 2040 interim emissions reduction targets to ensure that they are in line with the 2050 net zero target.*"[21]

In this context, FSCS technologies and Agri-Tech will play a key role in reducing carbon emissions across the agri-food supply chain. Headline insights relating to key technologies are shown below:

- Data analytics: Digital and data analytics technologies can create value by supporting the optimisation of inputs and outputs within the complex agriculture and processing supply chain
- Life sciences/Genetics: Genetic engineering can increase crop yields, lower food costs, improve food quality, food security, and medicinal value
- Farm equipment and manufacturing: A number of farm equipment technologies are leading the way in reducing farm emissions. Examples of relevant activities/technologies include:
    - Replacing machinery and vehicles used for cultivation and transport with more sustainable and less carbon-intensive replacements
    - Precision applications reducing fertiliser and spays usage
    - Typical Low Emissions Slurry Spreading Equipment through a trailing hose, trailing show and shallow injection methods for applying slurry.

There are specific enablers/policy levers that can be used to capitalise on the opportunities in the Agri-Tech ecosystem, supporting exports and the diffusion of technology:

- Funding support: Support for R&D and capital expenditure can support the development of new technologies and the adoption of technologies in NI's agrifood/food and drink value chain
- Skills development: To address labour, skills, and training constraints, attract more students and generate a stronger pipeline of graduates / apprenticeships with the requisite skills needed to meet the sector's skills demands
- Support for Agri-Tech start-ups: Develop Agri-Tech start-up supports through innovation hubs (such as the Mid South West Growth Deal - Agri Bio Innovation Centre), incubators, and accelerator programs
- Collaboration: foster collaboration through industry forums, including government departments, Agri-Tech businesses, industry bodies and international peers
- Data systems: Establish data systems for the agri-food sector to support technology adoption and diffusion. This can be led by DAERA, with input by the Sustainability Body, Industry Bodies, DfE and Invest NI.

2.4 Technologies

As defined in section 1.3, the Agri-Tech sector consists of the businesses providing Agri-Tech related solutions (products and services) to various end users including FSCS technologies, for example, technologies serving the farming, food and drink, processing, logistics, cold chain, retail, and safety components of the broader value chain. For the purposes of this study, technologies have been split into six categories:

[21] The Climate Change Act (Northern Ireland) 2022 - Key elements.

- Advanced materials & supply chain technologies
- Agri-engineering
- Food processing technologies
- ICT
- Life Sciences
- Nutrition & animal feeds

Advanced materials & supply chain
Advanced materials and supply chain includes technologies used in packaging, storage and transport of primary / secondary produce. The following technologies are considered under advanced materials & supply chain in the Agri-Tech capacity:
- Cold chain & distribution
- Logistics & distribution
- High tech/sustainable packaging

Agri-Engineering
Agri-Engineering industry concerns the areas of manufacture, maintenance, and modification of agricultural equipment. It is also about sales, service, installation, and demonstration of agricultural equipment and in the importation and distribution of this equipment. The following technologies are considered under Agri-Engineering:
- Farm equipment & manufacturing thereof
- Farm automation/robotics
- Precision applications

Food and drink processing technologies
Food and drink processing technologies comprise technologies that improve efficiencies and safety/quality control in the processing of food/manufacturing of drink products. It also includes technologies used in product development and creating new value-added products. The following technologies are considered under food and drink processing technologies in the Agri-Tech sector:
- Factory/warehouse automation
- Safety/quality control
- Nutrition/product development
- Value added products

ICT
ICT in Agri-Tech focuses on the enhancement of agricultural output and food processing through improved information and communications processes. Increasingly, ICT tools are used to gather data on crop production and to measure efficiency of processes used for food processing. The following technologies are considered under ICT in the Agri-Tech sector:
- Ag finance
- Artificial Intelligence Monitoring
- Cyber security
- Traceability
- Data analytics
- Management software
- Sensors
- Wholesale/Retail (business-to-business business-to-consumers) technologies

Life sciences
Life sciences comprise fields of science involving the study of living organisms (including plants and crops). Research in the life sciences – such as on growth trajectories in single

species – can help to improve productivity in terms of quantity and quality. The following type of technologies are considered under life sciences in an Agri-Tech context:

- Animal data analytics and genetics
- Plant genetics
- Sustainability/ Environmental
- Farm animal drugs, vaccines, and diagnostics

Nutrition & animal feeds

In a conventional sense, animal nutrition is the science of feed preparation and feeding, with a focus on safety and efficiency. The following technologies are considered under nutrition & animal feeds:

- Soil sampling/DAERA LiDAR soils survey
- Plant/crop analytics
- Predictive analytics
- Stock feed genetics and analysis

There is overlap between a number of the above technologies with several of these complementary e.g. The smart use of data (data analytics) can serve as a common enabler to maximise the value and benefit that can be derived from the application of other technologies.

The above technology sub-sectors and longlist of technologies form the starting point to identify specific technologies within the Agri-Tech sector where NI has a current or future world class competitive advantage. In section 6 'Ranking of technologies' these technologies are discussed in more detail as part of a shortlisting process. These shortlisted technologies are as follows:

A) Animal data analytics & genetics
B) Cold chain management
C) Crop / feedstock genetics and analytics
D) Data analytics
E) Factory / warehouse automation
F) Farm equipment & manufacturing thereof
F) Food safety / quality control
G) Nutrition / product development[22]
H) Logistics & distribution
J) Sustainability / Environment
K) Traceability

Definitions and examples of the shortlisted technologies are summarised in Table 2-2 below.

[22] Note, this refers to human food rather than animal feed.

Table 2-2: Shortlisted technologies overview

Definition and technology examples	Market drivers	Example of Agri-Tech entities
A) Animal data analytics & genetics **Definition**: The study of animal data analytics & genetics helps to increase productivity, analyse different aspects of the animal`s welfare and to prevent any possible damage increasing disease resistance **Examples:** Animal breeding for optimal characteristics (Longevity, milk yield, physical characteristics, etc), sensors attached to animals for early disease detection and treatment, sensors on animal housing, software to process animal data and tailor a diet to optimise production/body condition, nutritional supplements	**Drivers of demand:** Increased animal efficiency can have financial benefits, reduce emissions, and increase animal welfare **Scalability:** Animal agriculture is prevalent worldwide and so technology improving efficiencies and output for animals has large global scalability opportunities **Risks/limitations:** Could lead to a lack of variety in animal species, potential for unanticipated welfare concerns if regulations not in place	**NI** • Cattle Eye • Afbi • Ai Services **International** • Herdwatch • Datamars Livestock • LIC
B) Cold chain management **Definition**: Technologies used throughout all phases of the cold chain **Examples:** Temperature logging devices to monitor changes during travel and storage, ensuring food is kept fresh, sensors within food to detect when chilled food has gone out of date rather than relying on date estimations	**Drivers of demand:** If chilled products are not kept cool during transport, quality and shelf life diminishes **Scalability:** Global prevalence of chilled products mean technology is likely highly scalable **Risks/limitations:** Due to being food safety related, cold chain technology may assume liability	**NI** • Granville Food Care Ltd **International** • Senoptica Technologies
C) Crop / feedstock genetics and analytics **Definition**: Crop / feedstock genetics and analytics studies help to understand how it is possible to increase agricultural productivity. One application includes the study of the effects of genetic variation and selection used to propagate valuable heritable trait combinations in crop and feedstock. Another can be the use of satellites to produce imaging of crops and landscapes for monitoring and managing crop health **Examples:** Crop breeding for optimal characteristics (drought resistance, maximise yields, pest resistance), analysis of crop utilising satellite imagery to identify areas affected by disease, utilising infra-red imagery for targeted nitrogen fertiliser application	**Drivers of demand:** Climate change causing more extreme crop growth conditions. Availability of new technologies (e.g. drones, satellite imagery) **Scalability:** Crop dependent, will depend on where in the world the target crop is grown **Risks/limitations:** Could lead to a lack of variety in plant species	**NI** • Afbi • Germinal • Devenish • CropSafe • Thompsons **International** • Seed-X • Clarifruit
D) Data analytics **Definition:** Analysing raw data to make conclusions to help inform decisions that will improve efficiencies, lead to returns and reduce wastage throughout the Agri-Food value chain **Examples:** Optimisation of processes, evidence supporting best practices, delivery truck routes efficiencies	**Drivers of demand:** Greater access to data **Scalability:** Highly scalable with majority farms / business globally collecting data **Risks/limitations:** Risk of too much information or information interpreted incorrectly, security risk of confidential data or data collected between farms / businesses not aligning	**NI** • Foods Connected • AgriWebb • VetIMPRESS • Unitas Software **International** • AgriDigital • agmatix
E) Factory / warehouse automation **Definition:** Warehouse automation takes many forms, including machines and robots that aid workers with processes related to inventory from when it arrives at the warehouse until it leaves. Automated seeding machines not only save time but also ensure seeds are dispersed evenly. **Examples:** generic automation technologies (PLCs, SCADA systems, temperature control), human replacement technology e.g., optical scanners rejecting unsuitable food, automatic food packaging	**Drivers of demand:** Labour shortage pushing factories towards automation **Scalability:** Innovative products may have global scalability **Risks/limitations:** High cost to integrate and long return on investment	**NI** • Matrixeng • PAC Group • FAST Technologies **International** • RoboticsPlus

Table 2-2: (Continued)

Definition and technology examples	Market drivers	Example of Agri-Tech entities[23]
F) Farm equipment & manufacturing there of **Definition**: Farming machinery and equipment used to improve overall production yields. **Examples:** Tractor implements (trailers, tankers, mowers, diet feeders), dairy technology – (robotic platforms, traditional parlours, etc), animal handling / weighing equipment, poultry sector equipment (feeding, heating, catching)	**Drivers of demand:** increasing demand in developing countries **Scalability:** Highly scalable with equipment being required globally, NI manufacturers are already exporting globally **Risks/limitations:** Highly fragmented market with many countries having localised equipment production, innovative solutions required to achieve global scalability	**NI** • NC Engineering • SlurryKat • Redrock • MAC Trailers • Fleming • Nugent Engineering **International** • miRobot • Greeneye Technology
G) Food safety / quality control **Definition**: Technologies used to quality control measures to ensure that food products meet certain safety and quality standards. A food control system ensures that food available within a country is safe, wholesome and fit for human consumption, conforms to food safety and quality requirements and is honestly and accurately labelled as prescribed by the law. **Examples:** Testing of food samples, equipment used to monitor quality for food processing (e.g., hyperspectral laser checking on the ageing of cheese)	**Drivers of demand:** Legislation and consumer demand for safe foods **Scalability:** Global scalability depending on local food regulations **Risks/limitations:** Food safety businesses may assume liability for their technology meaning any faults in food safety equipment may lead to significant claims	**NI** • Biopanda Reagents • IGFS • AFBI **International** • Safefood 3600
H) Logistics & distribution **Definition**: Technologies used to improve the efficiencies of distribution and logistics for the transport of agri-food products **Examples:** Route optimisation technologies, biofuel / Electric HGVs	**Drivers of demand**: Global population increase has led to an increase in food logistics/distribution **Scalability**: Transport is a global issue however the market is fragmented and typically localised, limiting scalability **Risks/limitations**: Limited scalability	**NI** • Huhtamaki • Lynas • Crossland • Greiner Packaging
I) Nutrition / product development **Definition**: Technologies used in nutrition / product development to identify, modified or enhanced products resulting in a higher market value and/or a longer shelf life. **Examples:** Nitrate free bacon, foods for specific dietary needs, food types that have additional health benefits	**Drivers of demand:** Change in consumer preferences, including greater awareness of health benefits **Scalability:** Global scalability depending on local food regulations **Risks/limitations:** Niche markets / consumers will require targeted marketing for initial product uptake.	**NI** • Moy Park • Dale Farm • Genesis • Cladeboye Estate • Artisan Finnebrogue • Ulster University **International** • Valid Nutrition • BFree • Plantruption

[23] Note that CAFRE, DAERA and Food Standards Agency NI play a crucial supportive role in the Agri-Tech industry testing or assisting in the development of technologies.

Table 2-2: (Continued)

Definition and technology examples	Market drivers	Example of Agri-Tech entities[24]
J) Sustainability / Environment **Definition**: Technologies used in the sustainable practices to protect the environment, make existing resources go further, maintain and improve soil fertility and develop waste streams **Examples:** Anaerobic Digestion technology, biogas, Lidar/multispectral scanning, pollution monitoring sensors, methanogenesis inhibiting ruminant feed additives, soil carbon sequestration, renewables	**Drivers of demand:** Global sustainability and CO2 reduction targets **Scalability:** With agriculture accounting for approximately 11% of global CO2 emissions, sustainability technology has global scalability **Risks/limitations:** High cost being unaffordable for smaller farms / businesses	**NI** • Granville Ecopark Ltd • Afbi • IGFS • Stream Bioenergy • Devenish **International** • Certhon
K) Traceability **Definition:** Technologies used to potential sources of contamination to efficiently prevent, contain or rectify outbreaks **Examples:** Ledger technology to ensure full traceability of product from farm to fork, animal electronic identification/RFID tags	**Drivers of demand:** A push for traceability from supermarkets and farm quality assurance bodies **Scalability**: Traceability standards may vary worldwide so scalability may be limited to countries with similar traceability standards **Risks/limitations**: Requires information from multiple entities throughout the full supply chain	**NI** • Foods Connected • IGFS **International** • Lumachain

Across the shortlisted technologies, Northern Ireland has several businesses that have world class competitive advantage. Examples of these businesses and their products are summarised in NI Agri-tech business with world class competitive advantage below.

[24] Note that CAFRE, DAERA and Food Standards Agency NI play a crucial supportive role in the Agri-Tech industry testing or assisting in the development of technologies.

Table 2-3: NI Agri-tech business with world class competitive advantage
(examples/not exhaustive.)

Technology	NI business and its product(s)
A) Animal data analytics & genetics	**Cattle Eye –** autonomous livestock monitoring platform. It uses a security camera to capture video footage for monitoring livestock and to provide insights on a herd's health and productivity.
B) Cold chain management	**Granville Food Care –** one of the leading cold storage providers to the food industry in NI. Its main activities include blast freezing, frozen warehousing, and the defrosting of primary meat products.
C) Crop / feedstock genetics and analytics	**Devenish –** An innovator in animal nutrition, providing a wide range of products and services. Supplies quality animal feeds for the pig, poultry, and ruminant sectors.
D) Data analytics	**Vet Impress –** A data management platform that gives farm animal vets the tools to collect and analyse animal data, delivering insights to enable evidence-based decisions **Analytics Engines –** Provides innovative software solutions for clients to understand their business, empower decision-making, optimise performance, and drive value from data **Unitas –** Provides a unique cloud-based solution that allows agri supply chain role-players to be connected, from vets, grading centres, farms, and hatcheries, through to factory processing
E) Factory / warehouse automation	**Fast Technologies –** An advanced manufacturing company, specialising in automation, robotics, and software solutions for companies worldwide
F) Farm equipment & manufacturing there of	**Slurrykat –** Are a market leader in the design and manufacture of slurry spreading equipment for farmers, farm-contractors and the biogas industries **Red Rock Machinery –** Manufacture and supply a range of livestock feeding and slurry handling equipment. For example, silage and grain trailers, blockcutters, paddle feeders, specialist trailers, rugged Redrock dump trailers, low loaders and flat trailers
G) Food safety / quality control	**BioPanda –** Produce in Vitro test kits for clinical laboratories, veterinary practices and the food industry
H) Logistics & distribution	**Crossland tankers –** Build and supply liquid tanker for; foodstuffs, milk, ADR / chemicals, bitumen, waste, or a completely unique and custom-built application
I) Nutrition / product development	Many agri-food processors actively undertake research and create technologies that assist with improving nutrition and product development. For example, Finnebrogue Artisan use technologies to create nitrate free bacon or meat-free products, such as plant-based beef and chicken as part of their “Naked” product range
J) Sustainability / Environment	**Granville Ecopark** - The largest anaerobic digestion facility in NI, which transforms food waste into biogas
K) Traceability	**Foods Connected –** Provides end-to-end food safety software across the supply chain. Giving customers the control to ensure that they have the right supplier, the right product and the right quality at the best price possible

2.5 Research strengths

Northern Ireland's Agri-Tech research strengths primarily flow from the work of a number of key education and research entities, including Queen's University Belfast, Ulster University, the Agri-Food & Biosciences Institute (AFBI), and the College of Agriculture, Food and Rural Enterprise (CAFRE). Note that CAFRE does not carry out research, CAFRE's role is to support the delivery of research outcomes through the delivery of Knowledge Transfer and innovation programmes. Each of these entities plays a valuable role in supporting the development of NI's Agri-Tech sector. An overview of the respective research entities and their strengths is supplied in Table 2-4 below.

Table 2-4: Summary of NI research strengths

Research & Educational Entity	Overview	Research strengths
AFBI	The Agri-Food & Biosciences Institute (AFBI) carries out research, development and testing for the Department of Agriculture, Environment and Rural Affairs (DAERA), and other public bodies and commercial companies.	• **Sustainability & environmental** • **Genetics** • **Traceability**
CAFRE	The College of Agriculture, Food and Rural Enterprise (CAFRE) offers courses to educate and support students in a range of specialist agriculture and food courses at further, higher and apprenticeship levels. CAFRE plays a crucial role in supporting the farming and food processing sectors, including their role in knowledge transfer activities. CAFRE's role is to support the delivery of research outcomes through the delivery of Knowledge Transfer and innovation programmes.	• **Food packaging** • **Animal data analytics & genetics** • **Robotics**
IGFS	The Institute for Global Food Safety (IGFS) is a Global Research Institute at Queen's University established to address key, international challenges – in this case, the integrity of our food systems. Areas researched include climate change, the integrity of complex food supply chains and deliberate food fraud. In addition to IGFS, Queen's university is home to the Advanced Manufacturing Innovation Centre providing significant to businesses R&D in the advance manufacturing space.	• **Food integrity & security** • **Advance manufacturing**
Ulster University	Ulster University has three centres / hubs that assist with research and development within the Agri-Tech sector. These are: 1 Nutrition Innovation Centre for Food and Health (NICHE) 2 The Food and Drink Business Development Centre. 3 Smart Manufacturing Data Hub	• **Nutrition** • **New product development** • **Value added products**

The two key universities' research capabilities are summarised in Table 2-5 below.

Table 2-5: Benchmarking of NI university research capability in Agri-Tech[25]

Research Entity	Staff / researchers	University World Ranking	Score out of 100		
			Citations	Industry Income	Research
IGFS	Over 60 academic, research, technical and support staff within IGFS. IGFS is rated No.1 in the UK for research in the area of Agriculture, Food and Veterinary Sciences in the REF research excellence rankings, which ranked 94% of their research as "world leading" or "internationally excellent"	198	84%	42%	40%
Ulster University: Nutrition Innovation Centre for Food & Health (NICHE)	Consists of 46 academic, research, technical and support staff and 30 PhD research students within NICHE	601 - 800	75%	35%	10%

Queen's University: Institute for Global Food Safety (IGFS)
IGFS has over 60 academic, research, technical and support staff within IGFS, and over 105 research projects have been initiated between 2018 and 2023. Examples of recent research includes[26]:

- Mapping exercise to identify potential feed ingredients for monogastric species
- Characterizing the role of vitamin D insufficiency on host immunity and recurrence of bovine tuberculosis on problem farms
- Transparency solutions for transforming the food system.

The IGFS play a key role with supporting Agri-Tech business with the development of technologies such as novel photo-detectors, AI, experimentation and trace elemental analysis. An example of its support is assisting Cattle Eye develop the autonomous dairy livestock management systems using a video feed from a milking parlour webcam.

The Advanced Manufacturing Innovation Centre, led by QUB in partnership with Industry, Ulster University and Antrim and Newtownabbey Borough Council, plan to launch their Factory of the Future at Global Point in Newtownabbey by 2025. This £98m factory (funded through the Belfast Region City Deal) will be a state-of-the-art, industry-driven game changer for the manufacturing sector and will elevate Northern Ireland globally. The factory will support the sector in the following ways:

- To create innovative and creative products
- Generate jobs
- Create economic growth.

Ulster University
Ulster University (UU) has three centres/schools that contribute to research and development in the Agri-Tech sector:

1 Nutrition Innovation Centre for Food & Health
2 The Food and Drink Business Development Centre
3 Smart Manufacturing Data Hub

[25] World University Rankings 2023 | Times Higher Education (ranking for each university is based off their respective life sciences ranking due to IGFS and NICHE are placed within life sciences).
[26] Example of research can be found here.

The Nutrition Innovation Centre for Food & Health (NICHE) is the largest centre for nutrition research on the island of Ireland and one of the largest in Europe, consisting of 46 staff (academic, research, technical and support staff), ~30 PhD research students, and ~400 BSc and MSc students in Food, Nutrition & Dietetics. The centre has attracted grant income of over £50 million for nutrition research over the past 25 years. NICHE aims to achieve tangible impacts through facilitating food, nutrition and health research focused on disease prevention, and to drive related innovation activities in the food and health sectors.

The second Ulster University centre that assists in Agri-Tech research is the Food and Drink Business Development Centre, which plays a vital role in product development. Examples of recent projects include:

- Industrial symbiosis and the circular economy: an exploratory study within the NI food & drinks industry integrating food waste into new product innovations
- To investigate new product development opportunities using the waste product from the production of almonds.

Thirdly, UU's Smart Manufacturing Data Hub, an initiative backed by £50m of government funds and business co-investment, aims to support small and medium-sized manufacturers to become more competitive by harnessing the power of data. Digital solutions and expert guidance are available to businesses through the hub, enabling them to explore and evaluate their processes, make operational savings, de-risk investments and become more digitally skilled.

In addition, UU's Food and Consumer Testing Suite (FACTS) offers businesses the opportunity to create, develop, refine and improve their food or drink products[27]. Examples of UU's industry research projects are summarised in Table 2-6 below.

Table 2-6: Examples of industry research[28]

Project	Problem	Solution	Impact
Industrial symbiosis and circular economy: an exploratory study within the NI food & drinks industry integrating food waste into new product innovations	This project sought to apply the concept of Industrial Symbiosis, where the use of redundant material from one business can be a useful resource for another business within the Food and Drinks Industry	Originally, the food and drinks companies named in this project had no avenue for food waste (e.g., apple peel goes to pig farmers, fruit and cake go directly to food refuse collection) however this project has resulted in the identification of various new products which utilise their waste resources	New product concepts were created for each business to further develop
To investigate new product development opportunities using the waste product from production of almonds	This project sought to explore the potential of repurposing food waste material (almond pulp) into new products	A number of new product concepts were developed	Product concepts were presented to the business for it to take forward for further development

[27] Examples of services include product development, shelf-life testing and measurements, and ingredient substitution/ingredient modification analysis.

[28] https://www.ulster.ac.uk/faculties/ulster-university-business-school/food-drink-business-development-centre/research-and-innovation/our-industry-projects

AFBI

The Agri-Food & Biosciences Institute (AFBI) carries out research, development and testing for the Department of Agriculture, Environment and Rural Affairs (DAERA), and other public bodies and commercial entities. AFBI have seven different sites across Northern Ireland, located in the following areas:

- Newforge Lane (Headquarters)
- Stormont
- Hillsborough (including the research farm)
- Crossnacreevy
- Loughgall
- Omagh
- Bushmills.

They play a significant role in the NI agri-food research. Table 2-7 below summarises the number of research reports published AFBI between 2018 and 2022 by research topic. AFBI research publications can be located here.

In addition to research, AFBI scientists support the wider sector through a very wide range of statutory and regulatory testing; diagnostic testing; trialling; and scientific advice across agriculture, food, marine and environment.

Table 2-7: AFBI number of research publications by topic, 2018 -2022[29]

Research topic	Number of publications
Animal Health and Welfare	**32**
Economics	**32**
Environmental Protection	**20**
Fisheries and Aquatic Ecosystems	**21**
Food Quality and Safety	**19**
Grassland and Plant Science	**100**
Sustainable Livestock.	**17**
Total	**241**

CAFRE

The Department of Agriculture, Environment and Rural Affairs (DAERA) provides a range of full time and part time education as well as industry short courses at the College of Agriculture, Food and Rural Enterprise (CAFRE). The DAERA Knowledge Framework aims to ensure that individuals, organisations, and businesses within the agri-food industry have access to high quality, relevant and accessible education, training, and technology exchange to improve productivity, resilience, environmental performance and sustainability[30].

While the College of Agriculture, Food and Rural Enterprise's (CAFRE) role is primarily focused on education and training, it also plays an important role through knowledge transfer by showcasing the latest technology and by seeking best practice in food manufacturing and farm innovation. CAFRE's role is to support the delivery of research outcomes through the delivery of Knowledge Transfer and innovation programmes.

In terms of knowledge transfer, the Food Technology Branch at CAFRE's Loughry Campus works with approximately 250 businesses per year on technology transfer projects[31]. This

[29] https://www.afbini.gov.uk/publications

[30] https://www.daera-ni.gov.uk/articles/daera-knowledge-framework

[31] https://www.cafre.ac.uk/2021/06/11/innovation-support-available-through-a-knowledge-transfer-partnership/

includes “factory ready” recipe formulation, new product development and food process optimisation. Projects are aligned to business needs, delivered in a bespoke manner to meet client objectives.

CAFRE’s activities help to encourage famers, and food and drink processors to adopt new technology and innovations. These activities are supportive to the wider Agri-Tech ecosystem. In addition, CAFRE contributes to applied research, for example, the current pilot Robotics and Automation programme at CAFRE, Loughry campus, uses data from a processing company to simulate the processes and production line in an individual business. By adjusting existing processes to improve efficiency and identify consequences in a safe environment, it supports the company to make decisions on improving its processes, adoption of automation or collaborative robots (Cobots) solutions.

The pilot uses technologies including Data Analytics; Digital Simulation; Virtual Reality; Augmented Reality; vision technologies; Machine Learning; AI; Automation and Cobots having brought in specialist assistance from the NI Technology Centre at Queen's University Belfast (QUB). In the meantime, the CAFRE Loughry Mid South West City/Growth Deal proposal continues to progress, it will further build on this pilot and continue to develop its innovation support for food and drink processing companies, for example, in relation to packaging technologies.

CAFRE offers a range of courses to educate and support staff working within agri-food. CAFRE consist of three different campuses:

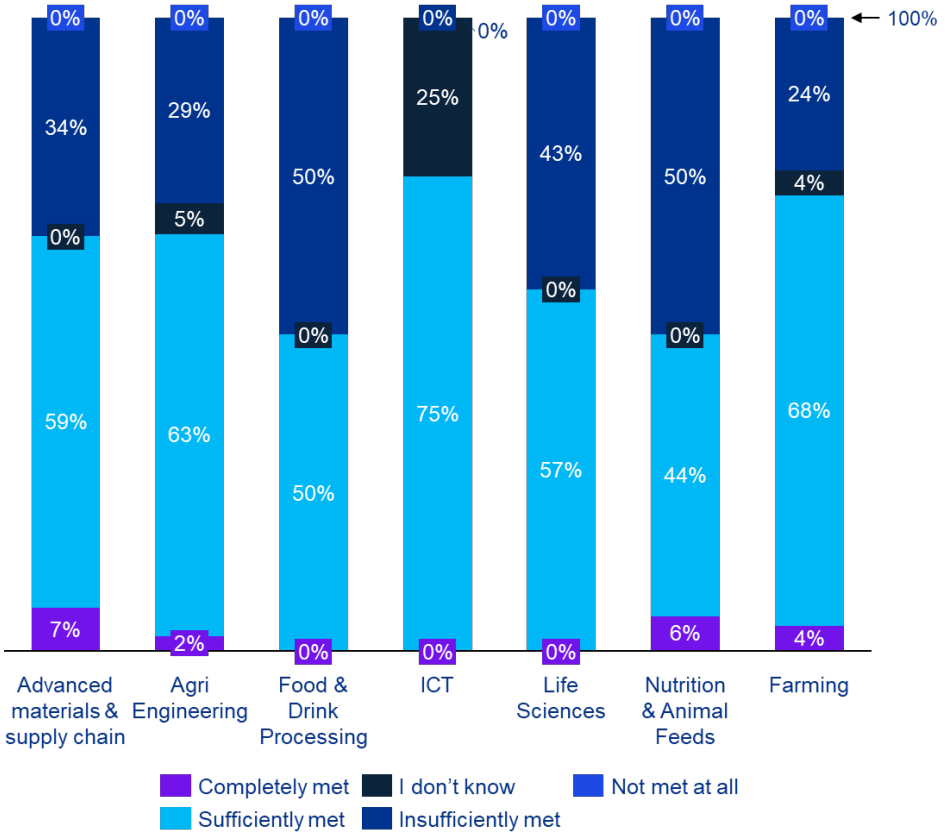
- **Enniskillen Campus** - Provides an indoor and outdoor arena for all aspects of equitation. In the racing yard they give potential jockeys invaluable experience in handling and riding racehorses
- **Greenmount Campus** – Provides on a mixture for theoretical and practical training with 200 hectares around the campus with Dairy Centre, Beef & Sheep Centre, and Machinery Centre
- **Loughry Campus** - Offering a range of courses in Food Technology, Food Nutrition and Health, Food Innovation and Nutrition, Food Business Management, Packaging and postgraduate courses in Business for Agri-food and Rural Enterprise. It is also home to the Food Innovation Centre which provides an environment to stimulate and support the process of idea generation, innovation and product development.

Industry’s research needs

As part of our industry survey, we asked 54 FSCS technology and Agri-Tech businesses if their research needs are being met. The results of which are displayed below in Figure 2-7. The key points are as follows:

- Across the sub-sectors 44% - 75% of surveyed businesses say that their research needs are being either sufficiently met or completely met
- The nutrition and animal sub-sector felt that they had the greatest misalignment or lack of research with 44% stating their research needs were being insufficiently met
- Out of the 54 surveyed business respondents, zero said their research needs were not met at all.

Figure 2-7: Percentage of respondents' research needs in agri-food technology being met, *% of respondents by Agri-Tech sub-sector*[32]



2.5.1 Survey responses

As part of the industry survey, survey respondents were asked how to improve research support in FSCS and Agri-Tech. A sample of responses is provided below:

"Supply chain and logistics management stations need to be analysed and re-developed for better operations".

"Introduce new technology-based agri-food processing methods".

"Proper diagnosis of soil and cultivational techniques needs to be improved with the help of new research methodologies".

Additional responses are supplied in Appendix B: Primary Research.

[32] Industry survey

2.6 Windows of opportunity

As discussed in section 1, businesses operating in the Agri-Tech sector globally are focused on creating solutions that can lead to many improvements, such as increasing productivity, yields, efficiency, profitability, sustainability, reliability, and quality or adding any other kind of value.

In a NI context, solutions focused on the above areas are of particular importance. The shortlisted technologies summarised in section 2.4 lend themselves to end users (an opportunity) who want to improve productivity, yields, efficiency, profitability, sustainability, reliability, quality and to create value added products. There are opportunities for NI Agri-Tech businesses to deploy their technology solutions to end users from the farm level through to food processors. Based on stakeholder consultations, technology adoption and the required capital outlay are two key constraints on wider adoption in NI. Initiatives aimed at increasing the adoption of technology (demand-side) and supports to encourage Agri-Tech start-ups (supply-side), are key mechanisms to develop the windows of opportunity for the Agri-Tech sector in NI.

With a view to providing solutions that help to improve yield, efficiency, profitability, sustainability, reliability, and quality, and to create value added products, the majority of the shortlisted technologies, discussed in section 2.4, align with NI's research strengths and market needs. This is summarised in Table 2-8 below.

Table 2-8: Technologies, research strengths and NI market need

Shortlisted technologies	Relevant research strength	NI Market need
A) Animal data analytics & genetics **Examples:** Animal breeding for optimal characteristics (Longevity, milk yield, physical characteristics, etc), sensors attached to animals for early disease detection and treatment, sensors on animal housing, software to process animal data and tailor a diet to optimise production/body condition, nutritional supplements	• Genetics • Farm data • Nutrition	• Increased yield, productivity, efficiency, profitability, sustainability
B) Cold chain management **Examples:** Temperature logging devices to monitor changes during travel and storage, ensuring food is kept fresh, sensors within food to detect when chilled food has gone out of date rather than relying on date estimations	• Food integrity & security	• Increased efficiency, sustainability
C) Crop/feedstock genetics & analytics **Examples:** Crop breeding for optimal characteristics (drought resistance, maximise yields, pest resistance), analysis of crop utilising satellite imagery to identify areas affected by disease, utilising infra-red imagery for targeted nitrogen fertiliser application	• Farm data • Food integrity & security • Sustainability & environmental	• Increased yield, productivity, efficiency, profitability, sustainability

Table 2-8 (Continued)

Shortlisted technologies	Relevant research strength	NI Market need
D) Data analytics **Examples:** Optimisation of processes, evidence supporting best practices, delivery truck routes efficiencies	• Food integrity & security • Farm data	• Increased efficiency, productivity, profitability, sustainability
E) Factory/warehouse automation **Examples:** generic automation technologies (PLCs, SCADA systems, temperature control), human replacement technology e.g. optical scanners rejecting unsuitable food, automatic food packaging	• Robotics / advance manufacturing	• Increased efficiency, productivity, profitability
F) Farm equipment & manufacturing thereof **Examples:** Tractor implements (trailers, tankers, mowers, diet feeders), dairy technology – (robotic platforms, traditional parlours, etc), animal handling / weighing equipment, poultry sector equipment (feeding, heating, catching)	• Robotics / advance manufacturing	• Increased efficiency, productivity, profitability
G) Food safety/quality control **Examples:** Testing of food samples, equipment used to monitor quality for food processing (e.g. hyperspectral laser checking on the ageing of cheese)	• Food integrity & security	• Increased efficiency, productivity, profitability, sustainability • Meeting compliance requirements
H) Logistics & distribution **Examples:** Route optimisation technologies, biofuel / electric HGVs	• Not applicable	• Increased efficiency, productivity, profitability, sustainability
I) Nutrition/product development **Examples:** Nitrate free bacon, foods for specific dietary needs, food types that have additional health benefits	• New product development, value added products	• Increased profitability
J) Sustainability/Environment **Examples:** Anaerobic Digestion technology, biogas, Lidar/multispectral scanning, pollution monitoring sensors, methanogenesis inhibiting ruminant feed additives, soil carbon sequestration, renewables	• Sustainability & environmental	• Increased efficiency, sustainability
K) Traceability **Examples:** Ledger technology to ensure full traceability of product from farm to fork, animal electronic identification/RFID tags	• Traceability • Food integrity & security	• Increased efficiency, profitability • Meeting compliance requirements

One technology area – logistics and distribution – does not have a clear research strength in NI, whilst the other technology areas align with research strengths and market needs.

2.6.1 Global windows of opportunity

Global windows of opportunity for NI's Agri-Tech sector are identified by considering the future outlook for global food markets, which are being driven by a range of factors: demographic changes, income growth and distribution, food prices, socio-cultural and lifestyles changes. The OECD-FAO Agricultural Outlook 2022-2031 provides an overview of the outlook for agricultural commodity markets[33]. Based on the OECD-FAO outlook, global agricultural demand is expected to slow down this decade. Population growth, changing income levels and cultural preferences around diets and nutrition will drive variations in consumption patterns across countries.

Global food demand is projected to increase by 1.4% p.a. over the next decade. Population and per capita income growth will be key drivers of additional demand, as additional demand for food comes from low and middle-income countries, while high-income countries are expected to be constrained by slow population growth and per capita consumption levels reaching a saturation point.

- The regions expected to drive global production growth are predominantly located in low and middle-income countries, including India, China and other Asian countries. There, growth in production is expected to be driven by productivity-increasing investments in agricultural infrastructure and research and development; the mobilisation of production resources, such as agricultural land and irrigation water; more intense use of agricultural inputs; and improved management skills
- Other areas of growth include Sub-Saharan Africa, driven by productivity gains, including an expansion and intensification of poultry flocks. Production growth in Near East and North Africa is expected to stem from productivity gains and growth in poultry meat production
- North America and Western Europe is expected to have limited production growth, with more stringent regulations on environmental sustainability and animal welfare.

These factors suggest that low and middle-income countries, including India and China, present a market opportunity for technologies that can increase efficiency and productivity in the growing agri-food sub-sectors in these jurisdictions. For example, in animal data analytics and genetics, factory/warehouse automation, and food safety/quality control technologies, NI has clear research strengths that can be built upon by developing partnership with agri-food players in key emerging markets.

Similarly, with an expected focus on increasing productivity and an increase in poultry meat production, Sub-Saharan Africa, and Near East and North Africa present an opportunity for solutions that increase productivity as well as technologies applicable to the poultry sector. For example, NI can leverage its research strengths in animal data analytics / genetics and its industrial strengths in the poultry sector to explore opportunities in markets in these regions.

On a policy level, with regional policies on sustainability set to become more stringent, North America and Western Europe show potential for technologies that support sustainability and animal welfare. For example, animal data analytics and genetics, crop/feedstock genetics and analytics, and sustainability / environment. The global windows of opportunity are mapped against NI's technologies and research strengths in the table below.

[33] OECD-FAO Agricultural Outlook 2022-2031, (2022).

Table 2-9: Technologies, research strengths and global windows of opportunity

Shortlisted technologies	Relevant research strength	Potential market need	Potential international markets
A) Animal data analytics & genetics **Examples:** Animal breeding for optimal characteristics (Longevity, milk yield, physical characteristics, etc), sensors attached to animals for early disease detection and treatment, sensors on animal housing, software to process animal data and tailor a diet to optimise production/body condition, nutritional supplements	• Genetics • Farm data • Nutrition	• Increased yield, productivity, efficiency, profitability, sustainability	• Middle- and low-income countries • Sub-Saharan Africa, and Near East and North Africa • North America and Western Europe
B) Cold chain management **Examples:** Temperature logging devices to monitor changes during travel and storage, ensuring food is kept fresh, sensors within food to detect when chilled food has gone out of date rather than relying on date estimations	• Food integrity & security	• Increased efficiency, sustainability	• North America and Western Europe
C) Crop/feedstock genetics & analytics **Examples:** Crop breeding for optimal characteristics (drought resistance, maximise yields, pest resistance), analysis of crop utilising satellite imagery to identify areas affected by disease, utilising infra-red imagery for targeted nitrogen fertiliser application	• Farm data • Food integrity & security • Sustainability & environmental	• Increased yield productivity, • efficiency, profitability, sustainability	• Middle- and low-income countries • North America and Western Europe
D) Data analytics **Examples:** Optimisation of processes, evidence supporting best practices, delivery truck routes efficiencies	• Food integrity & security • Farm data	• Increased efficiency, productivity, profitability, sustainability	• North America and Western Europe
E) Factory/warehouse automation **Examples:** generic automation technologies (PLCs, SCADA systems, temperature control), human replacement technology e.g., optical scanners rejecting unsuitable food, automatic food packaging	• Robotics / advance manufacturing	• Increased efficiency, productivity, profitability	• North America and Western Europe

Table 2-9 (Continued)

Shortlisted technologies	Relevant research strength	Potential market need	Potential international markets
F) Farm equipment & manufacturing thereof **Examples:** Tractor implements (trailers, tankers, mowers, diet feeders), dairy technology – (robotic platforms, traditional parlours, etc), animal handling / weighing equipment, poultry sector equipment (feeding, heating, catching)	• Robotics / advance manufacturing	• Increased efficiency, productivity, profitability	• North America and Western Europe
G) Food safety / quality control **Examples:** Testing of food samples, equipment used to monitor quality for food processing (e.g. hyperspectral laser checking on the ageing of cheese)	• Food integrity & security	• Increased efficiency, productivity, profitability, sustainability	• Middle- and low-income countries • North America and Western Europe
H) Logistics & distribution **Examples:** Route optimisation technologies, biofuel / electric HGVs	• Not applicable	• Increased efficiency, productivity, profitability, sustainability	• North America and Western Europe
I) Nutrition/product development **Examples:** Nitrate free bacon, foods for specific dietary needs, food types that have additional health benefits	• New product development, value added products	• Increased profitability	• North America and Western Europe
J) Sustainability/Environment **Examples:** Anaerobic Digestion technology, biogas, Lidar/multispectral scanning, pollution monitoring sensors, methanogenesis inhibiting ruminant feed additives, soil carbon sequestration, renewables	• Sustainability & environmental	• Increased efficiency, sustainability	• North America and Western Europe
K) Traceability **Examples:** Ledger technology to ensure full traceability of product from farm to fork, animal electronic identification/RFID tags	• Traceability • Food integrity & security	• Increased efficiency, profitability	• North America and Western Europe

2.7 Funding landscape

Invest NI (INI) supports businesses in NI through a number of different funding support programmes. Between 2017 and 2022, INI provided ~£48m in R&D related support to agri-food businesses. Previous funding schemes provided to the sector for R&D has the potential to be further deployed and potentially updated. Figure 2-8 and Table 2-10 illustrate and summarise the breakdown of this support.

Figure 2-8: Support 2017/18 – 2021/22 across all Invest NI activities[34]
(Invest NI support offered for agri-food sector only, £m)

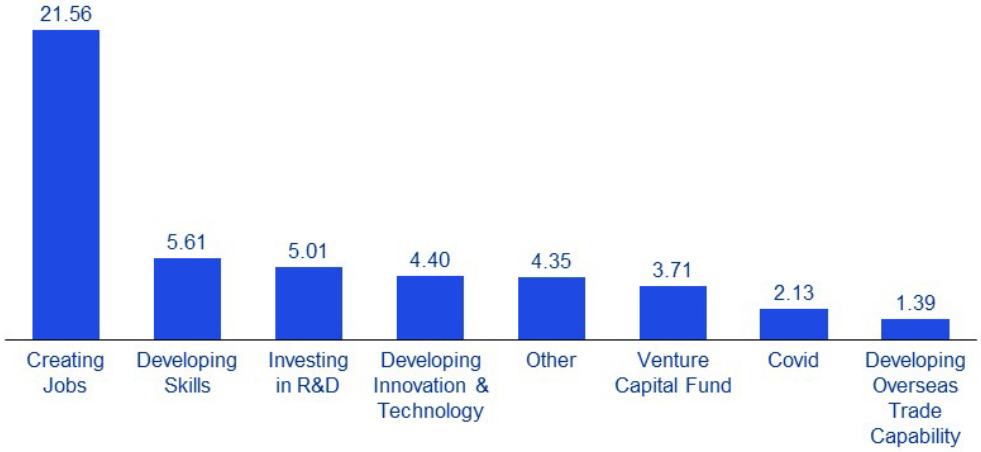


Table 2-10: Research and development support[34]

R&D support name	Description of support	Total budget
Innovation Vouchers (Click here for additional information)	£5K Innovation Vouchers allow businesses or potential entrepreneurs to seek expertise from a public sector knowledge provider, such as a University or College (NI and ROI) for your innovation project.	Current annual budget: £800k
Technical Development Incentive (Click here for additional information)	The Technical Development Incentive (TDI) is designed to encourage companies to engage in the innovation activities of product development, process improvement and the identification and protection of intellectual property. TDI provides local SMEs with funding of up to £10,000 towards the cost of technical service providers (test-houses, product development consultants, certification bodies, IP specialists etc) to implement innovative solutions.	Current annual budget: £1 million
Grant for R&D (Click here for additional information)	Financial assistance for planning and developing new or better products, processes, and services.	2023-34 budget: £20-£30 million

[34] Invest NI data.

Table 2 -10: (Continued)

R&D support name	Description of support	Total budget
Knowledge Transfer Partnership (KTP) (Click here for additional information)	A KTP is a subsidised three-way partnership between a business, a high-calibre graduate and an academic institution. It is a cost-effective way for businesses to attract fresh talent and access the expertise in universities and colleges to deliver strategic innovative solutions to achieve business growth. Graduates gain vital experience delivery projects in their fields of expertise and many are offered a permanent job with the company after the project is completed. The scheme is funded by Innovate UK and Invest NI. They partner businesses and graduates, matching project requirements with management or technical skills and academic disciplines. They also offer both Technical KTP and Management KTP Programmes. For both programmes, projects typically last about two years and funding is available for up to 67% for SMEs, 50% for Large Companies.	Invest NI contribution: £4.9 million over 5-years.
Innovate UK (Click here for additional information)	Invest NI is a proud partner of Innovate UK. An executive, non-departmental public body sponsored by the Department for Business, Energy and Industrial Strategy (BEIS). Innovate UK is the UK's innovation agency. Innovate UK understand that taking a new idea to market is a challenge. They fund, support and connect innovative businesses through a unique mix of people and programmes to accelerate sustainable economic growth.	N/A
Innovate UK EDGE (Click here for additional information)	Innovate UK EDGE, formerly known as Enterprise Europe Network (EEN), is the UK innovation agency's resource for innovative SMEs from any sector which are ambitious to grow and scale. Although the UK has left the European Union, Innovate UK EDGE provides businesses with all the benefits associated with EEN, including access to international networks and innovation and growth experts. Invest NI hosts Innovate UK Edge in Northern Ireland; advisors can be a mentor, critical friend, and champion to innovative businesses, enabling them to grow and scale. They can help organisations access support from Innovate UK EDGE including one-to-one mentoring, peer-to-peer networks, brokerage events, partnership opportunities and programmes such as the Global Business Innovation and Global Incubator programmes.	N/A
Agri-Food QUEST (Click here for additional information)	Competence centres offer companies an opportunity to develop new products, processes and services and bring them more quickly to global markets, as well as giving local businesses access to leading edge solutions and skills. Competence centres bring together universities, research institutes and innovative businesses to carry out strategic collaborative research in areas with a direct industrial focus. It is open to any company based in Northern Ireland or internationally, that wants to collaborate in applied research relevant to them at a reduced cost.	Scheme closed Budget: £5 million (£1 million per year)

2.7.1 City and Growth Deals

The above summary highlights the breadth of R&D support available to the sector. In addition, growth deals present further opportunities to support the agri-food sector, examples include the City and Growth Deals:

1 **Belfast Region City Deal (£850m)[35]:** One of the foci of the Belfast Region City Deal is 'Building our Digital and Innovation Capability', focused on driving investment towards growing resilient sectors. A sample of what this funding is being invested in relation to Agri-Tech includes:

- Advanced Manufacturing Innovation Centre (AMIC) which will provide the Advanced Manufacturing and Engineering sectors with access the very latest manufacturing technology and Industry 4.0 smart automation
- i4C Innovation Centre at St Patrick's Barracks which involves the construction of a new, significant scale innovation and clean technology centre for SMEs
- Deliver a series of Innovation Hubs across the region

In addition, a project in the following area is being considered:

Global Innovation Centre (GII):

- The proposal will be a nexus for co-innovation between researchers and industry in data security, connectivity and analytics. It is a cross-disciplinary project led by Queen's University, focusing on Cyber Security, Health Sciences and Food Safety
- GII will expand upon the research infrastructure already in place in the areas of Cyber Security, Health Sciences and Food Safety. The Institute for Global Food Security is engaged in specialist research on the integrity and sustainability of food systems across the world

2 **Mid South West Growth Deal (£252m)[36]**: Agri-food is a key focus of the Mid South West Growth Deal. A sample of the proposed agri-food actions include:

- The development of a network of Digi-Hubs in Mid South West

In addition, projects in the following areas are being considered:

Agri Bio Innovation Centre (ABiC):

- ABiC will be a location to support product development for the agricultural and Agri-Tech industry, fostering the commercialisation of new technology and improving uptake amongst primary producers
- The Food Incubation space will support early-stage food and drink producers by overcoming typical barriers to growth such as access to food-grade equipment, facilities, and specialist support

Robotics, Automation and Packaging Innovation Centre (RAPIC):

- The Robotics Automation and Packaging Innovation Centre (RAPIC) will aim to provide innovation, knowledge transfer and education through CAFRE's well-established provision and will focus on key industry challenges such as robotics, automation, vision systems, hygienic design, and digitisation
- The proposal will also enhance existing work on alternative packaging solutions for increased sustainability, and explore new, low-energy processing technologies

[35] https://belfastregioncitydeal.co.uk/
[36] https://midsouthwestregion.org/

3 **Derry and Strabane City Deal (£250m)[37]:** Using innovation and digital to drive productivity and competitiveness is one of the four goals of the Derry and Strabane City Deal. A sample of the proposed agri-food actions include:

— Centre for Industrial Digitalisation, Robotics and Automation (CIDRA)
— Cognitive Analytics Research Laboratory (CARL)

4 **Causeway Coast and Glens Growth Deal (£72m)[38]:** This deal has identified six key themes/ sectors to help grow the local economy and covers; innovation, tourism and regeneration, infrastructure, employability and skills, digital connectivity, energy / green economy

In addition, projects in the following areas are being considered:

Foodovation:

- The proposal is looking at supporting current and aspiring industry producers across the region
- Foodovation, will be a new state-of-the-art research and development centre which offers facilities to develop excellence in food Innovation, science and technology

Centre for Food and Drug Discovery (CFDD):

- The proposal is looking at supporting Ulster University's significant position of strength in drug discovery, food and pharmaceutical health innovation
- CFDD will be leveraging existing research excellence to provide a single-site, preclinical hub for the biopharmaceutical and food industry delivering capability, capacity, and expertise at all key stages of the discovery pipeline

2.7.2 Capital Grant for Food Processors

Based on feedback received from stakeholders, especially food processors, relatively low industry margins curtail commercial funding options for capital investments that could enhance productivity. Whilst capital grants are available, these are more focused on small and medium-sized enterprises (SMEs). Businesses are able to access supports, however, this is capped as a percentage of the business's investment. This was cited as a constraint to significant investment by larger businesses.

[37] https://derrycitydeal.com/
[38] https://www.investni.com

3 Economic profile

This section provides an economic profile of the sector, based on the sector definition outlined in section 1, considering NI businesses that provide Agri-Tech related solutions (products and services) to various end users.

Sector metrics, discussed in the market sizing section, have been derived based on a survey of NI Agri-Tech businesses and publicly available information on NI businesses that provide Agri-Tech related solutions. In addition, sector metrics are used to provide an estimate of the sector's economic impact in terms of Gross Value Added (GVA) and employment.

Agri-Tech spans a number of areas and includes technologies that provide both traditional/current solutions and/or emerging/novel solutions. The sector plays a key role in improving productivity for both primary agriculture and the food processing sector.

3.1 Market sizing

Sector metrics are based on a survey of NI Agri-Tech businesses, with survey metrics being scaled up based on assumptions of the total number of businesses currently active in the sector, considering a range for the total number of businesses to account for possible variation in the actual total number of active businesses.

3.1.1 Methodology and assumptions

Using publicly available information, a list of 97 businesses was compiled. To account for businesses not included on the list, a sensitivity of 10% was assumed, giving a total of 107 businesses. Accordingly, the total number of businesses currently active in the sector is assumed to range between 97 (lower estimate) and 107 (upper estimate). Based on the type of solutions these businesses provide, each was categorised into the six technology sub-sectors outlined in section 2.4:

- Advanced materials & supply chain technologies
- Agri-engineering
- Food processing technologies
- ICT
- Life Sciences
- Nutrition & animal feeds

These totals are used to scale up the survey results into sector level metrics. A total of 54 businesses completed the survey. Each was asked to specify the share of their revenue derived from their businesses Agri-tech activities and these responses are summarised in Table 3-1 below.

Table 3-1: Agri-Tech related revenue[39]

Proportion of Agri-Tech derived revenue	Share of respondents
Up to 10%	0%
11% - 25%	17%
26% - 50%	30%
Greater than 50%	54%

3.1.2 Sector metrics

Considering the proportion of Agri-Tech derived revenue, respondents' revenue figures were scaled up for the range of 97 to 107 businesses active in the sector. Respondents were also asked to classify their business as indigenous or foreign owned, and in which local council area their business is located. Industry metrics derived from survey responses are summarised in Table 3-2 below.

Table 3-2: Industry metrics (upper market size estimate used)[39]

Agri-Tech sub-sector	Number of businesses	Total Agri-Tech derived revenue (£m)	Average Annual Agri-Tech revenue per business (£m)	Full time employment
Advanced materials & supply chain technologies	14	78	5.54	690
Agri-Engineering	54	274	5.07	1,790
Food processing technologies	6	12	2.02	110
ICT	18	17	0.93	220
Life sciences	6	155	25.85	850
Nutrition & animal feeds	9	278	30.90	720
Total	107	813	7.60	4,380

Note: Sub-sectors were identified by considering the existing sector classifications used by Invest NI and through input from stakeholder consultations.

The 97-107 businesses make up the NI Agri-Tech sector. These are spread across areas including advanced materials & supply chain technologies, agri-engineering, food processing technologies, ICT, life sciences, nutrition & animal feeds. The sector accounts for up to £813 million in annual revenue and up to 4,380 full time employees.

Average revenue for the Agri-Tech sub-sectors nutrition & animal feeds and life science have an average income well above the rest of the Agri-Tech sub-sectors. There are two large businesses that drive up the average for their respective sub-sectors. Excluding these two businesses, the average annual Agri-Tech derived revenue is £5.2M per business.

[39] Industry survey, KPMG analysis

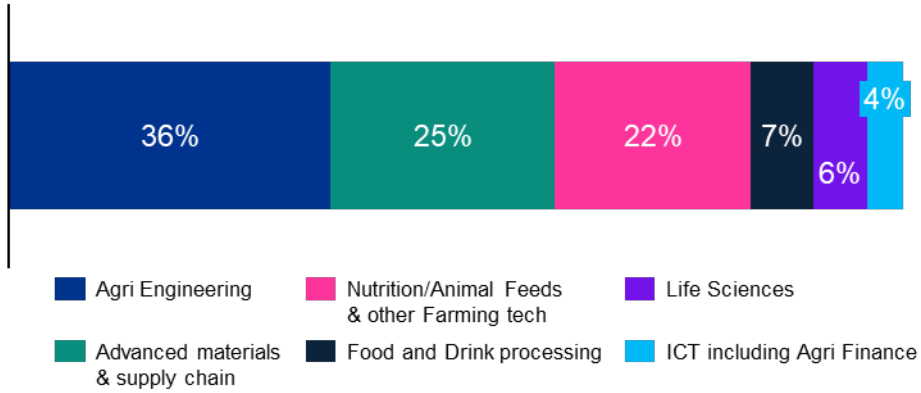
Table 3-3: Regional split of Agri-Tech businesses[40]

Council area	% split of business	% split of revenue
Belfast City Council	15%	36%
Newry, Mourne and Down District Council	7%	19%
Mid Ulster District Council	35%	17%
Armagh City, Banbridge and Craigavon Borough Council	9%	14%
Fermanagh and Omagh District Council	9%	5%
Derry City and Strabane District Council	9%	5%
Other Council areas	16%	4%

Over 57% of Agri-Tech businesses are located within Belfast City Council, Newry, Mourne and Down District Council and Mid Ulster District Council administrative areas and collectively make up 72% of the sector's revenue. It is estimated that ~97% of the Agri-Tech sector revenue is linked to indigenous owned business.[40]

Figure 3-1 below shows the share of respondents to the industry survey by sub-subsector. Agri-engineering accounts for the largest share of the sector (36% of respondents), followed by advanced materials & supply chain (~25% of respondents).

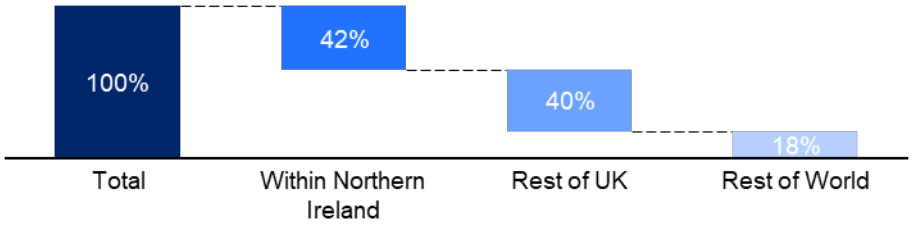
Figure 3-1: Breakdown of respondents by sub-sector, % of total[41]



[40] Industry survey, KPMG analysis
(Note: Business that have multiple offices have not been taken into account)
[41] Industry survey

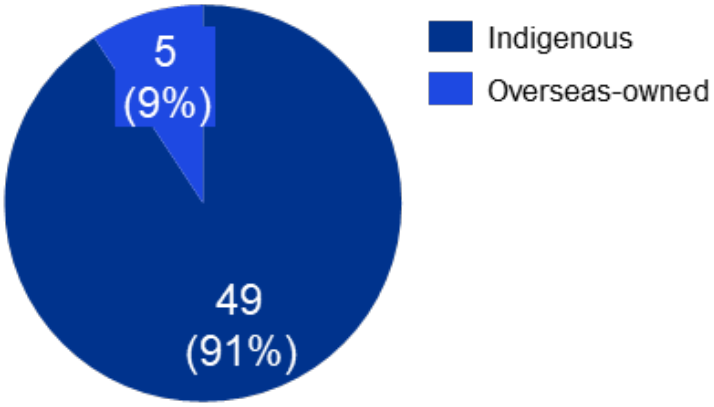
Based on the industry survey, 42% of Agri-Tech businesses' revenue is generated from sales in NI. Of the remaining 58%, 40% and 18% are generated from sales to the rest of the UK and to the rest of world. This is illustrated in Figure 3-2 below. A breakdown of revenue by destination for each Agri-Tech subsector is provided in Appendix B.

Figure 3-2: Breakdown of average Agri-Tech revenue by destination, % of total[42]



Of the 54 survey respondents, 91% of are indigenous businesses and 9% are overseas owned.

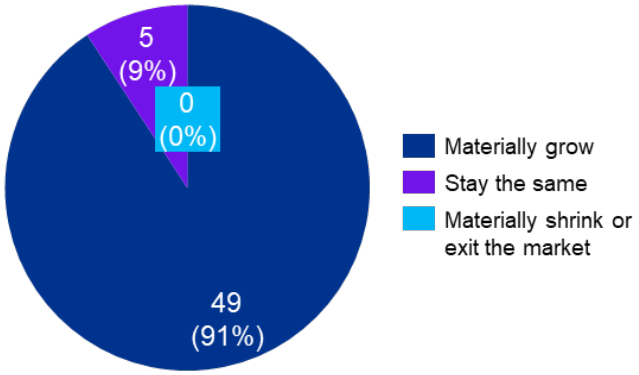
Figure 3-3: Ownership of business, % of total[43]



Survey respondents were asked what their business expectations for Agri-Tech revenue over the next 5 years are (answer options were; 'materially grow, 'stay the same' or 'materially shrink or exit the market'). Over 90% of the 54 respondents stated they expect the sector to materially grow. No responses anticipate that the market will materially shrink or if their business is considering exiting the market. Overall, there is a strong positive outlook for the sector.

[42] Industry survey
[43] Industry survey

Figure 3-4: Agri-Tech sector outlooks[44]



The Agri-Tech sector supports up to 4,380 jobs, and the workforce has a breadth of skills and good employment opportunities. Table 3-4: Agri-Tech job titles and salaries, *202320F* below provides a sample of these roles and a lower and upper bound estimate of their annual salaries. The annual salary is exclusive of bonuses, benefits and commissions.

Table 3-4: Agri-Tech job titles and salaries, *2023*[45]

Job title		Annual salary (£'000)	
		Lower bound	Upper bound
R&D	R&D Scientist	22	35
	Formulation Scientist	22	35
	Senior Scientist/Chemist	28	40
Technology	Software Engineering & Development	35	70
	Data Scientist	45	75+
	Data Analyst	35	75+
	Insights Analyst	35	75+
	BI Analyst	35	75+
Engineering	Automation Engineer	60	90+
	Design Engineer	45	75
	H&S Engineer	50	75+
	Instrumentation Engineer	45	70
	Instrumentation Technician	45	50
	Maintenance Engineer	50	65
	Manufacturing Engineer	55	75
	Manufacturing Technician	30	45
	New Product Development Technologist	40	50
	Process Engineer	60	90+
	Process Improvement Engineer	55	75+
Sales	Field Sales Representative	30	40
	Area Sales Manager	35	65+
	Senior Business Developer	35	45
	Technical Sales Rep	20	40
	Technical Sales Manager	45	55

[44] Industry survey
[45] CPL, NISRA, KPMG analysis

A number of the Agri-Tech job titles shown in the table above are also outlined in the DfE's Bulletin on Food Careers (June 2023). This bulletin provides information on the jobs in the food sector in Northern Ireland including:

- Skills in demand
- Career snapshots from local people in the sector
- Local entry routes

3.2 Economic impacts

Economic impact assessments consider the injection of income as a result of a specific event, policy choice or economic activity from a specific industry. The Agri-Tech sector buys inputs that are produced in different sectors within the economy. The purchase of production inputs creates a flow of expenditure and a multiplier impact within the economy.

The geographic/spatial viewpoint assumed in an economic impact analysis will influence the extent of leakage of expenditure. For example, on a local authority level, more value chain inputs will be sourced from "outside" the focus area, resulting in leakage of expenditure outside the focus area. Similarly, on a national level, imported components will create a leakage of expenditure that lowers the overall economic impact.

3.2.1 Economic impact analysis

An increase in demand for Agri-Tech technology products and services require producers (the sector) to increase their purchases of goods and services from their suppliers to produce the product/service in question.

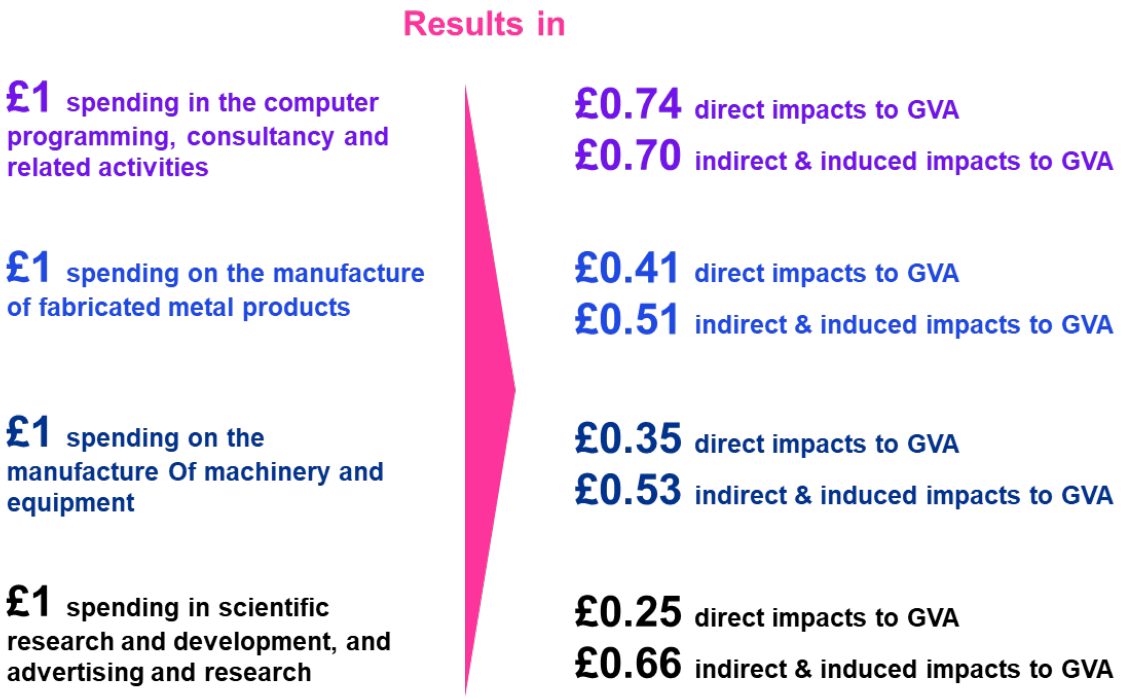
In turn, suppliers to the Agri-Tech sector increase their purchases of the goods and services they need to produce the products they supply to the Agri-Tech sector. This creates additional rounds of expenditure in the value chain, also referred to as the multiplier impact, that leads to increased output and employment. The overall economic impact can be categorised in terms of the following components:

1 **Direct**: impacts directly accruing from expenditure by Agri-Tech businesses in the sector (e.g., purchase of component inputs)
2 **Indirect**: impacts generated by expenditure by firms within the sector's supply chain
3 **Induced**: impacts generated by the spend of individuals and firms outside the sector as a result of increased incomes (e.g., additional household expenditure as a result of increased incomes).

The sector's estimated total revenue of £813 million stated in section 3.1 has been used to calculate the flow of expenditure and the multiplier impact within the economy through a range of multipliers. Economic multipliers vary across sectors due to different inter-industry linkages within the economy.

We have supplied a sample of GVA direct and indirect & induced multipliers in Figure 3-5 below. An example of how this is applied is £1 spent on computer programming by a Agri-Tech businesses results in £0.74 in direct impact to GVA from the Agri-Tech sector and £0.70 indirect & induced impacts to GVA for the economy from additional rounds of expenditure in the value chain.

Figure 3-5: Sample of GVA multipliers for Agri-Tech sector[46]



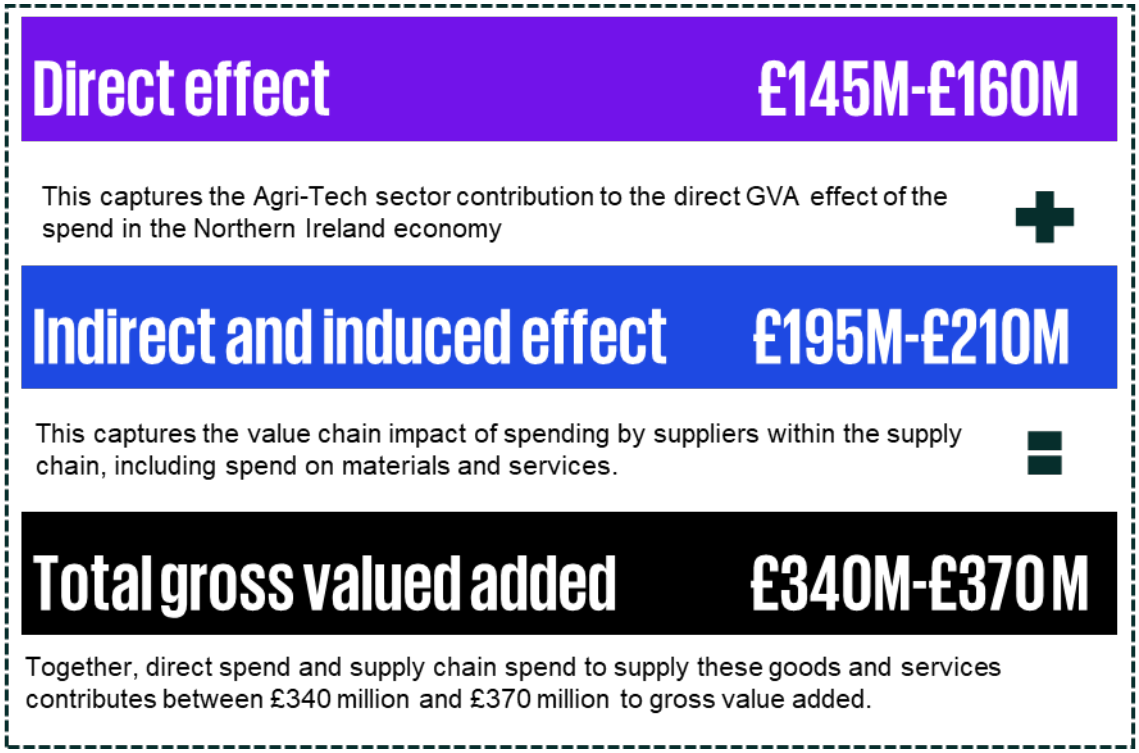
We estimate the NI level economic impact of the Agri-Tech value chain in terms of Gross Value Added (GVA). Based on the geographic spread of Agri-Tech businesses surveyed, we estimate the potential regional dispersion of these impacts.

[46] NISRA: Supply-Use tables for the Northern Ireland Economy.

3.2.2 Findings and implications

The sector's multiplier impact in terms of Gross Value Added (GVA) was estimated by considering the assumed range of 97 to 107 Agri-Tech businesses, and the associated sector revenues, the results are summarised in Figure 3-6 below.

Figure 3-6: Economic output - composition of the multiplier impact[47]



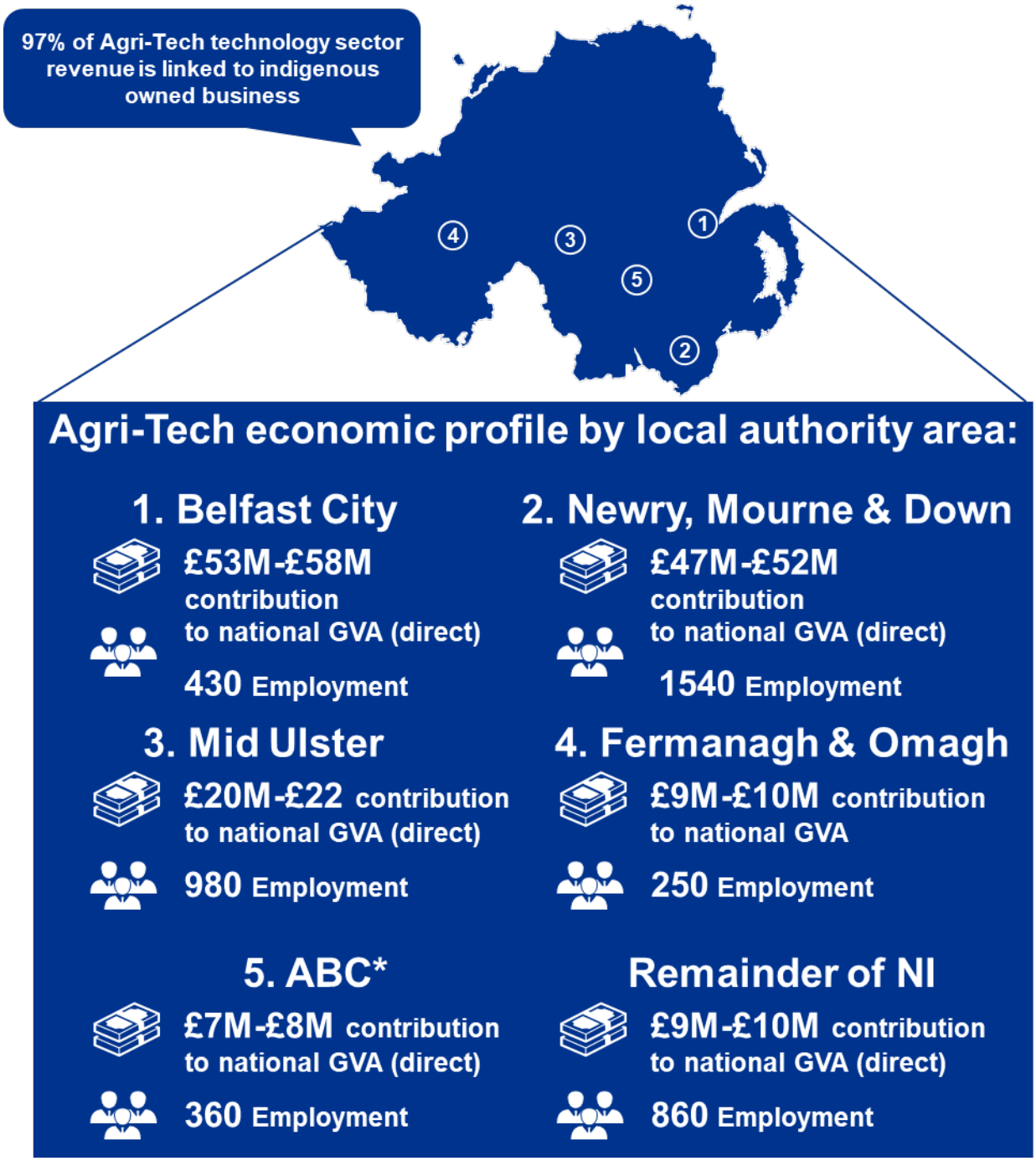
The sector is estimated to have a direct GVA impact of between £145 million and £160 million accruing from expenditure by Agri-Tech businesses in the sector (e.g. purchase of component inputs)

The spill over/value chain impacts in terms of indirect and induced impacts range between £195 million and £210 million, giving an estimated total contribution to GVA of between £340 million and £370 million.

Survey responses on businesses' local council area are used to determine Agri-Techs relative direct GVA contribution of Agri-Tech businesses operating in specific councils. Similarly, responses on employment are used to estimate the regional dispersion of employment in the sector. This is illustrated in Figure 3-7 below.

[47] Industry survey, KPMG analysis

Figure 3-7: Regional impact (Direct GVA and employment)[48]



[48] Industry survey, KPMG analysis

Note: *Armagh City, Banbridge & Craigavon. GVA and employment is based on the head office location for each business. Businesses that have multiple offices have not been taken into account

4 International learnings

4.1 Introduction

This section provides an overview of global trends in Agri-Tech, considering the following jurisdictions: Australia, Israel, New Zealand, Ireland, the Netherlands, and the United Kingdom (excluding NI).

4.2 Benchmarking and case studies

4.2.1 Australia

Australia exports more agricultural goods than it uses, exporting 72% of agricultural production. This strong agricultural sector is backed up by a thriving Agri-Tech sector, with over 2,500 companies active in Agri-Food. Australia has a particularly large start-up scene, in 2022 Australia was home to over 480 Agri-Tech start-ups, backed up by 15 Agri-Tech incubators/accelerators. Australia also has a leading food-tech market, ranking 14th in the world for food patenting globally.

Examples / not exhaustive of Australia's Agri-Tech businesses include:

- **AgriDigital** – Digital grain management software connects data, inventory and finance all in one place
- **AgriWebb** – A farm management software for feed, field treatment and livestock medicine available on your mobile device
- **AquaSpy** – An intelligent precision Agri-Tech to monitor soil moisture, 24/7. Helps optimise when & how to water / fertilise crops
- **FoodByUs** – Online platform that enables its users to find, buy, and sell a range of food, including doughnuts, cupcakes, pies, and more
- **Lumachain** – A platform that tracks and traces the origin, location and condition of individual items in a supply chain, in real time, from farm to fork

4.2.2 Israel

The Agri-Tech sector in Israel is a homeland for innovation with the country developing technologies to make the sector work with unfavourable growing conditions. The industry is made up of more than 500 companies, including 265 start-ups with a vast array of technologies across automation, indoor farming, seed technologies, climate control technologies, smart control, water technology and many more. Israel supports innovation through the Ministry of Agriculture, over 10 research and development centres and through entrepreneurship centres and universities.

Examples / not exhaustive of Israel's Agri-Tech businesses include:

- **Agmatic** - Company delivering digital solutions for Ag professionals, harnessing agronomy data science for Agri value-chain optimisation
- **Arugga** - Develops ground robots to treat and monitor individual plants in the greenhouse
- **Beewise** – A robotic beehive that can house 24 colonies, allowing beekeepers to remotely treat their hives and care for their bees
- **ClariFruit** - Offers a cloud-based platform that automatically collects your fresh produce QC data and analyses it
- **Greeneye Technology** – Utilises artificial intelligence and deep learning technology to revolutionise the pest control process in agriculture

- **miRobot** – Automates the entire farm milking routines with a cost effective, add-on robotic solution, integrating with existing milking parlour infrastructures to offer full automation of milking routines.
- **Save Foods** – Improves the food safety and shelf life of fresh produce. By controlling human and plant pathogens, Save Foods allows growers, packers, and food retailers to reduce their waste

4.2.3 New Zealand

New Zealand (NZ) has long been a world leading exporter of quality food. The country has a history of innovation across the primary sector e.g. the electric fence, gold kiwifruit and AI-enabled smart cow collars. The country has a strong relationship between its companies and government entities within the Agri-Tech sector. NZ has significant strengths in the following technology areas animal & crop health, growing & harvesting, post-harvest, environment. NZ also has an 'New Zealand Food Innovation Network' which gives business access to the facilities and expertise needed to develop new products and processes.

Examples / not exhaustive of New Zealand's Agri-Tech businesses include:

- **Gallagher** – Delivers animal management solutions such as electric fencing, weighing and electronic identification, data collection, and wireless water monitoring systems
- **LIC** – An Agri-Tech and herd improvement co-operative which provides livestock farmers with genetics and technology
- **Robotics Plus** – Design and build robotic technologies such as mobile log scaler, unmanned ground vehicle, robotic fruit packer
- **Tomra Food** – develops, designs and adapts optical food sorting solutions to protect and empower food business

4.2.4 Ireland

The Irish Agri-Tech sector is currently made up of a relatively small cohort of companies, however the strong state backing through funding, accelerator programmes and establishment of industry bodies has created a conducive environment to grow this sector. Ireland aims to become a hub for Agri-Tech start-ups. The food-tech sector has similar state provisions to Agri-Tech and is supported by a range of research centres such as Teagasc Moorepark.

Examples / not exhaustive of Ireland's Agri-Tech businesses include:

- **Keenan** – Provide precision diet feeding technology to optimally mix and prepare feed for maximum animal performance
- **Farmers Business Network** – Have unveiled a AI chatbot that pulls information from publicly available data on weather, soil monitoring, application rates, current events and other areas relevant to provide insight to farmers
- **Moocall** – Provide livestock monitoring sensors that monitor pregnant cows
- **Proveye** – Is an AI-powered digital image analysis platform. It employs proprietary market-leading image correction technology to produce a faster, more accurate picture of what happened, what's happening, and what might happen.
- **Safefood 360** – Offers innovative food safety software designed to provide an integrated solution for food safety and supplier management needs
- **Senoptica** – Developed a new sensor that can be printed into active packaging that will help reduce food waste on the most resource intensive and valuable food

4.2.5 The Netherlands

Agri-Tech in the Netherlands is highly innovative and well advanced in terms of sustainable practice featuring technology providers such as Holstcenter and innovative universities like Wageningen University & Research (Foodvalley) and is home to 335 Agri-Tech start-ups.

The sector has a highly collaborative model of working, with competitors and various elements of the supply chain collectively working together to provide solutions internationally enabling international competitive advantages.

Examples / not exhaustive of The Netherlands' Agri-Tech businesses include:

- **Aris** – Develop research, produce, install and maintain advanced vision systems for agro and food such as high-speed sorting of poultry in slaughterhouses, counting day-old chicks in hatcheries at high speed, robotic handling for plant cultivation
- **Green Automation** – Designs, develops, manufactures and markets fully automated NFT growing systems for commercial hydroponic leafy greens production
- **Protix** – Create natural and sustainable proteins from insects for livestock and pet food
- **Solynta** – Developing hybrid potato varieties with superior traits and performance to help grow a more sustainable future

4.2.6 The United Kingdom (excluding NI)

The agricultural sector in the UK contributed a total income from farming of £5,998m in 2021 and provides a large source of employment, exports and innovation across the UK. The Agri-Tech sector in the UK has seen the development of a number of multi million dollar start-ups through their development, growth and innovation throughout the UK. The UK government has enhanced their offerings towards new Agri-Tech start-ups and innovation leaders through their offerings within innovation centres and funding.

The UK has a number of incubators and innovation hubs that specialise in Agri-Tech and the wider tech sector. These include:

- **Barn4** – Barn4 based in Cambridge is a specialist National Institute of Agricultural Botany incubator dedicated to providing the facilities and support that start-ups need to succeed in Agri-Tech. They provide a range of facilities from hot desks, labs, glasshouses, for start-ups and SME

- **ONE (Opportunity North East) Tech Hub** in the former Gray's School of Art in Aberdeen, Scotland. The building offers hot-desking, co-working spaces, offices, a café, meeting rooms and event spaces for up to 150 people. The space is home to 13 digital technology businesses and five partner organisations. More than 70 people regularly work in ONE Tech Hub. On top of the physical space, ONE Tech Hub runs events and education programmes for start-up founders and entrepreneurs. These range from informal coffee meetups through foundational courses in product development for early-stage businesses through to Hackathons, where teams compete to develop a business proposal or product in very short timeframes.

  For example, ONE Tech Hub launched a three-year innovative Agri-Tech programme in 2022. The programme engages widely with the farming community in north east Scotland, as well as the supply chain, including trade, processors and end users. The focus is to maximise the benefits from closer collaboration, to improve information sharing, drive out waste and improve efficiency. As part of the programme, there are two Agri-Tech demonstrator farms which install, test and monitor a range of Agri-Tech solutions.[49]

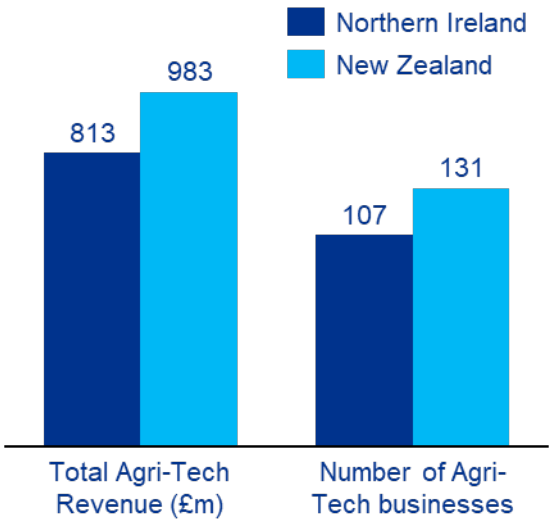
Additional information on Benchmarking and case study analysis of the Agri-Tech sector in a number of jurisdictions has been included in the Appendices.

[49] https://www.opportunitynortheast.com/food-drink-agriculture/oneagritechprogramme

4.3 Comparative metrics

Due to Agri-Tech businesses reaching across a number of different sectors such as agri-food, advance engineering, ICT and life sciences there is little data on the size of each counties Agri-Tech sector. Of the six international comparators, only New Zealand had recent Agri-Tech data. We have compared this data against Northern Ireland in Figure 4-1 below.

Figure 4-1: Agri-Tech comparative metrics, *Northern Ireland and New Zealand*[50]



4.4 Key learnings from case studies

Case studies of these jurisdictions are used to identify key lessons for NI, several of which are set out below:

- The Australian Government has allocated funding for specific programmes within the Agri-Tech sector, identifying opportunities which could support multiple farms. This highlights the importance of funding support. Australia has lots of start-ups, driving innovation across the sector. Supporting start-ups can grow the NI Agri-Tech ecosystem
- Israel has developed Agri-Tech to provide food stability in a challenging agricultural environment with unfavourable growing conditions. Lessons could be learned for a similarly challenging environment in NI. Israel has more than 500 Agri-Food Tech start-ups, which are supported by accelerators and incubators. Accelerators and incubators can support NI Agri-Tech start-ups, providing an environment for testing new products and develop ideas
- New Zealand is a world leading exporter of quality food with a history of innovation across the primary sector. The Government has published an Agri-Tech Sector Transformation Plan (2020) which provides a clear outline and plan for the sector. Development of a NI plan for the sector can set out a clear path to grow the sector
- The Irish Agri-Tech sector has a strong backing from the state, including funding, accelerator programmes and industry bodies. This organisational structure allows for collaboration, funding applications and a wider international reach. Funding, accelerator programmes and industry bodies can support the NI Agri-Tech sector
- The Netherland's agri-food sector is innovative at adopting new technologies at scale. The Netherlands hosts 15/20 of the largest global agri-food players' major research and

[50] Industry survey, TIN: New Zealand Agritech Insights Report, KPMG analysis
Note: Agri-Tech definitions varies between countries and as a result there are differences in calculating their respective metrics

development centres. Promoting technology adoption can help to grow the NI Agri-Tech sector

- The UK Government encourages innovation in the Agri-Tech sector through funding, developing centres of excellence and supporting research. A clear action plan sets out a pathway for the UK to become a world-leader in Agri-Tech. NI could develop a similar approach through using centres of excellence and targeted funding for innovation
- Several of the international technology examples are based on technologies that are easily adopted and can be linked to a farmer's / processer's phone. This means the technologies are easier to implement without equipment or need for significant capital investment. This can include the use of generative AI and the likes of ChatGPT to use publicly available data on weather, soil monitoring, application rates, and current events to provide insight to farmers/producers

Seven global trends have emerged that are also applicable to the NI Agri-Tech sectors:

1 **Efficiency:** There is a focus on increasing efficiency to make inputs go further, creating a market opportunity for technologies that can automate processes, eliminate waste and save time. For example, automation technologies (e.g., PLCs, SCADA systems, temperature control) and human replacement technology (e.g., optical scanners rejecting unsuitable food)
2 **Environmental sustainability:** There is increased awareness of, and policy focus on, reducing the agri-food sector's environmental footprint. This creates a market opportunity for technologies that can reduce emissions, such as anaerobic digestion technology and methanogenesis inhibiting ruminant feed additives
3 **New product development/value added products:** There is an increasing focus on developing novel/value added products and developing waste streams for both the primary agriculture and the food processing industry, linked to trend one and two above. Examples include the use of technologies to create nitrate free bacon
4 **Novel meat products:** Evolving consumer preferences[51] are providing a space for the sector to create alternative protein sources such as plant-based meat and lab-grown meat products. This is linked to the broader sustainability focus, mentioned in trend 1
5 **Data systems:** The collection, processing, use and ownership/custodianship of data is a challenge for the wider adoption of smart data/data analytics and the interoperability of technology solutions. This is also a constraint in the NI context
6 **Skills and training:** A lack of relevant skills and technical training is generally a constraint in the sector. In particular, a lack of candidates with Science, Technology, Engineering and Maths (STEM) qualifications. In NI, more students need to be attracted to study STEM subjects across all levels, and current employees need to be upskilled. Career initiatives could help to attract STEM candidates into food and drink processing, and Agri-Tech businesses. Developing and attracting a pipeline of STEM talent is needed to address this challenge
7 **Funding and capital investment:** In terms of technology adoption, access to capital funding for investment is a constraint for the food processing sector. During consultations, stakeholders have strongly indicated that expanded capital grants, especially for large businesses, could help to support the adoption of Agri-Tech within NI.

[51] Note that consumer preferences are not static and continue to evolve. In addition to price, purchasing decisions are driven by factors such as culture, taste, health, and environmental concerns, including concerns over animal welfare and meat consumption. Alternative dairy products have gained more appeal with mainstream consumers, while alternative meat products (especially lab-grown meat) still have some way to go to garner a similar appeal with mainstream consumers.

5 Challenges and opportunities

Through stakeholder consultations and an industry survey, a number of key challenges and opportunities for the NI Agri-Tech sector have been identified. These challenges and opportunities are explored in this section.

5.1 SWOT analysis

The below figure provides an overview of the strengths, weaknesses, opportunities and threats for the Agri-Tech Sector

Figure 5-1: SWOT analysis

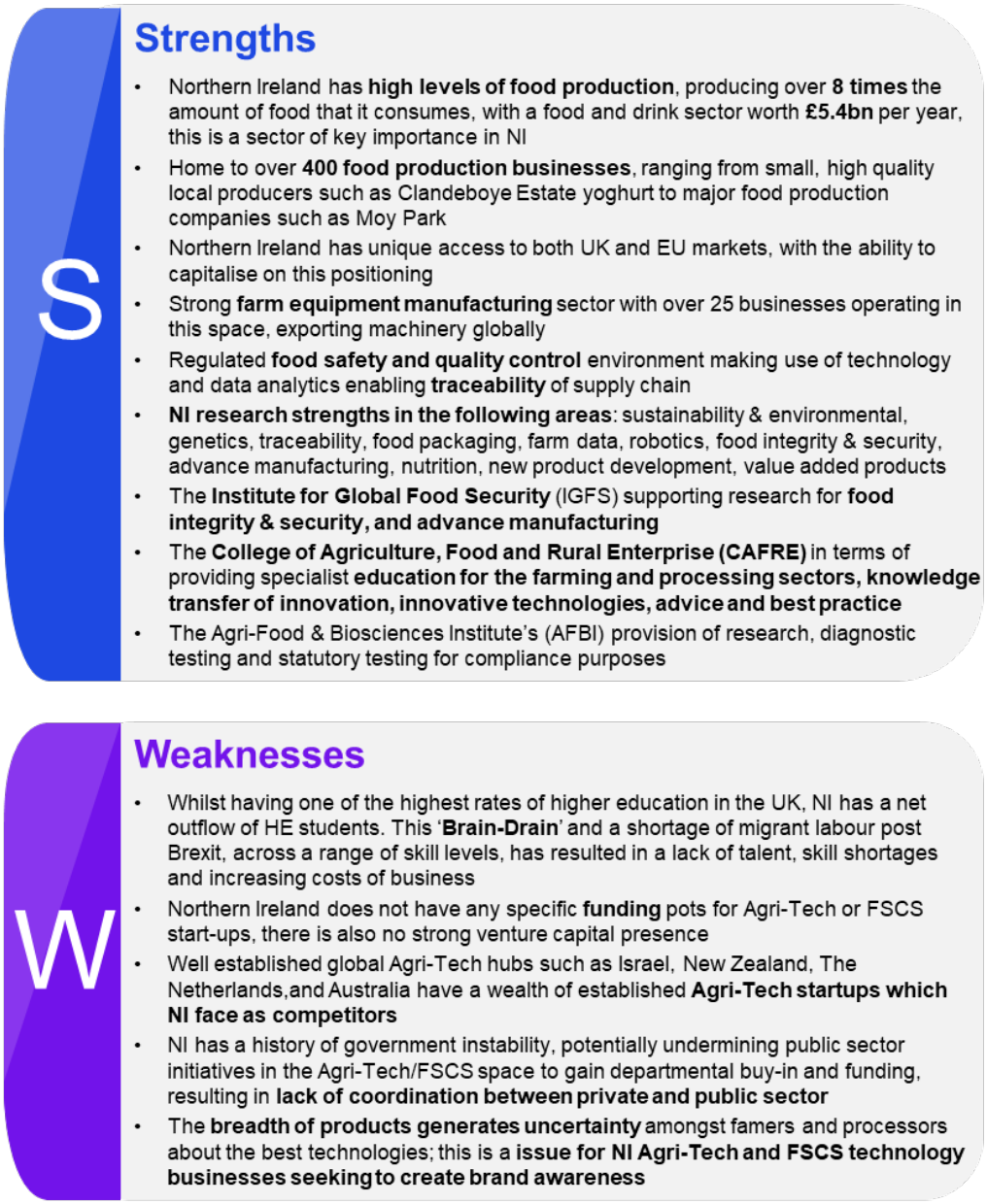
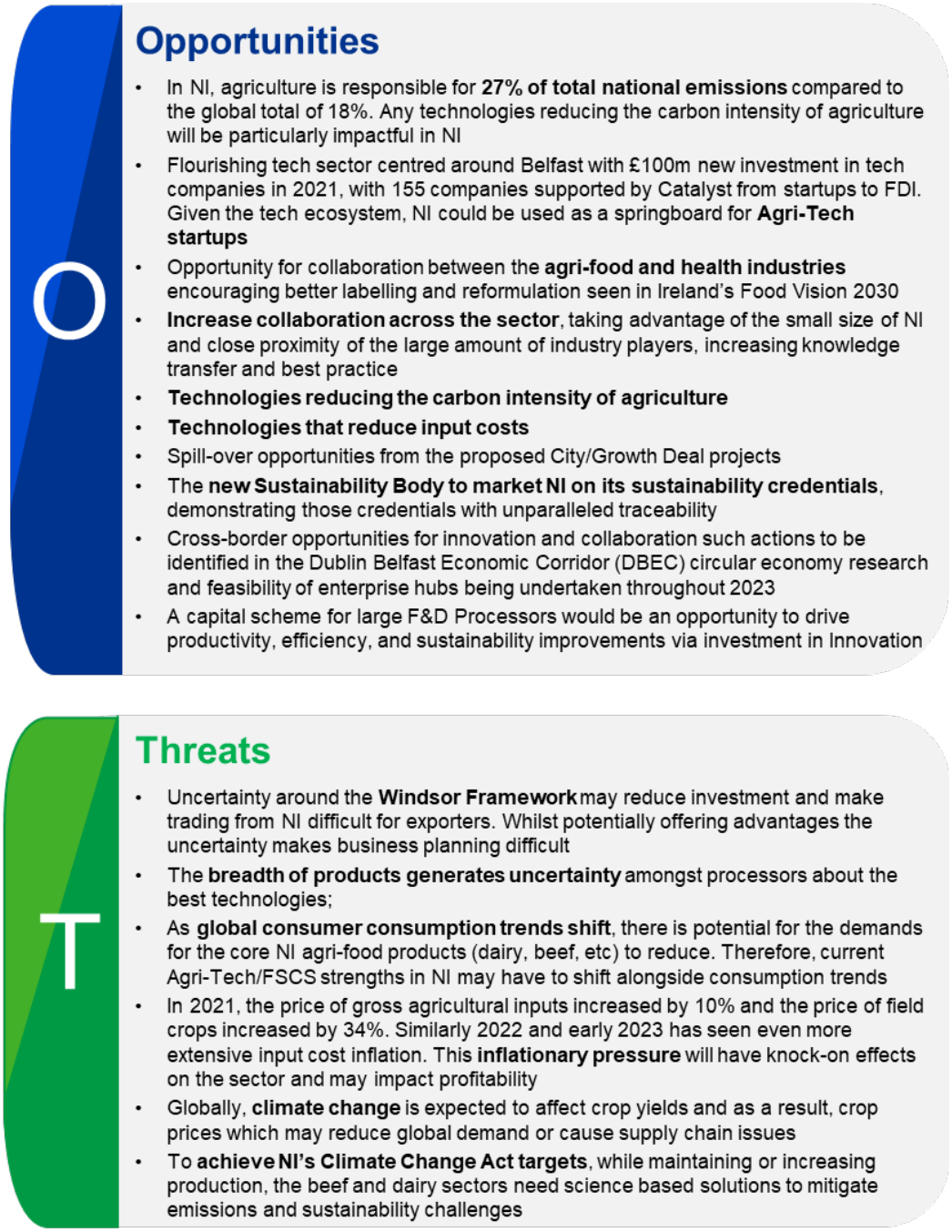


Figure 5-1 (Continued)

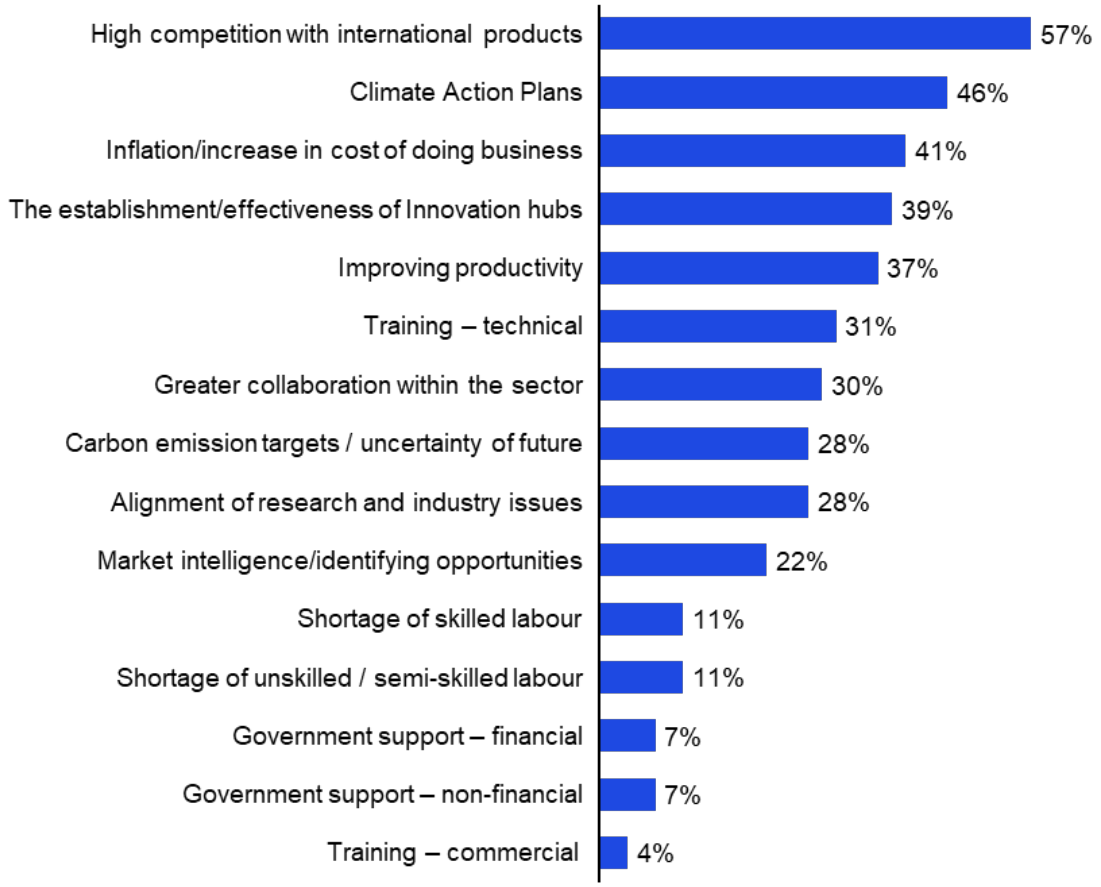


5.2 Overview of key challenges

Through the industry survey, NI based Agri-Tech businesses were asked what the top issues facing the sector are. 57% responded that 'high competition with international products' is a common challenge, followed by Climate Action Plans (46%). The survey respondents noted Government support (7%) and commercial training (4%) as less concerning.

The survey responses on the top issues are summarised in Figure 5-2 below.

Figure 5-2: Responses to the top issues needing to be addressed to make Northern Ireland's agri-food technology sector world leading over the next 10 years[52]



Note: For Government support – financial (7%), and Government support – non-financial (7%), this refers to Agri-Tech companies and not food and drink processing companies

In addition to the industry survey, stakeholder consultations with Agri-Tech businesses and Agri-Food processors were undertaken to identify the main challenges facing the sector and the wider Agri-Food eco-system. This informed the identification of the top five issue that need to be addressed/mitigated to enable NI's FSCS technologies and Agri-Tech sector to be world leading over the next 10 years.

[52] Industry survey

Top five Issues to be addressed over the next 10 years:

1 High competition with international products
Globally there is a wide range of Agri-Tech and FSCS technologies available. The breadth of products generates uncertainty amongst processors about the best technologies; this is a challenge for NI Agri-Tech and FSCS technology businesses seeking to create brand awareness. This challenge pertains to end users in deciding on a solution to use, and for Agri-Tech businesses in terms of brand awareness and being able to sell their product/service.

2 Labour, skills and training
The shortage of skills is a significant restraint holding back NI Agri-Tech and FSCS technology businesses from growing. In a small high-growth sector, skills shortage presents a particularly acute problem. As noted in the SWOT, NI has a net outflow of HE students and a shortage of migrant labour post Brexit. This challenge pertains to Agri-Tech businesses but also applies to the agri-food sector.

3 Inflation / increase in cost of doing business
Rising costs and pressures on margins are a key challenge for a range of businesses in the sector. This has resulted in a number of processors delaying capital investments in technologies. This challenge pertains to the whole agri-food sector, including Agri-Tech businesses. End users experiencing cost increases can delay their decision to invest in Agri-Tech solutions.

4 Improving productivity / adoption of smart data
The high cost of improving productivity across the agri-food sector is a major issue. Currently NI does not have any specific funding available for capital support in the sector for large processors, meaning few businesses are materially investing in productivity improving technologies. Note that the relatively lower importance attributed to 'government support' as a challenge in Figure 5-2 above, pertains to support to Agri-Tech businesses[53], whereas the lack of funding for improving productivity/adoption of smart data technologies relates to processers'[54] access to support for adopting these technologies.

5 Lack of environmental and sustainability metrics
A number of businesses have identified sustainability readiness as a key issue in the sector. A significant share of Agri-Tech and FSCS technology businesses still need to prepare a decarbonisation plan. Additionally, the carbon emission targets in legislation have resulted in uncertainty around future trajectory of the Agri-food sector, in turn stalling private sector investments. This challenge pertains to the whole agri-food sector, including Agri-Tech businesses. However, it also creates an opportunity for Agri-Tech businesses (see 5.3 below).

Actions to address these challenges are discussed in section 7.

[53] Based on responses to the survey of Agri-Tech businesses.
[54] Based on stakeholder consultations, with reference to food and drink processing businesses.

5.3 Overview of key opportunities

Key opportunities identified through stakeholder consultations are as follows:

1 Collaboration between agri-food, health, life sciences, and advance engineering sectors

NI has a number of sectors that have a strong established innovation and technology foundation, such as health, life sciences, and advance engineering. Agri-Tech businesses can collaborate with their counterparts in these sectors to take advantage of indigenous knowledge and best practice. This opportunity is relevant for the whole agri-food sector, including Agri-Tech businesses.

2 Establishing clear data systems for the agri-food sector

There is a need to establish clear data systems for the agri-food sector, to ensure that the potential benefits from the smart use of data across the value chain can be realised. This opportunity is relevant for the whole agri-food sector, this can create opportunities and synergies for Agri-Tech businesses.

3 Encouraging new value-added product development and the development waste streams

Developing new value-added products from existing processes and know-how, as well as monetising waste streams, is often a quick way to increase revenue and efficiency, with little additional inputs. This is becoming increasingly important in the agri-food sector, to manage resource constraints. This opportunity is relevant for the whole agri-food sector, this can create opportunities for Agri-Tech businesses.

4 Exploring export opportunities for food safety/quality control technologies

As a result of historic issues with meat quality control, NI now has a successful range of food safety / quality control technologies. There is potential to export more of these technologies and to more explicitly advertise NI as producing good quality food and drink, where these technologies are used to validate product claims. This opportunity is relevant for Agri-Tech businesses providing food safety/quality control technologies, for example, Biopanda Reagents. AFBI and IGFS have research strengths in this area and can support Agri-Tech businesses in developing/refining technologies that can be exported to international markets, for example Asia. Collaboration between AFBI, IGFS and Agri-tech companies, and in terms of market access, collaboration with Invest NI can support the commercialisation of these opportunities.

5 Technologies contributing to lower carbon emissions and climate change mitigation

As legislated emission targets are being set within NI and globally, there is an increase in demand for technologies that can reduce carbon emissions and help to protect the environment. This opportunity is relevant for Agri-Tech businesses providing technologies that can help to reduce carbon emissions and other negative environmental externalities. Such technology solutions align with NI's Green Growth Strategy.

6 Ranking of technologies

NI's FSCS and Agri-Tech technologies are ranked by the degree to which NI has current and/or future world class competitive advantage. A multi-criteria analysis (MCA) is used to rank the top 11 technologies.

6.1 Introduction

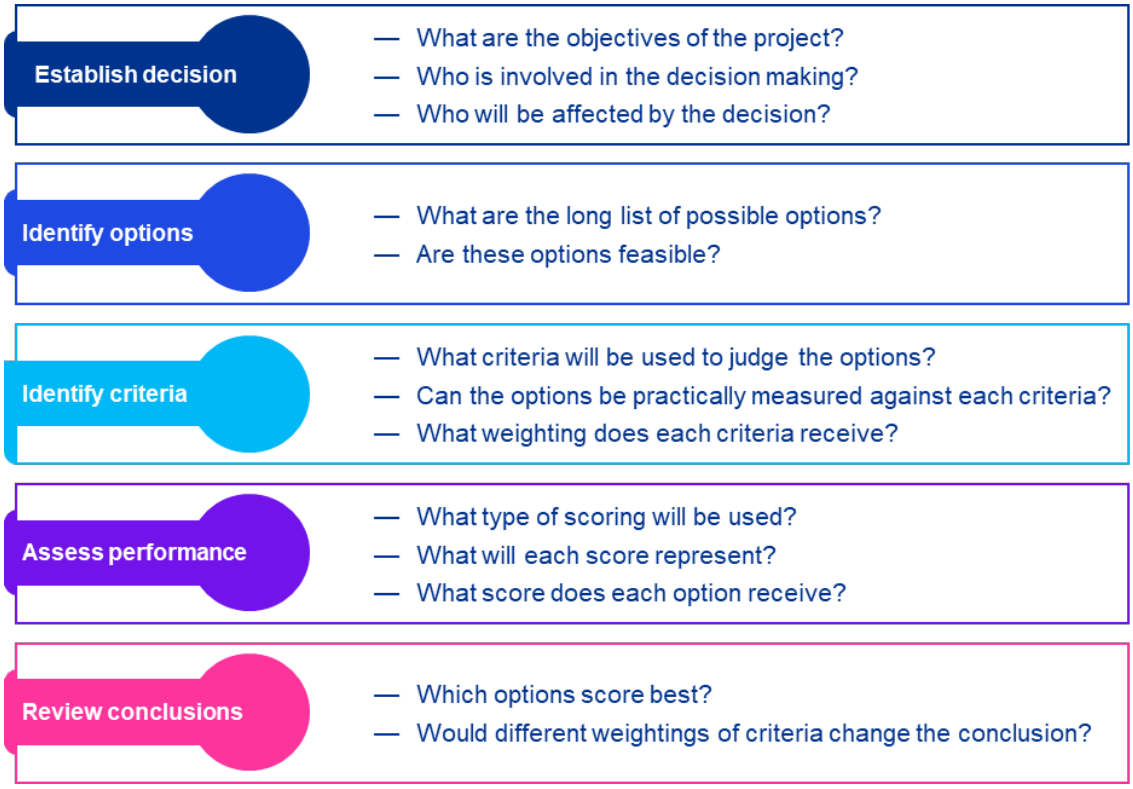
Multi-Criteria Analysis (MCA) provides a framework to draw on multiple pieces of information, to assess alternative options against defined criteria and identify the strengths of each option. The analysis considers available data and qualitative assessments, using a strong understanding of the intended impact of pursuing defined options.

Specific criteria are used to assign scores to alternative options. The results are a useful tool for ranking and identifying preferred options. The criteria can be grouped by theme, based on the objectives of the project being evaluated.

Themes: Each option (in this case, technology) is assessed against the assigned themes and the associated sub-criteria. Scores are awarded relative to each of the options.

Weighting: Each theme is given a weighting, reflecting its relative importance towards achieving the project objectives. Within each theme, sub-criteria are weighted to calculate the overall score per theme. The choice of criteria and weights are open to discussion and has been agreed between the Project Steering Group and KPMG.

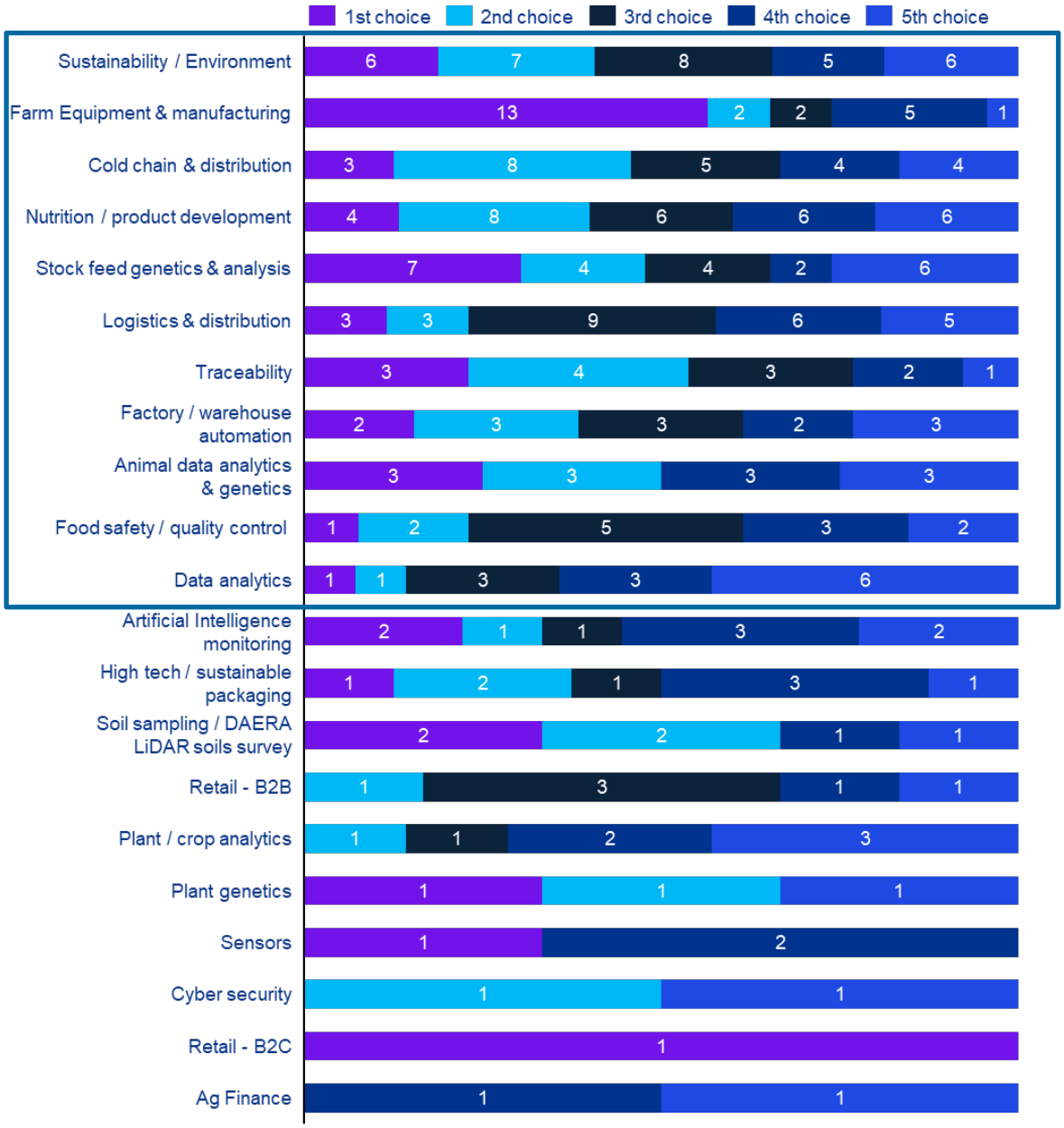
Figure 6-1: Key steps followed in MCA



6.2 Methodology and results

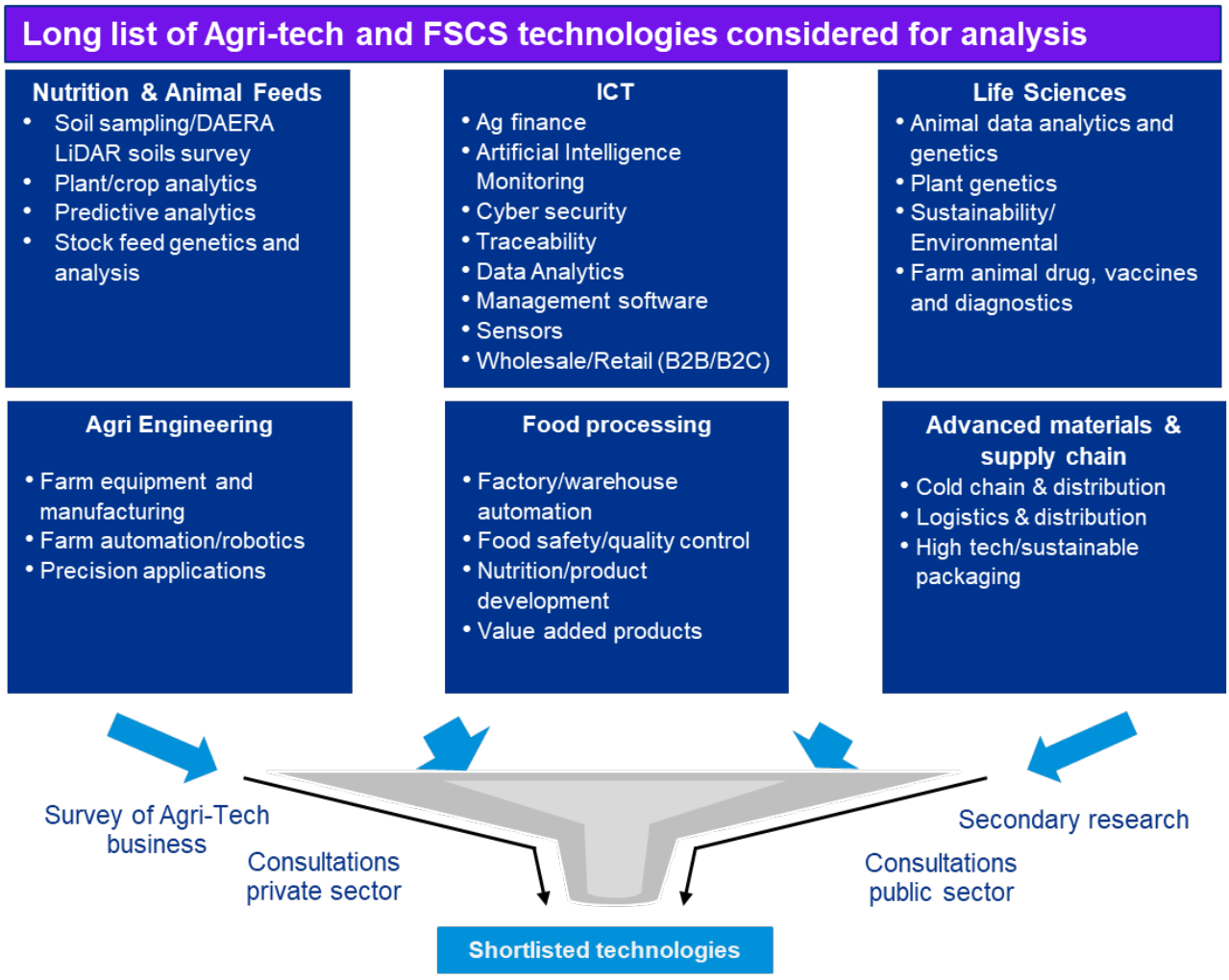
The first step for undertaking an MCA was shortlisting the technologies and identifying the most impactful NI technologies to be considered for analysis. This was achieved through an industry survey and stakeholder consultations. Figure 6-2 below displays the ranking results for each technology based on survey respondents ranking their top five choices. The top 11 technologies were then shortlisted as displayed in Figure 6-2 and Figure 6-3.

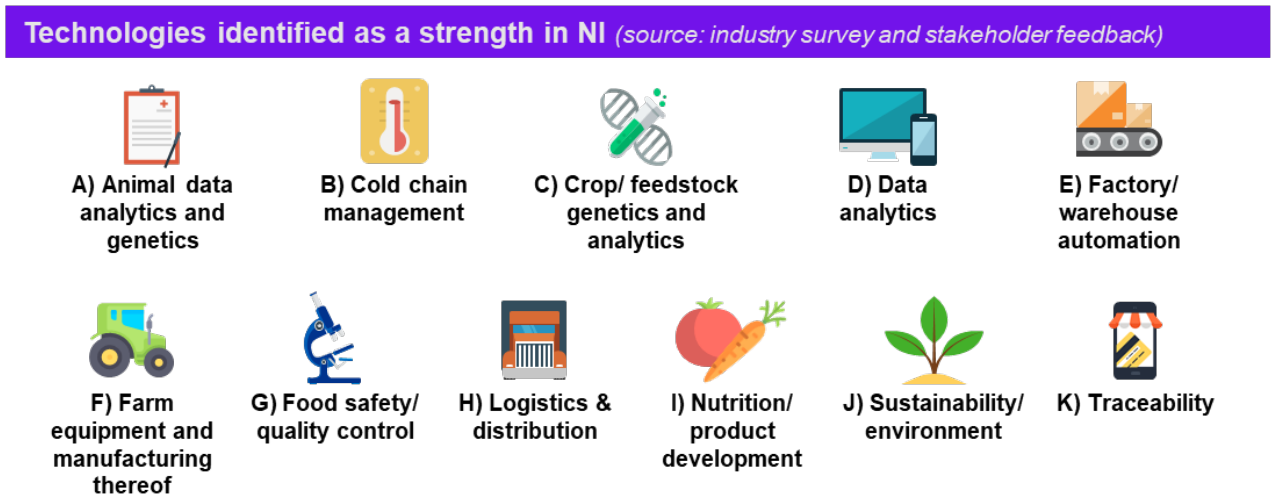
Figure 6-2: Ranking of NI technologies strengths from industry survey[55]



[55] Industry survey

Figure 6-3: Refinement of technologies





Several different themes and criteria have been developed for the MCA as shown in Table 6-1 below. Each criterion has weightings applied to analyse the technologies' range of impacts. Weightings have been applied to reflect the relative importance of each theme/criterion. For this reason, the 10X Vision pillars are allocated a weighting of 45%.

Table 6-1: MCA criteria weightings

Theme		Criteria	Weighting (%)
10X Vision Pillars	Innovation Growth	Greater level of R&D	15%
		Increase the number of Innovation Driven Enterprises	
	Inclusiveness Growth	Increase in skill development	15%
		Increase in Household disposable income	
	Sustainable Growth	Reduction in energy use/emissions/waste	15%
		Green employment opportunities	
Scalability		Scale of market opportunity	15%
		Availability of resources (skills/materials)	
International Advantage		Current NI competitive advantage	20%
		Increasing productivity	
Delivery		Availability of funding	10%
		Costs (high, medium, low)	
Timing of Impact		Short-medium	10%
		Long	
Total			100%

Table 6.2: MCA scores

Theme		Criteria	A) Animal data analytics & genetics	B) Cold chain management	C) Crop / feedstock genetics and analytics	D) Data analytics	E) Factory / warehouse automation	F) Farm equipment & manufacturing thereof
10X Vision Pillars	Innovation Growth	Greater level of R&D	4	3	3	3	3	2
		Increase the number of innovation driven enterprises	4	3	3	3	3	2
	Inclusiveness Growth	Increase in skill development	5	2	2	3	5	2
		Increase in Household disposable income	2	3	3	3	3	3
	Sustainable Growth	Reduction in energy use/emissions/waste	2	4	2	3	4	3
		Green employment opportunities	5	3	3	3	3	3
Scalability		Scale of market opportunity	2	3	4	4	3	4
		Availability of resources (skills/materials)	5	3	5	3	2	5
International Advantage		Current NI competitive advantage	3	5	4	2	3	5
		Increasing productivity	4	3	3	5	4	3
Delivery		Availability of funding	4	3	3	4	3	4
		Costs (high, medium, low)	3	4	5	3	1	4
Timing of Impact		Short-medium	2	3	5	5	2	5
		Long	5	3	2	4	5	1
Overall weighted score			3.58	3.35	3.33	3.38	3.20	3.30

Table 6-2 (continued)

Theme		Criteria	G) Food safety / quality control	H) Logistics & distribution	F) Food nutrition / product development	J) Sustainability / Environment	K) Traceability
10X Vision Pillars	Innovation Growth	Greater level of R&D	4	4	4	4	4
		Increase the number of innovation driven enterprises	4	3	5	4	4
	Inclusiveness Growth	Increase in skill development	3	3	3	3	3
		Increase in Household disposable income	3	4	3	3	3
	Sustainable Growth	Reduction in energy use/emissions/waste	3	5	4	5	5
		Green employment opportunities	4	3	3	5	3
Scalability		Scale of market opportunity	4	4	4	2	4
		Availability of resources (skills/materials)	5	3	4	3	3
International Advantage		Current NI competitive advantage	3	4	4	5	3
		Increasing productivity	4	3	4	2	3
Delivery		Availability of funding	3	3	3	5	3
		Costs (high, medium, low)	4	4	2	2	3
Timing of Impact		Short-medium	3	3	3	2	3
		Long	3	3	3	5	3
Overall weighted score			3.60	3.53	3.60	3.58	3.38

When applying the weightings to each score, the following MCA results are achieved, as shown in Table 6-3 below.

Table 6.3: MCA results

Technology ranking	Technologies	Rankings
1	G) Food safety / quality control	3.60
	F) Food nutrition / product development	3.60
3	A) Animal data analytics & genetics	3.58
	J) Sustainability / Environment	3.58
5	H) Logistics & distribution	3.53
6	D) Data analytics	3.38
	K) Traceability	3.38
8	C) Crop / feedstock genetics and analytics	3.33
9	F) Farm equipment & manufacturing thereof	3.30
10	B) Cold chain management	3.25
11	E) Factory / warehouse automation	3.20

These results show that of the 11 shortlisted technologies there is a cluster of the top seven technologies with similar scores. These include:

- Food safety / quality control
- Nutrition / product development
- Animal data analytics & genetics
- Sustainability / Environment
- Logistics & distribution
- Data analytics
- Traceability

These technologies (excluding logistics & distribution[56]) align with the NI research strengths stated in Table 2-3. Recommendations on the top technologies are included in the section 7.

[56] Does not have a clear research strength in NI.

6.3 Sensitivities

Sensitivity tests have been carried out to understand the impact of changes in key assumptions on the results. As a sensitivity analysis, we consider scenarios where the weightings are changed to differentiate between key aspects of each theme, highlighting the advantages and disadvantages of each technology under each scenario. These help to test the robustness of findings in response to external changes or if outcomes differ to assumptions made. The following three scenarios have been used:

- Scenario 1: Base case – weightings determined from discussions with DfE
- Scenario 2: 10X Vision and Scalability – Weightings signed to 10X Vision criteria
- Scenario 3: Even split – an even split of weightings between the criteria

The weightings for the three scenarios are shown in Table 6-4 below.

Table 6.4: Scenario weightings

Theme		Criteria	Weighting		
			Scenario 1: Base case	Scenario 2: 10X Vision and Scalability	Scenario 3: Even split
10X Vision Pillars	Innovation Growth	Increase the number of innovation driven enterprises	15.0%	30.0%	14.3%
		Greater level of R&D			
	Inclusiveness Growth	Increase in skill development	15.0%	30.0%	14.3%
		Increase in Household disposable income			
	Sustainable Growth	Reduction in energy use/emissions/waste	15.0%	30.0%	14.3%
		Green employment opportunities			
Scalability		Scale of market opportunity	15.0%	10.0%	14.3%
		Availability of resources (skills/materials)			
International Advantage		Current NI competitive advantage	20.0%	0.0%	14.3%
		Increasing productivity			
Delivery		Availability of funding	10.0%	0.0%	14.3%
		Costs (high, medium, low)			
Timing of Impact		Short-medium	10.0%	0.0%	14.3%
		Long			
Total			100%	100%	100%

When applying the respective weightings from each to each score, the following MCA results are achieved, as shown in Table 6-5 below.
The results show that there is little change in the ranking across the three different scenarios, with consistency across the top five technologies:

- G) Food safety / quality control
- F) Nutrition / product development
- A) Animal data analytics & genetics
- J) Sustainability / Environment
- H) Logistics & distribution

However, lower ranking technologies remain important in the overall ecosystem and there is a degree of complementarity across technologies and a number of lower ranking technologies can support delivery of higher-ranking technologies (e.g. animal data analytics & genetics (3) and crop / feedstock genetics and analytics (8)).

Table 6.5: MCA Scenario results

Technology ranking	Technologies	Scenario		
		Scenario 1: Base case	Scenario 2: 10X Vision and Scalability	Scenario 3: Even split
1	G) Food safety / quality control	3.60	3.60	3.57
2	F) Food nutrition / product development	3.60	3.70	3.50
3	A) Animal data analytics & genetics	3.58	3.65	3.57
4	J) Sustainability / Environment	3.58	3.85	3.57
5	H) Logistics & distribution	3.53	3.65	3.50
6	D) Data analytics	3.38	3.05	3.43
7	K) Traceability	3.38	3.65	3.36
8	C) Crop / feedstock genetics and analytics	3.33	2.85	3.36
9	F) Farm equipment & manufacturing thereof	3.30	2.70	3.29
10	B) Cold chain management	3.25	3.00	3.21
11	E) Factory / warehouse automation	3.20	3.40	3.14

7 Conclusions and recommendations

This section provides a summary of the research and outlines actions and recommendations from the analysis.

7.1 Conclusions

As outlined in section 1, the “Agri-Tech sector” is defined as consisting of the businesses providing Agri-Tech related solutions (products and services) to a range of end users across six Agri-Tech sub-sectors. The Agri-Tech sub-sectors include advanced materials and supply chain, agri-engineering, food processing, information and communications technology (ICT), life sciences, and nutrition and animal feeds. Agri-Tech is considered with a wide lens to include technologies that range from traditional/current solutions to emerging/novel solutions. NI’s Agri-Tech sector is a component in a wider ecosystem that includes Agri-Tech businesses, end users of Agri-Tech solutions and organisations that support the sector.

Agri-Tech solutions have been categorised into specific sub-sectors (see section 2), based on the type of solution in question. The sub-sectors were identified by considering the existing sector classifications used by Invest NI and through stakeholder consultations.

A longlist of technologies was shortlisted using an MCA (see section 6) and by considering the findings from the industry survey and stakeholder feedback. In section 2, these technologies are considered relative to NI’s research strengths and windows of opportunity. Based on the MCA analysis, NI’s Agri-tech sector has an advantage in the following technologies (see section 6.2, Table 6-3):

- Food safety / quality control
- Nutrition / product development
- Animal data analytics & genetics
- Sustainability / Environment
- Logistics & distribution
- Data analytics
- Traceability
- Crop / feedstock genetics and analytics
- Farm equipment & manufacturing thereof
- Cold chain management
- Factory / warehouse automation

NI’s research strengths (see section 2) span across the areas of sustainability and environmental, genetics, traceability, food packaging, animal data analytics and genetics, robotics, food integrity and security, nutrition, new product development and the creation of value-added products. NI’s technology and research strengths align with NI’s market needs and international windows of opportunity (see section 2.6). However, one technology area – logistics and distribution – does not have a clear research strength in NI, whilst the other technology areas align with research strengths and market needs.

Section 3 outlined a profile of the sector, based on a survey of 54 Agri-Tech businesses and a wider market size of 97-107 businesses currently active in the sector. These cohorts include businesses that are purely focused on Agri-Tech as their core business and businesses primarily involved in other areas within the agrifood/food and drink value chain, but which generate a share of their revenue through Agri-Tech related activities.

For this reason, a value chain perspective is important when considering the development of the Agri-Tech sector, specifically, the end users of Agri-Tech solutions in primary agriculture, the food and drink processing sector, as well as the retail sector and other ecosystem role-players.

As part of international learnings (section 4), learnings from the following jurisdictions were considered: Australia, Israel, New Zealand, Ireland, the Netherlands, and the United Kingdom (excluding NI). This included benchmarking, comparative metrics, key learnings and the identification of global Agri-Tech trends.

Taking account of **international case studies**, key learnings applicable for NI include the following:

- The Australian Government has allocated funding for specific programmes within the Agri-Tech sector, identifying opportunities which could support multiple farms. This highlights the importance of funding support. Australia has lots of start-ups, driving innovation across the sector. Supporting start-ups can grow the NI Agri-Tech ecosystem
- Israel has developed Agri-Tech to provide food stability in a challenging agricultural environment with unfavourable growing conditions. Lessons could be learned for a similarly challenging environment in NI. Israel has more than 500 Agri-Food Tech start-ups, which are supported by accelerators and incubators. Accelerators and incubators can support NI Agri-Tech start-ups, providing an environment for testing new products and developing ideas
- New Zealand is a world leading exporter of quality food with a history of innovation across the primary sector. The Government has published an Agri-Tech Sector Transformation Plan (2020) which provides a clear outline and plan for the sector. Development of a NI plan for the sector can set out a clear path to grow the sector
- The Irish Agri-Tech sector has a strong backing from the state, including funding, accelerator programmes and industry bodies. This organisational structure allows for collaboration, funding applications and a wider international reach. Funding, accelerator programmes and industry bodies can support the NI Agri-Tech sector
- The Netherland's agri-food sector is innovative at adopting new technologies at scale. The Netherlands hosts 15/20 of the largest global agri-food players' major research and development centres. Promoting technology adoption can help to grow the NI Agri-Tech sector
- The UK Government encourages innovation in the Agri-Tech sector through funding, developing centres of excellence and supporting research. A clear action plan sets out a pathway for the UK to become a world-leader in Agri-Tech. NI could develop a similar approach through using centres of excellence and targeted funding for innovation
- Several of the international technology examples are based on technologies that are easily adopted and can run off a farmer's / processer's phone. This means the technologies are easier to implement without equipment or need for significant CAPEX. This can include the use of generative AI and the likes of ChatGPT to use publicly available data on weather, soil monitoring, application rates, and current events to provide insight to farmers/producers

Seven global Agri-Tech trends were identified, each of which has relevance in a NI context and is applicable to the NI Agri-Tech sector:

1 **Efficiency:** There is a focus on increasing efficiency to make inputs go further, creating a market opportunity for technologies that can automate processes, eliminate waste and save time. For example, automation technologies (e.g., PLCs, SCADA systems, temperature control) and human replacement technology (e.g., optical scanners rejecting unsuitable food)
2 **Environmental sustainability:** There is increased awareness of, and policy focus on, reducing the agri-food sector's environmental footprint. This creates a market opportunity for technologies that can reduce emissions, such as anaerobic digestion technology and methanogenesis inhibiting ruminant feed additives
3 **New product development/value added products:** There is an increasing focus on developing novel/value added products and developing waste streams for both the

primary agriculture and the food processing industry, linked to trend one and two above. Examples include the use of technologies to create nitrate free bacon

4 **Novel meat products:** Evolving consumer preferences[57] are providing a space for the sector to create alternative protein sources such as plant-based meat and lab-grown meat products. This is linked to the broader sustainability focus, mentioned in trend 1
5 **Data systems:** The collection, processing, use and ownership/custodianship of data is a challenge for the wider adoption of smart data/data analytics and the interoperability of technology solutions. This is also a constraint in the NI context
6 **Skills and training:** A lack of relevant skills and technical training is generally a constraint in the sector. In particular, a lack of candidates with Science, Technology, Engineering and Maths (STEM) qualifications. In NI, more students need to be attracted to study STEM subjects across all levels, and current employees need to be upskilled. Career initiatives could help to attract STEM candidates into food and drink processing, and Agri-Tech businesses. Developing and attracting a pipeline of STEM talent is needed to address this challenge
7 **Funding and capital investment:** In terms of technology adoption, access to capital funding for investment is a constraint for the food processing sector. During consultations, stakeholders have strongly indicated that expanded capital grants, especially for large businesses, could help to support the adoption of Agri-Tech within NI.

Section 5 outlined several challenges and opportunities for the sector. The survey of NI Agri-Tech businesses highlights a number of these key challenges, including 'high competition with international products', 'Climate Action Plans', and 'the establishment/effectiveness of innovation hubs.

The latter, in particular, can play an important role in supporting Agri-Tech start-ups. By way of example, the Dublin Belfast Economic Corridor (DBEC) received funding from the Shared Ireland Unit to assess the feasibility of innovation hubs located on the corridor between Belfast and Dublin. There may be opportunities to explore cross-border opportunities for innovation arising from such hubs.

In addition to the industry survey, stakeholder consultations with Agri-Tech business and Agri-Food processors were undertaken to identify the main challenges facing the sector and wider Agri-Food eco-system. This informed the identification of the **top five issues that need to be addressed/mitigated** to enable NI's FSCS technologies and Agri-Tech sector to be world leading over the next 10 years:

- **High competition with international products:** Globally there is a wide range of Agri-Tech and FSCS technologies available. The breadth of products generates uncertainty amongst processors about the best technologies; this is a challenge for NI Agri-Tech and FSCS technology businesses seeking to create brand awareness. This challenge pertains to end users in deciding on a solution to use, and for Agri-Tech businesses in terms of brand awareness and being able to sell their product/service
- **Labour, skills, and training:** The shortage of skills is a significant restraint holding back NI Agri-Tech and FSCS technology businesses from growing. In a small high-growth sector, skills shortage presents a particularly acute problem. As noted in the SWOT, NI has a net outflow of HE students and a shortage of migrant labour post Brexit. This challenge pertains to Agri-Tech businesses but also applies to the agri-food sector

[57] Note that consumer preferences are not static and continue to evolve. In addition to price, purchasing decisions are driven by factors such as culture, taste, health, and environmental concerns, including concerns over animal welfare and meat consumption. Alternative dairy products have gained more appeal with mainstream consumers, while alternative meat products (especially lab-grown meat) still have some way to go to garner a similar appeal with mainstream consumers.

- **Inflation / increase in cost of doing business:** Rising costs and pressures on margins are a key challenge for a range of businesses in the sector. This has resulted in a number of processors delaying capital investments in technologies. This challenge pertains to the whole agri-food sector, including Agri-Tech businesses. End users experiencing cost increases can delay their decision to invest in Agri-Tech solutions
- **Improving productivity / adoption of smart data:** The high cost of improving productivity across the agri-food sector is a major issue. Currently NI does not have any specific funding available for capital support in the sector for large processors, meaning few businesses are materially investing in productivity improving technologies. Note that the relatively lower importance attributed to 'government support' as a challenge in Figure 5-2 above, pertains to support to Agri-Tech businesses , whereas the lack of funding for improving productivity/adoption of smart data technologies relates to processers' access to support for adopting these technologies
- **Lack of environmental and sustainability metrics:** A number of businesses have identified sustainability readiness as a key issue in the sector. A significant share of Agri-Tech and FSCS technology businesses still need to prepare a decarbonisation plan. Additionally, the carbon emission targets in legislation have resulted in uncertainty around future trajectory of the Agri-food sector, in turn stalling private sector investments. This challenge pertains to the whole agri-food sector, including Agri-Tech businesses. However, it also creates an opportunity for Agri-Tech businesses (see 5.3 below)

Section 5 further highlights **key opportunities**, identified through stakeholder consultations:

- **Collaboration between agri-food, health, life sciences, and advance engineering sectors**: NI has a number of sectors that have a strong established innovation and technology foundation, such as health, life sciences, and advance engineering. Agri-Tech businesses can collaborate with their counterparts in these sectors to take advantage of indigenous knowledge and best practice. This opportunity is relevant for the whole agri-food sector, including Agri-Tech businesses.
- **Establishing clear data systems for the agri-food sector:** There is a need to establish clear data systems for the agri-food sector, to ensure that the potential benefits from the smart use of data across the value chain can be realised. This opportunity is relevant for the whole agri-food sector, this can create opportunities and synergies for Agri-Tech businesses.
- **Encouraging new value-added product development and the development waste streams:** Developing new value-added products from existing processes and know-how, as well as monetising waste streams, is often a quick way to increase revenue and efficiency, with little additional inputs. This is becoming increasingly important in the agri-food sector, to manage resource constraints. This opportunity is relevant for the whole agri-food sector and can create opportunities for Agri-Tech businesses.
- **Exploring export opportunities for food safety/quality control technologies:** As a result of historic issues with meat quality control, NI now has a successful range of food safety / quality control technologies. There is potential to export more of these technologies and to advertise NI more explicitly as producing good quality food and drink, where these technologies are used to validate product claims. This opportunity is relevant for Agri-Tech businesses providing food safety/quality control technologies, for example, Biopanda Reagents. AFBI and IGFS have research strengths in this area and can support Agri-Tech businesses in developing/refining technologies that can be exported to international markets, for example Asia. Collaboration between AFBI, IGFS and Agri-tech companies, and in terms of market access, collaboration with Invest NI can support the commercialisation of these opportunities.
- **Technologies contributing to lower carbon emissions and climate change mitigation**: As legislated emission targets are being set within NI and globally, there is an increase in demand for technologies that can reduce carbon emissions and help to

protect the environment. This opportunity is relevant for Agri-Tech businesses providing technologies that can help to reduce carbon emissions and other negative environmental externalities.

7.2 Recommendations

The preceding analysis is the basis for the actions and recommendations that follow. As a starting point, the following enablers/policy levers are considered to provide context in formulating the recommendations. These **enablers/policy levers** can be used to capitalise on the opportunities in the Agri-Tech ecosystem, supporting exports and the diffusion of technology:

- Funding support: Support for R&D[58] and capital expenditure[59] can support the development of new technologies and the adoption of technologies in NI's agrifood/food and drink value chain
- Skills development: To address labour, skills, and training constraints, attract more students and generate a stronger pipeline of graduates / apprenticeships with the requisite skills needed to meet the sector's skills demands
- Support for Agri-Tech start-ups: Develop Agri-Tech start-up supports through innovation hubs, incubators, and accelerator programs
- Collaboration: foster collaboration through industry forums, including government departments, Agri-Tech businesses, industry bodies and international peers
- Data systems: Establish data systems for the agri-food sector to support technology adoption and diffusion. This can be led by DAERA, with input by the Sustainability Body, Industry Bodies, DfE and Invest NI

Considering the key challenges facing the sector (see section 5.2), the top five recommendations include the following:

1 Promote technology adoption
2 Expand and better signpost the support available
3 Address skills shortages
4 Develop an Agri-Tech sectoral plan
5 Support the development of environmental and sustainability metrics

The overall recommendations, including the top five, are grouped into three themes:

- Theme 1: Technology, research strengths and windows of opportunity
- Theme 2: International learnings
- Theme 3: Challenges and opportunities

[58] For universities, AFBI, Agri-Tech businesses, and food and drink processors.
[59] For farmers and processors.

7.2.1 Theme 1: Technology, research strengths and windows of opportunity

The recommendations for Theme 1 are summarised in Table 7-1 below.

Table 7-1: Theme 1 recommendations

Recommendation	Actions	Lead	Partners	Timescale
Theme 1: Technology, research strengths and windows of opportunity				
Technology adoption Note: consider the technologies that the local farming and processing sectors need to adopt, even if there is a need to buy in from outside NI	• Increase the adoption of Agri-Tech solutions within NI's primary agriculture and processing sectors • DAERA to consider inviting local Agri-Tech businesses to their knowledge transfer events, where possible • Increase technology adoption for food and drink processors by introducing a capital scheme to promote the 10x triple bottom line of Innovation, Environmental Sustainability, Inclusion plus improving productivity and the adoption of digitalisation/data analytics	• DAERA lead, DfE, Invest NI, primary production and processing sectors • Invest NI to lead with input from DfE	• Industry bodies, Agri-Tech businesses, Sustainability Body[60]	• Short to medium-term
Grow the NI Agri-Tech sector's global footprint	• Grow the NI Agri-Tech sector's global footprint by focusing on the international windows of opportunity for these technologies	• Lead by Invest NI, industry bodies, Agri-Tech businesses	• DAERA, DfE, industry bodies, Sustainability Body	• Medium to long-term

[60] Sustainability Body has a role to play in supporting the adoption of technologies that improve sustainability and to collaborate in the adoption/promotion of industry data and data interoperability.

Table 7-1: Theme 1 recommendations (continued)

Recommendation	Actions	Lead	Partners	Timescale
Theme 1: Technology, research strengths and windows of opportunity				
Expand and better signpost the support available Note: This would generate benefits for Agri-Tech businesses and end users	• Government entities should expand and better signpost the support available for primary producers and food and drink processors. This would generate benefits to both AT businesses and the primary producer and processor end users	• For primary producers: DAERA lead • For food and drink processors: Invest NI lead with input from DAERA	• Industry bodies, Agri-Tech businesses	• Short to medium-term
Support the commercialisation of research: Note: to create further alignment between research and industry needs, increasing commercialisation of research	• Review the R&D process between universities and companies, and facilitate industry engagement • Establish innovation hubs, incubators and accelerator programs to enable start-ups and established businesses to get involved in the R&D process. Use the proposed Mid South West Growth Deal Agri-Tech centre as a starting point	• Overall research and commercialisation: NI Diamond, universities and industry • Incubators and accelerator programs: Lead by Invest NI, industry bodies and proposed Agri-Tech centre	• Industry bodies, AFBI, DfE, DAERA and Invest NI	• Medium to long-term

7.2.2 Theme 2: International learnings

The recommendations for Theme 2 are summarised in Table 7-2 below.

Table 7-2: Theme 2 recommendations

Recommendation	Actions	Lead	Partners	Timescale
Theme 2: International learnings				
Develop an Agri-Tech sectoral plan	• Develop an Agri-Tech sectoral plan to set out a clear path to promote the growth of Agri-Tech businesses in NI	• DfE lead, with input from Invest NI, industry bodies, DAERA, AFBI	• Invest NI, industry bodies, DAERA, AFBI	• Medium-term
Foster Agri-Tech sector collaboration	• Develop key Agri-Tech initiatives that can foster collaboration within the NI Agri-Tech ecosystem and promote technology adoption • Foster international collaboration with industry bodies in other jurisdictions to facilitate knowledge sharing	• Within NI: Universities, industry associations/bodies and Agri-Tech businesses • International: Industry associations/bodies with support from Invest NI	• Invest NI, DAERA, DfE	• Medium to long-term

7.2.3 Theme 3: Challenges and opportunities

The recommendations for Theme 3 are summarised in Table 7-3 below.

Table 7-3: Theme 3 recommendations

Recommendation	Actions	Lead	Partners	Timescale
Theme 3: Challenges and opportunities				
Address skills shortages	• Increase the level of skills in the sector through graduate, postgraduate, further education, and apprenticeship courses. Additionally, increase skills of existing employees through training and upskilling initiatives • Focus on STEM areas (science, technology, engineering, and mathematics). Schools can help in increasing the promotion and attractiveness of STEM subjects. This can follow through to support a greater uptake of STEM subjects when students go on to Further or Higher Education	• DAERA , UU, QUB, FE Colleges, DfE Careers Service and industry	• Department of Education (DE), Industry bodies, Agri-Tech businesses	• Medium-term

Table 7-3: (Continued)

Recommendation	Actions	Lead	Partners	Timescale
Theme 3. Challenges and opportunities				
Address skills shortages (Continued)	• Provide promotional activities to attract students on courses and promote careers in the sector • This could also include initiatives such as bursaries, marketing events, international student exchange programs and student internship programmes)			
Increase productivity and the adoption of smart data practices	• Government to continue to promote the use of smart data to improve productivity and efficiency. • Expand capital grants, especially for large businesses, to support the adoption of Agri-Tech products and services • Promote interoperability of data across the supply chain	• For primary producers: DAERA • For food and drink processors: Invest NI • For interoperability of data: DAERA lead with input by the Sustainability Body and Industry	• DfE, industry bodies, Agri-Tech businesses, Sustainability Body, DAERA and universities	• Medium to long-term
Support the development of environmental and sustainability metrics	• Develop a coordinated approach to develop and establish environmental and sustainability metrics across the agri-food value chain	• NI Diamond[61], DAERA, DfE, AFBI, Sustainability Body	• Industry bodies, Agri-Tech businesses, universities, retailers	• Medium to long-term

[61] The proposed NI Diamond will identify research gaps and prioritise research needs for the wider Agri-Food sector with representation from Industry, Academia, civic society, and Government.

Table 7-3: (Continued)

Recommendation	Actions	Lead	Partners	Timescale
Theme 3. Challenges and opportunities				
Foster collaboration with other sectors	• Foster collaboration between Agri-Tech businesses and University research departments in other disciplines to assist with innovation or new product development	Industry bodies and universities	DfE, Invest NI	Medium to long-term
Establish data systems for the agri-food sector	• Establish data systems for the agri-food sector: for the collection, processing, storing and interoperability of data	• DAERA, DfE, Invest NI, Sustainability Body	• Industry bodies, retailers	• Medium to long-term
Support the development of technologies that can contribute to climate change mitigation	• Develop and support technologies contributing to lower carbon emissions and climate change mitigation • Align these efforts with the Green Growth Strategy, NI Energy Strategy and the draft Circular Economy Strategy	• Universities, DAERA, DfE, Invest NI, NI Diamond	• AFBI, DAERA, Sustainability Body	• Medium to long-term

7.2.4 Implementation roadmap

An implementation roadmap for all the actions identified is provided in Figure 7-1 below:

Figure 7-1: Implementation roadmap

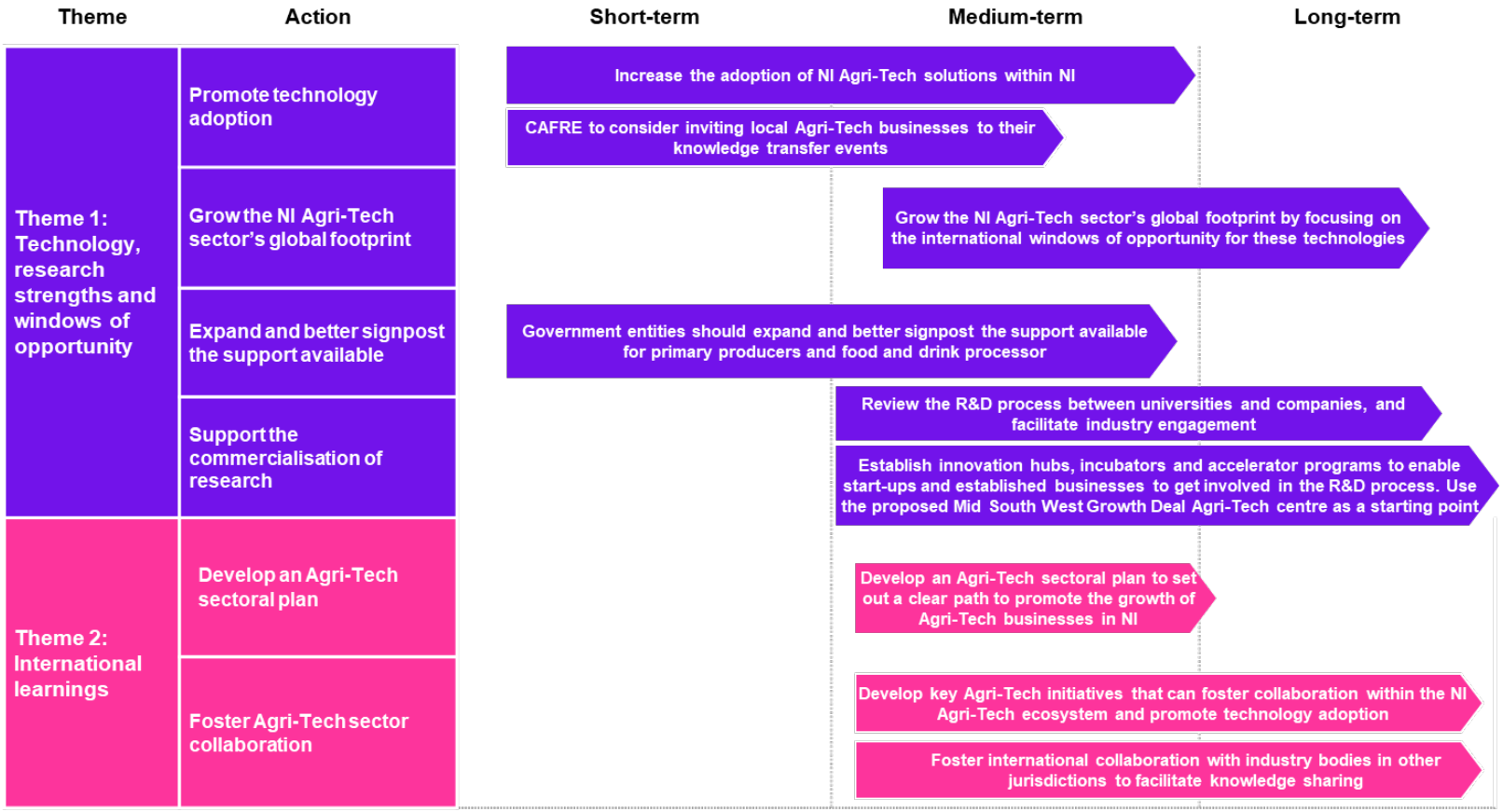
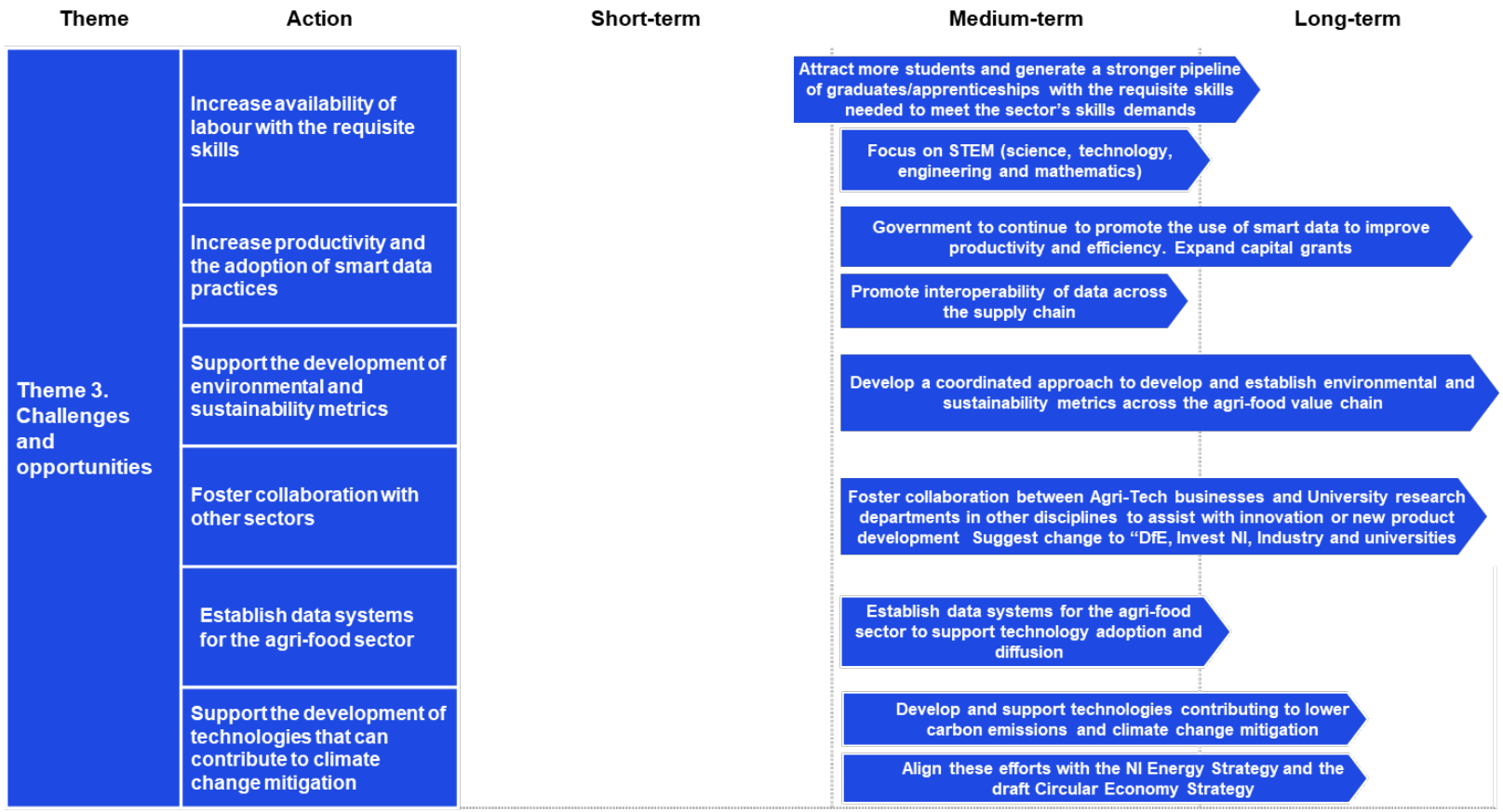


Figure 7-1: (Continued)



7.2.5 Metrics to measure success

There is no single solution that can ensure the successful development of the NI Agri-Tech sector. Success requires that a range of actions, focusing on policy change and collaboration between government, businesses, and industry bodies, be implemented.

Metrics to measure the success of actions, that should ultimately support the growth and development of the sector, could include the following:

- Increase in the number of Agri-Tech start-ups
- Increase in employment or sectoral employment in the Agri-Tech sector
- Increase in Agri-Tech sector revenue
- Export intensity
- The number of networking events and collaboration projects between government departments and industry bodies

Note that because each country defines their Agri-Tech sector differently, there is limited comparable Agri-Tech data available. This is likely to improve as the sector becomes better defined over time, and more research and analysis is undertaken within other countries.

Appendices

A MCA detailed scoring

The detailed MCA scoring is summarised in Table A-1 below.

Table A-1: MCA detailed scores

Theme		Criteria	Weighting	Technologies							
				A) Animal data analytics & genetics		B) Cold chain management		C) Crop / feedstock genetics and analytics		D) Data analytics	
				Score	Reasoning	Score	Reasoning	Score	Reasoning	Score	Reasoning
10X Vision Pillars	Innovation Growth	**Greater level of R&D**	7.5%	4	Large amount of existing and scope for additional R&D	3	Some existing R&D and medium scope for additional R&D	3	Large amount of existing R&D and some scope for additional R&D	3	Large amount of existing R&D and some scope for additional R&D
		Increase the number of innovation driven enterprises	7.5%	4	A handful of established service providers. Significant opportunities for additional growth	3	A handful of established service providers. Significant opportunities for additional growth	3	Strong base of established service providers. Some opportunities for additional growth	3	A handful of established service providers. Significant opportunities for additional growth
	Inclusiveness Growth	**Increase in skill development**	7.5%	5	Significant additional skills development and training needed	2	Some additional skills development and training needed	2	Some additional skills development and training needed	3	Moderate additional skills development and training needed
		Increase in household disposable income	7.5%	2	Small number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income
	Sustainable Growth	**Reduction in energy use / emissions / waste**	7.5%	2	Will assist slightly with reducing energy use/emissions/waste	4	Helping reduce wasted energy in throughout the cold chain	2	Will assist slightly with reducing energy use/emissions/waste	3	Will assist with reducing energy use/emissions/waste
		Green employment opportunities	7.5%	5	Largely green employment	3	Some green employment	3	Some green employment	3	Some green employment
Scalability		**Scale of market opportunity**	7.5%	2	A large number of small farms making it harder to implement	3	A relatively small number of large players resulting in it being easier to scale/purchase the technologies in NI	4	Few barriers to scale	4	Same barriers to scale.
		Availability of resources (skills / materials)	7.5%	5	Strong existing Agri life sciences research	3	Moderate existing skills and business in Cold chain management sector in NI	5	Strong existing feed stock sector and Agri life sciences research	3	Moderate existing skills and business in data analytics in NI
International Advantage		**Current NI competitive advantage**	10%	3	Ranking between 6 and 10 for NI technological strength in the industry survey	5	Rank in the top 3 for NI technological strength in the industry survey	4	Ranking between 4 and 6 for NI technological strength in the industry survey	2	Ranking between 11 for NI technological strength in the industry survey
		Increasing productivity	10%	4	Will result in an increase in primary sector output	3	Decrease in waste and increase in distribution efficiencies	3	Will result in an increase in primary sector output	5	Will result in an increase in primary and secondary sector output
Delivery		**Availability of funding**	5%	4	Large amount of funding available for research and purchasing the technology	3	Little funding available for research on the technology	3	Some funding available for research on the technology	4	Large amount of funding available for research and purchasing the technology
		Costs (high, medium, low)	5%	3	Medium cost	4	Medium to low cost	5	Low costs	3	Medium cost
Timing of Impact		**Short-medium**	5%	2	Little impact in the short-medium term	3	Moderate impact in the short-medium term	5	Large impact in the short-medium	5	Large impact in the short-medium
		Long	5%	5	Large impact in the long term	3	Moderate impact in the long term	2	Minimal change in the long term	4	Moderate to large impact in the long term
Total			**100%**	**3.58**		**3.25**		**3.33**		**3.38**	

Table A-1: (continued)

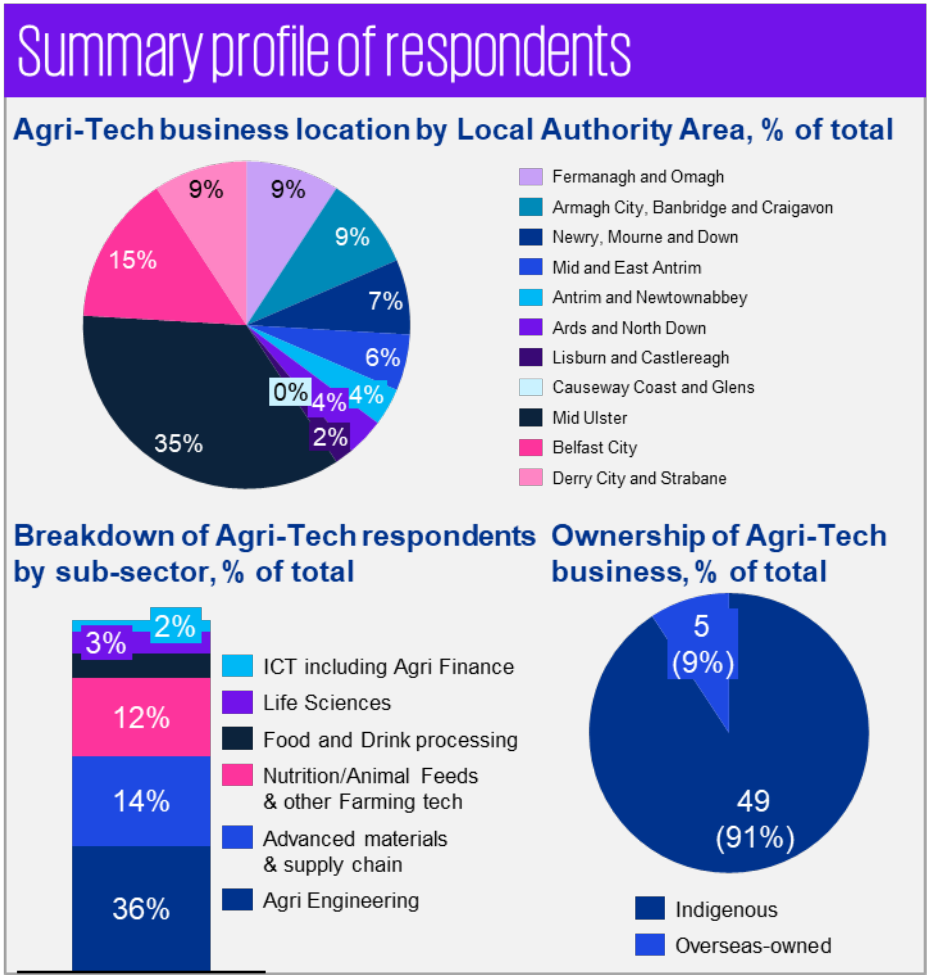
Theme		Criteria	Weighting	Technologies							
				E) Factory / warehouse automation		F) Farm equipment & manufacturing thereof		G) Food safety / quality control		H) Logistics & distribution	
				Score	Reasoning	Score	Reasoning	Score	Reasoning	Score	Reasoning
10X Vision Pillars	Innovation Growth	**Greater level of R&D**	7.5%	3	Little current existing R&D and significant scope for additional R&D	2	Standardised solutions less scope for R&D	4	Large amount of existing R&D and medium scope for additional R&D	4	Some existing R&D and significant scope for additional R&D
		Increase the number of innovation driven enterprises	7.5%	3	A handful of established service providers. Significant opportunities for additional growth	2	Strong base of established service providers. Limited additional growth	4	Strong base of established providers. Significant opportunities for additional growth	3	A handful of established service providers. Significant opportunities for additional growth
	Inclusiveness Growth	**Increase in skill development**	7.5%	5	Significant additional skills development and training needed	2	Some additional skills development and training needed	3	Moderate additional skills development and training needed	3	Moderate additional skills development and training needed
		Increase in household disposable income	7.5%	3	Medium number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income	4	Large number of higher paid jobs resulting in higher average household disposable income
	Sustainable Growth	**Reduction in energy use / emissions / waste**	7.5%	4	Additional investment in this technology will assist with reduction in energy use/emissions/waste	3	Will assist with reducing energy use/emissions/waste	3	Will assist slightly with reducing energy use/emissions/waste	5	increasing transport/logistics efficiencies and reducing transport emissions
		Green employment opportunities	7.5%	3	Some green employment	3	Some green employment	4	Mostly green employment	3	Some green employment
Scalability		**Scale of market opportunity**	7.5%	3	A relatively small number of large players resulting in it being easier to scale/purchase the technologies in NI. However large capital cost	4	Same barriers to scale.	4	A relatively small number of large players resulting in being it easier to scale/purchase the technologies in NI	4	A relatively small number of large players resulting in it being easier to scale/purchase the technologies in NI
		Availability of resources (skills / materials)	7.5%	2	Limited existing skills and business in NI installing automation however strong advance engineering sector to draw on	5	Strong advance engineering sector to draw on	5	High existing skills and knowledge in safety/quality control through universities and NI businesses	3	Moderate existing skills and business in Logistics & distribution technology sector in NI
International Advantage		**Current NI competitive advantage**	10%	3	Ranking between 6 and 10 for NI technological strength in the industry survey	5	Ranked in the top 3 for NI technological strength in the industry survey	3	Ranking between 6 and 10 for NI technological strength in the industry survey	4	Ranking between 4 and 6 for NI technological strength in the industry survey
		Increasing productivity	10%	4	Will result in an increase in productivity in the processing sector	3	Increase in primary sector productivity	4	Decrease in wastage and risk of contamination. Strengthens NI branding for good quality food	3	Will result in an increase in distribution efficiencies
Delivery		**Availability of funding**	5%	3	Some funding available for research on the technology. Limited funding for capital investment of the technology	4	Large amount of funding available purchasing the technology	3	Some funding available for research on the technology	3	Little funding available for research on the technology
		Costs (high, medium, low)	5%	1	High cost	4	Medium to low costs	4	Medium to low cost	4	Medium to low cost
Timing of Impact		**Short-medium**	5%	2	Little impact in the short-medium term	5	Large impact in the short-medium	3	Moderate impact in the short-medium term	3	Moderate impact in the short-medium term
		Long	5%	5	Large impact in the long-term	1	Little impact in the long-term	3	Moderate impact in the long term	3	Moderate impact in the long term
Total			**100%**	**3.20**		**3.30**		**3.60**		**3.53**	

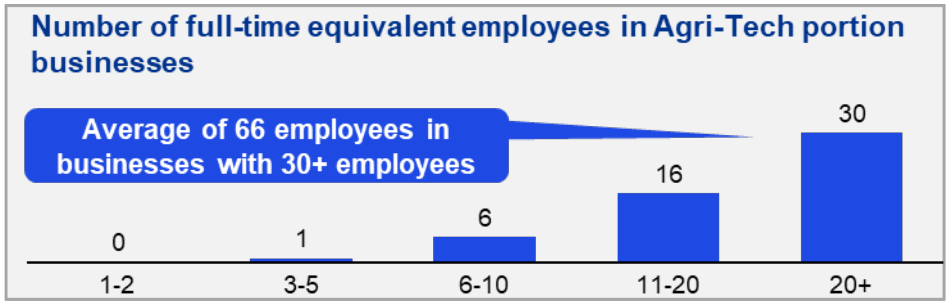
Table A-1: (continued)

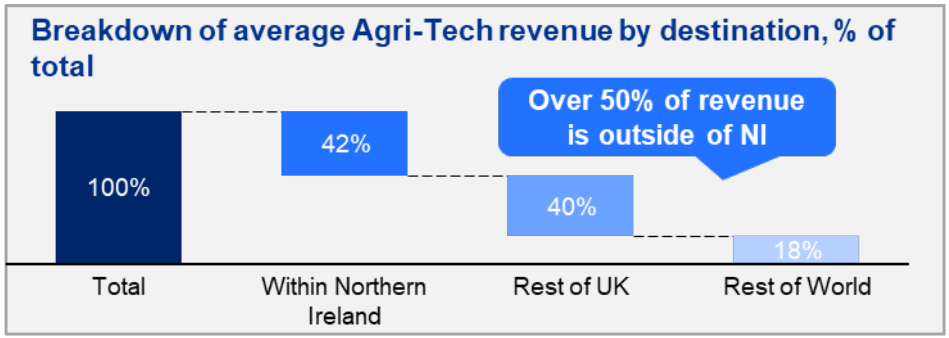
Theme		Criteria	Weighting	Technologies					
				I) Nutrition / product development		J) Sustainability / Environment		K) Traceability	
				Score	Reasoning	Score	Reasoning	Score	Reasoning
10X Vision Pillars	Innovation Growth	**Greater level of R&D**	7.5%	4	Large amount of existing R&D and scope for additional R&D	4	Large amount of existing R&D and significant scope for additional R&D	4	Some existing R&D and significant scope for additional R&D
		Increase the number of innovation driven enterprises	7.5%	5	Strong base of established providers. Significant opportunities for additional growth	4	Significantly large potential for innovation driven enterprise	4	Some established service providers. Significant opportunities for additional growth
	Inclusiveness Growth	**Increase in skill development**	7.5%	3	Moderate additional skills development and training needed	3	Some additional skills development and training needed	3	Moderate additional skills development and training needed
		Increase in household disposable income	7.5%	3	Medium number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income	3	Medium number of higher paid jobs resulting in higher average household disposable income
	Sustainable Growth	**Reduction in energy use / emissions / waste**	7.5%	4	Additional investment in these technologies will assist with reduction in energy use / emissions / waste	5	Additional investment in these technologies will significantly assist with reduction in energy use/emissions / waste	5	Helping consumers understand the sustainability of their purchases and help with their decision making
		Green employment opportunities	7.5%	3	Some green employment	5	Majority of jobs will be green employment	3	Some green employment
Scalability		**Scale of market opportunity**	7.5%	4	A relatively small number of large players resulting in it being easier to scale/purchase the technologies in NI	2	A lot of barriers for uptake. Working with a large number of small farms	4	A relatively small number of large players resulting in it being easier to scale/purchase the technologies in NI
		Availability of resources (skills / materials)	7.5%	4	A number of food processing business are highly innovative with new product development	3	Moderate skills and business in sustainability/Environment sector in NI	3	Moderate existing skills and business in traceability sector in NI
International Advantage		**Current NI competitive advantage**	10%	4	Ranking between 4 and 6 for NI technological strength in the industry survey	5	Ranked in the top 3 for NI technological strength in the industry survey	3	Ranking between 6 and 10 for NI technological strength in the industry survey
		Increasing productivity	10%	4	Will result in an increase in value added products	2	May result in an increase or decrease in productivity. Increase in environmental sustainability	3	Will result in an increase value of end product to retailers/consumers
Delivery		**Availability of funding**	5%	3	Some funding available for research on the technology	5	Significant large amount of funding available for research and purchasing the technology	3	Some funding available for research on the technology
		Costs (high, medium, low)	5%	2	Medium to high cost	2	Medium to high cost	3	Medium cost
Timing of Impact		**Short-medium**	5%	3	Moderate impact in the short-medium term	2	Some impact in the short-medium	3	Moderate impact in the short-medium term
		Long	5%	3	Moderate impact in the long term	5	Large impact in the long-term	3	Moderate impact in the long term
Total			**100%**	**3.60**		**3.58**		**3.38**	

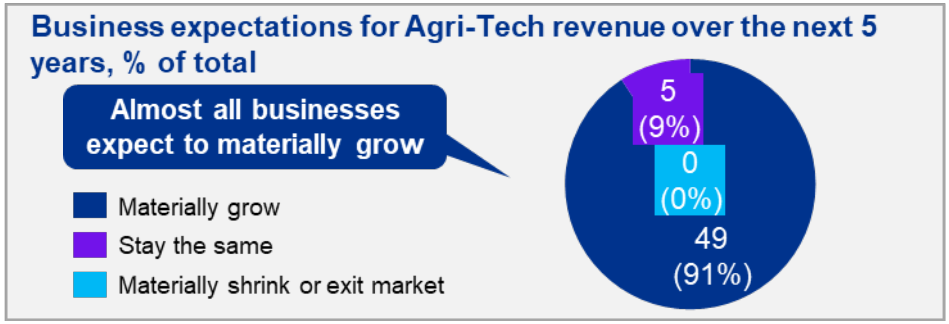
B Primary research

Background information on the survey of Agri-Tech business is summarised in the figures below.



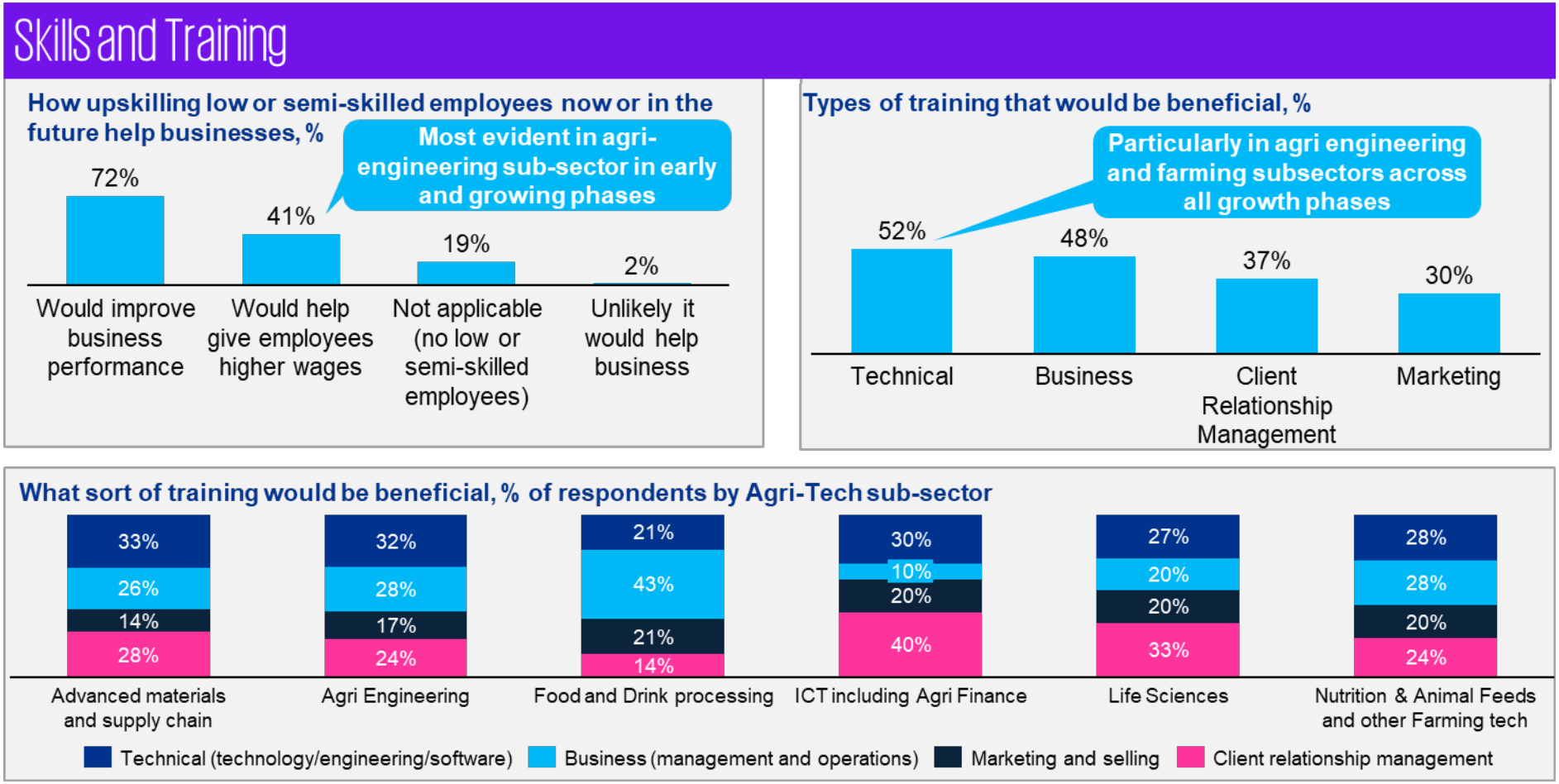






Sources: Industry survey

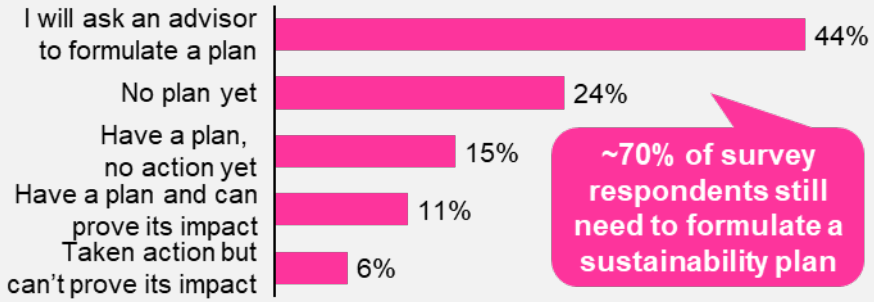
Skills and Training



Sources: Industry survey

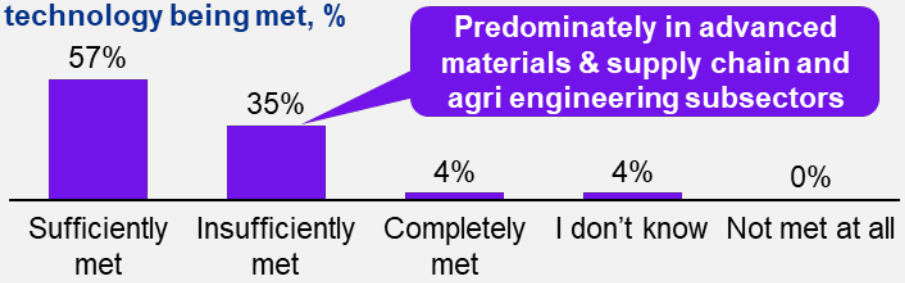
Sustainability

Respondents' sustainability/decarbonisation readiness, %



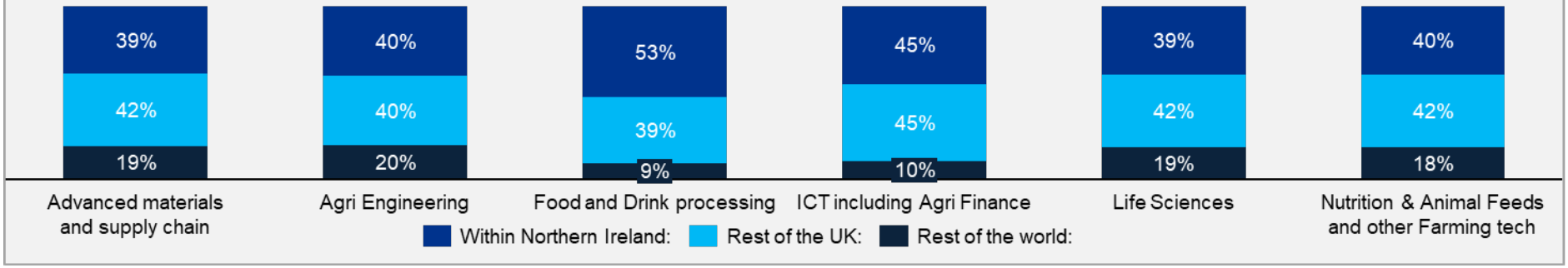
Research

Percentage of respondents' research needs in agri-food technology being met, %



Exports

Breakdown of average Agri-Tech revenue by destination, % of respondents by Agri-Tech sub-sector



Sources: Industry survey

Respondents were asked how the international competitive position of NI's Agri-Tech and FSCS technology sector could be improved.

Increased competitiveness eventually leads to higher quality agri-business standards

In terms of agricultural innovation and digital food technology, Northern Ireland is at the forefront

For changing landscapes, modifications are necessary in both the education system and in-work training supply

More emphasis should be placed on investing in education and skills for future development in order to improve competitive position

Building Sustainable Economic Prosperity for improvement and Protecting and Enhancing our Natural Resources for more sustainable company growth

There needs be a trend towards closer cooperation between supply chain participants, such as agreements between farmers and retailers

Government should offer funding and a platform for Agri-Tech businesses to market their goods since primary producers like farmers, fishers, and foresters make up the core of the agri-food system

Big data synchronisation should be implemented

Northern Ireland can assist the region's top retailers in maintaining output with its best-in-class expertise in food security and technological advancements

The capacity to know where our food comes from and how it is produced, which can be done through the digitalisation of food supply networks, is crucial to food security

For improving competitive position, more focus on Investment in education and skills for the future development is required

The government should put more emphasis on sustainability because a sustainable food system includes the entire food supply chain and incorporates environmental sustainability as one of its essential components

If we adapt simple, modern technologies, like smartphone apps to monitor and manage agriculture irrigation systems, then the international competitive position of Northern Ireland's agri-food technology can be improved

A strategic food framework will aid in concentrating efforts to address many of the major societal issues in Northern Ireland

Themes			
Sustainability	Digital/data	Skills	Other

Sources: Industry survey

Respondents were asked how to improve research support in FSCS and Agri-Tech.

Food security, which depends on the openness of the food system, depends on knowing exactly where

The food and feed sectors need a source of science-based solutions

A more comprehensive participatory approach engaging a variety of stakeholders will facilitate the adoption of technologies for sustainable farming systems

Designing new methodologies in productive farming practices

Knowing where our food comes from and how it is made is essential for food security, which depends on the food system's

Introduce new technology-based agri-food processing methods

Agriculture is becoming more linked into the global market and the food supply chain, and rules governing animal welfare, food safety, and the environment are having a growing impact on the

New additional research on weather and forecasting for climate control needs to be well designed for better support

Proper diagnosis of soil and cultivational techniques needs to be improved with the help of new research methodologies

Creation of an Institute for Agricultural Sciences and Technology

Supply chain and logistics management stations need to be analysed and re-developed for better operations.

Agricultural technology development should be prioritized, and farmers should receive assistance with decision making as well as answers to data-related problems like security and interoperability

Because of its agricultural heritage, Northern Ireland provides a variety of solutions for the agriculture industry on a local and worldwide scale but more improved techniques need to be implemented with new policies for better support

The goal should be to use modern technologies to make sustainable production of food possible in the ensuing years

New polices and frameworks should be introduced in terms of agricultural upliftment for better business support and growth.

With superior research and development facilities, a strong emphasis on safety, quality, and innovation is required

Themes			
Sustainable	Digital/data	Policies	Other

Sources: Industry survey

C International case studies

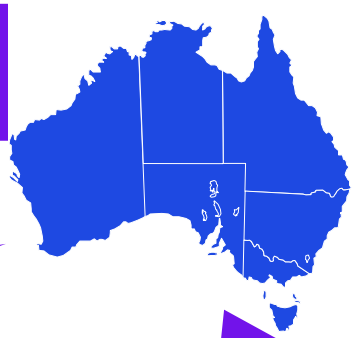
The international case studies are summarised below.

Australia

Overview

Australia exports more agricultural goods than it uses, exporting 72% of agricultural production. This strong agricultural sector is backed up by a thriving Agri-Tech sector, with over 2,500 companies active in Agri-Food. Australia has a particularly large start-up scene, in 2022 Australia was home to over 480 Agri-Tech startups, backed up by 15 Agri-Tech incubators/accelerators. Australia also has a leading food-tech market, ranking 14th in the world for food patenting globally.

Western Australia is aiming to set up a new **Food Technology Facility**



CSIRO food innovation offering world class labs and expertise for research and industry

Western Sydney University is aiming to set up a AUD50m Agri-Tech hub for both research and industry

External expectations / targets

All food and fibre exports from Australia to be fully digitally enabled, supporting traceability and provenance (2025)

Australia's first Agri-Tech investment fund (Cultiv8) aims to raise AUD100m

Australian government aims to transform agriculture into a AUD100bn sector by 2030

Key Agri-Tech/FSCS activities:

- **In response to the global pandemic**, Agri Futures evokeAg and Agristart launched a new start-up network to support connections between Australian startups and growers in order to **encourage the uptake of on farm technology**
- The Australian Farm Institute has estimated that uptake of digital technologies on the farm could **increase farming output by AUD20bn**
- In 2009, a joint venture between Australian Capital Ventures and CSIRO **created a new breed of grain called BARLEYmax**, a high-fibre wholegrain grain, they then worked with food manufacturers to **incorporate this in to food products**

Agric

Agri-Tech companies	Local government	FSCS companies	Industry bodies
• AgriWebb • AquaSpy • Loam • The Yield • Zetifi • AgriDigital • Stacked Farm	• Department of Agriculture, Fisheries and Forestry	• Lumachain • Australia Plant Proteins • Nourish • FoodByUs	• Australian Agri-Tech Association • AgriFutures Evoke

Government initiatives

- The Australian government has allocated AUD136m to a 'smart-farms' programme to support the uptake of best practice and technologies amongst farms
- An R&D tax incentive is available for the agri-food sector to stimulate the development of new food products and technologies

Key learnings for NI:

- The Australian Government has allocated funding for specific programmes within the Agri-Tech sector, identifying opportunities which could support multiple farms. This highlights the importance of funding support. Australia has lots of start-ups, driving innovation across the sector. Supporting start-ups can grow the NI Agri-Tech ecosystem.

Sources: Ausagritech, Agri-Tech Australia

Israel

Overview

The Agri-Tech sector in Israel is a homeland for innovation with the country developing technologies to make the sector work with unfavourable growing conditions. The industry is made up of more than 500 companies, including 265 startups with a vast array of technologies across automation, indoor farming, seed technologies, climate control technologies, smart control, water technology and many more. Israel supports innovation through the Ministry of Agriculture, over 10 research and development centres and through entrepreneurship centres and universities.

$668bn total capital investments raised in 2021 for Agri-Food Tech

External expectations / targets

Continuance of developing further technologies aimed at combatting **climate crisis** and mitigating scarcity of natural resources to ensure **food security** e.g. adjusted crops to desert climate

Increased consumer demand **for healthy and sustainable products** including alternative proteins provide opportunity to advance the markets

Reduce total greenhouse **gas emissions by 27%** by 2030 with initiatives around promoting sustainable agriculture & innovative technologies

Key Agri-Tech/FSCS activities:

- Israel makes use of technology in each stage of the value chain from primary through to processing. The country has developed **seed technologies for seed improvement and gene editing** enabling seasonal produce to be grown year round
- Government offer support across business incubators, **through contributed continuous funding and co-share funding. Both fundings** encourage research and development of technology through seed funding and subsidies and encourage investment
- Government provides investment to drive innovation and growth in the sector from e.g. **Israel Innovation Authority, Ministry of Agriculture and Rural Development, R&D centres** such as Volcani Centre

Agric

Agri-Tech companies	Local government	FSCS companies	Industry bodies
• Greeneye Technology • Cropx • Seed-X • miRobot • Arugga • BeeWise	• Israel Innovation Auhority • Ministry of Agriculture and Rural Development	• SaveFoods • Agmatix • Agritask • Oko • Clarifruit	

Government initiatives

- **The Bio-Convergence Programme:** aiming to promote collaboration between Agri-Tech, biotech and food industries
- **Smart Agriculture Initiative:** provides funding around technology development
- **Greenhouse of the Future Project**

Key learnings for NI:

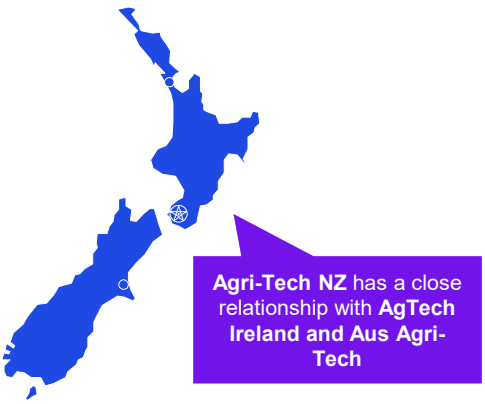
- Israel has developed Agri-Tech to provide food stability in a challenging agricultural environment with unfavourable growing conditions. Lessons could be learned for a similarly challenging environment in NI
- Israel has more than 500 Agri-Food Tech start-ups, which are supported by accelerators and incubators
- Accelerators and incubators can support NI Agri-Tech start-ups, providing an environment for testing.

Sources: Food Navigator, Agri-Tech 2023, Start-Up Nation Central

New Zealand

Overview

New Zealand (NZ) has long been a world leading exporter of quality food. The country has a history of innovation across the primary sector e.g. the electric fence, gold kiwifruit and AI-enabled smart cow collars. The country has a strong relationship between its companies and government entities within the Agri-Tech sector. NZ has significant strengths in the following technology areas animal & crop health, growing & harvesting, post-harvest, environment.



External expectations / targets

Aim to establish an agricultural data interoperability that allows the exchanging of trusted data underpinning the digital agricultural ecosystem in New Zealand's primary sector

- Baselining Primary Sector Digital Adoption to provide insights to on-farm utilisation of digital agricultural practices and the strategies to enable increased benefit from the technologies
- Reduce biogenic methane emissions by 10% by 2030 and 24% to 47% by 2050

Key Agri-Tech/FSCS activities:

- **Callaghan Innovation** is an NZ innovation agency helping with innovative solutions to businesses of all sizes incl startups, funding, R&D technical solutions, industries, networking & partnerships and learning
- **AgriTechNZ** is leading **Agricultural Data Interoperability** intends to enable the efficient exchange of agricultural data across all sub-sector
- New Zealand produce a number of informative Agri-Tech reports which help inform the public and private secto. Some of these include:
  - NZ Agri-Tech Insights Report
  - AgriTechNZ Digital Adoption in Primary Industries
  - Agri-Tech industry transformation plan

Agric

Agri-Tech companies	Local government	FSCS companies	Industry bodies
• Gallagher • Datamars Livestock • Robotics Plus • LIC	• Ministry for Private Industries • Ministry of Business, Innovation and Employment • Ministry for the Environment • Callaghan Innovation	• Nda Group • Tomra Food	• AgriTech

Government initiatives

- New Zealand Growth Capital Partners
- Agri-Tech Industry Transformation Plan
- The Pre-Seed Accelerator Fund
- Strategic Science Investment Fund
- Provincial Growth Fund
- Sustainable Food and Fibre Futures
- New Zealand Green Investment Finance

Key learnings for NI:

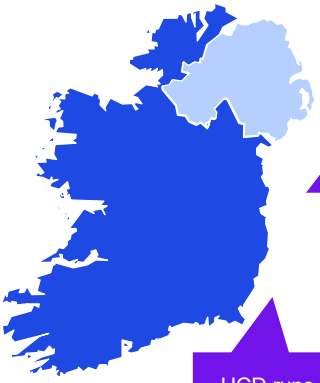
- New Zealand is a world leading exporter of quality food with a history of innovation across the primary sector
- The Government has published an Agri-Tech Sector Transformation Plan (2020) which provides a clear outline and plan for the sector
- Development of a NI plan for the sector can set out a clear path to grow the sector.

Sources: Agri-Tech NZ, Ministry for Primary Industries

Republic of Ireland

Overview

The Irish Agri-Tech sector is currently made up of a relatively small cohort of companies, however the strong state backing through funding, accelerator programmes and establishment of industry bodies has created a conducive environment to grow this sector, Ireland aims to become a hub for Agri-Tech startups. The food-tech sector has similar state provisions to Agri-Tech and is supported by a range of research centres such as Teagasc Moorepark.



Agtech investor Finisterre has set up a base in Dublin after receiving state sponsorship

UCD runs an Agri-Tech accelerator called 'AgTechUCD'

External expectations / targets

- 90% of all agricultural slurry to be spread using Lower Emission Slurry Spreading (LESS) technology (2027)
- South West Ireland's plan to develop a network to support food production to be completed (2024)
- 25% reduction in agricultural emissions (2030)

Key Agri-Tech/FSCS activities:

- **Enterprise Ireland** operates a **Food-Tech Cluster** consisting of seven technology gateways to support various sectors in the Irish food-tech network including photonics solutions for examination of foodstuffs and medicinal nutrition
- **Ireland encourages farmers to invest in new technology**, often focussing on emissions reduction technology through a 'Targeted Agricultural Modernisation Scheme' (TAMS) which will **fund 60% of capital expenditure**
- **AgTech Ireland has signed an MoU with AgriTechNz** to develop shared insights and opportunities for innovative food production
- UCD has commenced development on €4.8m agtech and herd health education facilities to be opened in Q3 2023

Agric

Agri-Tech companies	Local government	FSCS companies	Industry bodies
• Keenan • Moocall • Farmflo • ApisProtect • Hexafly • Cropbiome • Herdwatch • Proveye • Plantedit	• Enterprise Ireland • Bord Bia • National Treasury Management Agency	• Senoptica • Plantruption • Greencore • Safe Food 360 • Bfree • Valid Nutrition • nualtra	• Agtech Ireland

Government initiatives

- The Ireland Strategic Investment Fund (ISIF) in conjunction with Canadian VC firm Finistere Ventures has created a €20m find for Agri-Tech investment called the Ireland AgTech Fund (IAF)
- State backed Agri-Tech investor YieldLab Europe is investing in Irish startups after receiving support from Enterprise Ireland

Key learnings for NI:

- The Irish Agri-Tech sector has a strong backing from the state, including funding, accelerator programmes and industry bodies. This organisational structure allows for collaboration, funding applications and a wider international reach. Funding, accelerator programmes and industry bodies can support the NI Agri-Tech sector.

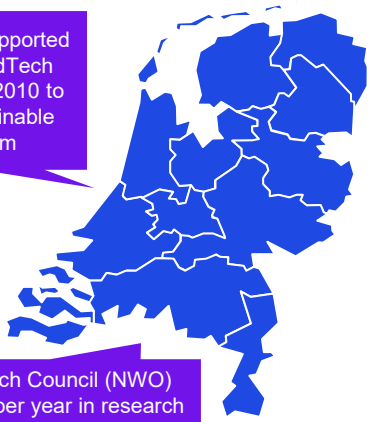
Sources: AgTech Ireland, Enterprise Ireland

The Netherlands

Overview

Agri-Tech in the Netherlands is highly innovative and well advanced in terms of sustainable practice featuring technology providers such as Holstcenter and innovative universities like Wageningen University & Research (Foodvalley) and is home to 335 Agri-Tech startups. The sector has a highly collaborative model of working, with competitors and various elements of the supply chain collectively working together to provide solutions internationally enabling international competitive advantages.

StartLife has supported 400+ AgriFoodTech startups since 2010 to shape a sustainable food system



Dutch Research Council (NWO) invests ~€1bn per year in research including agri e.g. opportunities and barriers of circular agriculture

External expectations / targets

90Transition from field farming to controlled environments and vertical farming systems and mono-crop to multi-crop approach

Netherlands aim to be the global leader in circular agriculture by 2030 and increased use of precision agriculture technology. TNO has role in research

Nitrogen emissions to be reduced by 50% by 2030. €25bn allocated from cabinet for reductions within the farming industry

Key Agri-Tech/FSCS activities:

- The government offers research incentives and collaboration is a strong focus in the industry across stakeholders such as researchers, companies and Government org Several institutions e.g. New Agri-Tech initiative **OnePlanet Research Centre, Foodvalley and Wageningen University & Research**
- Government target of circular agriculture sector by 2030, publishing a plan of action which requires key enabling technologies to reduce nitrogen deposition and develop robust cultivation processes
- €60m allocated by the government to support a cellular agriculture ecosystem by education, research and upscaling facilities with an additional €25m expected.

Agric

Agri-Tech companies	Local government	FSCS companies	Industry bodies
• Aris • In Ovo • Viscon • Bosman van zaal • Certhon • Green Automation • PlantLab • Heliopas.ai	• Netherlands Enterprise Agency • Ministry of Agriculture, Nature & Food Quality of the Netherlands	• Solynta • DNA • Protix • Friesland Campina • eden	• LTO

Government initiatives

- **Knowledge and Innovation Agenda for Agriculture, Water & Food** (2020)
- **Foodvalley and Dutch Agri Food-tech Platform**: public-private partnerships, promoting innovation and collaboration in Agri-Tech e.g. precision farming
- **Agro-Proeftuin de Peel:** pilot around manure, cropping techniques and climate

Key learnings for NI:

- The agri-food sector is innovative at adopting new technologies at scale
- The Netherlands hosts 15/20 of the largest global agri-food players major research and development centres
- Promoting technology adoption can help to grow the NI Agri-Tech sector.

Sources: Wageningen University & Research, Tracxn, Government of the Netherlands, European Commission, Ministry of Agriculture, Nature and Food Quality of the Netherlands, Startlife Agrifoodtech Accelerator

United Kingdom (excl NI)

Overview

The agricultural sector in the UK contributed a total income from farming of £5,998m in 2021 and provides a large source of employment, exports and innovation across the UK. The Agri tech sector in the UK has seen the development of multi million start-ups through their development, growth and innovation throughout the UK. The UK government has enhanced their offerings towards new Agri-Tech start-ups and innovation leaders through their offerings within innovation centres and funding.

Agri-tech is continuing its growth throughout the UK by new infrastructure to become a global leader (Fisher Farms)

External expectations / targets

The project focuses on three main axis's and aims to double down on economic growth areas for the UK. One main focus within Agri, digital and technologies.

The Innovate UK strategy delivery for 2022 to 2025, demonstrates the UK's plan to become a global leader in Agri-tech innovation through funding and centres of excellence

Under WWF's scenario, emissions from agriculture would be reduced by at least 35% by 2030

Key Agri-Tech/FSCS activities:

- **Centres of Excellence** have been established across the UK increasing their innovation, R&D and focus across the Agri-Tech industry. The centres include:
  1. **Agri-EPI:** focused on pioneering innovation, technology and precision engineering within UK farming
  2. **Centre for Innovation Excellence in Livestock**: Focusing on livestock and aquatic food production challenges
  3. **Crop Health and Protection:** Encouraging uptake of new technologies to advance sustainability and crop production
  4. **Agrimetrics:** Data marketplace for sharing and collaboration of food and Agri data
- **Government funding** has been allocated to encourage uptake of new technologies through the Farming Investment fund (FIF). Farming Equipment and Technology fund for grants between £1,000 and £25,000

Agric

Agri-Tech companies	Local government	FSCS companies	Industry bodies
• Barn • Agribot • Actisense • Oxford Analytical • Ardra • Agrisound	• Department for Environment Food and Rural Affairs • Welsh Government	• NMRO • Alex Stewart Food Test Lab	• Chap • Agritech UK

Government initiatives

- Farming Equipment and Technology Fund (FETF) 2023
- Farming Innovation Programme UK Research & Innovation partnership with Department for Environment, Food & Rural Affairs
- Agri-Tech Catalyst
- Knowledge Transfer and Innovation Fund

Key learnings for NI:

- The UK Government encourages innovation in the Agri-Tech sector through funding, developing centres of excellence and supporting research
- A clear action plan sets out a pathway for the UK to become a world-leader in Agri-Tech
- NI could develop a similar approach through using centres of excellence and targeted funding for innovation

Sources: Agritech UK, Department For Environment Food & Rural Affairs, Government Rural Grants and Payments UK, Gov.uk (Net Zero Strategy: Build Back Greener)

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