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Northern Ireland
Science Industry Panel

**Engineering
Biology
Research in
Northern
Ireland**

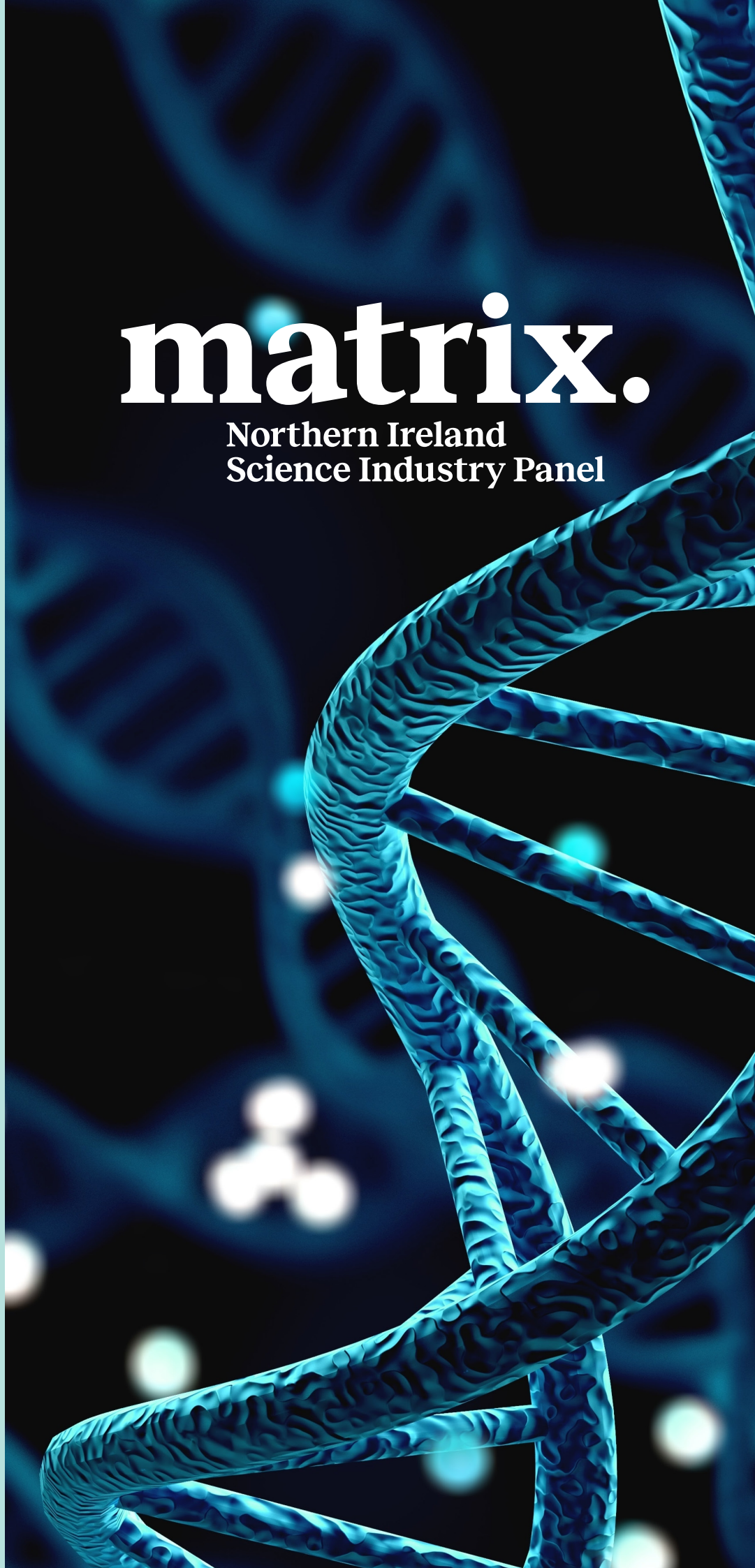
**A Strategic
Roadmapping
Study**

Summary Report

April 2026

Delivered by

IfM Engage



**Stakeholders Engaged
from Organisations**

- Agri-Food and Biosciences Institute (AFBI)
- Animal Health and Welfare Northern Ireland (AHWNI)
- Almac Group
- Advanced Manufacturing Innovation Centre (AMIC) Belfast
- Catalyst
- Causeway Sensors
- Department of Agriculture, Environment and Rural Affairs (DAERA)
- Department for the Economy (DfE) / Matrix
- Department of Business and Trade Northern Ireland
- Department of Science, Innovation and Technology (DSIT)
- Invest Northern Ireland (Invest NI)
- Northern Ireland Antimicrobial Resistance (NI AMR) Network
- Navico Group
- Peter Simpson Consulting
- Queen's University Belfast (QUB)
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This report has been prepared by the project delivery team at IfM Engage on behalf of Matrix, the Northern Ireland Science Industry Panel, for the Department for the Economy.

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Foreword

Professor Sam Turner

Chair of the Study

Engineering biology has moved decisively from the margins of scientific research to the centre of economic, environmental and health policy. As this report demonstrates, it is now a foundational technology with the potential to reshape food systems, healthcare, manufacturing and environmental stewardship. For Northern Ireland, the question is no longer whether engineering biology matters, but how deliberately and effectively we choose to engage with it. This study provides a clear, evidence-based assessment of Northern Ireland's position.

It shows that the region has genuine strengths: internationally recognised research excellence, established industry anchors, a strong agri-food base, and unique dual market access under the Windsor Framework. At the same time, it is candid about the barriers that constrain progress—most notably fragmented coordination, skills shortages, limited scale-up infrastructure, and a persistent gap between research and commercial deployment.

A central message from the work is the importance of focus. Northern Ireland cannot and should not attempt to compete across the full breadth of engineering biology. Instead, the opportunity lies in building depth in a small number of areas where existing capability, market demand and societal need align most strongly. The six priority initiatives identified in this report should be treated as an integrated portfolio, not a set of disconnected options.

The study also highlights a narrow but important window of opportunity. Significant UK-wide investment is now being directed towards engineering biology, global bioeconomy markets are expanding rapidly, and Northern Ireland's scale offers advantages as a living laboratory that larger regions cannot replicate. Capturing these benefits will require coordinated leadership, sustained investment, and a willingness to act on the evidence set out here.

I would like to thank the many contributors from industry, academia, government and the wider ecosystem who gave their time and insight. Their collective input has ensured that this report is both ambitious and grounded in reality. My hope is that it serves not simply as an analysis of opportunity, but as a practical foundation for decisive action to position Northern Ireland as a credible, focused and competitive participant in the engineering biology economy.



Overview and Context

1. Strategic Overview

This strategic summary report presents the findings, analysis, and recommendations of the Engineering Biology Research Project in Northern Ireland, commissioned by Matrix on behalf of the Department for the Economy and delivered by IfM Engage, University of Cambridge. The study employed the Cambridge strategic roadmapping methodology, integrated with the UK Government Futures Toolkit, to assess Northern Ireland's opportunities, strengths, gaps, and strategic positioning in engineering biology.

Engineering biology is one of five critical technologies identified by the UK Government, backed by £2 billion in public investment over the next decade. The global bioeconomy is projected to generate up to \$4 trillion per year by 2030–2040. Northern Ireland possesses genuine strengths—internationally recognised research, globally operating diagnostic and pharmaceutical companies, a significant agri-food sector, and unique dual market access through the Windsor Framework—but these are constrained by fragmented governance, limited scale-up infrastructure, skills shortages, and insufficient integration with UK-wide funding and innovation networks.

The study engaged over 50 stakeholders through interviews, surveys, and a structured roadmapping workshop. Over 1,200 individual evidence statements were gathered, clustered, and analysed across the roadmapping framework. Six priority topic roadmaps were developed: Food Security and Resilience; Scale-Up Capabilities; Circular Bioeconomy; Agri-Tech Innovation and Policy Alignment; Diagnostics and Biosensors; and One Health. These should be pursued as an integrated portfolio, not in isolation.

The recommendations centre on five policy priorities (cross-departmental coordination, regulatory strategy, skills and workforce, data infrastructure, and public engagement), four investment priorities (shared engineering biology infrastructure, a TRL 3–4 bridging fund, a diagnostics accelerator, and a Lough Neagh circular bioeconomy demonstrator), and six future research opportunities. A phased implementation framework provides a pathway from foundation-building through to a self-sustaining, internationally recognised engineering biology cluster.

The window of opportunity is now. UKRI is ring-fencing significant engineering biology funding. Northern Ireland's unique Windsor Framework positioning creates advantages no other UK region can replicate. Failure to act risks not only missing new opportunities but seeing existing industries displaced by engineering biology advances developed elsewhere.

2. Strategic Context

2.1 The Wider Opportunity

Engineering biology—the design, scaling, and commercialisation of biology-derived products and services—is transforming sectors worldwide. The UK Government’s National Vision for Engineering Biology (December 2023) positions it alongside quantum technologies, AI, semiconductors, and future telecommunications as a critical technology for national competitiveness.

\$4tn	Projected annual global impact of engineering biology by 2030–2040 (McKinsey)
60%	Of physical inputs that could potentially be produced biologically
50+	Governments with national bioeconomy strategies
£2bn	UK Government commitment to engineering biology over 10 years
~1,000	Engineering biology firms in the UK, raising £5.2bn (2017–2022)

However, the House of Lords Science and Technology Committee (January 2025) warned that the UK is in “severe danger” of falling behind without urgent action, citing persistent failures to translate scientific excellence into commercial success, insufficient scale-up infrastructure, and under-investment in doctoral training.

2.2 Northern Ireland's Distinctive Position

Northern Ireland occupies a unique position in the engineering biology landscape. Its life and health sciences sector contributes over 2.5% of regional economic output, worth £1.2 billion GVA across 170+ firms employing 19,500 people. Over £200 million in City and Growth Deals is targeting life sciences infrastructure. The region's agri-food sector is proportionally the largest in the UK, valued at £8 billion and employing 110,000 people, with 80% of production exported.

The Windsor Framework creates a globally distinctive dual market access arrangement. Northern Ireland companies can potentially serve both the UK market (69 million) and the EU Single Market (450 million). For medicines, the MHRA now provides UK-wide licensing, whilst the Framework's dual-access provisions create a compelling proposition for clinical trials, diagnostics, and medical devices. US companies are already seeking Northern Ireland partnerships specifically to access both MHRA and EMA regulatory pathways.

However, the Framework also introduces constraints: Northern Ireland remains aligned with EU GMO regulations whilst England has diverged through the Genetic Technology (Precision Breeding) Act 2023. This creates barriers for plant-based engineering biology applications that do not apply in other UK regions.

2.3 Why Engineering Biology Matters for Northern Ireland?

Engineering biology applications may directly address many of the NI Executive's Programme for Government priorities: reducing health waiting times through advanced diagnostics and personalised medicine; protecting Lough Neagh through bioremediation; supporting sustainable agriculture to meet Net Zero targets; and creating high-value employment. The convergence of political priorities with technological opportunity creates a compelling case for strategic investment.

Steering Group Members

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Methodology Overview

3. Methodology Overview

The study employed the Cambridge strategic roadmapping methodology, developed over 25 years at the Institute for Manufacturing, University of Cambridge, and applied in over 300 organisations and sectors worldwide. Notable precedents include the UK Synthetic Biology Roadmap, the Cancer Research UK Early Detection Roadmap (published in *The Lancet Oncology*), and the AMIC Strategic Roadmap for Belfast City Region.

The roadmapping framework is structured around three fundamental dimensions:

- **Why** – External drivers, trends, and opportunities shaping the engineering biology landscape
- **What** – Applications, capabilities, products, and services where engineering biology can create value
- **How** – Resources, technologies, infrastructure, and enabling conditions required for delivery

These layers are set against time horizons: short-term (2026–2027), medium-term (2028–2030), and long-term (2031–2035). The methodology integrates proven foresighting techniques from the UK Government Futures Toolkit, including driver mapping, horizon scanning, SWOT analysis, Delphi methods, and scenario planning.

The evidence base comprises: a literature review of over 200 sources; 10 semi-structured interviews with senior stakeholders across academia, industry, and government; a stakeholder survey with 16 responses; a strategic roadmapping workshop (3 February 2026, Belfast) with 35 participants; and international benchmarking against seven comparator jurisdictions. Over 1,200 individual statements were gathered, clustered, and mapped to the roadmap framework.



**Global Landscape
and Lessons for
Northern Ireland**

4. Global Landscape and Lessons for Northern Ireland

The study examined seven comparator jurisdictions—the United States, Australia, the Netherlands, Scotland, Ireland, China, and India—to identify global trends and draw practical lessons for Northern Ireland.

4.1 Key Global Drivers

- **Strategic competition and sovereign capability:** Engineering biology is framed as a matter of economic security across major economies. The US, China, and the EU all position biotechnology as strategic infrastructure.
- **Climate and sustainability imperatives:** Climate action is a principal driver across all jurisdictions, with engineering biology positioned as an enabling platform for the green transition.
- **AI and digital convergence:** The 2024 Nobel Prize for AlphaFold underscores the transformative potential of AI-biology integration. Most executives consider AI important in accelerating engineering biology adoption.
- **Mission-driven policy:** The most effective strategies are organised around clear, time-bound, measurable targets—from the US “Bold Goals” to Scotland’s “delivery sprints.”
- **The scaling challenge:** The transition from laboratory to commercial production remains the critical global bottleneck, with talent shortages a universal concern.

4.2 Lessons for Northern Ireland

Lesson	Implication for NI
Institutional coordination is essential	Every successful ecosystem has a dedicated coordinating anchor (Scotland’s IBioIC, Australia’s CSIRO, India’s BIRAC). NI currently lacks an equivalent mechanism.
Build on existing sectoral strengths	Scotland leverages whisky co-products; Ireland leverages biopharma manufacturing. NI should anchor its strategy in precision medicine, diagnostics, agri-food, and advanced manufacturing.
Skills are a foundational enabler	Skills gaps are a universal bottleneck. NI’s under-supply at mid-tier level (RQF 3–5) and clinical academic shortage require urgent attention.
Scale-up infrastructure is the critical bottleneck	Jurisdictions investing in shared pilot and scale-up facilities see faster commercialisation. NI has no CPI-type bioengineering centre.
Regional strategies must nest within national frameworks	NI should maximise access to UKRI’s engineering biology funding whilst developing a distinctive local proposition.
All-island collaboration offers scale advantages	Shared agri-food base, cross-border supply chains, and complementary research strengths make all-island partnership a natural priority.

4.3 Comparator Jurisdictions at a Glance

Each of the seven comparator jurisdictions offers distinctive models and lessons relevant to Northern Ireland's strategic development:

Jurisdiction	Key Features	NI Relevance
Scotland	IBioIC centralised hub model since 2014; £50m+ invested; 43→147 active companies; £25bn life sciences target by 2035; delivery sprints and local feedstock value chains	Most directly comparable: similar scale, devolved governance, agri-food heritage. Hub coordination model is the clearest precedent for NI.
Ireland	€100bn exports; 84,000 employed; BiOrbic, NIBRT, Lisheen Campus; strong biopharma manufacturing base and FDI track record	Natural all-island partner. Complementary strengths: ROI manufacturing scale, NI research and indigenous companies. Shared agri-food challenges.
Netherlands	€30bn annual target by 2040; triple-helix collaboration; campus ecosystems (Brightlands Chemelot); complete circular value chains	Circular bioeconomy model highly relevant. Building value chains from local feedstocks mirrors NI agri-food opportunity.
United States	Executive Order 14081; Bold Goals with 20-year quantitative targets; world's deepest VC markets; BioMADE manufacturing institutes	Mission-driven target-setting model. VC depth contrast highlights NI's need for alternative funding models.
Australia	CSIRO-led coordination; AUD \$30bn target by 2040; \$1.3bn Modern Manufacturing Initiative; integration with national missions	Science agency coordination model. Integration of EngBio within broader economic transition strategies.
China	State-coordinated scale; 52.4% of world's top-cited synthetic biology papers; STAR Market fuelling growth; integration with digital policy	Demonstrates transformative potential of long-term policy certainty. Competitive threat if NI does not act.
India	\$1tn bioeconomy target; 5,300+ startups supported; BIRAC venture funds; Bio-Manufacturing Platform for shared infrastructure; frugal innovation	Shared infrastructure model reduces capital risk for SMEs. Annual benchmarking is best practice for NI to adopt.

4.4 All-Island Perspectives

The analysis identified significant potential for all-island collaboration in engineering biology. Both jurisdictions share agri-food as an important economic sector, comparable livestock-dominated feedstock bases, and supply chains that already operate cross-border. Both face acute climate and environmental pressures, and both have relatively small domestic markets, meaning collaboration offers economies of scale in research infrastructure, skills, and market access.

The Republic of Ireland's institutional assets—BiOrbic's multi-institutional research network, NIBRT's globally recognised bioprocessing training, the National Bioeconomy Campus at Lisheen—offer tangible partnership opportunities. Northern Ireland's established capabilities in advanced manufacturing, agri-food technology, and data analytics complement Ireland's strengths in biopharma manufacturing, bioeconomy research, and marine bioresources. The IMPACT initiative, an all-island cell therapy programme with approximately €100 million funding through Research Ireland, demonstrates that such collaboration is already operational at scale.



Northern Ireland's Engineering Biology Capabilities

5. Northern Ireland's Engineering Biology Capabilities

The stakeholder engagement programme revealed a consistent picture of genuine but fragmented strengths across Northern Ireland's engineering biology landscape.

5.1 Research and Industry Strengths

- **Precision medicine and diagnostics cluster:** QUB, Ulster University, Almac, and Randox collectively anchor an integrated life sciences ecosystem. The combination of university research alongside globally operating indigenous companies is unusual for a region of Northern Ireland's size.
- **Research excellence across two universities and AFBI:** World-leading capabilities in antibody engineering, biocatalysis, bioprocessing, cell therapies, biomaterials, food security, and diagnostics “across the entire spectrum from environment to farm to fork to human health.”
- **Digital infrastructure:** Northern Ireland's electronic patient records system was described as “probably the best in UK/world,” creating a distinctive platform for data-driven engineering biology applications.
- **Agri-food ecosystem:** Northern Ireland produces protein output vastly exceeding the needs of its 1.9 million population, creating both environmental challenges and engineering biology opportunities.
- **Advanced manufacturing transferable skills:** Northern Ireland's aerospace, polymers, and engineering pedigree offers directly transferable capabilities for bioengineering and biomanufacturing.

5.2 Critical Gaps

- **No life sciences Catapult or scale-up hub:** Northern Ireland lacks regional specialist shared manufacturing infrastructure to progress from laboratory to production. While GB-based facilities are accessible, the absence of local provision adds cost and logistical barriers, risking lost business.
- **Valley of death at TRL 3–4:** A persistent gap between academic research and commercial application, with no structured pathway for prototyping and early-stage commercialisation.
- **Skills shortages:** The single most cited barrier—spanning biomolecular discovery, synthetic biology, biomanufacturing, regulatory expertise, data science, and entrepreneurial training.
- **Fragmented governance:** No unified coordination mechanism for engineering biology; artificial divides between DfE and DAERA impede cross-sectoral innovation.
- **Limited UK funding engagement:** NI receives approximately 1% of total UKRI funding despite comprising 2.8% of the UK population, with the lowest application success rate of any UK region or nation.

5.3 Stakeholder Vision

Every interviewee emphasised that engineering biology must be treated as a core driver of the economy, not a niche research interest. The consistent message was that Northern Ireland's economy “is going to have to reinvent itself in the next two decades” and that the window of opportunity to develop engineering biology capabilities is now—whilst the field is still emerging and leading UK centres are not yet far ahead.



Strategic Landscape and Priorities

6. Strategic Landscape and Priorities

The strategic roadmapping workshop synthesised over 1,200 evidence statements into a comprehensive landscape structured across the Why–What–How framework. A rigorous prioritisation process identified the highest-impact themes.

6.1 Top Priorities from the Workshop

Priority Theme	Prioritisation Rank
Circular bioeconomy replacing fossil feedstocks with bio-based materials	1
Climate change impacts driving demand for biological solutions	2
Funding access and industry–academia collaboration lagging behind other UK regions	2
Skills deficit, brain drain, and fragmented leadership constraining competitiveness	2
Food security and supply chain resilience	3
World-class agri-food research ecosystem (AFBI and universities)	3
UK industrial policy and strategic alignment	4
Missing CPI-type bioengineering facility	4
Biocatalysis and enzyme engineering for sustainable manufacturing	4

The strategic narrative is clear: Northern Ireland possesses genuine research strengths in life sciences and agri-food, but is constrained by inadequate scale-up infrastructure, fragmented coordination, and insufficient connection to national funding and innovation networks. The circular bioeconomy emerged as the single most compelling cross-cutting opportunity, whilst biocatalysis and enzyme engineering were identified as potentially the region's most distinctive technical capability.

6.2 Priority Cases

Six priority topic roadmaps were developed through expert working groups, each exploring a strategic opportunity in depth. The workshop's opportunity–feasibility scoring provides a framework for investment prioritisation:

Initiative	Opp. (1-5)	Feas. (1-5)	Key Implication
Food Security & Resilience	5	3	Highest opportunity; constrained by TRL 3–4 gap
Scale-Up Capabilities	5	3	Known customer pull; infrastructure investment needed
Circular Bioeconomy	4	3	Driven by Lough Neagh; nascent technology
Agri-Tech Innovation	4	2	Lowest feasibility due to data access barriers
Diagnostics & Biosensors	4	4	Strongest combined score; most immediately actionable
One Health	3	3	Exploratory but strategically important

These six initiatives should be treated as an integrated portfolio. Siloed implementation would negate the synergies that make engineering biology transformative. The following section summarises each topic roadmap.

6.3 Case Summaries

Food Security and Resilience

Northern Ireland's food sector is valued at £8 billion, employs 110,000 people, and exports 80% of production globally. Queen's University Belfast ranks first for research excellence in food security. This initiative aims to ensure accessibility to safe and nutritious food through engineering biology, building resilience to climate change and geopolitical disruption.

Key engineering biology applications include precision breeding using CRISPR and gene editing for climate-resilient crops; rumen microbiome manipulation to reduce livestock methane emissions; engineered soil microbiomes for sustainable agriculture; and biosecurity tools for rapid disease detection across plant and animal populations.

Development pathway: In the short term (1–3 years), priorities centre on mapping current engineering biology expertise across NI, addressing plant growth facility and fermentation capacity gaps, and establishing the 'NI Diamond' triple helix model connecting government, industry, and academia. In the medium term (4–6 years), the focus shifts to bridging TRL 3–4 gaps and educating the next generation of engineering biology practitioners. Long-term objectives (5–20 years) centre on establishing NI as a global leader in climate-smart food production.

Critical barriers include the absence of a specific engineering biology cluster, uncoordinated expertise, GM regulatory constraints under EU-aligned rules, significant TRL 3–4 capability gaps, and institutional silos between DfE and DAERA. The initiative requires DfE PhD awards to explicitly include engineering biology and government departments to overcome the pre/post farm-gate divide.

Scale-Up Capabilities

This initiative addresses Northern Ireland's most critical infrastructure gap: the absence of affordable, accessible capabilities for scaling innovations from laboratory towards commercial production. Both industry and academia highlighted the need for intermediate-scale fermentation capacity—specifically, a minimum 1,000-litre fermenter would enable NI companies to win business currently lost to competitors.

The UK has established six engineering biology mission hubs, but none are located in Northern Ireland. Connection to the Catapult network—including CPI, the Cell and Gene Therapy Catapult, and the Medicines Discovery Catapult—is essential but currently inadequate.

Development pathway: Short-term priorities include utilising existing assets (Food Manufacturing Innovation Centre, Almac, AMIC), installing 1000-litre bridging fermentation capability, establishing cell-free systems, and securing permanent Catapult staff presence in NI. Medium-term plans envisage a 'research hotel' model, potentially through all-island collaboration. The long-term vision is a thriving ecosystem of engineering biology SMEs with easy access to scale-up infrastructure.

Key enablers include QUB's MSc in Engineering Biology, the BioAID bioresource initiative, and existing entrepreneurship programmes. Critical barriers include the declining focus on biomanufacturing, a lack of specialised skills, few engineering biology companies currently operating in NI, and the need for differentiation from the Republic of Ireland's offering. The buy-in of a major industry partner as an anchor tenant would provide credibility and guaranteed utilisation.

Circular Bioeconomy

This initiative focuses on developing renewable, traceable circular bioeconomy systems that utilise biomaterials and waste to create sustainable products and fuels. The Lough Neagh environmental crisis—blue-green algae threatening drinking water for a third of NI's population—provides both an environmental imperative and a demonstrator opportunity with global export potential.

Key engineering biology applications include bioremediation systems using engineered algae and microorganisms for water treatment; biopolymer production converting agricultural waste or algae into biodegradable PHA polymers; protein engineering for bio-based food packaging; and designed microbial consortia for breaking down complex waste materials.

Development pathway: In the short term, a flagship project would establish bioremediation in Lough Neagh, potentially harvesting algae for PHA polymer production. AMIC serves as a key capability hub given its strengths in polymers and composites. Medium-term efforts develop coordinated circular bioeconomy clusters with North–South coordination. The long-term vision sees NI as a global blueprint for circular bioeconomy implementation, with Lough Neagh's bioremediation model exported as a toolkit.

Critical barriers include cost competitiveness of biobased materials versus synthetic alternatives, paradoxical waste legislation that sometimes prohibits circular approaches, TRL 4–6 technology readiness gaps, high NI energy costs, and the need for a comprehensive strategy bringing DfE and DAERA together.

Agri-Tech Innovation and Policy Alignment

Northern Ireland has untapped potential for engineering biology in Agri-tech. The region features a small but technologically advanced Agri-tech sector serving a large number of small, often part-time farms. The export-oriented nature of NI agriculture (c.80% exports) means locally developed solutions must meet international standards, giving them global applicability. NI's small regional scale makes it an ideal living laboratory for testing innovations comprehensively.

Key engineering biology applications include precision livestock management through biosensors and engineered diagnostics; soil microbiome engineering for improved nutrient management; genomic selection tools for breeding; biological control systems for sustainable pest management; and environmental sensing through biological sensors for water quality and soil health.

The critical barrier is data access. The workshop team was unequivocal: without solving data access for the farming community—addressing legacy data systems, data security concerns, and fragmented government approaches—this initiative cannot proceed. This assessment is reflected in the lowest feasibility score of any initiative (2 out of 5). DAERA is the clear lead agency, with the go/no-go decision resting on making relevant data available in a secure, accessible format.

Diagnostics and Biosensors

This initiative scored the strongest combined opportunity–feasibility rating, reflecting NI's most established engineering biology capabilities. The aim is to develop the complete pipeline for diagnostic design, prototyping, and manufacturing, positioning NI as a diagnostics powerhouse across human health, animal health, and environmental monitoring.

NI possesses an established diagnostics industry with significant global presence, anchored by Almac and Randox, alongside extensive research at QUB, Ulster University, AFBI, and NIBEC. Infrastructure assets include the £30 million Nanotechnology and Photonics capability at AMIC and the emerging Centre for Digital Healthcare Technology.

Key engineering biology applications include biomolecular design of proteins, antibodies, and aptamers for target detection; biosensor development using biological recognition elements; synthetic biology circuits for signal amplification; cell-free diagnostic systems; and multiplexing capabilities for simultaneous multi-target detection.

Development pathway: Short-term priorities include establishing a Diagnostics Forum (potentially through HIRANI), launching training schools on biosensor design, and beginning biomarker development work. Medium-term actions focus on creating hostable, rentable laboratory space for SMEs, establishing a bespoke accelerator programme, and building an experienced entrepreneur pool. Platform funding—supporting foundational technologies serving multiple applications rather than disease-specific targets—is the preferred funding approach.

One Health

This initiative explores how bioengineering can be employed across One Health domains—human health, animal health, and environmental health—to address global challenges. Multiple converging factors create urgency: climate-driven zoonotic disease emergence, accelerating antimicrobial resistance, pandemic preparedness requirements, and mounting ecosystem pressures.

Key engineering biology applications include disease surveillance and diagnostics across human, animal, and environmental samples; pathogen surveillance systems using engineered biosensors in agricultural settings and water systems; cross-species vaccine platforms; antimicrobial resistance solutions including bacteriophage therapy and CRISPR-based approaches; ecosystem restoration through bioengineered microorganisms; and climate-adapted crop cultivars and animal breeds.

Development pathway: Short-term actions include gaps analysis, data management infrastructure, multi-stakeholder collaboration establishment, and a comprehensive Agri-food forum. By end of 2026, a cross-sector steering group should be operational. Medium-term developments include plug-and-play deployment platforms, cross-species vaccines, and a dynamic genetic evolution database. Long-term objectives encompass resistant livestock and plants through selection and potentially GMO approaches, and comprehensive biodiversity conservation strategies.

Critical barriers include skills retention challenges, isolated sector operations, incompatible data formats across sectors, limited ring-fenced funding, and public perception concerns around genetic modification of animals and plants.

6.4 Windsor Framework: Sector-by-Sector Implications

The Windsor Framework's dual market access creates differentiated opportunities and constraints across the four priority engineering biology domains:

Domain	Opportunities	Constraints
Healthcare & Medicine	UK-wide MHRA licensing provides regulatory clarity. Dual market access enables both UK and EU product reach. Strong existing pharmaceutical sector as foundation.	Higher dual-compliance costs for products requiring both UK and EU approval. Policy uncertainty may deter long-term investment.
Agri-Food & Environment	Non-GM approaches proceed without barriers. Potential to position for EU regulatory evolution on New Genomic Techniques.	Most constrained domain. EU-aligned GMO regulations mean precision-bred crops approved in England cannot be grown in NI. Field trials effectively blocked.
Industrial Biotech	Microbial production faces less regulatory complexity. Waste valorisation benefits fully from dual market access.	Cost competitiveness of bio-based vs synthetic materials remains a challenge regardless of regulatory framework.
Environmental Solutions	Contained-use applications face relatively aligned UK-EU regulatory frameworks.	Open-environment deployment of engineered organisms may face additional scrutiny under EU-aligned regulations.

6.5 Cross-Cutting Themes

Several themes recur across all six topic roadmaps and deserve particular attention from policymakers:

- **The TRL 3-4 gap is universal.** Every topic roadmap identified the valley of death between laboratory research and commercial application as a binding constraint. This is not a sector-specific problem but a systemic infrastructure and funding gap.
- **Skills are the common denominator.** Every initiative identified skills shortages as a critical barrier. The specific gaps vary—biomolecular discovery for diagnostics, data science for Agri-tech, process engineering for scale-up—but the underlying challenge of insufficient multidisciplinary talent affects all.
- **Cross-departmental coordination is essential.** The artificial boundaries between DfE, DAERA, and DoH directly impede progress across food security, One Health, circular bioeconomy, and Agri-tech initiatives. Engineering biology is inherently cross-sectoral and cannot be governed through traditional departmental silos.
- **All-island collaboration amplifies impact.** Multiple roadmaps identified the Republic of Ireland as a natural partner—for shared scale-up infrastructure, clinical trial networks, bioprocessing research, and talent pools. The combined all-island population of approximately 7 million approaches the scale of established biotech hubs.
- **AI convergence is an accelerator.** From digital twins in drug formulation to AI-driven enzyme engineering and precision agriculture, the integration of artificial intelligence with engineering biology emerged as a cross-cutting capability that could differentiate NI's offer.
- **Public engagement underpins acceptance.** The Lough Neagh crisis and agricultural methane reduction provide powerful, locally relevant narratives for demonstrating engineering biology's practical value. Without proactive communication, public perception—particularly around genetic modification—could constrain progress.



SWOT Analysis

7. SWOT Analysis

The following synthesises evidence from the literature review, stakeholder engagement, workshop, and six topic roadmaps into a consolidated assessment of Northern Ireland's position in engineering biology.

Strengths

- Internationally recognised research base across QUB, Ulster University, and AFBI, with particular depth in precision medicine, antibody engineering, biosensors, food security, and animal genetics.
- Anchor companies with global reach—Almac, Randox, Norbrook—providing industrial foundation and demonstrated commercialisation pathways, alongside an emerging biotech start-up ecosystem.
- Unique Windsor Framework dual market access creating a globally distinctive proposition for diagnostics, medical devices, clinical trials, and pharmaceutical products.
- The UK's largest agri-food sector (proportional to GDP), providing a substantial demand base for engineering biology in food security, sustainable agriculture, and biosensors.
- Significant infrastructure investments through City and Growth Deals, such as AMIC (£30m in nanotechnology and photonics), the Future Medicines Institute (£55m), and iReach clinical trials facility (£64m).
- Compact geography enabling rapid stakeholder convening and ecosystem-wide coordination.

Weaknesses

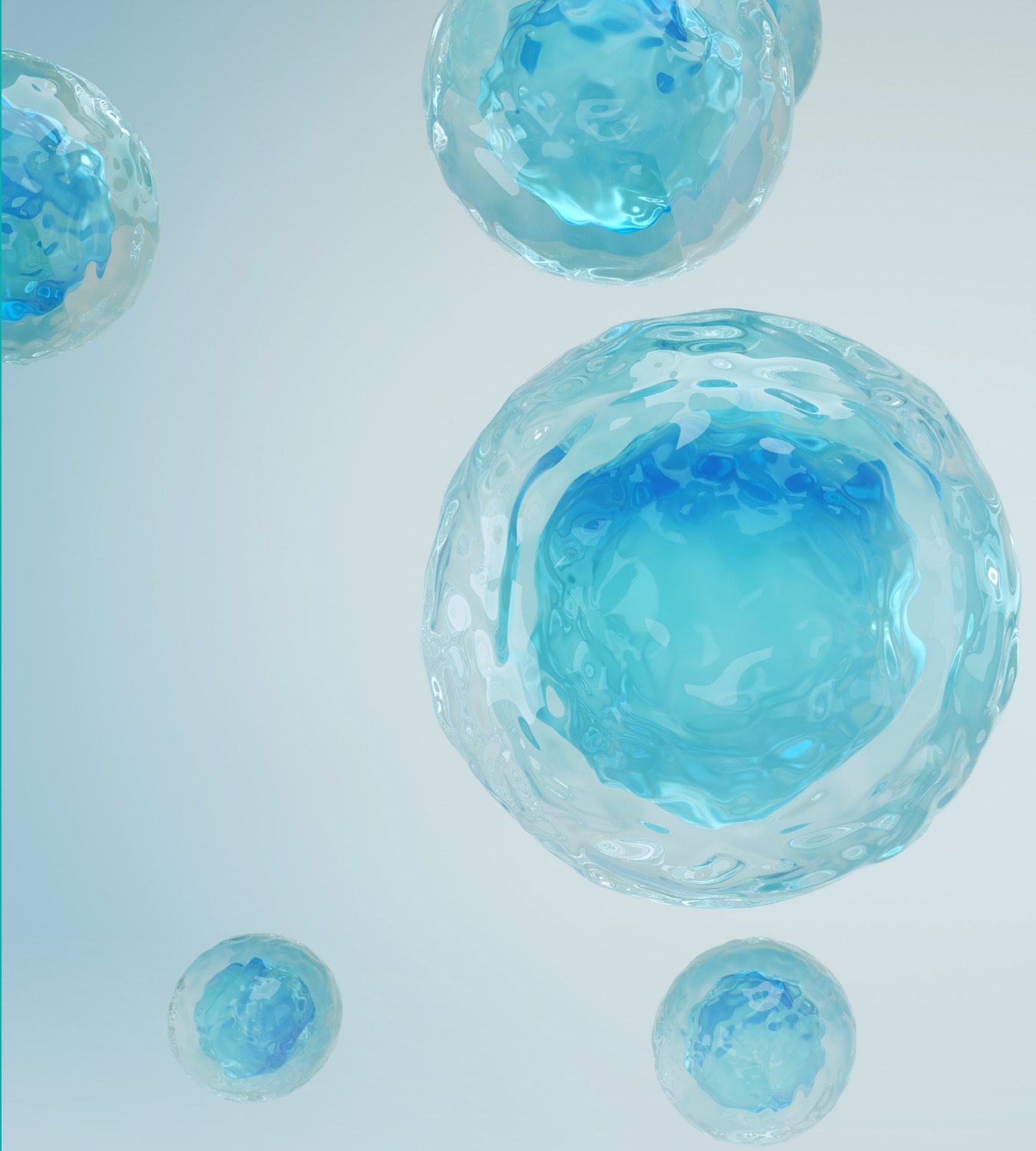
- No life sciences Catapult, CPI presence, or equivalent shared scale-up facility. Companies are losing business due to this infrastructure gap.
- Persistent valley of death at TRL 3-4: promising research does not progress to commercial production due to missing infrastructure, skills, and patient capital.
- Skills shortages across the board—biomolecular discovery, synthetic biology, biomanufacturing, data science, regulatory expertise, and entrepreneurship—compounded by brain drain.
- Fragmented governance with no unified engineering biology coordination mechanism across DfE, DAERA, and DoH.
- NI receives ~1% of UKRI funding (vs. 2.8% of UK population) with the lowest application success rate of any UK nation or region. No UKRI engineering biology mission hubs are led from NI.
- Limited venture capital presence and risk capital availability, driving start-ups to relocate to access funding.

Opportunities

- Food security and resilience (opportunity score: 5/5) leveraging QUB's world-leading food security research and NI's agri-food strengths.
- Lough Neagh bioremediation as a potential high-profile demonstrator with environmental, economic, and political salience, and global export opportunity.
- Diagnostics and biosensors (combined score: 4/4) as the most immediately actionable initiative, building on existing industry, research, and infrastructure.
- Windsor Framework regulatory arbitrage for attracting FDI in regulated biotechnology, clinical trials, and medical devices.
- UKRI ring-fenced engineering biology funding represents a significant, under-exploited opportunity. A coordinated bidding strategy could yield disproportionate returns.
- All-island collaboration with the Republic of Ireland (combined population approx. 7 million), leveraging complementary strengths and shared challenges.
- AI-biology convergence, drawing on NI's data science and cybersecurity strengths for digital twins, bioprocess optimisation, and precision agriculture.

Threats

- Disruption of existing industries by engineering biology advances developed elsewhere—the agri-food sector faces existential risk if competitors adopt engineering biology faster.
- Intensifying global competition: the US, China, and Australia are investing at scales that dwarf NI's capacity. Without niche specialisation, NI risks irrelevance.
- Risk of falling further behind other UK regions that already have established life sciences clusters and Catapult presence.
- Windsor Framework regulatory divergence constraining precision breeding and gene-edited crop development in NI.
- Public perception challenges around genetic modification, particularly in agriculture, requiring sustained engagement.
- Geopolitical disruption: potential US pharmaceutical manufacturing incentives could redirect FDI; supply chain vulnerabilities in consumables (predominantly sourced from China) remain acute.



Recommendations

8. Recommendations

The recommendations are structured around three interconnected dimensions: policy reforms, investment priorities, and future research opportunities. They are designed to be mutually reinforcing—policy coordination creates the governance environment within which investment can be effective; investment addresses barriers that policy reform alone cannot bridge; and future research ensures Northern Ireland positions itself at the frontier, as covered in the next chapter.

8.1 Policy Recommendations

1. Establish a Cross-Departmental Engineering Biology Coordination Body

Every stakeholder engagement activity identified fragmented governance as the primary barrier to progress. The coordination body should have formal representation from DfE, DAERA, DoH, Invest NI, both universities, AFBI, and industry, with a clear mandate to coordinate strategy, align funding, harmonise definitions, and report to Matrix on progress.

2. Develop a Proactive Windsor Framework Regulatory Strategy

Maximise the dual market access advantage through a dedicated regulatory advisory service for engineering biology companies, advocacy for proportionate regulatory application, and creation of regulatory sandbox environments for low-risk innovations in agriculture and environmental applications.

3. Implement a Strategic Skills and Workforce Policy

A comprehensive engineering biology workforce strategy spanning doctoral training, technician-level apprenticeships, industry-academic secondments, and CPD. Key elements include expanding QUB's MSc in Engineering Biology, co-funded PhD studentships with industry, KTPs for engineering biology, and ensuring DfE PhD awards explicitly prioritise engineering biology. The strategy should recognise that computer scientists, data scientists, and bioprocess engineers will dominate the future workforce alongside molecular biologists.

4. Create an Integrated Data Strategy

Commission a Northern Ireland engineering biology data strategy addressing farm-level data access (the go/no-go decision point for the Agri-Tech initiative), health data integration, environmental monitoring data, and supply chain transparency. This should include governance frameworks, privacy protections, and an all-island data sharing dimension.

5. Strengthen Public Engagement

Develop a sustained public engagement programme using compelling local case studies—particularly Lough Neagh bioremediation and agricultural methane reduction—to communicate the benefits of engineering biology to both the public and policymakers.

8.2 Investment Priorities

1. Shared Engineering Biology Infrastructure

The single most impactful investment identified: a shared “research hotel” providing fermentation capacity (minimum 1,000L), cell-free systems, flexible laboratory space, and advanced analytical equipment accessible to SMEs, spinouts, and established companies across multiple sectors. This should be formally partnered with a UK Catapult (CPI) and host a permanent NI presence of relevant Catapult staff. AMIC’s existing strengths provide a foundation for adding biological capability.

2. TRL 3–4 Bridging Fund

A dedicated, department-agnostic bridging mechanism targeting the valley of death across engineering biology sectors, supporting proof-of-concept to early prototype development with cross-departmental governance and clear assessment criteria.

3. Diagnostics and Biosensors Accelerator

A bespoke accelerator programme, building on the sector’s strongest combined opportunity-feasibility dimensions, beginning with a diagnostics forum, training schools, capability mapping, and platform funding that supports foundational technologies serving multiple applications.

4. Lough Neagh Circular Bioeconomy Demonstrator

A flagship project encompassing algae harvesting, biopolymer creation, and a modular biorefinery proof-of-concept. This delivers visible environmental benefit, economic value, and a globally exportable bioremediation model.

5. Leverage UK-Wide and International Funding

Adopt a coordinated approach to accessing UKRI ring-fenced engineering biology funding, Innovate UK competitions, and Horizon Europe, supported by a dedicated funding advisory function and coordinated rather than competing NI bids.



Implementation Framework

A phased implementation approach ensures foundational elements are established before subsequent activities, whilst enabling parallel progress where dependencies permit.

Phase	Key Actions	Key Outcomes
Phase 1: Foundation (Year 1)	Establish Coordination Body; launch skills programmes; commission data strategy; prepare major funding bids; establish Diagnostics Forum	Cross-departmental governance operational; engineering biology cluster mapped; PhD/MSc pipeline initiated
Phase 2: Capability Building (Years 2-4)	Build shared infrastructure; establish data platform; launch TRL 3-4 bridging mechanism; diagnostics accelerator; begin Lough Neagh demonstrator; pilot One Health surveillance	Scale-up capacity operational; first accelerator cohort; agricultural data platform piloted; bioremediation proof-of-concept delivered
Phase 3: Scale and Integration (Years 4-6)	Scale successful pilots; expand commercial deployment; attract additional companies; pursue international partnerships; public engagement at scale	Innovations reaching market; international reputation emerging; private sector co-investment increasing
Phase 4: Cluster Maturity (Years 6+)	Self-sustaining ecosystem; international positioning; export of technologies and approaches; next-generation strategy	Engineering biology cluster operating sustainably; global niche reputation; revenue from exported technologies

9.1 Critical Path Items

Certain elements are critical to overall success—failure in any would jeopardise multiple initiatives:

- **Data access for Agri-Tech:** A binary go/no-go decision point. Without solving agricultural data access, a major pillar of the strategy fails.
- **Cross-departmental policy coordination:** Affects all initiatives. Continued governance silos undermine the entire ecosystem approach.
- **TRL 3-4 infrastructure:** Determines whether research excellence translates to commercial impact across all sectors.
- **Skills pipeline:** Without adequate talent, all initiatives struggle regardless of investment. Brain drain accelerates without demonstrable career pathways.
- **Anchor tenant engagement:** Securing participation of established companies (e.g. Almac, Randox, Norbrook) in shared infrastructure provides credibility, guaranteed utilisation, and market signals.

9.2 Future Research Opportunities

Six priority research areas were identified requiring deeper investigation beyond this study:

- **Advanced cell and gene therapy manufacturing:** Feasibility study for NI as a cell therapy clinical trial hub, leveraging Windsor Framework dual market access and the €100m IMPACT all-island initiative.
- **Agricultural microbiome engineering:** Rumen microbiome manipulation for methane reduction and soil microbiome enhancement, building on AFBI's existing capabilities.
- **Bio-based packaging and materials:** Linking agricultural waste streams with engineering biology approaches to biopolymer production, connecting food production strengths to packaging capabilities.
- **Digital twins and AI for bioprocess optimisation:** Cross-sectoral programme leveraging NI's data science strengths for pharmaceutical, agricultural, and environmental applications.
- **One Health surveillance and biosecurity:** An integrated surveillance platform combining biosensors, genomic sequencing, and wastewater monitoring across human, animal, and environmental health.
- **Disruptive impact assessment:** A defensive analysis examining which existing NI economic sectors are most vulnerable to displacement by engineering biology advances developed elsewhere.



Conclusion

10. Conclusion

This study has revealed an engineering biology landscape in Northern Ireland that possesses genuine strengths but faces systemic barriers to realising its potential. The region's research excellence, anchor companies, Windsor Framework positioning, and compact scale create a credible foundation—but fragmented governance, infrastructure deficits, skills gaps, and limited national funding engagement risk squandering these advantages.

The recommendations are designed to be mutually reinforcing. Policy coordination creates the governance environment within which investment can be effective. Shared infrastructure addresses the valley of death that policy reform alone cannot bridge. Future research opportunities ensure Northern Ireland is positioning itself at the frontier, not merely catching up.

Northern Ireland's small scale, often perceived as a limitation, becomes a genuine advantage when leveraged strategically. Comprehensive coordination across the engineering biology ecosystem is feasible in a way that would be impossible in a larger region. The living laboratory approach—developing, testing, and validating innovations across an integrated system spanning agriculture, environment, and health—is practical at Northern Ireland's scale.

The current moment represents a window of opportunity. UKRI is ring-fencing significant engineering biology funding. The global bioeconomy is expanding rapidly. The Windsor Framework creates advantages no other UK region can replicate. All-island collaboration is supported by active funding mechanisms and political goodwill. The question is not whether engineering biology will be important, but whether Northern Ireland will be a contributor to, or merely a consumer of, the innovations it produces.

A fragmented approach—maintaining departmental silos, spreading limited resources thinly, and treating the six topic roadmaps as independent initiatives—risks missing this window. An integrated approach, informed by the strategic roadmap and implemented through the coordination mechanisms recommended here, maximises the probability of transformative success. **The evidence from this study strongly favours the integrated path.**

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This strategic summary is drawn from the full Engineering Biology Research in Northern Ireland: Roadmapping Report (April 2026). For the complete evidence-based, detailed topic roadmaps, annexes, and full methodology, please refer to the main report.

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**Northern Ireland
Science Industry Panel**

**Engineering Biology Research in
Northern Ireland**

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