Innovate UK

Creating a shared vision for the agri-food sector

How the UK and Canada can stay competitive by working together

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Contents

Executive Summary

Agricultural productivity must rise to meet the challenge of feeding a global population of 9 billion by 2050. New technologies such as precision farming and genetics could help to increase productivity and reduce the considerable environmental impact of food production.

The Canadian agriculture and food sectors were worth C$108.1 billion in 2014 and employed more than 2.3 million people. The UK agri-food sector is worth £109 billion a year and employs 4 million. There are significant opportunities for both countries to increase exports into a rapidly growing global market.

UK and Canada working together

The UK and Canada have both identified the agri-food sector as of strategic economic importance and made significant investments in agri-food research over the last few years. Government investment in agricultural research and innovation in Canada in 2015-16 was worth more than C$1 billion. Innovate UK has overseen investments of £160 million since 2010, and £80 million has been invested in UK agri-tech centres.

Innovate UK has recognised the potential for both the UK and Canada to benefit economically by working together to meet the challenges facing the agri-food sector. A mission from the UK to Canada was organised in early 2017 to establish international connections. This was followed up with an online workshop in June 2017 that established a number of priority themes of mutual interest:

- genomics and advanced breeding technologies
- precision farming systems
- diagnostics and sensors
- big data
- disease and pest management
- food manufacturing and quality

The Canadian High Commission hosted a workshop in September 2017 instigated in the UK by Innovate UK and attended by delegates from the UK and Canada. It developed these themes further into a series of roadmaps based on:

- improving the food manufacturing chain
- genomics and breeding to tackle pests and disease
- antimicrobial resistance and antimicrobial use
- phenotyping: collection of biological data
- diagnostics and sensor technologies
- understanding soil health
- improving feed efficiency
- data standards, better connectivity and analytics

Conclusion and recommendations

The 2017 activities have established new partnerships between the UK and Canada and demonstrated a shared appetite for further work to meet challenges and goals. The work has identified a number of shared issues including:

- a lack of understanding across the sector of value and of the benefits of addressing challenges
- ensuring the research community is focused on solving the challenges faced by farmers
- a need for a holistic view
- a need to invest in skills and to import technology from other sectors
- the importance of big data and diagnostics and sensors
- a need for strategic and financial support

Increased collaboration between the UK and Canada in agri-tech will help both countries meet the challenges facing the sector and take advantage of the global opportunities. To achieve this, partners should:

- develop new organisational and professional relationships within and between the UK and Canada, for example, establish 'information exchange forums' between national partners
- create working groups or targeted focus groups to develop theme ideas, opportunities and project proposals
- create cross-cutting theme groups (such as diagnostics and sensors and big data), which could be taken forward through a bilateral special interest group
- use roadmaps to explore development opportunities and resourced work programmes
- explore further missions between the UK and Canada based around themes in the roadmaps
- integrate further agri-food workstreams in the UK and Canada into continued development of greater and new partnerships and establish an annual conference to provide an overview of work across the key sectors
- continue to develop organisational profiling to create a better picture of the sector and opportunities for further collaborations, including reaching out to a wider audience with this report and the roadmaps

Introduction

Agricultural science and technology is one of the world's fastest growing and most exciting markets. Agricultural productivity must increase to meet the needs of more than 9 billion people by 2050. This global challenge means increasing demand for land, energy, water, feed, fertilisers and other resources. Agriculture is responsible for almost a quarter of all global greenhouse gas emissions. New technologies and approaches, such as genetics and precision farming practices, could increase agricultural productivity and reduce the environmental impact of food production.

The UK and Canadian agri-food sectors are well established and vital to the economic welfare of both countries. The Canadian agriculture and agri-food sectors were worth C$108.1 billion in 2014, or 6.6% of GDP. The sector employs more than 2.3 million people and accounts for 1 in every 8 Canadian jobs. Canadian exports grew by 12% on 2013 levels to reach C$51.5 billion in 2014, maintaining the country's position as the world's 5th largest agri-food exporter [1].

The UK agri-food sector is valued at approximately £109 billion a year. It employs 4 million (13% of the working population) [2]. UK exports of £20.1 billion (feed, food and drinks) represent just 2.3% of the global agri-food export market [3].

There are significant opportunities to grow exports from both Canada and the UK, particularly in agri-tech innovations and high-value food and drink products of provenance.

Opportunities for the UK and Canada

Innovate UK has identified agri-tech as an area where the UK and Canada could work together for mutual benefit. A UK mission to Canada, an online partnering workshop and a two-day roadmap workshop in 2017 explored the potential in more detail. This report summarises a two-day roadmap workshop held in London in early September 2017. Delegates were also challenged to develop specific propositions for UK-Canada agri-food partnerships, and some of these are presented alongside the roadmaps.

No one individual or organisation owns these roadmaps, propositions and wider activities. We recommend individuals, companies, organisations, governments and funding bodies review them and identify opportunities for new collaborations and partnerships in the years ahead.

UK and Canadian investment in agri-tech

The UK and Canada have both made significant recent investments in agri-food research.

Innovate UK has overseen £90 million of funding since 2010 for industry-led collaborative projects through the Sustainable Agriculture & Food Innovation Platform. A further £70 million from 2013 through the Agri-Tech Catalyst supported a more open programme.

The UK government has invested £80 million in 4 UK agri-tech centres with cutting-edge capability in big data and agrimetrics (www.agrimetrics.co.uk), agricultural engineering and precision innovation capability (www.agri-epicentre.com), crop health and protection (www.chap-solutions.co.uk) and innovation excellence in livestock (www.cielivestock.co.uk). A further £90 million is to be invested in transforming food production under the government's Industrial Strategy Challenge Fund.

The Canadian federal government invested C$705 million in agricultural research and innovation in 2015-16, and a further C$440 million was invested by provincial ministries of agriculture. Canada spent 0.046% of its GDP on agricultural innovation in 2015, the 7th highest in the world [4]. Agriculture and Agri-Food Canada (AAFC) leads federal efforts in the growth and development of the agriculture sector. The National Research Council of Canada (NRC), through its aquatic and crop research programme, and the federal research funding organisations (NSERC, CIHR, SSHRC, Genome Canada and CFI) also play an important role in research and development and innovation. Innovation loans and public-private partnerships are becoming increasingly popular as an investment vehicle in Canada.

The UK-Canada roadmap workshop explored how these national programmes could be the basis of partnerships for mutual benefit.

Growing a shared interest

The UK and Canada signed a memorandum of understanding in 2017 that promises to improve bilateral co-operation in complementary areas of innovation and entrepreneurship including in agricultural technologies.

The '*UK strategy for agricultural technologies*' [5] sets out how the agri-tech sector will work to maximise best practice and knowledge transfer by increasing coordination and integration of on-farm demonstrations, and the use of demonstration and monitor farms. It also sets out the scale of the commercial opportunity for trade and inward investment – for example, the global market for agricultural inputs, such as feed, seed and fertiliser, is worth more than US$355 billion and continues to grow rapidly.

Canada's Advisory Council on Economic Growth, chaired by Dominic Barton and usually known as The Barton Report [6], identified agriculture as an area where Canada had the potential to raise itself from the fifth to the second largest agricultural exporter in the world. This growth will rely heavily on agricultural innovation to drive productivity gains. The 2017 federal budget targets growth in Canada's agri-food exports from C$55 billion in 2015 to C$75 billion by 2025.

Energising the UK-Canada agri-food sectors

Innovate UK set out a programme of activities during 2017 to explore and develop partnerships between the UK and Canadian agri-food sectors.

International missions in March from the UK to Canada created connections. An online interactive workshop was held in June 2017 to test interest in a number of thematic areas. These were developed in more detail through the two-day workshop in London in September 2017, hosted by the High Commission of Canada. The workshop was developed and facilitated by 100%Open, who were commissioned to produce this report by Innovate UK, with help from those who took part.

The London workshop aimed to:

- develop priority theme areas for industry-led research
- develop a roadmap with key actions
- establish new bilateral partnerships between the UK and Canada

The roadmaps

More than 50 people from the UK and Canada took part in the June 2017 online workshop. They identified 6 shared topics of interest between the two countries:

- genomics and advanced breeding technologies
- precision farming systems
- diagnostics and sensors
- big data
- disease and pest management
- food manufacturing and quality

The two-day roadmapping workshop in September was attended by 65 delegates, 20 from Canada and 45 from the UK and elsewhere. They included representatives from large and small businesses, researchers, funders and policymakers.

Attendees identified and clarified issues and challenges before selecting themes and topics that were then refined to those selected for the roadmaps. They also outlined a series of business propositions to demonstrate the breadth of potential commercial opportunities.

Improving the food manufacturing chain

Food manufacturing is dominated by low-tech, small-scale producers and has a poor image compared to other manufacturing sectors (such as automotive or aerospace).

Fragmentation and poor connectivity between actors are seen as a significant issue, and there is evidence of a silo mentality and of institutional and regulatory barriers.

This roadmap emphasises the need to better understand customers and develop a shared understanding of the whole value chain and the actors within it. There was a strong appetite for UK-Canada collaboration.

The roadmap identifies key steps towards a strategic alliance or partnership focused on SMEs. The first is to establish a partnership and understanding of the supply chain, followed by a communications and information campaign to overcome barriers and address industry issues.

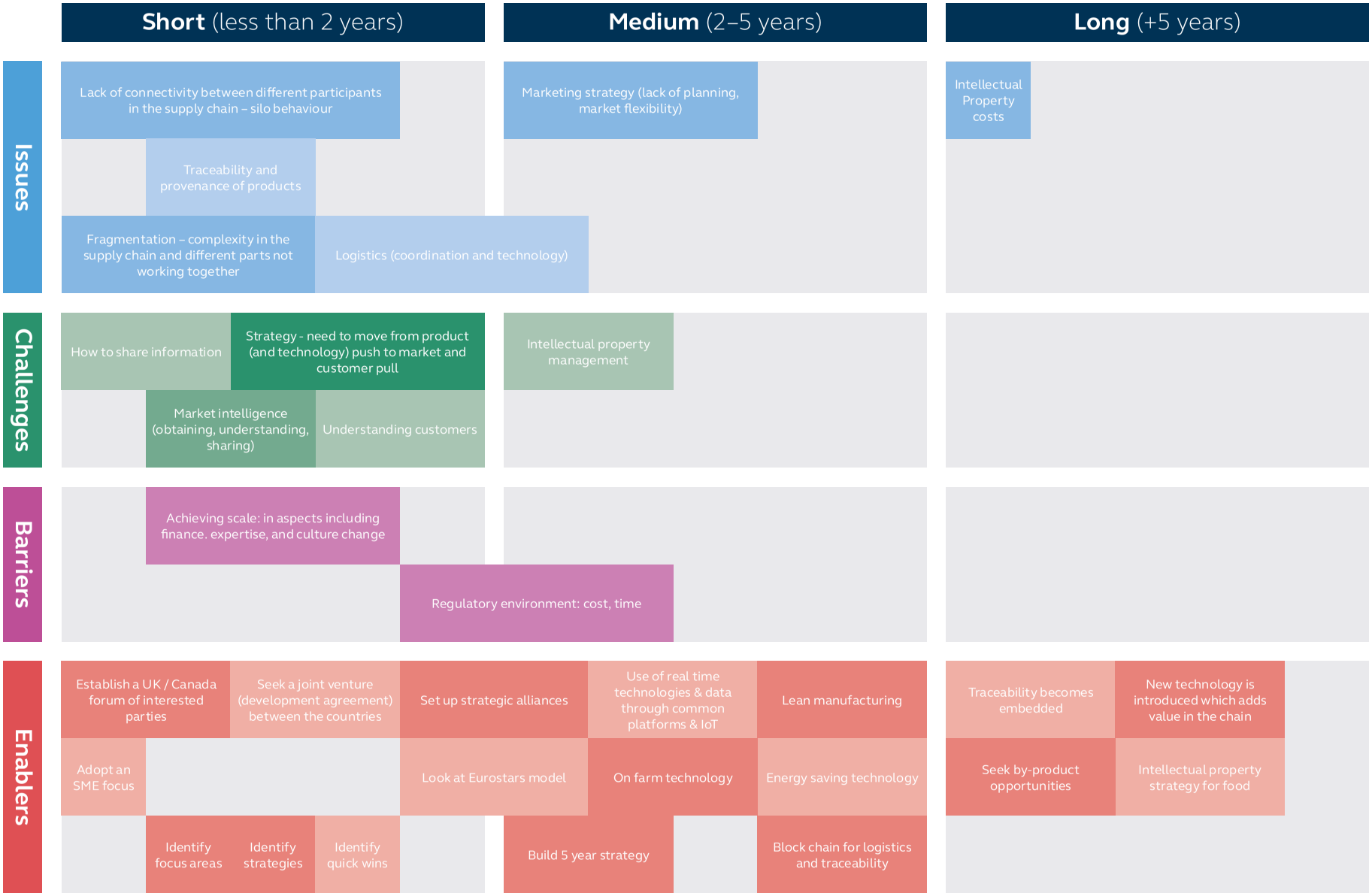
The partnership could also consider encouraging enabling technologies and approaches such as lean manufacturing and learning from other sectors. There should be an emphasis on the technologies that help break down the barriers identified. The partnership should concentrate on building transformational solutions with the underlying theme of "adding value to food".

Business opportunity: one trace

Consumer confidence in the provenance of food products is an issue in both the UK and Canada.

This project could bring together UK experience and technology in traceability and legislation with Canadian expertise in sales and export. Both countries have good reputations in food safety and obtaining export licences. Traceability would integrate the system from the farmer to the consumer.

New technology would be used to link the whole supply chain to ensure a flow of data, increase transparency and reduce fraud.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
Lack of connectivity between different participants in the supply chain – silo behaviour
Traceability and provenance of products
Fragmentation – complexity in the supply chain and different parts not working together
Logistics (coordination and technology)
Marketing strategy (lack of planning, market flexibility)
Intellectual Property costs
Challenges
How to share information
Strategy - need to move from product (and technology) push to market and customer pull
Market intelligence (obtaining, understanding, sharing)
Understanding customers
Intellectual property management
Barriers
Achieving scale: in aspects including finance. expertise, and culture change
Regulatory environment: cost, time
Enablers
Establish a UK / Canada forum of interested parties
Seek a joint venture (development agreement) between the countries
Adopt an SME focus
Identify focus areas
Identify strategies
Identify quick wins
Set up strategic alliances
Look at Eurostars model
Use of real time technologies & data through common platforms & IoT
On farm technology
Lean manufacturing
Energy saving technology
Build 5 year strategy
Block chain for logistics and traceability
Traceability becomes embedded
New technology is introduced which adds value in the chain
Seek by-product opportunities
Intellectual property strategy for food

Genomics and breeding to tackle pests and disease

There are a number of challenges and barriers facing genomics and breeding technologies including the length of time it takes to find solutions and the need for long-term strategic funding. These new technologies often struggle to gain public and regulatory acceptance and there are challenges in proving their value and relevance.

This roadmap emphasises the need for a long-term view in all aspects and approaches to achieving better disease resistance – not just through breeding. A long-term view should be adopted by governments and funders too. Sustained investment is likely to be needed in order to stay ahead of the problem.

The first priority is to jointly achieve a better and detailed understanding of what needs to be done in key areas such as disease modelling. There was agreement on the desirability of collectively identifying and agreeing what technology currently exists and what needs to be adapted or developed.

The focus of this roadmap was on genetics rather than other methods of creating resistance – but the importance of a multi-faceted strategy was agreed. A high-level roadmap for gene/genotype/microbiome and pathogen discovery and understanding was presented and key technologies (such as cheap and accurate gene editing technology and delivery systems) were identified.

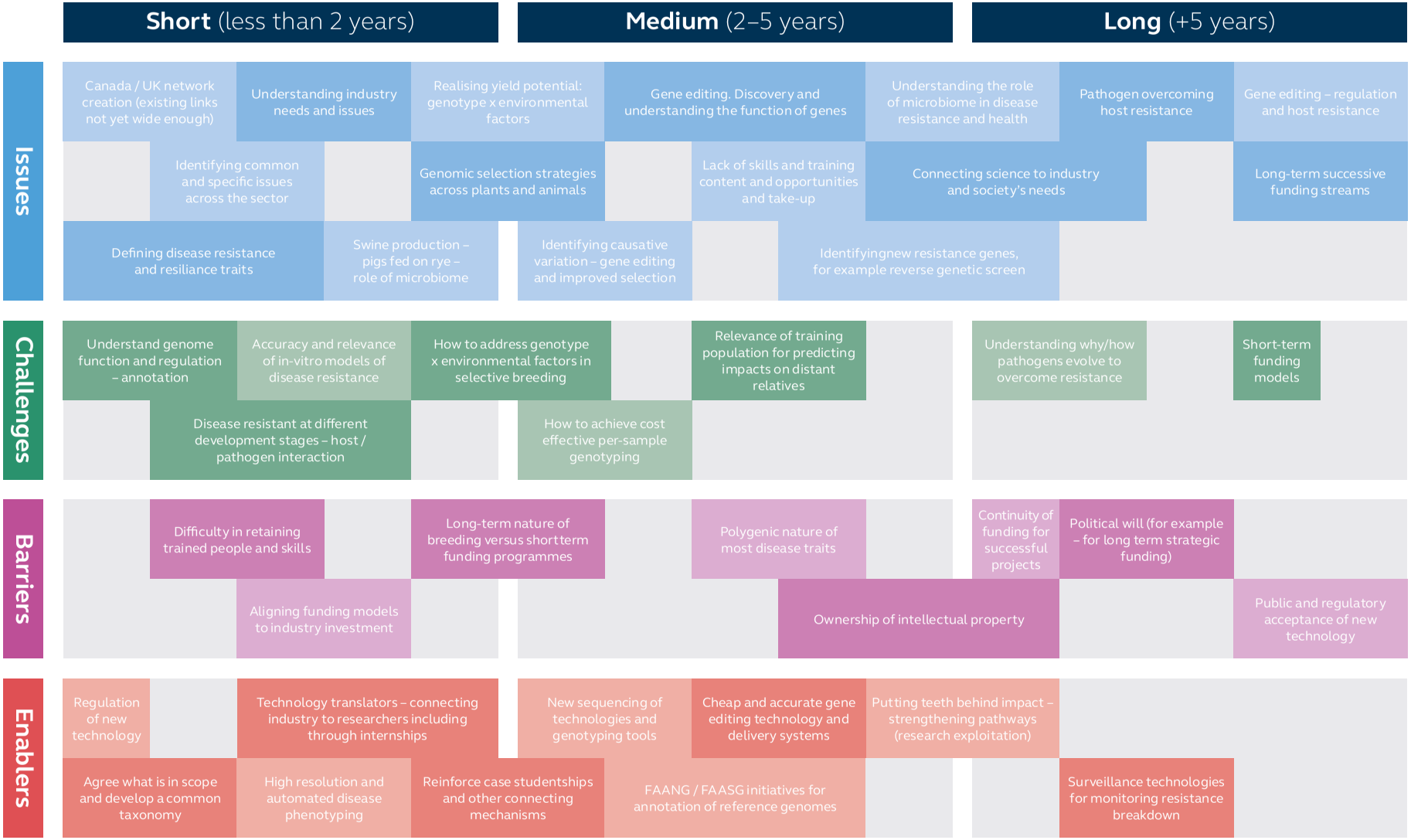
Collaboration is a key feature of the roadmap (in particular between industry and research) but it was acknowledged that intellectual property issues would have to be addressed (in the industry as a whole – not just between the partners). Mechanisms for connecting industry and research do exist but need to be strengthened and greater focus on the impact of research will help. Although impact would really be seen only in the long term (5 years plus) there is a need to start the process now.

Business opportunity: sustained plant disease and pest resistance

Farmers in the UK and Canada need a constant source of solutions to diseases and pests of crops.

This project suggests using conventional and new technologies, such as genome editing, to ensure the continuous delivery of resistant plants and to avoid duplication of research resources.

The project requires a consortium of industry and researchers to define a long-term roadmap and for funding to be aligned to it.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
Canada / UK network creation (existing links not yet wide enough)
Understanding industry needs and issues
Realising yield potential: genotype x environmental factors
Gene editing. Discovery and understanding the function of genes
Understanding the role of microbiome in disease resistance and health
Pathogen overcoming host resistance
Gene editing – regulation and host resistance
Identifying common and specific issues across the sector
Genomic selection strategies across plants and animals
Lack of skills and training content and opportunities and take-up
Connecting science to industry and society's needs
Long-term successive funding streams
Defining disease resistance and resiliance traits
Swine production – pigs fed on rye – role of microbiome
Identifying causative variation – gene editing and improved selection
Identifyingnew resistance genes, for example reverse genetic screen
Challenges
Understand genome function and regulation – annotation
Accuracy and relevance of in-vitro models of disease resistance
How to address genotype x environmental factors in selective breeding
Relevance of training population for predicting impacts on distant relatives
Understanding why/how pathogens evolve to overcome resistance
Short-term funding models
Disease resistant at different development stages – host / pathogen interaction
How to achieve cost effective per-sample genotyping
Barriers
Difficulty in retaining trained people and skills
Long-term nature of breeding versus shortterm funding programmes
Polygenic nature of most disease traits
Continuity of funding for successful projects
Political will (for example – for long term strategic funding)
Aligning funding models to industry investment
Ownership of intellectual property
Public and regulatory acceptance of new technology
Enablers
Regulation of new technology
Technology translators – connecting industry to researchers including through internships
New sequencing of technologies and genotyping tools
Cheap and accurate gene editing technology and delivery systems
Putting teeth behind impact – strengthening pathways (research exploitation)
Agree what is in scope and develop a common taxonomy
High resolution and automated disease phenotyping
Reinforce case studentships and other connecting mechanisms
FAANG / FAASG initiatives for annotation of reference genomes
Surveillance technologies for monitoring resistance breakdown

Antimicrobial resistance and antimicrobial use

The global and long-term nature of disease and pest management mean most of the challenges, barriers and solutions identified in this roadmap will take time to address and are also likely to change in nature over time.

Public perception is largely influenced by negative media and will take time to change – as will attitudes of some groups within the industry itself. The cost of these technologies needs to fall to improve industry take-up.

The roadmap proposes that a longer term solution may lie in the manipulation of the microbiome – but there are a number of steps that need to be taken before this can even be attempted. It will be necessary first to collect evidence regarding the link between antimicrobial resistance/ antimicrobial use and human health.

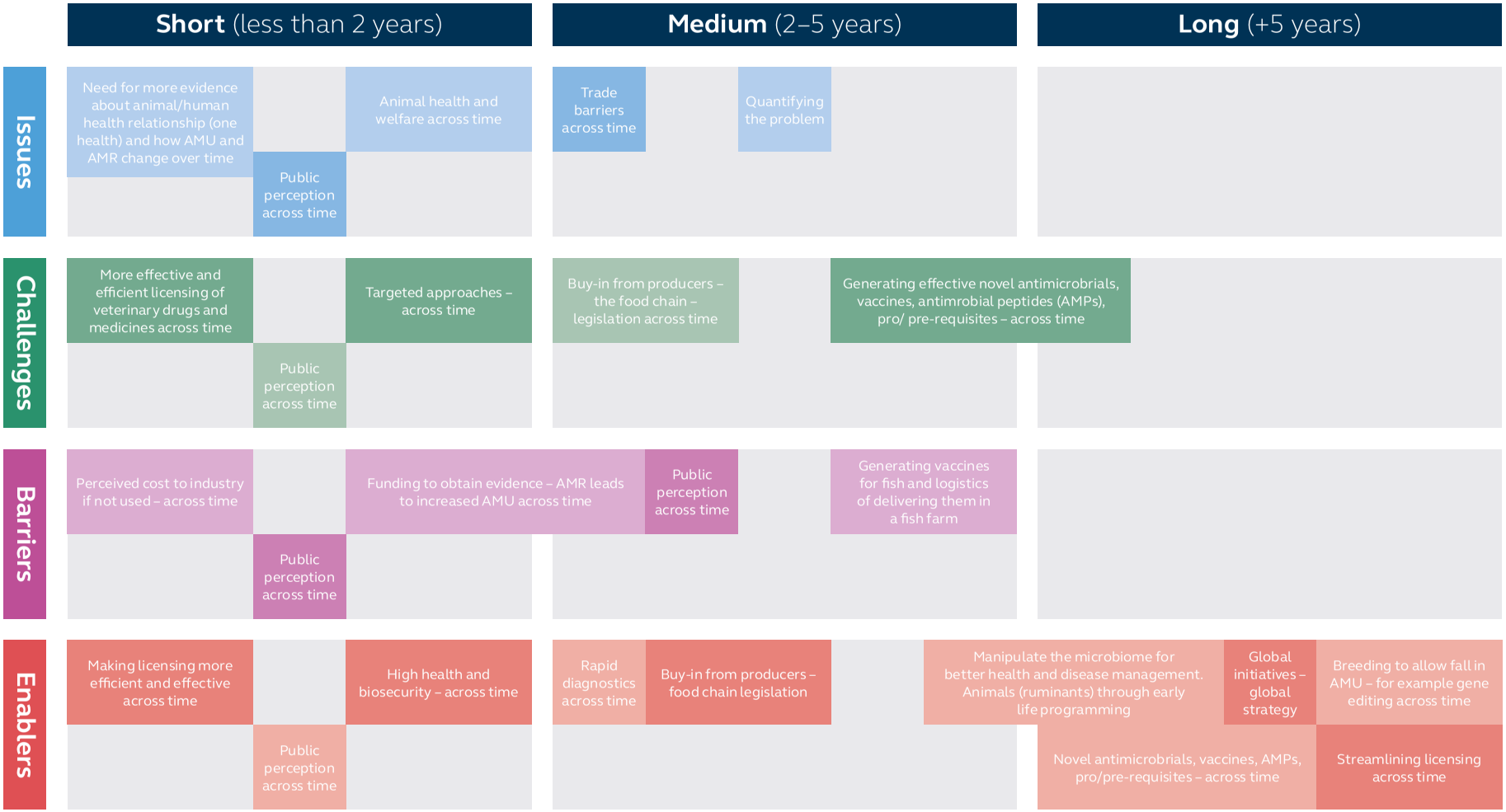
The importance of addressing intellectual property and licensing arrangements was raised. Rapid diagnostics was seen as a key enabler. The roadmap also identified a number of longer term corrective and preventative measures, including investment in particular technologies. Ultimately, greater value needs to be placed on food safety by both consumers and the industry.

Business opportunity: global initiative on resistance

There are gaps in public understanding of antimicrobial resistance and antimicrobial use and a need to build public policies and strategies based on evidence.

This project proposes a UK-Canada-led global centre of excellence to develop rapid diagnostics and decision-support systems, targeted diagnostics, and better biological systems.

New approaches could save money for producers, increase revenue for pharma companies and improve human and animal health.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
Need for more evidence about animal/human health relationship (one health) and how AMU and AMR change over time
Public perception across time
Animal health and welfare across time
Trade barriers across time
Quantifying the problem
Challenges
More effective and efficient licensing of veterinary drugs and medicines across time
Public perception across time
Targeted approaches – across time
Buy-in from producers – the food chain – legislation across time
Generating effective novel antimicrobrials, vaccines, antimrobial peptides (AMPs), pro/ pre-requisites – across time
Barriers
Perceived cost to industry if not used – across time
Public perception across time
Funding to obtain evidence – AMR leads to increased AMU across time
Public perception across time
Generating vaccines for fish and logistics of delivering them in a fish farm
Enablers
Making licensing more efficient and effective across time
Public perception across time
High health and biosecurity – across time
Rapid diagnostics across time
Buy-in from producers – food chain legislation
Manipulate the microbiome for better health and disease management. Animals (ruminants) through early life programming
Global initiatives – global strategy
Breeding to allow fall in AMU – for example gene editing across time
Novel antimicrobrials, vaccines, AMPs, pro/pre-requisites – across time
Streamlining licensing across time

Phenotyping: collection of biological data

This roadmap describes steps towards achieving better understanding, development and implementation of phenotyping technologies and practices.

It acknowledges that data acquisition techniques are different for plants and animals but contends that there are many common areas and that data analysis techniques are evolving and in some aspects converging. Common systems between plants and animals are becoming possible and could provide simpler, more cost-effective solutions in the medium and long term.

Standardisation is key. There are already positive changes in practice – for example, on-farm data collection is beginning to happen but is currently expensive. If the cost can be brought down, then good practice will become more widespread. Multi-layered data collection and analysis is also becoming available. However, the sheer volume of data and the cost of its management is a significant challenge.

The roadmap recommends the investigation and promotion of technology transfer from other sectors. For example, using sensors and other technologies developed for the geotechnical industry for above and below-ground (soil) analysis on farms. People with relevant skills should also be encouraged to enter the industry. For example, data analysts and computer scientists should be encouraged to work in the sector rather than enter other industries such as finance.

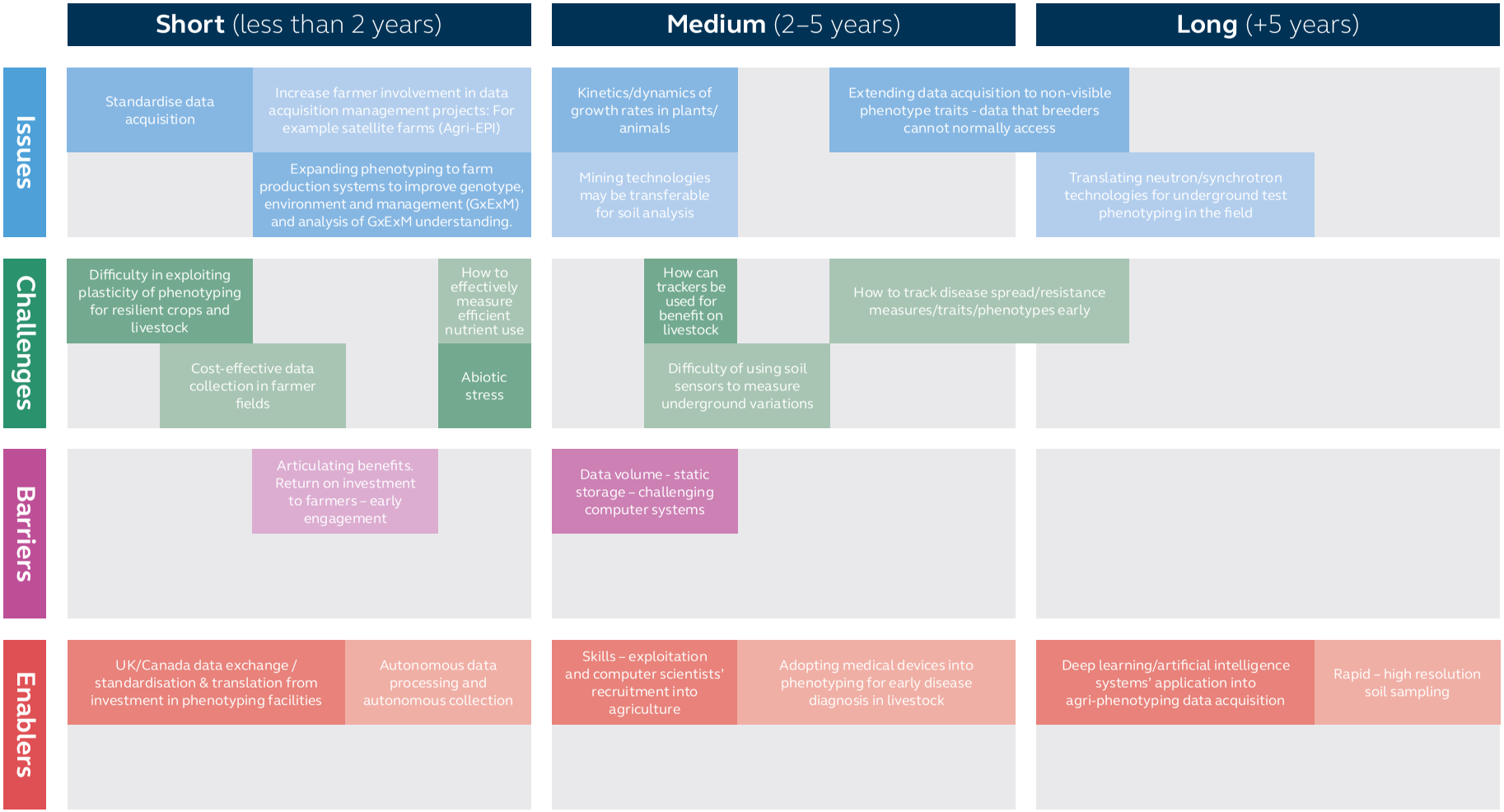
The roadmap acknowledges that a number of initiatives and funding are already in place so this is fertile ground for further collaboration. A workshop on data standardisation was suggested as an important first step.

Business opportunity: farming carbon

Farmers are facing increasing costs due to carbon taxes. This could be offset with carbon credits if farmers could demonstrate how much carbon their farms were capturing through sustainable practices.

Solutions could include inexpensive testing of ground conditions and use of drones, cameras and data generated by satellite technologies.

This solution may require changes to regulations. It will also need investment in monitoring equipment and access to satellite data, drones, soil sensors, software, and data processing.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
Standardise data acquisition
Increase farmer involvement in data acquisition management projects: For example satellite farms (Agri-EPI)
Expanding phenotyping to farm production systems to improve genotype, environment and management (GxExM) and analysis of GxExM understanding.
Kinetics/dynamics of growth rates in plants/ animals
Extending data acquisition to non-visible phenotype traits - data that breeders cannot normally access
Mining technologies may be transferable for soil analysis
Translating neutron/synchrotron technologies for underground test phenotyping in the field
Challenges
Difficulty in exploiting plasticity of phenotyping for resilient crops and livestock
How to effectively measure efficient nutrient use
Cost-effective data collection in farmer fields
Abiotic stress
How can trackers be used for benefit on livestock
How to track disease spread/resistance measures/traits/phenotypes early
Difficulty of using soil sensors to measure underground variations
Barriers
Articulating benefits. Return on investment to farmers – early engagement
Data volume - static storage – challenging computer systems
Enablers
UK/Canada data exchange / standardisation & translation from investment in phenotyping facilities
Autonomous data processing and autonomous collection
Skills – exploitation and computer scientists' recruitment into agriculture
Adopting medical devices into phenotyping for early disease diagnosis in livestock
Deep learning/artificial intelligence systems' application into agri-phenotyping data acquisition
Rapid – high resolution soil sampling

Diagnostics and sensor technologies

This roadmap addresses fragmentation in the diagnostics and sensors industry and the belief that it is not addressing the needs of the agri-food sector. Diagnostics and sensor technologies are often seen as a cost and not part of the value chain. The diagnostics and sensors industry also tends to have a focus on technology rather than on benefit or impact to end-users.

The roadmap seeks to demonstrate and prove value to all stakeholders, technology developers and end-users in the agri-food sector.

It is predominantly technology-focused and identifies a number of trade-offs to be regularly addressed – such as volume against accuracy and value and cost against reliability. It is possible however to identify some clear gaps where more work/technology is needed – such as the maintenance of quality.

Diagnostics and sensor technologies can support the sector's ability to address long-term challenges such as antimicrobial resistance/antimicrobial use and pest resistance. There are also potential synergies, for example in key markets for animal health and human health.

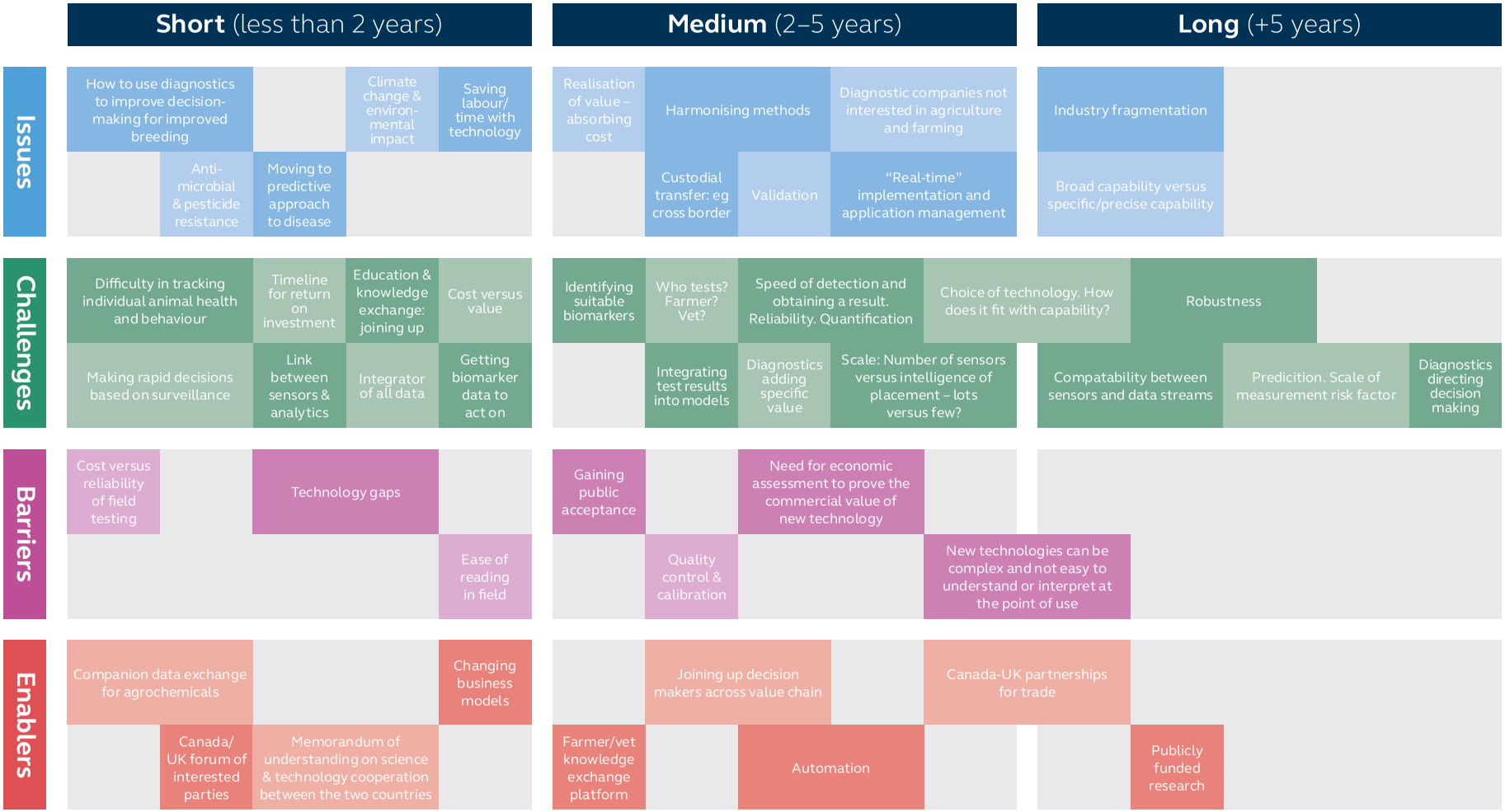
Finally, the roadmap identifies that knowledge transfer needs to be encouraged. Multiple solutions will be needed in the long term (no one size fits all), and new business models will have to be designed that enable everyone to benefit. The roadmap recommends that the UK-Canada partnership should first choose some areas where they can join forces, develop synergies and be in a position to compete more effectively in global markets.

Business opportunity: happy hooves

Economic losses caused by poor quality animal produce such as meat and dairy products could be lessened by earlier detection of problems and immediate intervention.

Detection would be based on a two-pronged approach of alert-based remote disease surveillance at the level of an entire farm and more specific detection of disease at the animal level.

Funding would be required for trials of the hardware and software across hundreds of animals and to demonstrate how a system could be brought together in an integrated way.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
How to use diagnostics to improve decision-making for improved breeding
Climate change & environ-mental impact
Saving labour/ time with technology
Anti-microbial & pesticide resistance
Moving to predictive approach to disease
Realisation of value – absorbing cost
Harmonising methods
Diagnostic companies not interested in agriculture and farming
Custodial transfer: eg cross border
Validation
"Real-time" implementation and application management
Industry fragmentation
Broad capability versus specific/precise capability
Challenges
Difficulty in tracking individual animal health and behaviour
Timeline for return on investment
Education & knowledge exchange: joining up
Cost versus value
Making rapid decisions based on surveillance
Link between sensors & analytics
Integrator of all data
Getting biomarker data to act on
Identifying suitable biomarkers
Who tests? Farmer? Vet?
Speed of detection and obtaining a result. Reliability. Quantification
Choice of technology. How does it fit with capability?
Robustness
Integrating test results into models
Diagnostics adding specific value
Scale: Number of sensors versus intelligence of placement – lots versus few?
Compatability between sensors and data streams
Predicition. Scale of measurement risk factor
Diagnostics directing decision making
Barriers
Cost versus reliability of field testing
Technology gaps
Ease of reading in field
Gaining public acceptance
Need for economic assessment to prove the commercial value of new technology
Quality control & calibration
New technologies can be complex and not easy to understand or interpret at the point of use
Enablers
Companion data exchange for agrochemicals
Changing business models
Canada/ UK forum of interested parties
Memorandum of understanding on science & technology cooperation between the two countries
Joining up decision makers across value chain
Canada-UK partnerships for trade
Farmer/vet knowledge exchange platform
Automation
Publicly funded research

Understanding soil health

Soil health has been well researched over the last few years, but there remains a diversity of opinion about its importance among the public, policy makers and funders. A decade of research has helped to identify a range of issues but interest in studying (or funding) soil health appears to be waning. New issues are emerging, such as pressures on price, margins and timescales, and the roadmap outlines a holistic approach.

The roadmap aims to increase awareness, understanding and perception of soil health before it becomes a significant problem. It recommends a similar approach and timeline to other areas – for example first developing a common understanding of specific needs. Better and consistent data acquisition is needed now, and this can be supported through standard use of appropriate diagnostics and measures. This will improve knowledge in the medium term, with technologies being adopted in the medium to long term helping to demonstrate the value of good soil to the community.

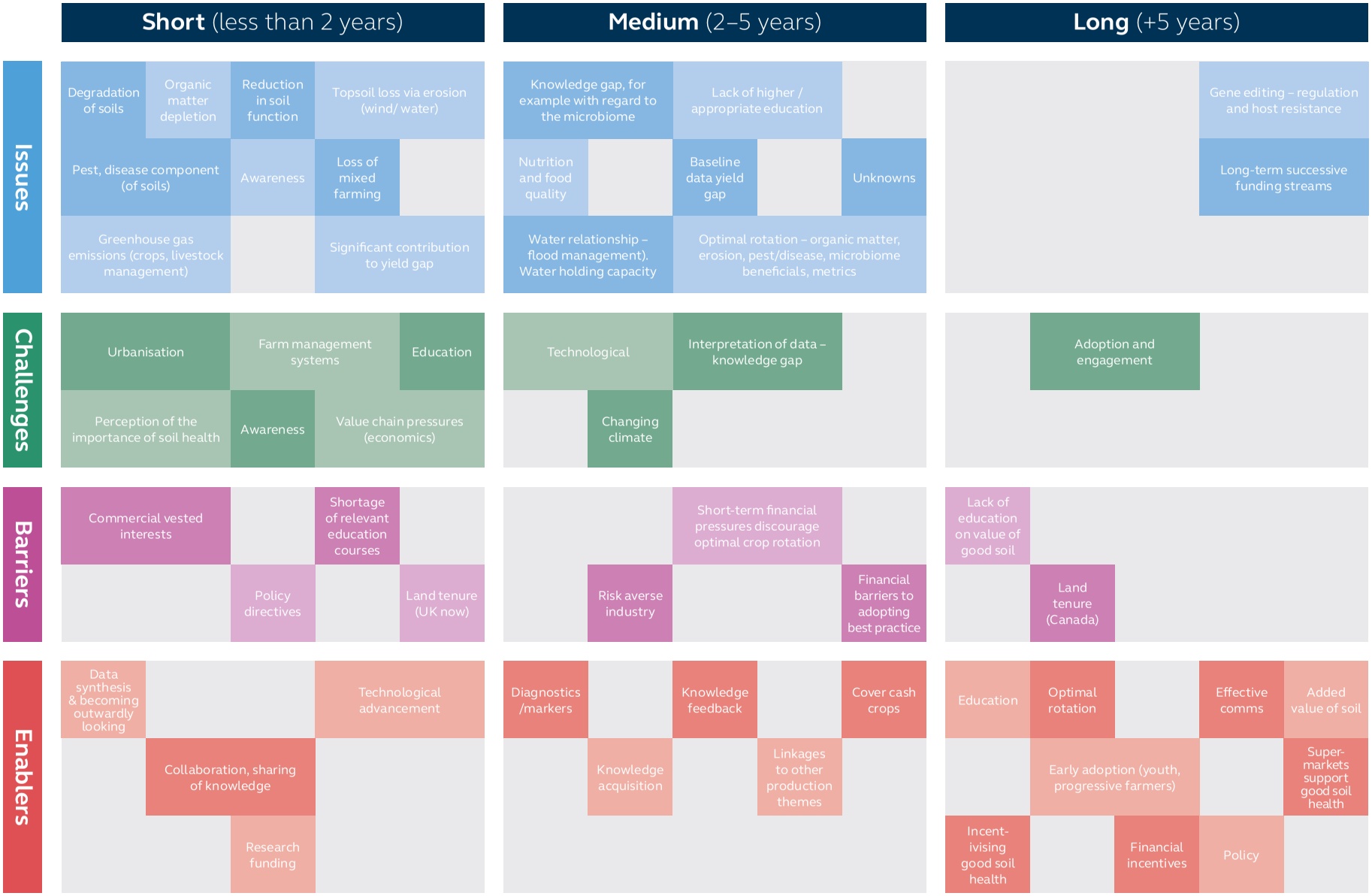
The roadmap also suggests some initial technologies that need developing and a number of longer term ones that will underpin this process.

Business opportunity: integrated farm systems

The UK and Canada could work together to forge a better understanding of how integrated farm systems impact on soil health.

The project would look at ways of optimising a crop, livestock and cover crop production system. It would examine the contribution of each agricultural system to soil health and look at interactions between plants/organic matter and the microbiome.

Optimised systems could help farmers to reduce costs and increase their margins through greater crop yield and quality.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
Degradation of soils
Organic matter depletion
Reduction in soil function
Topsoil loss via erosion (wind/ water)
Pest, disease component (of soils)
Awareness
Loss of mixed farming
Greenhouse gas emissions (crops, livestock management)
Significant contribution to yield gap
Knowledge gap, for example with regard to the microbiome
Lack of higher / appropriate education
Nutrition and food quality
Baseline data yield gap
Unknowns
Water relationship – flood management). Water holding capacity
Optimal rotation – organic matter, erosion, pest/disease, microbiome beneficials, metrics
Gene editing – regulation and host resistance
Long-term successive funding streams
Challenges
Urbanisation
Farm management systems
Education
Perception of the importance of soil health
Awareness
Value chain pressures (economics)
Technological
Interpretation of data – knowledge gap
Changing climate
Adoption and engagement
Barriers
Commercial vested interests
Shortage of relevant education courses
Policy directives
Land tenure (UK now)
Short-term financial pressures discourage optimal crop rotation
Risk averse industry
Financial barriers to adopting best practice
Lack of education on value of good soil
Land tenure (Canada)
Enablers
Data synthesis & becoming outwardly looking
Technological advancement
Collaboration, sharing of knowledge
Research funding
Diagnostics /markers
Knowledge feedback
Cover cash crops
Knowledge acquisition
Linkages to other production themes
Education
Optimal rotation
Effective comms
Added value of soil
Early adoption (youth, progressive farmers)
Super-markets support good soil health
Incent-ivising good soil health
Financial incentives
Policy

Improving feed efficiency

The current level of industry fragmentation, and some institutional inertia, are key challenges that need to be addressed.

This roadmap takes a holistic and systems-based approach to optimising feed efficiency – linking animals and plants in a new way and adopting a circular economy.

Collaboration between the UK and Canada on breeding and growing programmes is desirable and feasible (in the medium to long term). The roadmap identifies forages and legumes for beef cattle as a starting point. It sets out a number of key actions and begins with the creation of a better testing, measuring and evaluation framework between the partners.

An entire programme of work is set out at high level: identifying the best forages and wild grasses; improving cattle to allow them to make best use of the identified forages; and adopting forages that maximise output in the system through recycling through the animals. There is a need at the outset to identify the variations, attributes, traits and characteristics that need to be changed in both plants and animals.

The roadmap envisages a 5-year research and selection programme (a joint animal/plant breeding programme between the countries that exploits the various strengths – for example, vast tracts of land in Canada). Once the model has been trialled it can be extended to include other species. This will be particularly important in the context of climate change impact.

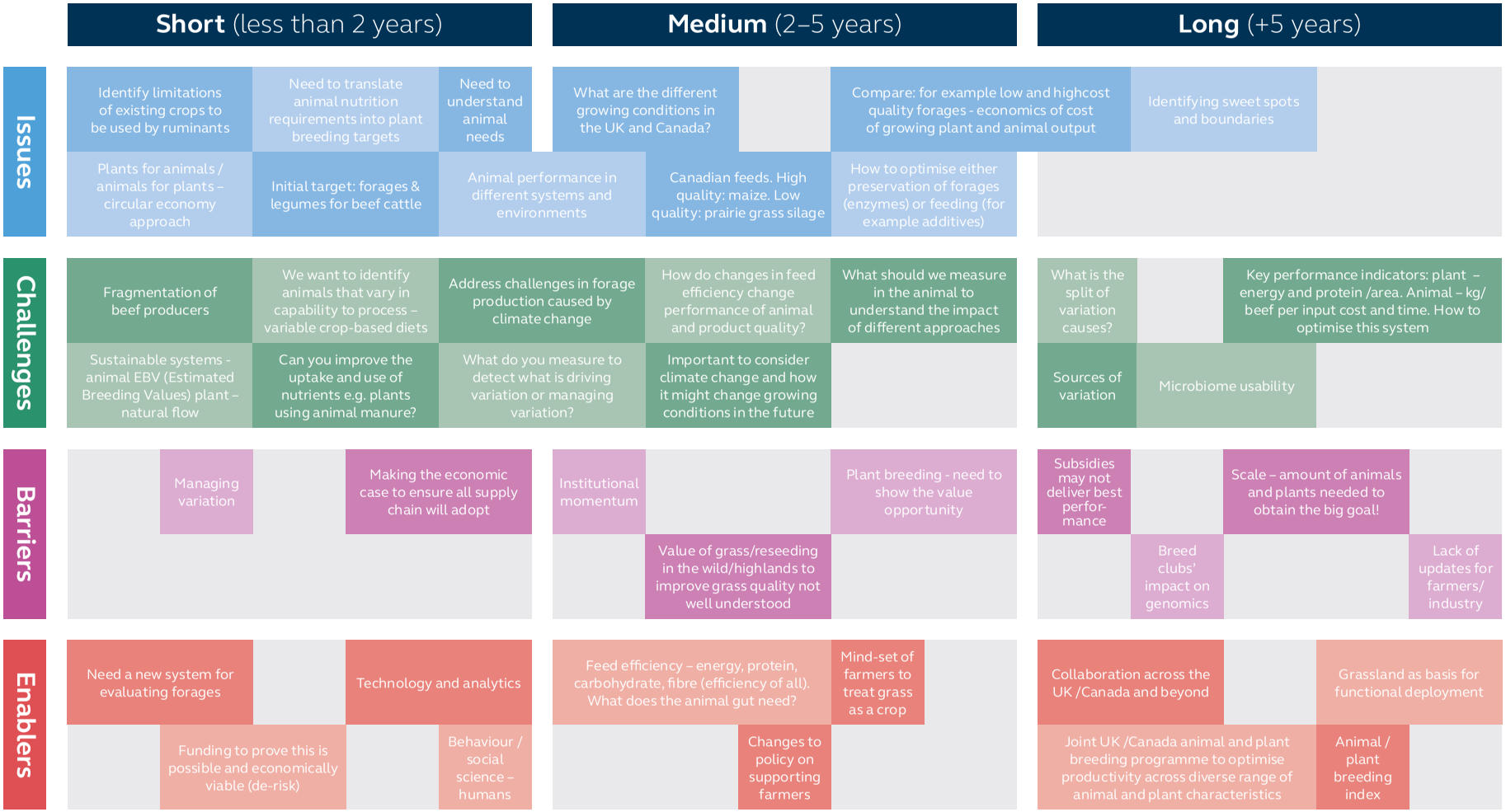
Business opportunity: combined plant and animal breeding

A lot of land is used to grow feed for animals and efficiency of use is quite poor.

Plant and animal breeders could be brought together to use modern breeding technologies to improve the efficiency of the whole system for the first time.

The project would require a public-private partnership involving at least one major plant and animal breeding company and significant funding to create the test subjects and to test feeds on animals in both the UK and Canada.

It would also require an earlier project to assess the potential economic benefits.


Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Issues
Identify limitations of existing crops to be used by ruminants
Need to translate animal nutrition requirements into plant breeding targets
Need to understand animal needs
What are the different growing conditions in the UK and Canada?
Compare: for example low and highcost quality forages - economics of cost of growing plant and animal output
Identifying sweet spots and boundaries
Plants for animals / animals for plants – circular economy approach
Initial target: forages & legumes for beef cattle
Animal performance in different systems and environments
Canadian feeds. High quality: maize. Low quality: prairie grass silage
How to optimise either preservation of forages (enzymes) or feeding (for example additives)
Challenges
Fragmentation of beef producers
We want to identify animals that vary in capability to process – variable crop-based diets
Address challenges in forage production caused by climate change
How do changes in feed efficiency change performance of animal and product quality?
What should we measure in the animal to understand the impact of different approaches
What is the split of variation causes?
Key performance indicators: plant – energy and protein /area. Animal – kg/ beef per input cost and time. How to optimise this system
Sustainable systems - animal EBV (Estimated Breeding Values) plant – natural flow
Can you improve the uptake and use of nutrients e.g. plants using animal manure?
What do you measure to detect what is driving variation or managing variation?
Important to consider climate change and how it might change growing conditions in the future
Sources of variation
Microbiome usability
Barriers
Managing variation
Making the economic case to ensure all supply chain will adopt
Institutional momentum
Plant breeding - need to show the value opportunity
Subsidies may not deliver best perfor-mance
Scale – amount of animals and plants needed to obtain the big goal!
Value of grass/reseeding in the wild/highlands to improve grass quality not well understood
Breed clubs' impact on genomics
Lack of updates for farmers/ industry
Enablers
Need a new system for evaluating forages
Technology and analytics
Feed efficiency – energy, protein, carbohydrate, fibre (efficiency of all). What does the animal gut need?
Mind-set of farmers to treat grass as a crop
Collaboration across the UK /Canada and beyond
Grassland as basis for functional deployment
Funding to prove this is possible and economically viable (de-risk)
Behaviour / social science – humans
Changes to policy on supporting farmers
Joint UK /Canada animal and plant breeding programme to optimise productivity across diverse range of animal and plant characteristics
Animal / plant breeding index

Data standards, better connectivity and analytics

The acquisition, analysis, interpretation, ownership and use of data was a recurrent theme in virtually all of the activities of this programme. This roadmap concentrates on data platforms and the issues that need addressing. Managing this effectively will be critical to the benefit of all other areas being considered.

Return on investment and governance must be addressed first, and in advance of technical or technology challenges. There is a need to establish consistency and trust between all parties.

Barriers and problems were grouped into "relationships" and "best practice" and enablers were grouped into return-on-investment pilots, business-model generation and the drivers that are expected to be important over the next few years. Answering "what's in it for me?" is a key initial step of any development or improvement.

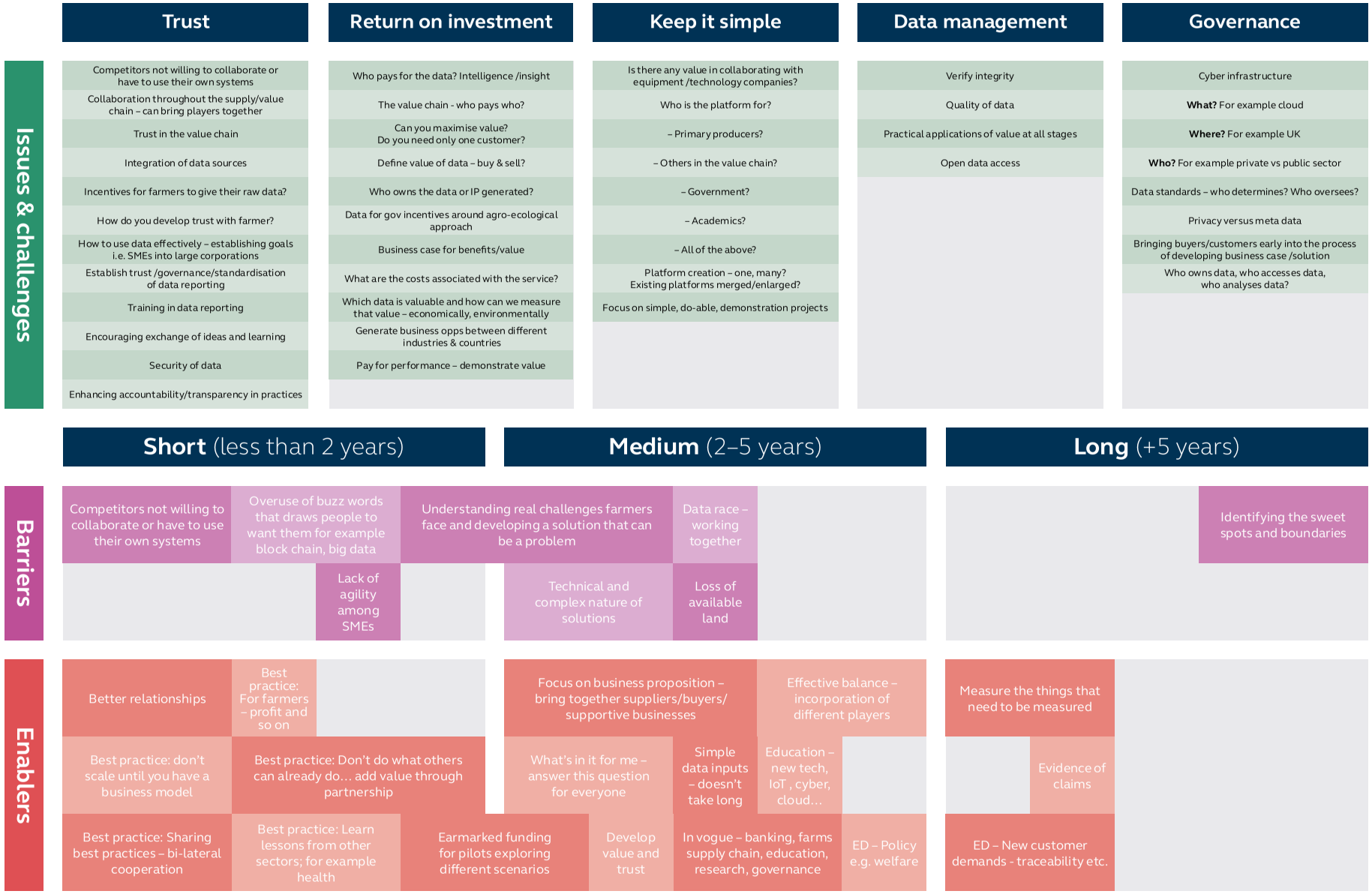
The roadmap starts with a bilateral sharing of best practice and moves on to pilots to demonstrate return on investment. The pilots would help to establish common infrastructures and the standardisation and quality of data that would be the key to future development. There is good/best practice that can be transferred from other areas, and simplification should be an underlying objective of all of the initiatives.

Business opportunity: tracing the potato to the crisp

Data and blockchain technology could help the potato crisp industry to provide traceability and authenticity for its products.

Data could be collected on potato production, potato storage and transportation, processing and on integrity across the chain. The information would be valuable to producers, shippers, retailers and consumers.

The project would need partners, funding and access to data. It could be a template for other agri-food sector supply chains.


Trust
Return on investment
Keep it simple
Data management
Governance
Issues & challenges
Competitors not willing to collaborate or have to use their own systems
Collaboration throughout the supply/value chain – can bring players together
Trust in the value chain
Integration of data sources
Incentives for farmers to give their raw data?
How do you develop trust with farmer?
How to use data effectively – establishing goals i.e. SMEs into large corporations
Establish trust /governance/standardisation of data reporting
Training in data reporting
Encouraging exchange of ideas and learning
Security of data
Enhancing accountability/transparency in practices
Who pays for the data? Intelligence /insight
The value chain - who pays who?
Can you maximise value? Do you need only one customer?
Define value of data – buy & sell?
Who owns the data or IP generated?
Data for gov incentives around agro-ecological approach
Business case for benefits/value
What are the costs associated with the service?
Which data is valuable and how can we measure that value – economically, environmentally
Generate business opps between different industries & countries
Pay for performance – demonstrate value
Is there any value in collaborating with equipment /technology companies?
Who is the platform for?
– Primary producers?
– Others in the value chain?
– Government?
– Academics?
– All of the above?
Platform creation – one, many? Existing platforms merged/enlarged?
Focus on simple, do-able, demonstration projects
Verify integrity
Quality of data
Practical applications of value at all stages
Open data access
Cyber infrastructure
What? For example cloud
Where? For example UK
Who? For example private vs public sector
Data standards – who determines? Who oversees?
Privacy versus meta data
Bringing buyers/customers early into the process of developing business case /solution
Who owns data, who accesses data, who analyses data?
Short (less than 2 years)
Medium (2–5 years)
Long (+5 years)
Barriers
Competitors not willing to collaborate or have to use their own systems
Overuse of buzz words that draws people to want them for example block chain, big data
Understanding real challenges farmers face and developing a solution that can be a problem
Data race – working together
Lack of agility among SMEs
Technical and complex nature of solutions
Loss of available land
Identifying the sweet spots and boundaries
Enablers
Better relationships
Best practice: For farmers – profit and so on
Focus on business proposition – bring together suppliers/buyers/ supportive businesses
Effective balance – incorporation of different players
Measure the things that need to be measured
Best practice: don't scale until you have a business model
Best practice: Don't do what others can already do… add value through partnership
What's in it for me – answer this question for everyone
Simple data inputs – doesn't take long
Education – new tech, IoT , cyber, cloud…
Evidence of claims
Best practice: Sharing best practices – bi-lateral cooperation
Best practice: Learn lessons from other sectors; for example health
Earmarked funding for pilots exploring different scenarios
Develop value and trust
In vogue – banking, farms supply chain, education, research, governance
ED – Policy e.g. welfare
ED – New customer demands - traceability etc.

Conclusions & recommendations

New bilateral partnerships between the UK and Canada have been established across the agri-food sector through the current programme of activities. This will enhance existing trade and create mutual export opportunities for agri-food products. Participants had a clear appetite for greater and sustained UK-Canada alliances based on shared challenges, goals and ways of working.

The challenges and opportunities faced by the sector require long-term solutions and a long-term view. While there is an appetite for partnerships to emerge, the nature of these is yet to be established. Individual parts of the agri-food supply chain often appear to be working independently. Better integration would lead to shared benefits such as improved productivity.

General themes that emerged included:

- value is not sufficiently understood across the sector but working groups could address this reasonably quickly
- perceived low benefits often lead to weak economic arguments and poor decision-making, particularly when addressing global challenges such as food safety and soil health. Better understanding of value is important in obtaining public acceptance for many initiatives
- ensuring the research community is focused on solving the challenges faced by farmers the need for a holistic view and for whole-system optimisation to cut out duplication and waste, improve understanding of causal links and prevent unhelpful competition for resources
- need to invest in skills and to attract people with technology skills from other sectors
- big data and diagnostics and sensor technologies can help to solve challenges in all areas. Standardisation and better sharing of data is needed, as are better diagnostic and sensor technologies
- intellectual property issues could be a barrier
- strategic and financial support is important

Recommendations

Increased collaboration between the UK and Canada in agri-tech will help both countries meet the challenges facing the sector and help businesses take advantage of the global opportunities. To achieve this, partners should:

- develop new organisational and professional relationships within and between the UK and Canada, for example establish 'information exchange forums' between national partners
- create working groups or targeted focus groups to develop theme ideas, opportunities and project proposals
- create cross-cutting theme groups (such as diagnostics and sensor technologies and big data), which could be taken forward through a bilateral special interest group
- use roadmaps to explore business opportunities and resourced work programmes
- explore further missions between the UK and Canada based around themes in the roadmaps
- integrate further agri-food workstreams in the UK and Canada into development of greater and new partnerships and establish an annual conference to provide an overview of work across the key sectors
- continue to develop organisational profiling to create a better picture of the sector and opportunities for further collaborations including reaching out to a wider audience with this report and the roadmaps

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