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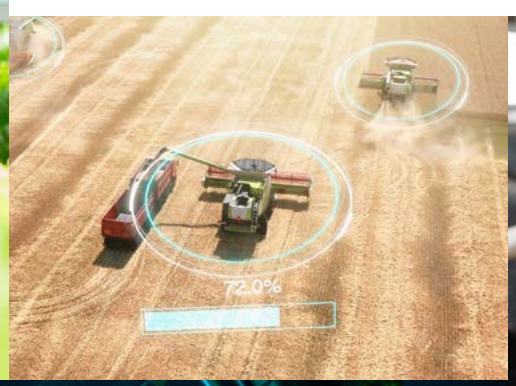
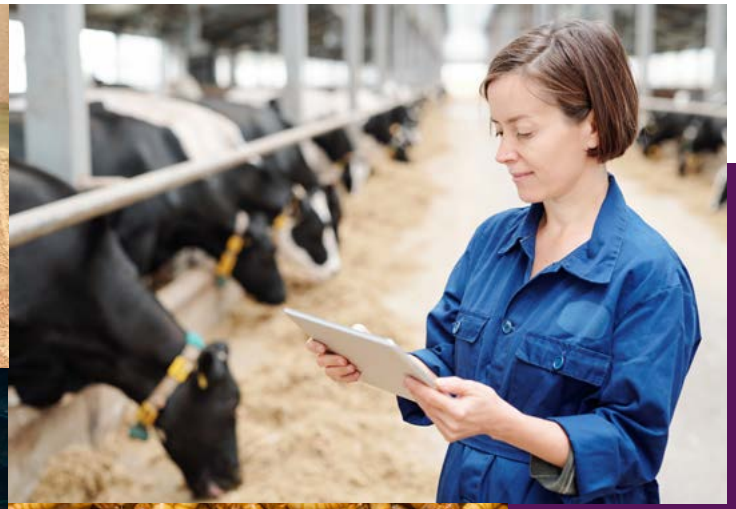
Catalysing the transition to net zero food production

Projects from the Transforming Food Production Challenge, a UKRI Challenge Fund Programme





Introduction

Katrina Hayter
Challenge Director,
Transforming Food Production
Challenge

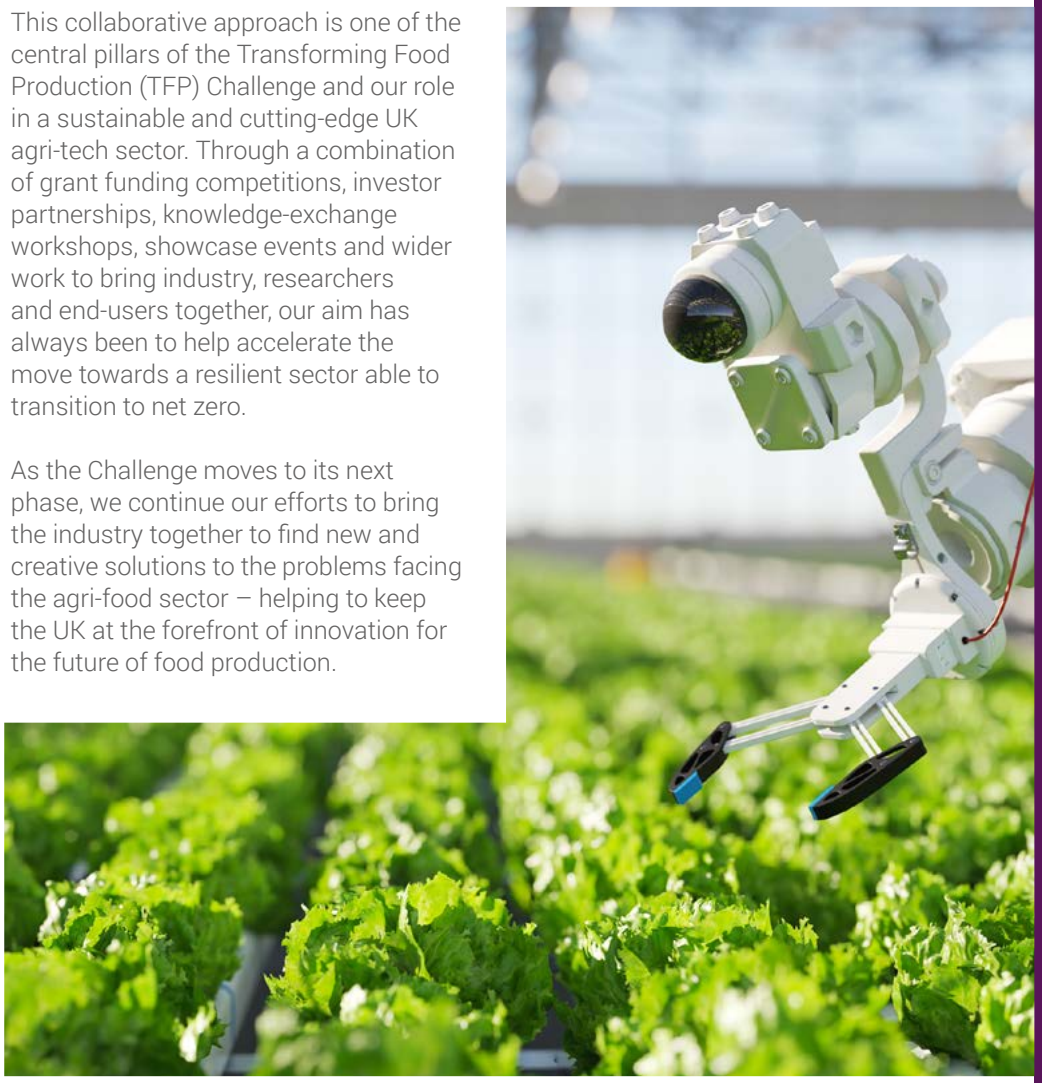
It's predicted that 60 per cent more food will be needed worldwide by 2050, to feed an expanding global population - but that does not simply mean scaling up the status quo. Instead, pressures on productivity, efficiency, sustainability and the environmental impact of food production are rightly driving a move to innovate the agri-food sector both in the UK and across the world.

In many ways, the answer comes in technology and its adoption. Whether that is in the form of on-farm robotics and machinery, digital monitoring, alternative production methods and produce, or data-led analysis and decision-making, the shift towards ground-breaking innovation is well underway.

To maximise the potential of the future food production systems, innovation must have collaboration at its core. The knowledge and experience of a wide range of stakeholders, from technology providers at universities and SMEs, through to large companies, growers, farmers and retailers, will be critical to new innovations being created and deployed across the agriculture sector and food industry.

This collaborative approach is one of the central pillars of the Transforming Food Production (TFP) Challenge and our role in a sustainable and cutting-edge UK agri-tech sector. Through a combination of grant funding competitions, investor partnerships, knowledge-exchange workshops, showcase events and wider work to bring industry, researchers and end-users together, our aim has always been to help accelerate the move towards a resilient sector able to transition to net zero.

As the Challenge moves to its next phase, we continue our efforts to bring the industry together to find new and creative solutions to the problems facing the agri-food sector – helping to keep the UK at the forefront of innovation for the future of food production.



Contents

92
projects funded by TFP

£104.6 million
Full project costs

£68.3 million
Amount of grant funding committed by TFP

£35.7 million
Pledged co-investment

Transforming Food Production Portfolio

Organisations funded

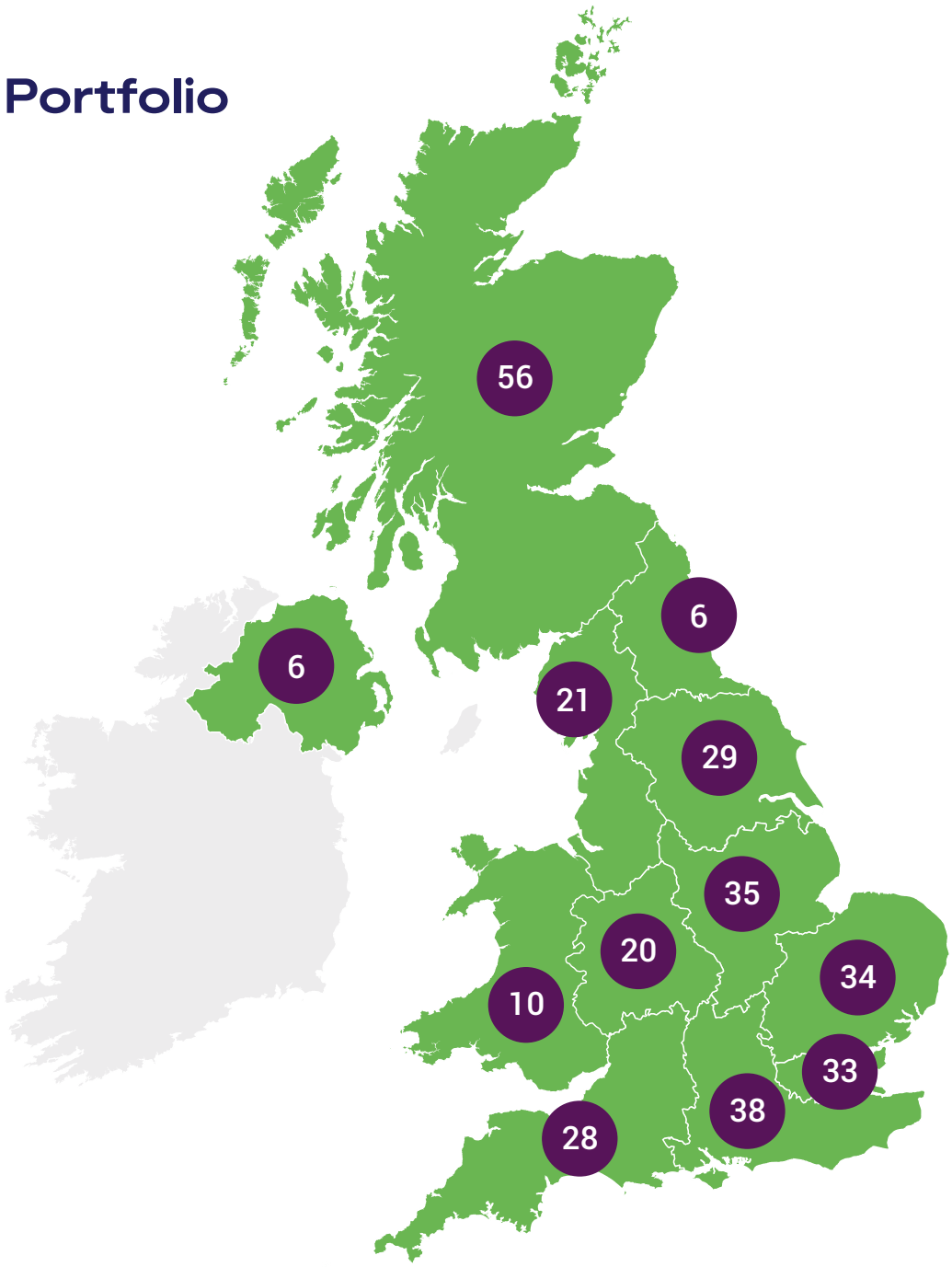
Business	**218**
Public sector, charity (or non Je-S registered research organisation)	**3**
Research (mostly academic institutions)	**72**
Research and Technology Organisation (RTO)	**23**
Total	**316**

Project participants and funding is as of February 2023.

Transforming Food Production Portfolio

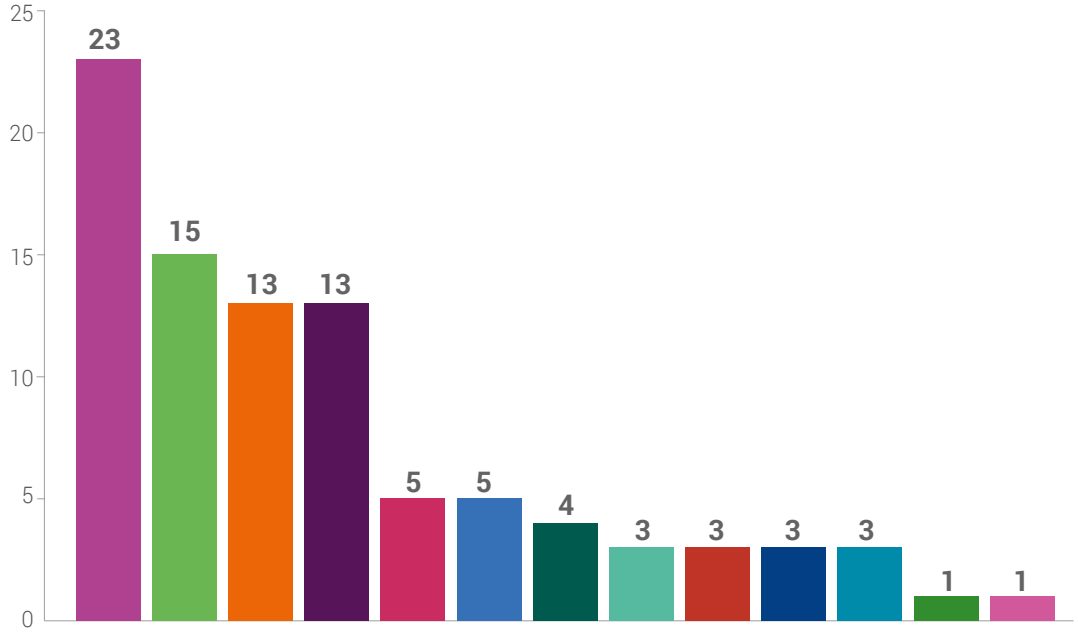
Geographic locations of project participants

Scotland	56
South East	38
East Midlands	35
East of England	34
London	33
Yorkshire and The Humber	29
South West	28
North West	21
West Midlands	20
Wales	10
North East	6
Northern Ireland	6
Grand Total	**316**



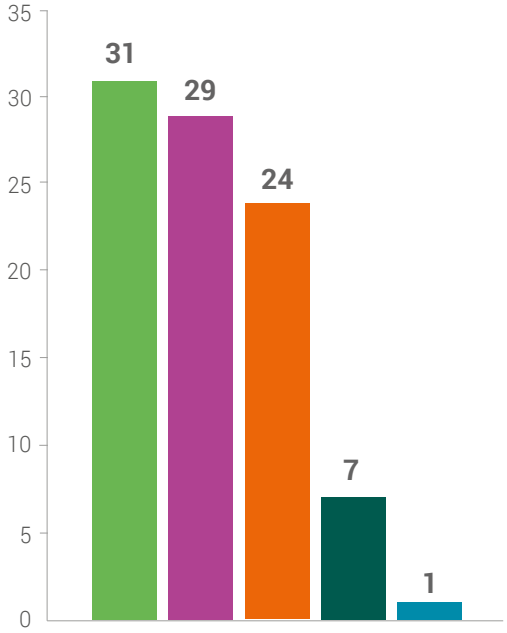
Transforming Food Production Challenge

Projects by technology and sector



Projects by technology

- Data/AI/Machine Learning
- Robotics
- Enhanced management/ Decision Support
- Diagnostics & sensors
- Automation/Engineering
- Imaging/Computer Vision
- Breeding and reproduction
- Cell culture
- Irrigation/Fertigation
- Nutrition/feed formulation
- Biopesticides, pesticide alternatives & biocontrol
- Algal Biotech/Fermentation
- Environmental control



Projects by sector

- Horticulture
- Livestock
- Broadacre
- New Proteins
- Aquaculture

Transforming Food Production

Towards net zero emission productive food systems

Here in the UK, farming is fundamental to our economy and our way of life. It provides the food and drink we need, while playing a vital stewardship role in the countryside. Employing nearly four million people, agriculture is the UK's biggest industrial sector.

Technological innovations are revolutionising farming and food production, making UK agri-businesses more productive and profitable than ever, while significantly reducing their environmental impact. By harnessing the UK's world-class research with our entrepreneurial business sector, we can drive new innovation across the UK agriculture sector to develop more efficient, resilient and sustainable food systems.

That is why the Government has invested so much to provide targeted support through the Transforming Food Production (TFP) Challenge. Led by Innovate UK and the Biotechnology and Biological Sciences Research Council, TFP is bringing businesses, researchers and farmers together to confront one of the biggest issues that the sector faces today, the transition to net zero by 2040.

In this brochure you can read about research projects that TFP has supported so far in different parts of the agriculture sector. In everything from using satellite imagery and artificial intelligence, to making better-informed decisions on farms, automating food production processes, and developing new methods of vertical farming, TFP has helped to develop innovative approaches and new technology – and shown how they can work in practice.

TFP has involved not just traditional agri-food companies, but also companies from other sectors in which the UK excels: such as Artificial Intelligence (AI), gaming, medical technology and robotics. It has also driven engagement of farmers and growers in projects to ensure the outcomes of the projects can be implemented on farm.

TFP is benefitting the UK in many ways. It is helping to make UK farming more productive, fuelling growth and creating high-skilled jobs – encouraging a new, diverse generation of agriculture professionals who embrace technology and innovation. By stimulating investment, it is also helping to create momentum in the agri-tech sector.

TFP is helping to make the UK food system more sustainable as well. Not just by reducing emissions, but also by producing food more efficiently, minimising waste and improving the soil.

Far beyond the UK, the projects that TFP is supporting have value. Some involve overseas partnerships, especially with China and Canada, while many others are developing processes and technologies that have export potential.

TFP is helping to transform existing agricultural production and spur whole new food production industries. Together, these projects can truly revolutionise food production systems in the UK and worldwide.

Assessment of commercial and technical feasibility of installing an automated milk sampling and reproduction testing system in a traditional milking parlour

This project was designed to demonstrate the technical and commercial feasibility of Davlec Limited's Automated Milk Sampling Device (AMSD) and the Lateral Flow (LF) reader, produced by Clarity Biosolutions Limited, to test for progesterone in cow's milk. By providing an easy to use and cost-effective progesterone test to work alongside the farmer's usual heat detection method gives them more precise information on the best timing for insemination of the cow, helping with decision-making, increasing the likelihood of successful inseminations, and reducing the number of days between calves, or the calving interval (CI). Reducing the CI ultimately helps to make the dairy industry more productive. The project was led by Davlec Limited, a Wales-based electronics manufacturing company that specialises in designing, manufacturing and servicing equipment for dairy production. It looked specifically at the feasibility of using the sampling and testing devices while cows are confined within a traditional milking parlour.

Project participants:
Davlec Limited, Ambic Equipment Limited, Clarity Biosolutions Limited

Funded amount:
£198,560

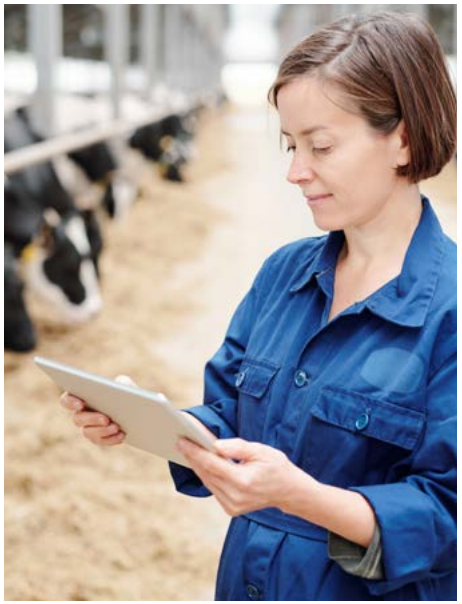
Conception to consumption: aligning farmers to consumers using modern data, decision support and precision agriculture techniques

The aim of this project, which was led by beef and lamb processor Dunbia (UK), was to drive significant improvements in the production efficiency, quality and productivity of the UK beef sector, worth an estimated £500m over five years.

Currently there is a great degree of variability in the red meat supply chain and the beef it delivers. This is a consequence of the breadth and range in enterprise type and systems of production, coupled to a lack of consistent and accurate data collection, analysis and interventions that drive improvement.

This three-year study of over 12,000 animals has centred on the development of advanced information technology solutions that help to pool, analyse and disseminate information, from genetics through to eating quality, for the purpose of supporting timely and more informed decision-making on farms. In particular, it has led to the creation of a farm-to-processor software management platform for the procurement of livestock that meets customer specifications and end market requirements.

Ultimately, further integration of the beef supply chain in this way should help to improve the consistency, quality and safety of the beef that is delivered to the consumer, and contribute to the long-term sustainability of the UK beef industry.



Project participants:
Dunbia (UK), Breedr Limited, SRUC

Funded amount:
£2,395,518

Artificial Intelligence for Artificial Insemination (AI4AI) technology standardising semen quality assurance across the supply chain, raising conception rates and reducing green-house emissions

In this project, Scotland-based Agritech specialists Dyneval Limited were working to bring to market precision technology for monitoring semen quality at any stage of the livestock reproduction process. The system uses proprietary technology powered by artificial intelligence to measure semen quality pen-side. Users are able to improve conception rates through eliminating semen that is sub-standard or that has been damaged during processing, distribution or storage.

The aim was to to create a robust, lightweight ergonomic tool, tailored for use on the farm. In the long term, the reliable data it produces will improve decision-making in artificial insemination. Data is stored on the cloud for retrieval, data mining and integration with other farming data systems.

Among cattle, today's conception rates are some 20% lower than they were 40 years ago, resulting in increased calving intervals that are estimated to cost farmers €2bn each year across Europe (equivalent to £25k per farm). Improving conception rates will also bring environmental benefits: some studies estimate that total herd emissions of methane could be reduced by up to 20% if conception rates are improved.

Through eliminating poor quality semen from their batches for artificial insemination, farmers will produce food more efficiently, improve their profitability, and be able to meet the sustainability goals set by cooperative buyers and supermarkets.

Project participants:
Dyneval Limited

Funded amount:
£575,509

Development and optimisation of the FECPAK^{G2} system to speciate protozoan infections in livestock and improve productivity and sustainability

Coccidiosis is one of the most economically significant diseases in cattle and sheep due to the considerable impact on production at herd/flock level. It is caused by infection of the alimentary tract with protozoan parasites species Eimeria. Affected animals usually suffer weight loss and pain, and have to go through a protracted convalescence, resulting in extra feeding and treatment costs.

Currently diagnosis involves faecal testing, but the interpretation of faecal samples is challenging and time-consuming; and involves a highly skilled technician. As a consequence, it is rarely undertaken in field outbreaks, due to the cost and time taken to get results from external laboratories. Given these limitations and the pressure for prompt treatment, farmers often blanket-treat animals with a non-targeted treatment.

The existing FECPAK^{G2} system, which has been developed by project partner Techion, is a rapid on-farm diagnostic platform for faecal testing, designed to detect other parasites. This project, which was led by Ripon-based RAFT Solutions Limited, assessed the feasibility of adapting the existing FECPAK^{G2} system to detect protozoan parasites, alongside the development and integration of automated image recognition software, to make it possible to diagnose cases of coccidiosis immediately, from fresh faecal samples.

Project participants:
RAFT Solutions Limited,
Techion (UK) Limited

Funded amount:
£117,397

Development and validation of an automated diagnostic system for the cattle industry to improve reproduction and metabolics and reduce associated economic losses

This collaborative project was a follow-on from a previous Innovate UK-funded project, which involved the development of powerful new diagnostic tests and portable reading technology for farmers in the dairy industry. This technology, named ReproTel, makes it much easier to monitor the health and reproductive condition of cattle, enabling farmers to improve productivity, improving herd health and to deliver significant environmental benefits through the reduction in methane and ammonia emissions from sick animals.

The project was intended to automate the existing ReproTel system, to allow it to be (retro-) fitted to existing and new (semi-)automated and robotic milking parlours. This enables the system to be used more easily, and produce better results. The diagnostic information that the technology provides helps to support better decision-making around cattle health, and the earlier and more accurate identification of health issues. As such it helps both to improve animal welfare and drive productivity, delivering social, environmental and economic benefits to the dairy industry.

Project participants:
Clarity Biosolutions Limited,
Davlec Limited,
RAFT Solutions Limited

Funded amount:
£312,461

Development of advanced breeding and metabolic indicator technology for the dairy and beef industries

This project, which was led by Salisbury-based Clarity Biosolutions Limited, was intended to increase productivity in the beef and dairy industry, through precision technology that makes it possible to measure key biological indicators among livestock, in particular in relation to their nutritional and reproductive health.

The project brought together Clarity Biosolutions' innovative lateral flow reader and test technology, and RAFT Solutions deep understanding of the needs of the beef and dairy industries. It has provided valuable information about the feasibility, both technical and commercial, of a series of innovative tests which can detect important biomarkers, monitoring a cow's levels of progesterone, for example, to show when it is most likely to conceive. Bringing this technology to market successfully has the potential to deliver environmental and economic benefits in the agricultural industry, both in the UK and worldwide. It would help to bring about improvements in herd health, and reduce the carbon emissions that are associated with beef and dairy production.

Project participants:
Clarity Biosolutions Limited,
RAFT Solutions Limited

Funded amount:
£142,536

Enhanced animal behavioural analytics for improved cattle welfare, health, productivity and sustainability

This project involved an in-depth feasibility study of Quant Foundry Limited's Artificial Intelligence (AI) Livestock Surveillance Solution, which the company developed in collaboration with Bristol Veterinary School at the University of Bristol. The solution is intended to identify anomalous cattle behaviour, to help with the rapid identification of different ailments. The solution uses AI-driven video analytics of animals, to improve their health and welfare and so lower production costs and greenhouse gas emissions.

While there are a number of existing solutions for remote monitoring of animals, many require the active involvement of people, and so have little potential for cost savings. Other solutions require the use of physical hardware that must be worn by the animal, requiring significant per-animal set-up and maintenance costs. The Quant Foundry system can identify and track multiple animals, largely autonomously, and without the animals needing to be fitted with hardware.

The feasibility study involved classifying and identifying key animal behaviour features to be applied to the system's deep learning algorithm, as well as a study to assess the commercial potential of the system.

Project participants:
Quant Foundry Limited, Agri-Epi Centre Limited, University of Bristol

Funded amount:
£205,993

GIS-based liver fluke risk forecasting system

Liver fluke is a common parasite that affects sheep and cattle in the UK. It is found throughout the world and in some countries it affects humans too, causing serious and sometimes fatal disease. Fluke-infected cattle lose weight, become anaemic and lethargic, and stop being productive. This has a serious effect on the welfare of the animal, and serious economic consequences for the farmer. It is thought that fluke costs UK agriculture at least £300million pounds a year through direct losses, but real costs are probably much higher.

Fluke has become much more common over the past 10 years, due in part to our changing weather patterns: wet summers and mild winters favour the development of the parasite and the mud snail that it lives in, found commonly throughout Britain. Studies have found that 75% of dairy herds show evidence of fluke infection.

Better understanding of the epidemiology and transmission of disease is vital if we are to develop control programmes that rely on improved on farm management practises rather than depending solely on drugs.

This project follows on from work carried out by the University of Liverpool, to produce new, sustainable, bespoke control programmes for beef and dairy farms, to reduce losses associated with fluke infection.

The project, led by agriculture forecasting specialists Farming Online Limited, has involved the development of Geographic Information System (GIS) mapping to analyse cow movements and categorise snail habitats, to provide a better understanding of the risk factors for fluke infection on particular farms.

Project participants:
Farming Online Limited, University of Liverpool

Funded amount:
£395,770

Gold nanorod diagnostic test and data management system for detection and control of bovine tuberculosis

Tuberculosis (TB) is a bacterial infection that mainly affects the lungs, causing illness, coughing and ultimately death. Bovine tuberculosis (bTB) is caused by a bacterium that affects cows but can be passed on to other mammals, including humans, usually through the inhalation of infected droplets. Because the course of the disease is slow, an undetected cow can spread it to many others in a herd before it shows any visible signs of illness.

Accurate and timely detection, herd management and movement control are critical to eradicate the disease. But the current test for bovine tuberculosis on farm herds is relatively subjective, relying on the interpretation of individual veterinary practitioners. It is also not sensitive enough to detect all the cows that are infected.

A new, effective test is urgently needed: bovine TB control measures are estimated to have cost over £500 million in the last 10 years, and without intervention, they are expected to top £1 billion over the next decade.

This project brought together an international consortium to lead the fight against tuberculosis in cattle. It involved a team of academic and industry experts, led by Lateral Flow Diagnostic specialists Clarity Biosolutions. The project combined the latest scientific and technological research with world-class facilities and expertise, to develop a new, highly accurate, objective and rapid test to detect, manage, control and ultimately eradicate bTB.

Project participants:
Clarity Biosolutions Limited, Bond Digital Health Limited

Funded amount:
£299,736

Healthy Heifer: precision solution to improve heifer rearing for increased productivity across the dairy sector

This project was led by Cambridge Animal Technologies Limited, an innovative technology start-up working to improve farming practices and animal welfare. The project involved the creation of a precision technology solution for dairy farmers, focused on improving the rearing of heifers.

The product that the project has developed includes a data collection system that integrates different sources of information, including that from advanced sensing technology and farm records, to provide a full picture of the condition of individual animals. A data analysis platform then continuously analyses this information, providing real-time feedback on animal health and performance, and flagging any issues, so that farmers can intervene in a timely fashion. A decision support system, developed using expert advice from veterinary and animal science specialists, then helps animal health to be managed in the best way.

Project participants:
Cambridge Animal Technologies Limited, Agri-Epi Centre Limited

Funded amount:
£198,546

Identifying best sensor technologies to deliver verifiable health & welfare, environment and processing quality benefits for dairy production

This project, which was led by Scotland's Rural College (SRUC), addressed some of the key concerns of consumers and retailers of milk and dairy products, who need to be reassured about the environmental footprint and animal welfare standards of dairy production systems. It developed new tools to provide verifiable information in these areas.

The project looked at how monitoring technologies could be used for this purpose, including environmental sensors, animal-mounted sensors and camera technologies that are already being used by farmers to manage technical aspects of their systems, such as feeding and fertility. By relating the information that these technologies provide to what is manually recorded, and using advanced machine learning techniques, the project developed new algorithms to monitor cow welfare and environmental emissions, in ways that are both easier, cheaper and more reliable.

The project has also helped to identify some of the key common indicators for both environment and welfare aspects of dairy production, which can contribute to accepted farm assurance standards, as well as reassuring consumers.

Project participants:
SRUC, First Milk Limited, McQueens Dairies Limited, Nestle UK Limited, University of Strathclyde

Funded amount:
£172,300

Improving bovine in vitro embryo production through follicular flushing and next generation embryo culture

This project, which was led by Cumbria-based Paragonvet Limited, involved the development of *in vitro* embryo production as a tool for improving the health and productivity of dairy cows. Specifically, it involved the development of a system, and manufacture of new equipment, to recover more oocytes (eggs) from each donor cow (using a technique known as ovarian-follicular flushing) and the creation of improved methods for the culture of embryos within the laboratory. Collectively, these technical innovations will increase the efficiency of embryo production and lead to higher pregnancy rates. This, in turn, will lead to increased genetic quality in dairy herds, by breeding from only the best cows.

Cattle breeders are eager to engage with and use this technology in order to improve the health, productivity and efficiency of their herds. It will enable farmers to produce and rear animals that are more suited to their particular farming systems, with greater precision. This will, in turn, reduce demand for resources such as animal feed, fertilisers and pesticides, leading to a reduction in animal waste and greenhouse gas emissions.

Project participants:
Paragonvet Limited, Boviteq, IMV Imaging (UK) Limited, University of Nottingham

Funded amount:
£518,069

Investigating the feasibility of adapting a direct PCR diagnostics approach to in-field animal testing

While human diagnostics has evolved, there has been little progress for testing animals for important pathogens. The UK foot and mouth disease outbreak in 2001 cost the country over £3bn in losses to the agriculture sector alone, and more rapid diagnostics would potentially have minimised the spread and impact of such diseases.

This project involved adapting lab-based technology for detecting pathogens such as Ebola from human blood, to being able to detect viruses such as foot and mouth disease virus or peste des petits ruminants virus from a simple swab from animals suspected of harbouring diseases, or within a group of animals where one or more animals are diagnosed as positive.

The project was led by biotechnology specialists BG Research Limited, a company focusing on novel field-based diagnostics. It built on their previous work developing methods for detecting viral pathogens directly from crude samples, without the need for expensive and time-consuming nucleic acid extraction, requiring lab facilities and expert involvement (testing can be carried out by trained local personnel such as vets and field workers).

The project involved developing methods for testing for up to six different veterinary diseases direct from a single blood sample, saliva or a nasal swab, including notifiable pathogens that have to be reported if suspected or found.

The technology can be adapted to test for diseases of consequence that are found globally in both animals and humans, and as such it has the potential to create a generic platform for 'pandemic-preparedness.'

Project participants:
B G Research Limited, Royal Veterinary College, The Pirbright Institute

Funded amount:
£674,288

OPTI-BEEF: precision agricultural solution to monitor lifetime productivity and product quality

There is currently extensive inefficiency in the UK beef sector. Producers routinely assess the condition of their animals by eye, and frequently keep them on the farm too long, causing them to become too fat, instead of being sent to abattoirs at the optimum point for yield and quality. For farmers it can mean unnecessary increased costs, as well as reductions in the price they receive for carcasses. Consistency and potential lack of confidence in the consistency of subjective carcass classification, when relying entirely on human judgement, can present challenges in delivering true carcass value. Over-fat animals also increase processing costs for abattoirs, and mean that production of beef has a higher environmental impact per kg of meat.

This project, which was led by Gloucestershire-based veterinary specialists HallMark Meat Hygiene Limited, developed technologies for use on farms and in abattoirs, to automate the process of selecting animals for slaughter and classifying (grading) their carcasses. The project involved the integration of automated data gathered across the whole life of individual beef animals (from calf to carcass), to create a platform that supports better decision-making, to help modernise and drive improvements in efficiency across the UK beef supply chain.

Project participants:
HallMark Meat Hygiene Limited, Agri-Epi Centre Limited, David Ritchie (Implements) Limited, Harbro Limited, Hectare Agritech Limited, Innovent Technology Limited, NPL Management Limited, Scotbeef Limited, SRUC, WM Morrison Supermarkets PLC

Funded amount:
£1,275,292

RapiPath: connecting rapid diagnostic testing with the wider dairy supply chain for improved milk yields, disease surveillance and product assurance

The use of diagnostics is widely recognised as a powerful tool for improving animal health as well as food hygiene and safety, with a wide variety of diagnostic tests being available, using a variety of biochemical and physical techniques.

However, a common challenge for most of the diagnostics tools that are used in agriculture and veterinary medicine is the difficulty involved in passing on information through the entire food supply chain. This can result in massive inefficiencies in logistics, increased wastage and a lack of evidence to support policy-making, especially in the dairy industry.

In this project, a consortium led by Ripon-based food sustainability specialists RAFT Solutions Limited has been working to develop assays designed to help vets choose suitable treatments. The project has developed a new hardware and software solution that helps to collate and share diagnostic results. Not only will this help to improve and protect animal health and welfare, but it will increase farm productivity maximised by reducing disease and overcoming logistical barriers relating to health management.

Project participants:
RAFT Solutions Limited, Cielivestock Limited, Fera Science Limited, Optisense Limited, Quality Milk Management Services

Funded amount:
£528,275

REMEDY: REal tiME DairY. Providing solutions for farmers, vets, consultants and the environment

This project involved the development of a new, data-driven solution for dairy farmers that will help them to use resources more efficiently and work towards Net Zero emissions. For the first time dairy farmers will be able to calculate and evaluate their efficiency, productivity and environmental impact and then use sophisticated simulation tools, calibrated for their own farm, to help them make the best management decisions in real time.

Current on-farm precision technologies often deliver isolated solutions to individual components of complex dairy production systems. This project focused on combining data and precision technologies (including cow wearables, health recording technology, detailed data from milk recording and animal health organisations, genomic data, nutritional data and data on carbon footprint and emissions), in a single real-time decision support system (REMEDY).

Integrating a diverse range of data sources, REMEDY used simulation models to predict the consequences of specific management decisions on a farms future productivity, animal health, profitability, and environmental impact.

REMEDY represents an important change in the use of farm data, enabling truly evidence-based decision-making by farmers, vets and advisors.

Project participants:
Quality Milk Management Services Limited, Icerobotics Limited, The Dairy Group Limited, University of Nottingham

Funded amount:
£1,788,853

Robotics and Artificial Intelligence for Sustainable Dairy (RAISD)

Among the many challenges facing dairy farmers today, one of the most time-consuming and difficult is the skilled labour that is involved in working with cows. This project, led by Stirling-based Peacock Technology Limited, applied robotics and AI to automate key tasks in cow management and milking, freeing labour to concentrate on the animals that most need attention.

Peacock Technology is an advanced engineering and robotic automation company that specialises in machine vision and artificial intelligence. Through the RAISD project it developed and validated an advanced robotics and remote monitoring platform, helping dairy farms to produce milk more efficiently and with full attention to animal welfare. By automating processes and enabling the continuous monitoring of the cows it will help to lower the carbon footprint of every litre of milk that farms produce. The system will also provide autonomous and objective accreditation of farm practices, helping to improve animal welfare. Finally, by exploiting the latest developments in artificial intelligence, it will be able to provide performance metrics for farmers, milk retailers and consumers.

The platform will be sold in the UK and internationally, supporting more sustainable dairy farming worldwide.

Project participants:
Peacock Technology Limited

Funded amount:
£1,290,356

SemenRate Canada/UK: transforming germplasm and genetic quality to drive livestock productivity

Good fertility is the cornerstone of a profitable and sustainable livestock enterprise. In the international dairy and beef herd, the ideal is to maintain a calving interval (CI) of 365 days. Every day that the CI increases beyond 365 days is estimated to cost the farmer £2 per cow, or more for high-yielding dairy cows. Increasing fertility drives productivity and in turn helps to mitigate greenhouse gas (GHG) emissions through reduced waste.

This project, which was led by Ripon-based food sustainability specialists RAFT Solutions Limited, researched and developed a number of innovative new technologies, and to establish referral facilities at the national level, for quality assurance and improvement of bovine germplasm – the cells containing the genetic material required for breeding.

The outputs of the project, which is a joint UK/ Canada undertaking, will help to transform the genetic quality of the livestock that is produced, through the adoption of precision technologies, diagnostics, advanced breeding and big data. This will lead ultimately to more sustainable livestock food production, and export opportunities in both the UK and Canada.

Project participants:
RAFT Solutions, Atelerix Limited, Dyneval Limited

Funded amount:
£398,894

Sensor integration for animal health early warning system

China's dairy consumption is rising, in per capita terms: the country has overtaken the USA as the world's largest dairy product consumer. Government policies in China are encouraging increased domestic dairy production, but sustainability in this growing industry is a huge challenge.

This project, which was led by Lancaster-based Agsenze Limited, involved the development, integration and validation of a number of animal health data collection systems, based on vision and 'wearables,' which will monitor and improve animal health and production, allowing producers to improve the management of their herds. The combination of technologies will improve productivity, as well as reducing environmental impacts.

The project developed advanced decision-support systems that will improve identification of dairy health issues such as lameness, removing subjectivity and inconsistency, and helping farmers to prioritise early intervention. The combination of the technologies and enhanced data reporting will improve producers' ability to monitor the physiological condition of cows, helping them to improve fertility and reduce calving intervals, leading to improved milk production and financial savings. By integrating multiple datasets, it will also be possible to develop new, innovative early warning alerts for a wider range of health and welfare outcomes than currently exist in the market.

The technology partners that were involved in the project are seeking to expand their reach to help dairy farmers in the UK and overseas, creating new opportunities to reduce labour and provide outcome reports that allow farmers to make better management decisions. End-users will gain from improved animal health and welfare and milk production with lower carbon emissions.

Project participants:
Agsenze Limited,
Agri-Epi Centre Limited,
Dairymaster (UK) Limited

Funded amount:
£328,843

Smart sheep: precision livestock farming and sustainable sheep production

This project, which was led by the Edinburgh-based Moredun Research Institute, addressed the adoption of precision livestock farming (PLF) technologies in sheep farming. PLF has been widely adopted in the management of high-value animals such as dairy cattle, but had not been applied to those with lower economic value, such as sheep, despite the potential to increase production efficiency. In the UK, there are around 23.3 million sheep, and since 2010, all individual sheep in the UK are equipped with EID (Electronic Identification) tags, further paving the way for use of PLF technologies. However, uptake is a major issue, with only a small minority of farmers using EID equipment for sheep management.

The project involved early engagement with end-users (members of the farming community and farming advisors), to co-design tools to increase the uptake of PLF on farms: these tools were then validated on a range of farms across the UK. It focused especially on one particular, proven PLF tool; a pen-side device for use during worming, which uses an algorithm for the early identification of under-performing lambs. While farmers had recognised a clear need for this type of approach on farm, there had been a lack of a user-friendly method for farmers to access the algorithm. The project involved integrating the algorithm into a cloud-based platform, thereby making it easily accessible to farmers.

Project participants:
Moredun Research Institute,
5 Agri LLP, Datamars Agri UK Limited,
Nighthawk Software Limited, SRUC,
Synergy Farm Health Limited

Funded amount:
£196,204

SmARtview: an AI-powered augmented reality tool for animal health and productivity

The emergence of precision agri-tech in the dairy sector has given rise to a multitude of data collection platforms in, around and on dairy cows, such as animal-mounted sensors (smart collars, pedometers, tags and boluses), smart milking machines and camera technologies. Farm staff, vets and other advisors need to access and interpret these multiple data-streams in order to make decisions around cow health and production management. But accessing multiple data-streams, let alone analysing and interpreting them, is extremely challenging. In practice, the value of much of this data is lost because it cannot be used in a timely and insightful fashion.

This project brought together technology from the gaming and agri-tech sectors to solve this problem. SmARtview integrates multiple data-streams from any technology platform that is deployed on the farm, using AI to identify an individual cow and access its data, together with augmented reality to visualise the data. It makes it easier for livestock keepers and vets to access and interpret – at the time and place of examining an animal – the data tools that are at their disposal, in an integrated form that can be used to inform point-of-care decisions.

Project participants:
Agri-Epi Centre Limited, Pocket Sized Hands Limited, Abertay University, VetPartners Limited

Funded amount:
£198,926

The use of GPS tracking and the LoRaWAN network to improve productivity of grazing dairy cows

British milk yields per cow have increased by 50% in the past 20 years, but whilst grazed grass is cheap and sustainable, current grazing systems do not support these increased yields, and so cows are often fed more expensive supplements.

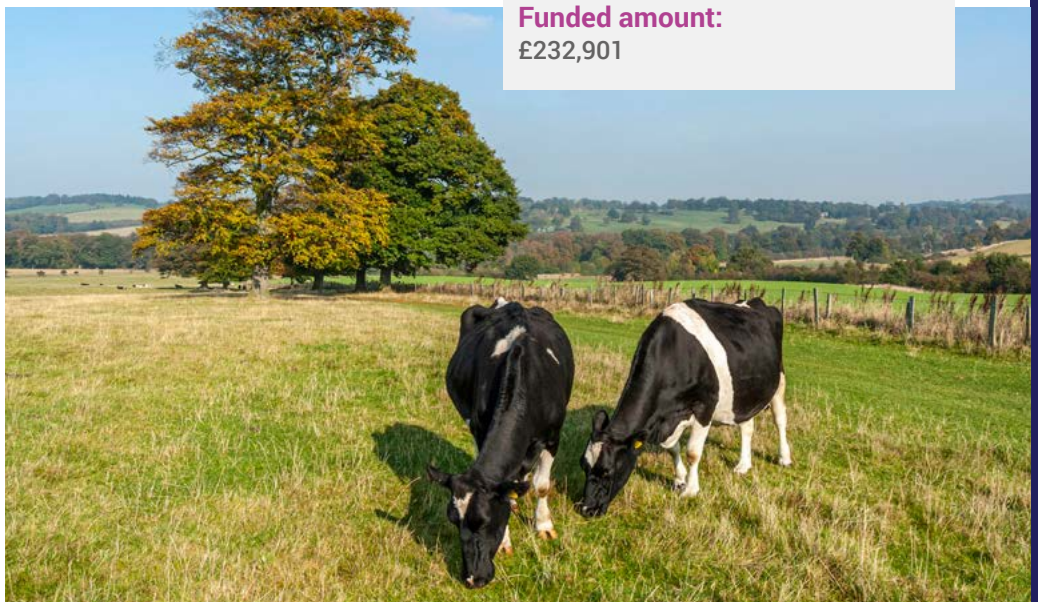
This project involved the development of a system that collects cow behavioural data in real time, and uses artificial intelligence techniques to determine when best to allocate additional pasture to grazed herds, resulting in more milk production from grass.

Small collar-mounted sensors track the cows using GPS signals. The collected data is then sent via a low power wide area network (LoRaWAN) to the internet. Requiring little power, the LoRaWAN system means that small batteries can be used to power the sensors over a full year. When extra grazing is needed a signal is generated to trigger a field gate to open, allowing the herd access to fresh pasture.

Over time the system builds up a database of where the cows have grazed, which can be used to quantify the productivity of each field, and support pasture management.

Project participants:
Chalcombe, Hoofprints Technologies Limited, Precision Grazing Limited, Rothamsted Research, WD Farmers

Funded amount:
£232,901



Towards net zero dairy farming through AI and machine vision (DAIRYVISION)

This project, which was led by Stirling-based engineering and robotics specialists Peacock Technology Limited, was a bilateral collaboration with China. It involved the development and trial of a new precision engineering solution to help dairy farming reach the goal of Net Zero greenhouse gas emissions, through the use of artificial intelligence and machine vision.

The system that was developed involves the autonomous monitoring and management of dairy cows to improve their welfare, health and productivity. An advanced vision-based system continuously monitors each individual cow's behaviour, nutrition and wellbeing. It automatically detects any anomalies that might be a sign that a human needs to intervene, alerting farm staff of specific animals that need their attention, for instance due to a nutrition issue or a health problem.

The system could help to bring about an entirely new approach to managing dairy cows worldwide, both improving animal welfare and reducing their environmental impacts. AI and new generation vision technologies can help dairy farmers contribute to achieving the UK's ambition of Net Zero farming by 2040.

Project participants:
Peacock Technology Limited, Harper Adams University, University of Nottingham

Funded amount:
£501,793

WELL-CALF: precision agricultural solution to improve health and productivity across the dairy-beef sector

This project, which was led by Agritech specialists Cambridge Animal Technologies Limited, was focused on developing a precision agriculture technology solution to help improve efficiency in the dairy-beef sector, through improvements in health and management throughout animals' lives.

The product that the project has developed includes a data collection system that integrates different sources of information, including from new and advanced sensing methods and farm records. A data analysis platform then continuously analyses this information, providing real-time feedback on animal health and performance, and flagging any issues, so that farmers can intervene in a timely fashion. A decision support system, developed using expert advice from veterinary and animal science specialists, then helps animal health to be managed in the best way.

The project has developed the first cloud-based decision support platform for the sector. It helps to support decisions from the level of individual farms (around health management, nutrition etc) through to policy and practice decisions at a systems level. The project has also developed the first precision agriculture integrated monitoring system specifically designed for calves, for the early detection of important diseases such as scour and pneumonia during the rearing period. This allows for early intervention and treatment at an individual animal level. The overall aim is to reduce the spread of disease, reduce the need to use antibiotics, and improve productivity and efficiency.

Project participants:
Cambridge Animal Technologies Limited, Agr-Epi Centre Limited, Parklands Veterinary Limited, SRUC

Funded amount:
£814,656

Advancing Bioprocess Sustainability for Poultry Feed from Algal Biotechnology (ABS-PFAB)

The aim of this project was to develop the next generation of algae-derived products for use in poultry production in the UK, Canada, and other commercial markets worldwide.

The project made improvements to existing processes to make significant reductions in the carbon footprint of omega-3 production, and to develop a sustainable protein source, which will contribute to the task of achieving net zero agriculture emissions by 2040.

As well as being more sustainably produced, the feed will lead to chickens that are more dense in nutrients, and that will provide a rich source of omega-3 oils in the human diet, whilst enhancing the overall efficacy of poultry production. It is anticipated that the project results will be applicable to other areas of primary agriculture (e.g. in aquaculture and pig rearing), and so will expand access to essential lipids in human diets globally.

Through commercial on-farm studies in both the UK and Canada, using a range of sensors and electronic (big) data, the project proved the validity of this innovative approach to poultry farming.

Project participants:
Devenish Nutrition Limited

Funded amount:
£384,216

Ideal Home: the net zero poultry house for the future

The UK poultry meat sector is the second largest in Europe, and this is a sector seeing continued expansion to meet retail demand. This expansion has to be balanced against the need for high levels of animal welfare, and the need to protect the environment. Globally poultry meat and egg production is responsible for 8% of agriculture emissions (FAO). Better animal health interventions and farm infrastructure/ management improvements will be key to increase productivity in a sustainable way.

In this project the Ideal Home partnership, led by Moy Park Limited, carried out a detailed baseline assessment, identifying the current situation within traditional poultry housing. It is now possible to evaluate precision solutions for alternative housing systems to produce feasible, sustainable new approaches to poultry housing and management. This will ultimately lead to improved well-being and performance, greater energy efficiency and improved resource efficiency.

Ideal Home sought to bring about a transformational change in sustainability and productivity across the UK's poultry production system.

Project participants:
Moy Park Limited, J.F. McKenna Limited, Queen's University Belfast

Funded amount:
£191,339

PRUEX

This early stage feasibility project trialled the effectiveness of applying disinfectant in a new way, to reduce greenhouse gas emissions and improve flock health and profitability in deep litter broiler houses. It used innovative sensor technology to assess bacterial contamination within broiler chicken sheds: the data that this provided was then used to provide the right dose of non-infective (good) bacteria, to be applied to the litter on the floor of the chicken sheds. The aim of doing this is to improve the environment within the building and reduce the need for antibiotic treatment of birds. Faecal bacteria in chicken litter is known to produce ammonia, but by applying the good bacteria less ammonia is generated.

The project also involved the design and manufacture of a robot which applies accurate, timed doses of good bacteria though spraying nozzles positioned close to the floor of chicken sheds. The technology developed in this project has already proved to be a commercial success. To date, over 10 systems have been installed on a mixture of broiler chicken, layer chicken, and dairy farms. Going forward, demand is expected to increase within the poultry market as the economics of meat and egg production improve, and the system has generated interest internationally.

Project participants:
Harper Adams University, Hudson & Sanders Limited, PRUEX Limited, Ross Robotics Limited

Funded amount:
£187,403

Sustainability and supply chain benefits of antibiotic replacement technology for Canadian and UK livestock sectors

Feed usage accounts for around 78% of the greenhouse gas emissions related to poultry farming. This project was a response to the growing demand to enhance sustainability in poultry production. Through a UK/ Canada consortium, it looked at the potential of 'bacteriophage' (bacteria-eating) technology to improve feed quality, and make it better able to counter gut disease in poultry.

Necrotic enteritis (NE) is an enteric disease that has a major impact on gut health, particularly in the broiler industry, costing it around US$6bn per year globally. Currently antibiotic growth promoters (AGPs) are used to control NE, but AGPs can negatively impact beneficial gut bacteria in birds, and are being banned or withdrawn in many countries due to consumer pressure and concerns around antimicrobial resistance. Without effective control for gut disease, more feed is required and a longer growing period for birds to reach optimum weight.

This project, which was led by Aparon UK, developed a novel bacteriophage cocktail, a natural feed additive to reduce pathogens in feed and in turn reduce the risk of disease. A natural product that maintains gut health will improve the sustainability of the poultry sector. The project also developed a platform to track food through the supply chain, and analyse the resulting data.

Project participants:
Aparon Limited

Funded amount:
£247,846

Towards improving efficiency through leg health and reproductive performance in commercial duck breeding flocks

The aim of this project was to increase productivity in commercial duck breeding, through improved reproductive performance and reduction in poor leg health in ducks. The project brought together innovations in data capture, sensors, image recognition, genomics and analytical techniques, to develop an integrated, data-driven solution for the whole duck production chain.

The project developed and evaluated a range of complementary tools to manage duck flocks and capture data associated with reproductive performance and leg health/ gait analysis. These tools can be exploited by duck breeding companies to capture relevant data more accurately on an individual basis. In addition, it assessed flock-based predictors of performance and related factors, including welfare and behaviour.

The project was innovative in the way that it combined technologies (sensors, image recognition and genomics) to improve reproduction and welfare both at the level of individual birds, and at flock level. Together, it will make it possible to improve productivity, reduce wastage and reduce competition for animal feed, helping to decrease the environmental footprint of production.

Project participants:
Cherry Valley Farms (UK) Limited, Hudson & Sanders Limited, University of Edinburgh

Funded amount:
£214,838

MothNet: novel approaches to enable fully-automated smart monitoring of codling moth

The MothNet project assessed the early-stage technical feasibility of a fully automated monitoring system for detecting codling moths, which are major pests in agricultural crops, especially fruits. The project gathered and analysed data on codling moths in order to identify features that can be used to distinguish the species. In addition new, long-life pheromone lure designs were trialled.

This project was conceived in response to feedback from fruit growers, regarding the urgent need for precision trapping and monitoring systems. Industry requirements are for highly accurate, real-time data collection without the need for skilled labour for moth identification and replacement of trap parts – such a system is not currently on the market. Alongside technical feasibility, dedicated work packages explored different business models for the product and routes to adoption in a range of geographical contexts. End-users were engaged from the outset to define target price points and technical requirements.

Successful completion of the MothNet project will lead to the development of a precision pest monitoring system that helps to reduce emissions and improve resource use efficiency by enabling rapid, targeted response to pest outbreaks. This in turn will reduce pesticide usage and increase yields from existing agricultural land.

Project participants:
Agsenze Limited, International Pheromone Systems Limited

Funded amount:
£174,601

IoT monitors for agricultural insect pests, delivering a 70% reduction in insecticide use

This project, which was being led by Cambridge-based insect monitoring specialists Spotta Limited, involved the development of specialised systems for detecting, identifying, and monitoring insect pests.

Insect pests are responsible for an annual crop loss worth £320 billion globally. This project aimed to apply technology to improve agricultural productivity with aid of early detection and real-time information on insect populations. This has a potential to dramatically reduce the damage done by insect pests to the food that is produced, and bring about a massive reduction in insecticide use. This will deliver substantial increases in productivity while also massively reducing the negative environmental impact.

Project participants:
Spotta Limited

Funded amount:
£889,556

Augmented Berry Vision (ABV) – real-time augmented display of spectral ripeness cues in berry farms

There is increasing consumer and retailer demand for high-quality, UK-grown soft fruits, and this will increase further post-BREXIT as retailers favour British produce. However, achieving consistent ripeness and quality across variable and challenging growing seasons is difficult, and there is great variability in the ripeness of fruit after picking. It can be extremely difficult for pickers to gauge the ripeness of fruit, due to the very subtle colour differences between almost-ripe, ripe, and over-ripe fruit. Despite the industry's best efforts in picking, punnets often still contain under- or over-ripe fruit, leading to negative perceptions of fruit quality among consumers.

This project has involved the development of a low-cost, spectral imaging-based Augmented Reality (AR) prototype glasses device for pickers. This device can determine fruit ripeness in real-time and help growers to produce high-quality berries with consistent ripeness in every punnet, leading to reduced waste throughout the value chain.

As a proof of concept, blackberries were used as an exemplar. Lab-based fruit quality assessments were carried out, helping to identify the light spectrum associated with fruit at different stages of ripeness. Built into glasses that pickers can wear, the AR technology helps to show when fruit is ready. It can be extended to other soft fruits and will have a large impact on the UK soft fruit industry, helping to ensure consistent fruit quality.

Project participants:
Opposable Games Limited, Berry Gardens Growers Limited, National Institute of Agricultural Botany, University of the West of England

Funded amount:
£206,694

CoolBerry 2: innovations for in-field cooling of soft fruit

Cooling perishable produce when it is picked is critical for its quality and storability. This project involved the development and testing of a mobile field-based rig designed for soft fruit, that enables growers rapidly to cool produce immediately after harvest to below 5°C.

Currently, in-field cooling options are not available in the UK, and the technology that exists elsewhere has low energy efficiency and lacks precision. By taking cooling technology to a higher level of sophistication, the project will have a major impact on fruit quality, increasing the shelf-life of fruit and reducing losses in the supply chain due to weight loss, bruising and disease. While the focus has initially been on soft fruit, the technology can be expanded to include stone fruit and fine vegetables.

The prototype cooling rig has been developed with growers to ensure that it is appropriate for the complex logistics of field harvesting conditions. It can accommodate several pallets of produce at once. Produce can then be removed via a cooled van to the pack-house.

Project participants:
J D Cooling Systems Limited, Berry Gardens Limited, Scorpion Vision Limited, University of Greenwich

Funded amount:
£311,390

Demeter

Through this project, Cambridge-based start-up Dogtooth Technologies was working to make farming more sustainable through the use of intelligent robotics. Project Demeter aimed to increase the number of berries that a picking machine is able to harvest in its lifetime.

The new picking machines being developed are battery powered, and the batteries are charged from renewable sources. Not only will the project help to reduce the operational carbon emissions involved in berry-picking to close to zero, but it will help to reduce the emissions that are often involved in travel to and from the field. As they go about their work, the robots are also able to collect data concerning the fruit that they are harvesting: the rich data sets that this builds up into will help to reduce waste in the supply chain, as the condition of fruit and its requirements will be much easier to forecast accurately. The project will deliver increased yield, consistency and quality from fewer inputs.

Project participants:
Dogtooth Technologies Limited

Funded amount:
£1,154,423

Feasibility study to develop a blueberry harvester

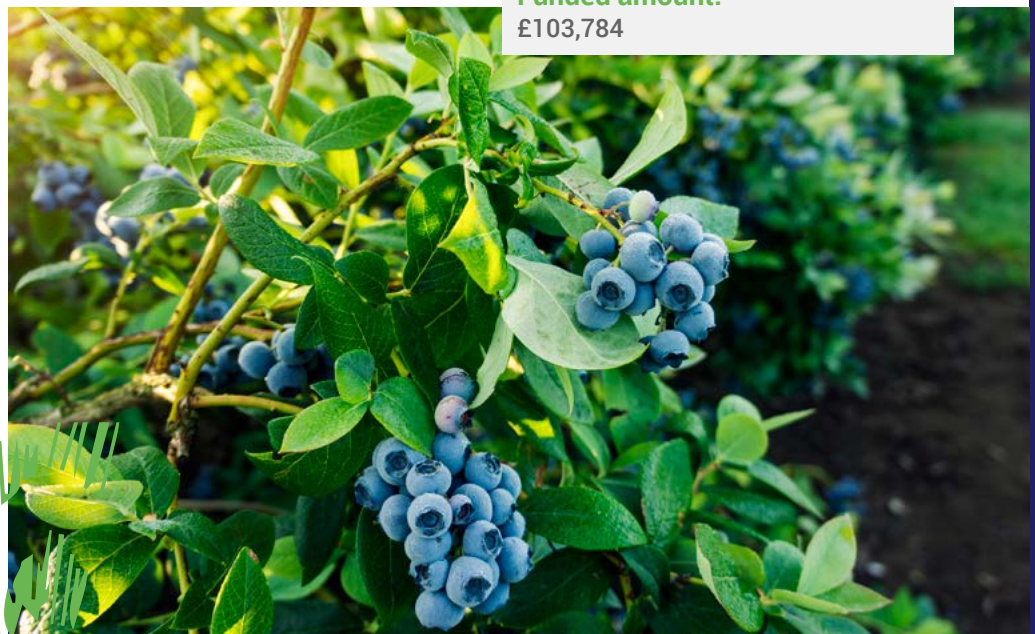
Ongoing limitations in labour availability, combined with uncertainty around the impact of Brexit, are placing the UK soft fruit industry under unprecedented pressure. The sector needs over 30,000 migrant fruit pickers each year, and growers are seeing this labour starting to disappear. This is despite increases in labour rates to attract workers and Government assurances that it will work with the industry to help secure future labour availability.

Given these issues it is clear that the industry needs to seek new ways to reduce its reliance on manual labour pools. This project involved developing an automated machine to pick blueberries, which are now the second-highest-value soft fruit sold in the UK (£337m in sales p.a.). Blueberries are well-suited to the UK climate, but (despite greater acreage being devoted to them) the UK only produces 7% of the marketable fruit that is sold in the UK. Demand continues to outstrip supply significantly.

The project, which was led by Maidstone-based Berry Gardens Limited, was a feasibility study that looked at the potential of developing an automated harvester, incorporating a novel approach to fruit removal without causing damage to the berries. This is currently being patented.

Project participants:
Berry Gardens Limited, Lutton Farm Partnership, University of Lincoln

Funded amount:
£103,784



Idaeus

Raspberries are fragile fruits that require significant manual labour to harvest. The raspberry industry has seen significant growth in production in recent years, due to consumer demand, but the cost and lack of availability of labour is threatening its economic viability.

This project involved the development of a raspberry picking robot that demonstrates the approach that is required to alleviate this bottleneck in the growth of the sector. Building on the developments that Royston-based Dogtooth Technologies has already achieved, in bringing to market a commercial strawberry-picking robot, the project continued the process of applying robotics to meet the needs of the agricultural sector.

Project participants:
Dogtooth Technologies Limited,
Driscoll's Genetics Limited,
Hugh Lowe Farms Limited

Funded amount:
£485,872

Integrating nutrient demand models and AI-based sensors with precision-dosing rigs to improve resource use and productivity, and reduce waste and emissions in commercial raspberry production

Although UK soft fruit production is growing by around 8% a year, demand for berries among UK consumers still exceeds supply. Continued growth is needed if the UK is not to rely on (often inferior) imports, but this must be achieved on a sustainable basis through efficient use of valuable resources (primarily water and inorganic fertilisers) and minimal environmental impact.

Soft fruit growers know that supply of macro- and micro-nutrients has a direct impact on yield and berry quality, but most guidelines on fertiliser inputs are outdated, often being based on anecdotal observations by growers and agronomists, with little scientific basis. Excess nutrients often accumulate in the substrate, and flushing them out wastes water, and can result in reduced berry firmness, flavour and shelf-life. In addition, the nutrients in the run-off pose a risk to local groundwater quality.

More closely matching fertiliser demand and supply reduces the inputs for these systems, and can also help to reduce nitrous oxide emissions arising from use of nitrogen fertilisers.

This project involved using real-time AI-based sensors to measure nitrogen, phosphorous and potassium, and modelling the amounts of each that different raspberry varieties require. It will help improve decision-making around the use of fertiliser, and so make soft fruit production more sustainable.

Project participants:
Netafim UK Limited,
Berry Gardens Growers Limited,
EDT Direct Ion Limited,
National Institute of Agricultural Botany

Funded amount:
£193,427

Plant sensing to determine environmental impacts on developmental processes leading to crop yield

Throughout their life cycle, plants are subjected to many environmental conditions including low light levels and periods of drought or extreme temperatures, which can dramatically affect their survival and limit productivity. In order to cope with such stresses, plants adjust metabolically and physiologically, but this can lead to variation in crop development, which can have a significant impact on the subsequent yield.

This project addressed a lack of existing methods to understand how and when a plant's development has been disrupted by environmental factors. This lack of knowledge severely limits growers' capacity to manage their crops to mitigate these factors and optimise the yield.

The project used a field-based plant and environmental monitoring approach to develop environmental models of blueberry and cherry development. It identified signals that arise from a plant's short-term responses to adverse environmental conditions, and identify the points at which the plant's development is affected.

Blueberry and cherry are key crops with great potential for increased UK production, but currently home-grown fruit only supplies 9% and 50% (respectively) of the market.

The project makes it possible, for the first time, to carry out in-field environmental monitoring to understand the environmental factors affecting crop production, and develop bespoke crop management systems that will mitigate the effect of environmental variation. This approach can also be applied to a wide range of other crops, beyond cherry and blueberry.

Project participants:
Berry Gardens Growers Limited, Castleton Fruit Limited, James Hutton Limited, Mothive Limited, The James Hutton Institute, Thomas Thomson (Blairgowrie) Limited

Funded amount:
£610,073

The First Fleet: the world's first fleet of multi modal soft fruit robots

Responding to concerns around the cost and availability of picking and husbandry labour in the soft fruit sector, especially following Brexit, this project has involved the development of the world's first fleet of robots that can carry out a wide variety of tasks in the field.

The focus of the project was strawberry production, which is complex and involves several different tasks, which need to be performed throughout the season. The robots that were developed through the project are completely autonomous, and can carry out several different tasks in the field. The robots make use of advanced vision systems and picking technologies, as well as a wide range of tools that the robots are able autonomously to pick up from a tool changer, when needed. The robots are also able to charge and dock autonomously.

The project has helped to take robotic strawberry production from the laboratory bench to the point where it is ready to be commercialised. The world-wide market for these machines, and the IP associated with them, is very significant.

Project participants:
Saga Robotics Limited, Berry Gardens Growers Limited, Fotenix Limited, University of Lincoln

Funded amount:
£1,242,624

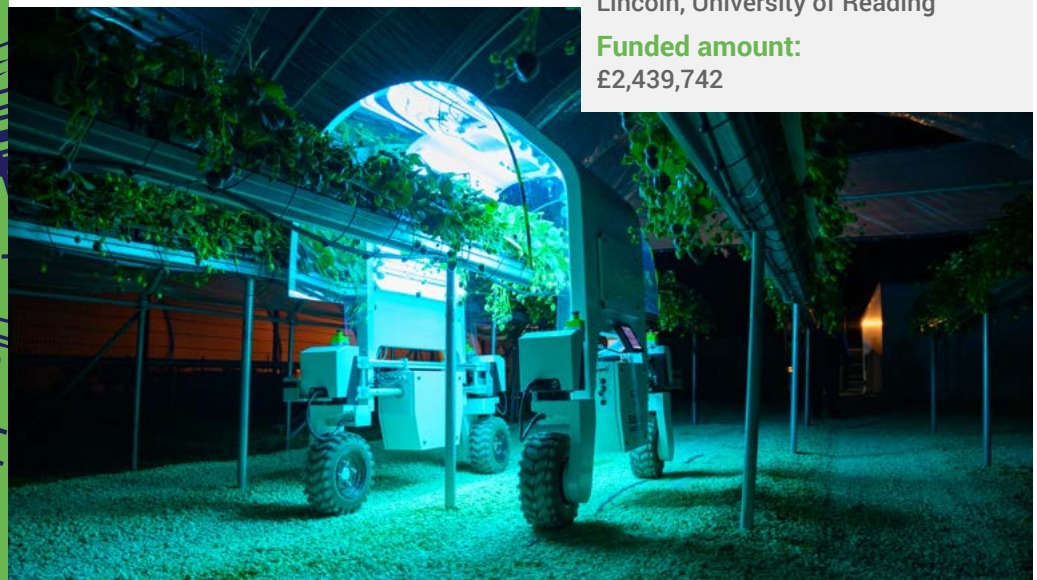
Robot Highways

This project involved the demonstration at scale of underpinning technologies, that will make it possible for future soft fruit farming to use fleets of electric robotic and autonomous systems, powered by renewable energy, that pick, transport and pack fruit, whilst gathering data to maximise yield, reduce waste and minimise environmental impacts. These technologies will also reduce sector reliance on low-skilled labour.

The project was the largest known global demonstration of robotic and autonomous technologies that bring together multiple application technologies across a single farming system. Robots were deployed for a number of physical farm processes, in particular to transport and pick fruit, pack fruit, and treat crops to reduce critical pests and diseases. In addition, they control the virtual farm by collecting data to monitor crop and fruit growth. Data was analysed using AI and machine learning technologies, to forecast fruit supply and optimise farm productivity. Through the project new insights were gained in the application of robotic systems across large commercial farming systems, in particular fleet control, charging and logistics operations, optimisation of data processing resources (edge / cloud) and the telecommunications infrastructure required to dispatch large volumes of data.

Project participants:
Saga Robotics Limited, Berry Gardens Growers Limited, British Telecommunications PLC, Clock House Farm Limited, Manufacturing Technology Centre, University of Lincoln, University of Reading

Funded amount:
£2,439,742



ScaleForImpact: enabling robots to have a real impact on the soft fruit industry

Uncertainty over access to seasonal migrant labour is placing the otherwise vibrant UK soft fruit sector under unprecedented pressure. Robotics and automation technology offer a permanent solution that can reduce the sector's labour dependency. However, critical challenges remain to develop robotic technology that can be scaled, to have a significant impact on the industry. Thousands of robots will need to be deployed over the next few years to perform a wide variety of tasks such as picking, plant protection and inspection.

Though robots have proven their potential in agriculture, the number of robots operating at a commercial scale in open fields globally is very low. There is a need for some specific technological advances and operational changes before robot use can be scaled. This project developed the fundamental and underpinning technology that will enable growers to deploy hundreds of robots, delivering commercial services at a wider scale across the UK by 2024.

The project synthesised and demonstrated the outputs of multiple Innovate UK-funded research and innovation projects. The technological gaps that it will help to fill are related to efficient and cost-effective deployment and operation of robots in the open field, without the need for constant supervision by humans.

Project participants:
Saga Robotics Limited

Funded amount:
£855,000

Soft Selective Raspberry Harvester (SoSeRaH)

In this project Fieldwork Robotics, which is a spin-out from the University of Plymouth, developed a prototype robot that is able to pick raspberries quicker, cheaper and to more consistent and higher standards than human labour.

The Soft Selective Raspberry Harvester, or SoSeRaH, helps growers overcome problems in finding labour, as well as cutting picking costs and reducing wastage. It helps to ensure that UK production is more competitive and sustainable, and reduces the need for imports.

The technology used in the harvester includes robot arms that are able to replicate the movements of a human arm, and controls to move the arms and their grippers rapidly to a delicate object and handle it sensitively. The harvester is able to operate in the ever-changing light, climatic and other conditions found in polytunnels, greenhouses and open fields.

The initial focus of the project has been on raspberries, as they are more delicate than other soft fruit and vegetables, and are easily damaged by rough handling. Raspberries are an important part of the UK's overall soft fruit market (the UK is the seventh-largest producer globally). The system is easily reconfigurable to other fruit, vegetables and delicate objects by simply changing the grippers. Advanced sensor technology helps to ensure that the raspberries picked will meet the standards of buyers, such as supermarkets.

Project participants:
Fieldwork Robotics Limited, NPL Management Limited, University of Plymouth

Funded amount:
£ 507,309

Raspberry Auxin Soil / Substrate Protectant (RASP)

Phytophthora infestans is the pathogen that caused the Great Irish Potato Famine. Today over 170 Phytophthora species cause crop disease on a global scale, costing commercial crop industries billions of dollars.

The UK fruit industry and raspberry particularly has been decimated by Phytophthora root rot (PRR), with an 80% reduction in field production leading to extensive fruit imports. Methods to control infection and spread are limited by current legislation that limit the use of prophylactic fungicides and increase the importance of novel control methods based on host resistance.

Manipulating the physical, chemical and biological properties of the medium that raspberry plants grow in has the potential to play a key role in inhibiting PRR: it can lead to a stronger healthier root and plant system, while also suppressing harmful root pathogens, such as PRR.

This project has involved the development of an innovative range of growth substrate additives, which stimulate raspberry root growth to improve the root system, and actively inhibit the growth and spread of root pathogens. Controlling PRR spread will help to transform the UK soft fruit industry, and has applications for other crops worldwide.

Project participants:
The James Hutton Institute, James Hutton Limited, Thomas Thomson (Blairgowrie) Limited, Westland Horticulture Limited

Funded amount:
£165,530

Advanced Growth Chamber for Rapid Optimisation of Vertical Farming Systems (AGROVerSe)

One reason why vertical farms are inefficient is that plant growth conditions, including light spectrum, temperature, and nutrition, have not been optimised for every crop. Finding the right plant growth conditions could mean dramatic increases in crop yield and the difference between a loss-making and profitable vertical farm.

This project involved the development of AGROVerSe, a controlled environment plant growth system that lets vertical farmers and agronomists carry out large-scale experiments in order to identify the best plant growth conditions for maximum crop quality and yield.

AGROVerSe is a small, stackable, climate-controlled chamber that includes an advanced hyper-spectral imaging system to collect data on plant growth and development. It has a spectrum-tuneable LED lighting system, so that the effects of different light spectra on plant quality and yield can be examined. The chamber also has a digitally controlled hydroponics system, so that precise nutrient dosing can be carried out. Finally, an array of sensors continuously measures and feeds back to a novel system that precisely regulates temperature and humidity throughout the crop cycle. All of these components are connected together and controlled through a web-based platform, which collects and analyses data and lets users identify plant growth conditions to maximise crop quality and yield.

Project participants:
Grobotic Systems Limited, Fraunhofer UK Research Limited, Stockbridge Technology Centre Limited, University of Sheffield

Funded amount:
£447,425

Assessing the feasibility of all-in-one growing sensor and innovative transmission node for vertical farms – driving energy efficiency, productivity and commercial viability

Vertical farming (VF) has been branded the future of food production, due to the environmental benefits and food security benefits it provides (small geographical footprint, pesticide-free, water reuse, all-year-round growing). However, the industry is in its infancy and littered with inefficiencies (high energy/ labour costs, limited crop choice, high levels of contamination).

Precise, integrated, real-time data solutions that are robust enough for the VF environment are critical to elevating the productivity of VF to a level where industrial-scale farms become commercially viable.

The aim of this project was to develop an Internet of Things precision data solution, compromising an all-in-one floating sensor, robust wireless data network, monitoring interface and Big Data platform. The delivery of this solution will have a significant impact on the VF industry, reducing labour costs by significantly reducing the need for human intervention, improving productivity and efficiency by ensuring that only the required amounts of resources are used, and ultimately improving profitability.

The wider long-term benefits to the UK include a reduction in the need for imports and associated emissions, offering farmers the option of growing all-year-round, reducing demand for land and water for arable use, and improving the UK's resilience to environmental shocks.

Project participants:
Light Science Technologies Limited, Nottingham Trent University

Funded amount:
£208,725

Co-ordinated technology development to provide an optimised and integrated system of leading vertical farming technologies

Vertical farming (VF) has the potential to revolutionise food production. The industry is experiencing enormous growth, propelled by the increased demand for pesticide-free foods, rising global populations, decreased availability of land and demand for year-round food production worldwide. But its further development is constrained by significant capital expenditure and energy costs.

Vertical farming can deliver numerous benefits over traditional farming methods, including lower water usage, reduced dependence on agrochemicals, and the ability to guarantee high-quality, consistent, year-round crop production. However, the industry requires further innovations to reduce operational costs and improve yields to be commercially viable beyond the production of high-value, niche crops.

This project brought together a multidisciplinary consortium of partners to develop a prototype VF growing system that is simpler and cheaper to build, and provides growers with better control through data-driven information. It also automates responses to detected changes, leading to higher-quality, higher-yield produce whilst better equipping growers to adapt to market demand and reduce the risks of business failures.

The system includes low-cost LED lighting that creates ideal growing conditions throughout the plant growth cycle, and an improved nutrient control and delivery system. The project also tested the feasibility of incorporating vision sensing at a large scale, which can provide valuable real-time feedback on crop health.

Project participants:
Larch Foundry Limited,
Crop Health and Protection Limited,
Fotenix Limited,
Iceni Labs Limited.

Funded amount:
£989,807

Development and demonstration of data-driven autonomous growing system to raise productivity and resource efficiency in commercial greenhouse horticulture. Dissemination of demonstration results across broad greenhouse sector

Industrial-scale greenhouses already supply over £500m of fresh vegetables to the UK and have great potential to meet the accelerating demand for healthy, locally grown food, whilst securing the UK food system against political disruption, population growth and climate change.

Through control of climate, irrigation and lighting, greenhouses can create the ideal conditions for crop growth, in all seasons. Crops can be grown for nutritional content rather than transportability, with much higher yields than with field farming, using significantly less water and pesticides.

This project involved developing an Autonomous Growing System that enables the data-driven growing of tomatoes, in any greenhouse, in any location. The project has successfully increased production levels and resource-efficiency beyond what is currently possible in existing greenhouses, and aims to accelerate the deployment of new greenhouses in the UK and around the world.

This project led by UK industry leading expertise had support from the Dutch horticultural industry.

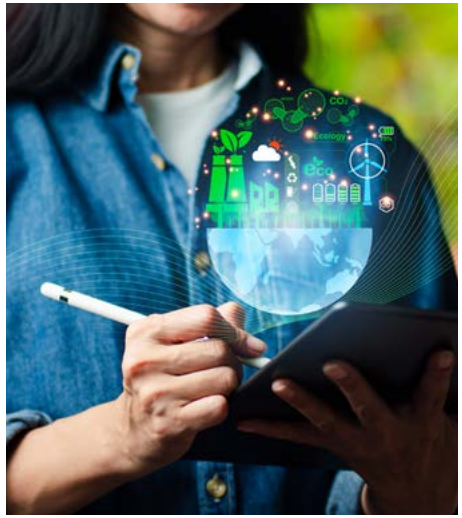
Project participants:
Optimal Labs Limited,
LA Serra Limited, National Institute of Agricultural Botany

Funded amount:
£2,062,082

Farmer-centred interoperable mobile-cloud system: integrating data from farming activities and environmental information for sustainable fertiliser management

Sustainable fertiliser management and reducing farming emissions have become high-priority agriculture issues in both the UK and China. Innovative, Internet of Things (IoT)-enabled smart farming technologies have the potential to enhance productivity and reduce emissions. But to make the most of the practical effectiveness and economic benefits of these technologies they need to be easy for farmers to use, even in remote locations.

This project took a comprehensive holistic approach to dealing with sustainable fertiliser management, by enhancing the deployment and use of farmer-centred, inter-operable mobile-cloud systems that enable farm data to be collected, aggregated and analysed. The new products and services will enable farmers to avoid soil degradation, pollution of soils and chemical residues in crop plants, unsustainable water use and polluted water, and inefficient use of inputs. The project involved a collaboration between UK and Chinese partners, and will stimulate the growth of both the UK and the Chinese market, providing safer working conditions, creating job opportunities and allowing local growers to receive a greater return for their produce.



Project participants:
Ant Data Limited,
University of Sheffield,
Velcourt Limited

Funded amount:
£485,868

Feeding the next generation: Indoor farming 2.0

This project, which was led by Bristol-based aeroponic specialists LettUs Grow Limited, involved the development and integration of aeroponic irrigation into hectare-scale indoor growing facilities. The aim is to increase the productivity, quality and sustainability of hectare-scale vertical farms and greenhouses.

Indoor farming combines soil-free irrigation systems, either in stacked shelves or in single layers, under UV lights and in controlled environments. They are able to produce crops all year round, protected from the elements, and without the need for pesticides or herbicides.

With aeroponics, plant roots are suspended in the air, and irrigated with a nutrient-dense mist, generated using ultrasonic sound waves. By using ultrasonics to disperse the nutrients, aeroponics requires a lower total volume of water, reducing water usage on a commercial scale whilst accelerating crop growth.

Large-scale indoor growing infrastructures have the potential to unlock increased levels of growing efficiency, leading to increased annual yields whilst reducing water consumption. The project tested the feasibility of applying ultrasonic aeroponic irrigation, lighting and environmental control technology to large-scale farm operation, demonstrating the economic benefits of using aeroponics at scale, and its ability to complement traditional agriculture with increased food security and crop production.

The vertical farming market is valued at over $2bn and estimated to exceed $13bn by 2024. The UK plays a growing part in this market.

The innovative technology developed through this project includes a water-cooled lighting system that improves electrical efficiency by maintaining LEDs at the optimum temperature to maximise their life (early failures in traditional products are typically heat-related), and reduce their running costs.

Project participants:
LettUs Grow Limited,
ECH Engineering Limited

Funded amount:
£488,981

GelPonic: smart hydrogels containing graphene-based sensors for precision control of vertical farms

To meet the demands of a growing population and reduce the environmental impact of agriculture, there is an acute need to improve crop production systems globally. Vertical farming, in which crops are produced in controlled environments, is a highly promising alternative to traditional agriculture, especially in water-stressed environments. The global vertical farming market is predicted to be worth $22bn by 2026.

This project aimed to revolutionise food production via controlled environment agriculture and make it globally accessible, including by opening new markets in the developing world and capitalising on growing Middle Eastern vertical farming markets. It involved developing and demonstrating the novel GelPonic system, which is based on an innovative, graphene-based growth medium that is affordable, long-lasting, re-usable, water-saving, conservative with respect to nutrients, and capable of filtering out pathogens. The new vertical farming system integrates the latest in renewable energy technologies, sensors and controls, to make a significant improvement in the precision, productivity and sustainability of controlled environment agriculture practices, whilst reducing carbon emissions.

Project participants:
AEH Innovative Hydrogel Limited, Crop Health and Protection Limited

Funded amount:
£1,049,974

Hydrobubbles to boost plant growth through captured carbon utilisation

Protected structures such as greenhouses, polytunnels and indoor farms are used in the production of high-value fruit and vegetable crops. They help to increase crop yields and quality by controlling environmental factors such as light, temperature and humidity. For countries based in northern latitudes these production systems are critical to maintaining longer growing seasons and for local production of many high-value and commercially significant crops. But despite their benefits, considerable risks remain for growers in this industry with high operational costs and economic returns that are sensitive to changes in price and yield.

Technological solutions are required to overcome these challenges of productivity and sustainable production. This project brought together farmers, technologists and researchers, to develop a 'hydrobubble' generation technology that will deliver significant benefits across the sector. Through the injection of oxygen-rich micro- and nano-sized bubbles into the irrigation water, plant growth in hydroponic systems can be increased by up to 30%. The physical properties of these bubbles means they are attracted to plant roots, where they cluster and supply oxygen constantly to the plant.

The project evaluated the feasibility of this new technology in three protected crop systems: glasshouse, polytunnel and vertical farming. It established that the application of micro-nanobubbles can increase plant yield, improve crop quality, boost nutritional content, reduce pathogen load and contribute to the target of net zero emissions from agriculture.

Project participants:
Larch Foundry Limited, Iceni Labs Limited, The James Hutton Institute, Vertical Future Limited

Funded amount:
£184,263

InFarm2.x: data enabled vertical farming with minimal waste and emissions and maximum efficiency and crop nutrition

The potential of vertical farming, for feeding a growing global population in a more sustainable way while taking up less space, has been widely recognised. This project, which is being led by vertical farming systems specialists Infarm, aims to develop systems to grow a wider variety of fruit and vegetables than at present. Retailers and consumers want more fresh produce to be grown through vertical farming, including peas, beans, tomatoes, strawberries, chillies and carrots. However, these products often have more complex growth cycles and needs, requiring more condition control and monitoring.

The project involved using additional gas sensors and monitoring cameras to monitor growth cycles and changes in a variety of crops, to work out the perfect growing conditions. Now that the Infarm2.x system and processes have been developed, they will be trialled in small-scale in-store systems in which produce goes straight from growing to the consumer, cutting out the need for expensive, energy-intensive transport.

Project participants:
Infarm - Indoor Urban Farming UK Limited, Marks and Spencer P.L.C., Newcastle University, RoboScientific Limited

Funded amount:
£3,327,974

Maximising profitability of vertical farming through integration of sales, climate and sensory data

Food production is responsible for a third of global greenhouse gas emissions, with the largest increase in recent years coming from non-farm activities such as processing, packaging and transportation. The UK imported over £10bn of fruit and vegetables in 2021, some of it from thousands of miles away, while domestic agriculture struggles with labour shortages.

Harvest Farms grows crops with much greater rates of productivity than traditional farming, using much less water and no chemical pesticides. Unlike field agriculture, there is no chemical or fertiliser runoff into rivers (a major source of waterway pollution in the UK). The company grows year-round, close to its customers, which results in shorter supply chains and fresher ingredients. It is building one of the world's largest, and most technologically advanced, vertical farms.

This project involved Harvest Farms developing its proprietary farm management software to maximise gains from this technology. The software is designed to integrate a vast array of data, ranging from prices and farm capacity to climate data, combined with information from advanced sensors. This will help to increase the profitability of vertical farming, and help the UK on its path to a more sustainable food system.

Project participants:
Harvest Farms Limited

Funded amount:
£752,793

Electrical weeding solution for agriculture

Controlling weeds in agriculture is key to maximising yield. Chemical herbicides are under pressure due both to weeds developing resistance and to increasing regulation of herbicide use. There is increasing awareness that conventional farming is unsustainable and that regenerative farming is required for healthy soils, to secure food production and capture carbon.

This project, which was led by Kineton-based agricultural technology specialists RootWave, has created a prototype that kills weeds in top fruit orchards and vineyards. This will enable conventional growers to end their dependency on herbicides, and provide an effective and efficient weed control tool without damaging soil structure.

Project participants:
Ubiqutek Limited (trading as RootWave)

Funded amount:
£974,476

Production at the point of consumption: a distributed network of intelligent growing systems for foodservice operators and consumers

Indoor growing systems have great potential for on-site growing of high-value produce (speciality salad leaves, herbs and micro-greens) by food service operators. This project involved the development of a complete integrated system, including hardware, consumables, remote monitoring and support services, which enables users to grow their own high-quality crops with minimal effort, and without needing horticultural expertise.

The system uses a cloud-based software platform that combines image processing, machine learning and artificial intelligence to enable every crop to be monitored. This distributed network approach means that production can be moved to the point of consumption. Leafy salad crops are inherently perishable and are wasted in huge quantities: this solution eliminates this wastage, and the associated negative environmental impacts of the conventional supply chain.

The project focused particularly on reducing the cost of existing autonomous growing systems: this will greatly expand the market. The project involved trialling the new system with volunteer groups of food service operators (including schools and care homes) and household consumers. This project has the potential to deliver improved nutrition and sustainability, with the potential to save tens of thousands of tonnes of food waste annually in the UK.

Project participants:
Evogro Limited, National Institute of Agricultural Botany, Therefore Limited

Funded amount:
£849,830

Smart and high-efficient technologies for fruits and vegetable production in greenhouse and plant factory

China is the largest market in the world for agricultural technologies, combining the world's largest population with one of the highest per capita vegetable consumption rates. Yet cultivation space is limited and there are major problems with soil quality, pollution and food safety. There is still a big gap in agricultural technologies between China and other developed countries, which restricts the country's crop yield improvement, sustainability of agriculture and food security. Therefore, there is an urgent need to increase yields per unit of land whilst decreasing resource inputs, through developing innovative and smart technologies.

The main aim of the project was to develop smart and highly efficient technologies for vegetable and fruit production in controlled environments, based on sensors and Internet of Things (IoT) technology to increase yield and food quality, whilst reducing costs and environmental impacts. It involved developing a smart nutrition control system, innovative LED lights and fertiliser optimisation for selected crops. The efficiency of these systems and technologies will be tested in China through a collaboration with Chinese partners, leading to a smart system that offers enhanced crop yield, while reducing input and waste.

Project participants:
Aptisens Limited,
Nottingham Trent University

Funded amount:
£292,240

Versatile – configurable, smart indoor harvesting of aubergine, tomato and strawberry crops

Targeting the autonomous harvesting of tomatoes, aubergines and strawberries in indoor controlled environments, the Versatile project aimed to introduce much-needed versatility to smart farming.

Recent trends in industry place strong emphasis on autonomous systems that can be configured to deal swiftly with diverse products. Agriculture can be considered an extreme case, with the critical challenge of being able to deal with a diverse range of produce (fruits and vegetables) and variations even in produce of the same type, as well as changing environmental conditions, and a wide range of tasks involved in production (spraying, cutting etc).

While automation solutions exist that are finely tailored to specific produce, there is a need to make the underlying sensing/ perception, manipulation and decision-making processes configurable and adaptable, so that they can be used in different automated harvesting processes.

The technology that the project developed will help to mitigate the critical labour shortage on farms, minimise waste and production costs through automation, and reduce energy consumption by more than 10% (an important step towards sustainable farming).

Project participants:
Wilkin & Sons Limited,
University of Essex

Funded amount:
£403,996

Blue Planet

This project, which was led by Hereford-based soft fruit producer S&A Produce (UK) Limited, involved the development of innovative equipment to produce better-quality fruit, and to enhance productivity through improved growing techniques.

Blue Planet brought together a leading international soft fruit producer (S&A Produce), a specialist SME, Capture Automation, and one of the High Value Manufacturing Catapult centres (the Manufacturing Technology Centre).

The project developed automated technology that incorporates machine vision systems: this will help to improve crop yield and quality. Blue Planet will help to accelerate and de-risk the process of bringing new and innovative equipment to market. The benefits to the end user customer will be better flavour and consistency of fruit, while farmers will benefit from higher quality yield quantity, better growing environments, and improved plant vigour.

Project participants:
S&A Produce (UK) Limited, Capture Automation Limited, The Manufacturing Technology Centre

Funded amount:
£716,905

Alpha Agriculture

Alpha Agriculture is the concept of driving on-farm decisions through digital twins that are accurate even down to individual leaves: it aims to be an integral part of the information age for agriculture. The project, led by Fotenix, involved the development of an integrated sensor system, which combines diagnostic vision technology with machine learning, to monitor crop health. The platform uses 3D spectral imaging, which uploads copies of the farm to allow for in-depth analysis of plant health to be carried out economically, enabling growers and their suppliers to make data-driven decisions.

Fotenix-enabled glasshouses or vertical farms can track crop development with real-time biomass and quality measurements, as well as picking up on early indications of stress, enabling timely interventions to be made. This information significantly improves forecasting and prevents over-production and resulting waste. Continuous monitoring supports increased production reliability, improving crop quality and shelf life.

The system that has been developed works directly with modern glasshouses and can be deployed in others, alongside robotic partners. The service has significant export potential to leading controlled environment agriculture markets, such as The Netherlands and United States.

Project participants:
Fotenix Limited

Funded amount:
£524,316

Development of a decision support tool to reduce asparagus tip breakdown in the UK

Currently, asparagus quality can be maintained in cold storage only for around one week. Thus, UK asparagus production is unable to provide year-round supply, meaning that large quantities of asparagus spears must be imported. This practise has a significant environmental impact, as much of the product is transported by air.

A previous Innovate UK and BBSRC-funded project had established the optimum 'dynamically controlled atmosphere' (DCA) conditions, to preserve the quality of UK-grown spears for three weeks (plus one week of shelf-life). However, the major limiting factor in implementing DCA commercially has been the physiological disorder known as tip breakdown (up to 10% of asparagus production is affected). High levels of tip breakdown were observed in 2018 across the UK: this was attributed to the warm temperatures during the harvest season.

This project aimed to identify the factors that cause tip breakdown, and thus to understand how it can be reduced, and when freshly harvested spears may be successfully stored in DCA. The project involved developing a decision support tool in order to identify and predict tip breakdown at an early stage.

Project participants:
JGHC Limited, Cardiff University, Cranfield University

Funded amount:
£191,367

Pilot plant for cultivated pork for sustainable food systems

Alongside the world's increasing population, we are seeing a huge rise in global meat consumption. Together these have a huge negative impact on the environment and are key drivers in climate change, land conversion and degradation.

Cultivated meat will allow people to continue eating meat but without the carbon footprint associated with farm-reared animals, helping the UK reach net zero by 2040. Cultivated meat is the same as conventional meat, but instead of slaughtering a whole animal for useful parts, a few cells are taken from the animal (e.g. from the skin or muscle) and used to make a re-useable stock of cells. Cells from the frozen stock are then grown under very controlled conditions to produce the equivalent constituents of meat (namely muscle and fat). This technology will provide us with sustainable, healthier meat products, which are nutritionally similar to conventional meat but with a greatly reduced carbon footprint.

Through this project, Cambridge-based HigherSteaks Limited developed the UK's first pilot plant for cultivated pork. It will also become the world's largest cultivated pork production plant – to date, only chicken, beef and fish products have been brought to pilot scale. This will put the UK at the forefront of a rapidly growing industry that will have a significant impact on reaching net zero by 2040.

Project participants:
HigherSteaks Limited

Funded amount:
£1,025,972

REACT-FIRST: Reduced Emission Aquaculture & Chicken Trial For Integrated, Responsible and Sustainable Transformation of CO_2 into animal feed

The world's population will reach 10 billion people by 2050: by this point, the demand for animal-based products will have doubled, yet we currently struggle to feed the animals we eat in a sustainable fashion.

The REACT-FIRST project developed feeds with 65-75% smaller carbon footprints, with no requirements for arable land and minimal water usage. By using carbon dioxide from Drax Power's Selby (Yorkshire) biomass power station, Deep Branch Biotechnology Limited have been generating Proton, a protein powder that can be used for aquaculture and poultry diets. The project consortium developed and validated Proton-based feeds.

The project was guided by the Scottish Aquaculture Innovation Centre and by Sainsbury's, ensuring that its outcomes are aligned with industry needs. The University of Edinburgh's Innogen Institute also worked to assess the full sustainability impact of the project.

Project participants:
Deep Branch Biotechnology Limited, AB Agri Limited, Biomar Limited, Drax Corporate Limited, Nottingham Trent University, Sainsbury's Supermarkets Limited, University of Edinburgh, University of Nottingham, University of Stirling

Funded amount:
£2,168,743

Roslin Technologies: leading the science of sustainable protein by developing tools for cellular agriculture

Roslin Technologies Limited (RTL) is a joint venture between the University of Edinburgh and two investment partners. It translates ground-breaking innovations into practical solutions that help address the increasing global protein gap and, in so doing, deliver products and services that support more sustainable food production.

A key strand of RTL's work is the generation of animal-induced pluripotent stem (iPS) cells. These are special types of cells that can be exploited for a wide range of purposes, including stem cell therapies and, now, cultured meat production.

RTL's iPS cell lines for livestock have been shown to be capable of differentiation into a range of key cell types (muscle, fat, bone and cartilage), meaning that they have considerable promise to supply a much-needed resource for the rapidly growing global Cellular Agriculture sector.

Following successful early work at laboratory scale, this project involved significantly scaling-up RTL's iPS cell platform based around pigs, widening the animal species that it can apply to, and tackling key bottleneck issues for making cultured meat generation cost-effective. The project took RTL's iPS cell platform technologies to the point where they can service the growing number of international cultured meat companies that have been launched in the flourishing Cellular Agriculture sector in the last few years.

Project participants:
Roslin Technologies Limited

Funded amount:
£448,703

Using macromolecular crowding to increase cellular meat production and feed a low-emission bioeconomy

This project, which was led by the Newcastle-based biotech company 3D Bio-Tissues Limited (3DBT), involved translating recent developments in cell biology and tissue engineering into food-related products. The company had developed a process that produces engineered tissues grown from cells, which is very similar to naturally grown meat. The project involved driving down the costs of producing these tissues, which is essential if they are to be used as food alternatives (cellular meat will necessarily have to be affordable for mass consumers), while eliminating at the same time the use of animal-derived ingredients from the process.

Several research groups and companies in Europe, the US and elsewhere are developing alternatives for the enhanced production of cellular meat. What made this project different was that it focused on the use of novel supplements derived from existing agricultural by-products, meaning that cellular meat production can be truly animal-free. 3DBT has successfully translated the results from this feasibility study into developing a media supplement that boosts cell and tissue growth and culture performance. Now commercially available, the supplement can be used in a range of applications, including cellular meat production, biotechnology and R&D.

This project represents a step towards providing natural-looking products with similar characteristics to meat, at a lower production price, but grown without the need of animal slaughter or use of antibiotics. Ultimately, this will result in a new system to produce meat equivalents that feel and taste like beef, chicken or pork, which in turn will support the adoption of cellular meat by consumers, reduce the need for intensive animal farming, and contribute to lower greenhouse gas emissions worldwide.

Project participants:
3D Bio-Tissues Limited, Centre for Process Innovation Limited

Funded amount:
£ 211,085

AGRI-SATT - Agricultural Growth using Remote-sensing, IoT, Satellite and Autonomous Telecommand Technology

The AGRI-SATT project combined newly available, high-resolution spatial and temporal satellite data with detailed data from production ponds, to determine the quality and productivity of natural algae for the production of high-value food and feed ingredients. Marine algae can be an important source of plant-based Omega-3 fatty acids and protein. The project developed an effective, scalable methodology for using algae to produce food and aquaculture feed, with widely available natural nutrients. Furthermore, it did so in locations where nothing grew before: the desert. By extracting CO_2 from seawater and using nutrients from the deep ocean, this highly sustainable project 'deacidified' enormous quantities of seawater, returning 99.98% of the seawater used during the process. This is very beneficial to the local ecosystem and aids coastal primary producers to sequester more carbon from the environment.

By controlling the production ponds with IoT-informed equipment, this methodology recreates the ideal growth conditions for algae. By being able to do this year-round, this production method will be able to compete with those of less sustainable commodities such as fishmeal or soy protein concentrate. This sustainable food will significantly increase the competitiveness of UK food production, while the data integration software that the project developed is applicable globally.

Project participants:
Brilliant Planet Limited, Scottish Association for Marine Science, University of Southampton

Funded amount:
£4,061,071

The insectrial revolution: stimulating the establishment of a world-leading sustainable insect industry in the UK

Farming of black soldier fly (BSF) has the potential to tackle some of the world's biggest challenges in agriculture. BSF can turn food waste into insect-based animal feed (a sustainable alternative to fishmeal) and bio-fertiliser (a sustainable alternative to chemical fertilisers). But while extensive research has been carried out on the transformative potential of BSF farming techniques, there is still a need to demonstrate large-scale, profitable BSF farming operations.

The UK is home to leading BSF specialists with expertise covering the entire value chain. This project aimed to establish the UK as the global industry leader by developing a complete BSF farming system that is profitable, sustainable and scalable.

This project demonstrated the viability of systems that can convert industrial quantities of food waste into insect-based animal feed and bio-fertilizer using highly automated technology. At the same time it generated the data to prove that BSF farming is profitable, low carbon and scalable in the UK, and that the insect-based animal feed and bio-fertiliser that it produces are safe and effective. By proving all of this, the project will help to unlock growth finance, which will rapidly scale the BSF farming industry in the UK and overseas.

Project participants:
Entocycle Limited, AB Agri Limited, Beta Bugs Limited, Better Origin, Cooke Aquaculture Scotland Limited, Durham University, Fera Science Limited, University of Stirling, University of Warwick

Funded amount:
£6,289,334

Designing a highly efficient production facility for insect-based products

As population levels rise, it is expected that fish and poultry consumption will increase, generating a greater demand for animal feedstocks, and therefore for animal-feed ingredients (feed costs account for 50-60% of aquaculture production costs, and 60-80% of poultry).

The global feed industry is energy-intensive, reliant on international imports, at risk of commodity price hikes, and associated with deforestation. This project's objective was to increase the UK's feed production resilience, and to make the UK's fish and poultry production more sustainable and productive.

The project involved designing a fit-for-purpose, highly energy-efficient and cost-effective insect rearing facility. It explored the basic science behind insect nutrition applied to animal feed, investigating efficient food production methodologies and integrating technology, to propose a high-tech, bespoke insect rearing facility that is completely aligned to market needs.

The project will encourage significant investment in the construction of this kind of cutting-edge production facility, bringing immediate economic benefits to the country. Additionally, the project has the potential to position the UK as a leader in using insect feed to lower the cost of production, and the environmental impact of the poultry and aquaculture industries.

Project participants:
Entec Nutrition Limited, Campden BRI (Chipping Campden) Limited, University of Exeter

Funded amount:
£197,557

aiScope - AI data platform for smart crop protection

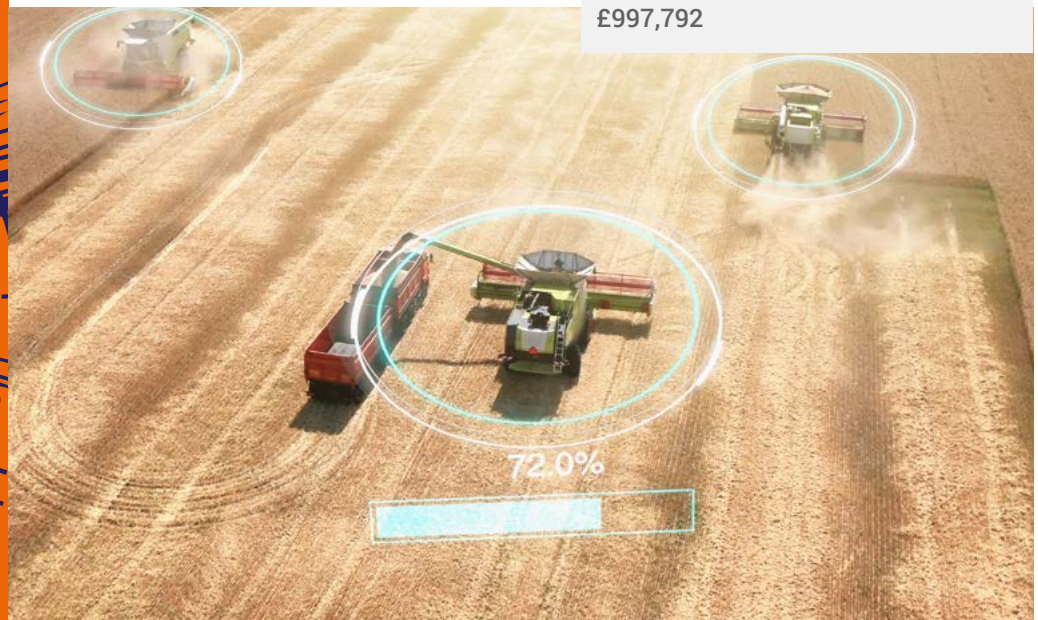
This project, which was led by IBM UK, brought together a range of innovative and disruptive technologies to transform the crop management market, with blackgrass as its first use case. Blackgrass is a weed that costs farmers more than £500m a year worldwide.

Data, management strategies and expertise have been fragmented in the agronomy sector, slowing down UK production and competitiveness. The project aimed to end this fragmentation by making possible an artificial-intelligence (AI) and Big Data platform approach, whereby all data and expertise is collated, allowing researchers to create new evidence-based models and offer farmers achievable ways of acting on that evidence.

The blackgrass forecasting models that the project generated will be made available by being integrated into existing offerings from agri-service providers. The platform has been built in an open way to enable collaboration and innovation, and for the insights that are generated to have an easy route to market. Such disruptive, data-driven approaches will help the UK agriculture sector to become world leaders in the area of smart agriculture.

Project participants:
IBM United Kingdom Limited, Hummingbird Technologies Limited, Precision Decisions Limited, Rothamsted Research, STFC Laboratories, University of Sheffield

Funded amount:
£997,792



Automated detection, and highly targeted and effective treatment and prevention, of bacterial blight infection in major world food crops

10% of global crop production is lost to incurable bacterial blight, with the disease costing $220bn annually. The diversity of crop diseases continues to expand, and new strains are constantly evolving. A study has suggested that the food lost to bacterial blight is enough to feed nearly 9% of the global population.

Xanthomonas blight is a particularly significant challenge to sustainable food production, affecting more than 400 species of plants. Once established, the bacteria can infect the entire crop within six weeks resulting in substantial, often devastating losses to crop yields. Staple world food crops such as rice, soybean and cassava have recorded yield losses of between 50% and 75% due to Xanthomonas infection.

Despite the urgency and scale of the problem, technology to identify, treat and prevent bacterial blight infection in crops has been ineffective, with detection largely reliant on manual processes.

This project, which was led by Bristol-based FOLIUM Science, has delivered a prototype of the first complete solution for the detection and treatment of Xanthomonas bacterial blight, by developing a dual-purpose drone and novel treatment. The drone uses an advanced AI-driven image analysis to identify Xanthomonas infection, which it locates precisely with GPS. It then makes highly targeted interventions to treat the infected plants.

The system has the potential to revolutionise food security, and can be used around the world.

Project participants:
FOLIUM Science, Rinicom Limited, University of East Anglia

Funded amount:
£909,983

Autonomous Robotic Weeder (in) Arable Crops

This project, led by Peterborough-based ARWAC Limited, focused on the development of an environmentally sensitive mechanical weed control system for use across arable farms in the UK. The widespread problem of blackgrass within arable cropping land requires an alternative to the current treatment using herbicides. Blackgrass and other weed species are developing resistance to the sprays used, and environmental pressures are forcing farmers to look to alternatives.

The objective is to control blackgrass mechanically to allow increased crop production and improve longer-term soil health and water quality, by reducing the need for herbicide applications on cropped land. Field trials are used to test the most effective methods of weed destruction, alongside precision digital mapping of fields.

The project is of significant interest due to the prevalence of blackgrass in cultivated land nationwide and internationally. Some 80% of fields surveyed in England show resistance to the treatments that are commonly employed by farmers to control the weed. This results in yields being reduced by up to 12%, costing around £300 per hectare in lost crops and additional spraying control costs. There is also an increase in herbicide resistance in other weed species such as poopy and ryegrass, that the ARWAC system can also help to address.

The project has resulted in a highly researched machine that is capable of replacing the existing control treatments that use herbicides. Several versions of the machine have been developed to date, all electrically driven to a specification which will enable farmers to operate the machine with minimum training.

Project participants:
Arwac Limited, University of Lincoln

Funded amount:
£439,100

A retrainable, smart-camera, vision system for agriculture – SKAi, the SoilEssentials KORE Artificial Intelligence platform

There is an urgent need to modernise the traditional practice of applying a uniform rate of agro-chemicals across the whole crop, to make the approach much more targeted. This is to reduce the amount of plant protection products that are applied to crops, to help reduce pollution, to lower the cost of food production, and as a response to continuing public pressure for a reduction in agro-chemical use.

This project developed a smart camera and artificial intelligence platform for use by farmers, agronomists and agro-chemical applicators. This platform will be integrated into the existing KORE precision agricultural platform to extend its functionality, to allow the support of in-field smart cameras using image transfer and machine learning. Using this system, the aim is to reduce the total amount of crop protection products that are applied to crops in the UK and worldwide.

Project participants:
SoilEssentials Limited,
Deimos Space UK Limited,
Scottish Agronomy Limited,
University of the West of England

Funded amount:
£609,251

A commercial intelligence platform to optimise farm productivity

Farming is facing long-term pressures on economic performance. Intense retailer price pressure and challenging weather patterns are pushing record numbers of farms out of business every year. They face even more uncertainty through Brexit and its potential impacts on global markets, labour and financing. Such challenges threaten the livelihoods and social fabric of the UK's rural communities.

This project, which has been led by Cambridge-based YAGRO Limited, involved the development of a big data analytical tool for optimising production on farms, called the Commercial Intelligence System. The main focus was to create a Data Ingestion Engine which could efficiently process and standardise large amounts of farming data for analysis and comparison between farms. The project has resulted in a product that is available for farmers: YAGRO Analytics. The technology developed through the project has the potential to transform data processing capabilities for agriculture, enabling farmers to have a much clearer picture of the effectiveness of their interventions on the farm, helping ultimately to make them much more productive.

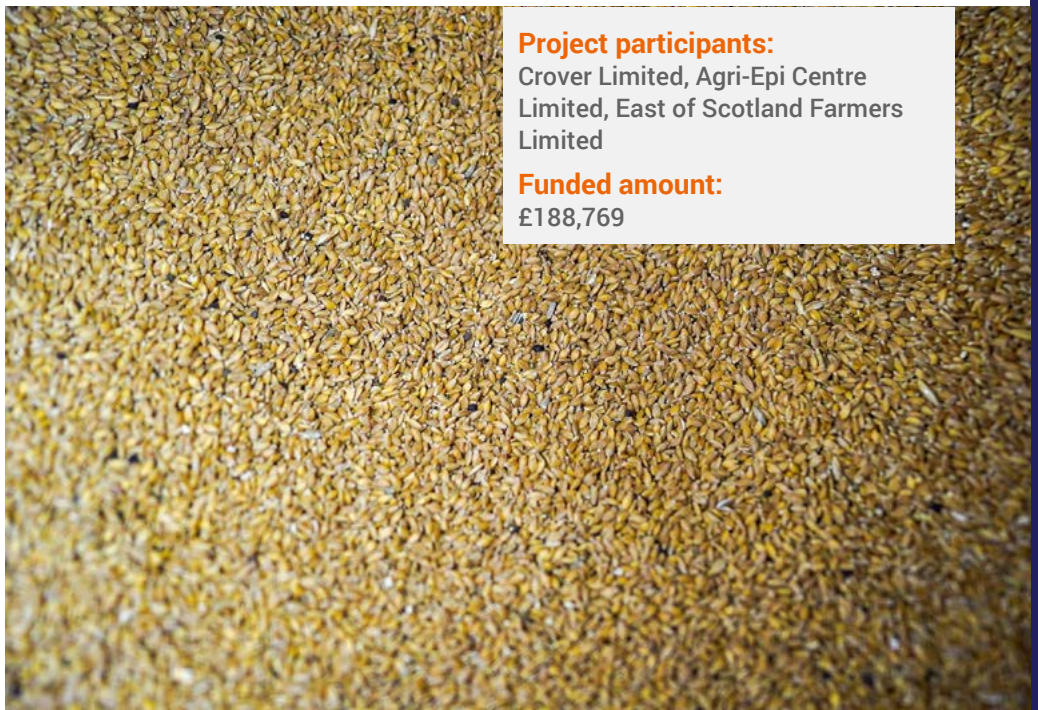
Project participants:
YAGRO Limited, J V Farming Limited, Parker Farms Limited, R.H. Topham & Sons Limited

Funded amount:
£558,146

Feasibility study of a Crover robot for the autonomous sampling of grain bulks

Cereal grains are the basis of many staple foods, yet post-harvest losses during long-term storage are exceptionally high for agricultural produce: above 20% in the UK and worldwide. Pests are to blame, with grain moisture content and temperature being the most significant factors in determining whether grains are attacked. The challenges of keeping grains from being spoiled are faced by many different cereal storage sites, such as farms, grain merchants, millers and breweries. Spoilage has significant cost implications in terms of lost revenue and cost to rectify.

The objective of this project, which was led by Edinburgh-based Crover Limited, was to create the first robotic device that is able to sample grain safely at various depths while it is held in storage, where existing methods cannot. Unlike current grain solutions that can only reach near the surface, and that represent a safety hazard for the operators who are collecting the samples, the remote probing device is able to collect samples throughout the whole silo or shed. This enables early detection of potential spoilage, allowing for proactive management to reduce losses and maintain grain quality.



Project participants:
Crover Limited, Agri-Epi Centre Limited, East of Scotland Farmers Limited

Funded amount:
£188,769

Fertiliser on-farm decision tool: optimising the use and reducing the environmental burden of fertigation

Agriculture depends on soil nutrients (primarily nitrogen, phosphorous and potassium) for plant development, growth, quality and yield. Soils contain these nutrients naturally, but growing and harvesting crops results in them becoming depleted, leading to plants suffering from nutrient deficiency and decreasing crop quality and yields. Nutrients can be added from a variety of sources – organic matter, chemical fertilisers, and certain plants (as traditionally done by crop rotation) – to maintain soil health and fertility.

Nitrogen especially is of prime importance for farmers and food production. However, nitrogen is rarely efficiently managed; 110 million tons of nitrogen is applied onto fields every year, but only about a third of this makes it into plants. Over-application of fertiliser results in leaching of the excess into watercourses (80 million tons of nitrogen is estimated to flow into the world's waterways every year). General overuse of nitrogen fertiliser leads to the release of nitrous oxide, a potent greenhouse gas. Production of inorganic fertilisers also requires a large input of energy, which further contributes to greenhouse gas emission as well as fossil fuel depletion; synthetic fertilisers are responsible for 20% of agriculture's greenhouse gas emissions.
This project developed a decision tool that enables farmers to apply fertiliser to crops more efficiently, increasing the percentage of nutrients taken up by plants and therefore resulting in less nitrogen being released into the environment.

Project participants:
Plant Bioscience Limited,
John Innes Centre,
Zimmer and Peacock Limited

Funded amount:
£1,189,637

Hands Free Farm

Hands Free Farm, which was led by York-based Precision Decisions Limited, was a collaborative industrial research project that aimed to create the technologies that are required to operate a farm autonomously. It built on the experience and learning that was gained from the earlier Hands Free Hectare project, which developed and showcased agricultural automation by completing the world's first fully autonomous cropping cycle.

The Hands Free Farm project developed swarm robotic skills, smart machines and implements, providing a platform to evaluate technology development and economic studies to build the business case for robotic systems in agriculture. It developed practical solutions that are suitable for use on farm by farmers, not software technicians. The project made use of compact farm equipment to demonstrate the benefit of smaller, more precise machines in agriculture and the wider world.

Project participants:
Precision Decisions Limited,
Agri-Epi Centre Limited,
Farmscan AG Limited,
Harper Adams University,
N Blacker & Son

Funded amount:
£1,577,869

Precision Agriculture Remote Connectivity System (Parcs)

Precision agriculture (PA) technologies are growing in momentum, and offer advantages in controlling advanced machinery and in using data analytics to increase the efficiency of farming operations. Farmers have faced the problem, though, that the communication protocols that are used to control and monitor agricultural equipment tend to be specific to particular brands of equipment, and are difficult to link together to collect and analyse data. This results in a major challenge for farmers who are trying to adopt PA technologies, in managing the complexity of combining data from machines that are produced by different manufacturers and that are used in different farming operations, when their systems do not integrate well or in a timely manner. This often results in farmers not using data as effectively as they could, to improve their operations through advanced analytics and machine control.

This project, which was led by York-based Precision Decisions Limited, now Map of Ag Solutions, involved the development of an integrated PA platform that can make data available seamlessly and in real time from different agricultural machine control applications, use data from a range of sources for planning and analytics, and direct fleets of different agricultural machines.

Project participants:
Map of Ag Solutions, Farmscan AG Limited.

Funded amount:
£396,034

Remote sensing for decision making in Smart Farm

The more progressive livestock farmers recognise that grassland needs to be carefully managed for grazing and to provide forage that can be stored for the winter. Monitoring grassland currently is time-consuming, using a plate meter to measure the height of the grass.

This project aimed to revolutionise grassland management for livestock farmers, by removing the need to use a plate meter. Earth observations using remote sensing from space, along with ground sensing to monitor grass swards throughout the growing season, were used to forecast the availability of dry grass. This was further supported by testing of grass quality for livestock nutrition: including its levels of sugar, dry matter, nitrogen and digestible energy.

Combining both yield and quality measures, the project has provided the farmer with practical, in-season recommendations for applying fertiliser in a more targeted way across the field, not only increasing productivity but at the same time minimising the environmental impacts of livestock farming.

Overall this will change farm practice not just for the more progressive livestock producer but for all producers.

Project participants:
AgAnalyst Limited, Assimila Limited, Farmscan AG Limited, University of Newcastle.

Funded amount:
£305,082

A robot-enabled, data-driven machine vision tool for nitrogen diagnosis of arable soils

Use of fertilisers rich in nitrogen (N) can significantly increase crop production and enhance soil fertility. On the other hand, high N inputs are costly for farmers and result in reductions in plant biodiversity, pollution of natural ecosystems, and increases in emissions of the potent greenhouse gas, nitrous oxide.

Current annual spend on fertilisers by UK farmers is £1.35bn. At present farmers use excessive amounts of N fertiliser because they are not aware of the different amounts of N already in the soil. Current practices in determining soil N are costly, labour-intensive and time-consuming.

This innovative, inter-disciplinary project involving researchers and farmers has co-developed a cost-effective, non-destructive tool that automatically detects nitrogen levels in plants and arable soils. The system collects data using a mobile robot equipped with imaging sensors, and applies Novel Big Data analytics/ machine learning/ AI to build up a picture of soil N values (a prescription map). Farmers can use the map for efficient farm management to optimise agricultural inputs.

This precision agriculture solution has the potential to transform food production by reducing N inputs, increasing farm profitability and contributing to Net Zero emissions, by providing accurate information on the efficiency of N use and assessing soil quality.

Project participants:
Manchester Metropolitan University, GMV NSL Limited, Royal Botanic Gardens Kew

Funded amount:
£249,614

RootDetect: remote detection and precision management of root health

Oilseed rape and canola are two closely related brassica crops which are widely grown in Europe and Canada for their oil-rich seeds. Their global market size is measured in the tens of billions of US dollars, but clubroot disease, caused by the soil-borne root pathogen plasmodiophora brassicae, is threatening production. Disease management depends on early detection followed by rapid treatment of affected areas of the field. However, clubroot disease occurs in patches, and clubroot patches can easily be missed in large fields. Furthermore, when clubroot is emerging it rarely causes above-ground symptoms which are visible to the naked eye.

The RootDetect project, which was led by London-based Airborne Robotics Limited, developed a semi-autonomous remote sensing tool that efficiently scouts large areas and 'sees' clubroot symptoms earlier than the grower or agronomist is able to. Affected areas in the field are then mapped and linked to precision farming technology, which enables the targeted treatment of infested patches. This will be cost-effective for the grower and will minimise wastage, thus lowering carbon emissions.

Project participants:
Airborne Robotics Limited, RSK ADAS Limited.

Funded amount:
£391,347

Scaling electrical weed control across different crop types and weeding platforms

The need for effective weed control is growing, as the world's population increases. The herbicide market is under significant pressure, however, both because weeds are increasingly becoming resistant to herbicides, and because regulators have started to ban their use because of health and environmental concerns. In addition, the costs of litigation against herbicide manufacturers are increasing.

Electrical weed control or eWeeding, in which high-frequency electricity is used to kill unwanted plants, is a scalable and sustainable alternative to herbicides, and addresses some of the fundamental shortcomings of using them. It also has advantages over thermal and mechanical approaches to weeding.

This project, which was led by Kineton-based Ubiqutek Limited (branded as RootWave), has involved the creation of prototype eWeeding solutions for orchards (in collaboration with SFM) and for row crops (in collaboration with Small Robot Company).

Project participants:
Ubiqutek Limited,
SFM Technology Limited,
Small Robot Company Limited

Funded amount:
£690,380

A Smart Robotic System for SmartFarm

This project, which was led by Salisbury-based Small Robot Company, involved the development of an autonomous pest and disease detection and treatment system, which is capable of detecting pest and disease issues before they result in visible symptoms, and of treating the problem with a precision spraying platform that can treat each individual plant. The aim is to prevent the kind of crop damage that can limit yields, by addressing pest and disease problems early, and minimising the use of pesticides through early intervention that targets only the affected plants, not the whole crop.

The deployment of small robots protects soils, avoiding the damage caused by conventional heavy machinery such as tractors. They also require a fraction of the energy to operate. This precision approach therefore helps both to drive efficiency on the farm, and contribute towards net zero emissions from agriculture. The project partners are working closely with a consortium in China to develop, test and demonstrate the technology that is involved, with a view to jointly commercialising the results of the project in the UK, China and beyond.

Project participants:
Small Robot Company Limited,
Agri-Epi Centre Limited,
University of Strathclyde

Funded amount:
£497,798

SpraySaver – full automated broad-spectrum crop pathogen spore detection using DNA and LFD

Today, the majority of farmers spray fungicides on crops to prevent disease. But while most farmers spend hours inspecting crops, they can't easily predict what incubating (invisible) infection is already in the crop, or what may start to develop as a result of increasing pathogens in the environment. Weather-based disease forecasting methods have been introduced to predict when to spray crops, but they often have unreliable results, especially against sporadic diseases.

The aim of this project, which was led by London-based Agri Samplers Limited, is to transform today's 'spray-and-pray' practices by offering a more reliable and precise method of determining when to spray, using locally gathered disease pathogen data and risk prediction and decision support models, to assess the risk of crop disease. This could lead to a big reduction in crop spray costs, improved crop yields and productivity, and greater effectiveness when sprays are applied.

SpraySaver is the world's first automated field analyser system that is specifically designed for early detection of disease pathogens within crop growing environments. One analyser can monitor a wide geographic area of around 100 Ha (dependant on local environmental conditions) and can be configured to detect multiple crop disease pathogens. Each in-field analyser transmits data that can be analysed alongside local weather information, to determine the risk of disease.

Project participants:
Agri Samplers Limited, H.L. Hutchinson Limited, Perpetuus Carbon Technologies Limited, Polygenyn Limited, RSK ADAS Limited, Rothamsted Research, Spearhead Marketing Limited, Velcourt Limited, Warwickshire College

Funded amount:
£926,972

Evaluating efficacy of novel green fertilisers using carbon capture technology

Carbon dioxide is one the greenhouse gases which is contributing towards climate change. One way to mitigate the high levels of carbon dioxide in the atmosphere is to capture it in organic waste material such as food waste. Under the right conditions, organic waste can convert carbon dioxide into a renewable source of fertiliser.

This project built on existing analytical methods used to trace carbon at its capture point, through to its final destination within the soil. Its aim was to evaluate how effective is the fertiliser developed by CCM Technologies, in terms of providing nutrients to crops.

The project involved using field-scale trials to determine the effectiveness of zero carbon fertilisers in providing the required nutrients to meet crop demands. In these trials, root scanners were used to determine root network and density as a measure of below-ground carbon stock. Soil samples were also collected in the field experiments to determine nutrient content while earthworm counts were carried out as an indication of soil health. Total yield of crops were also measured against the control. Runoff and leachate were measured for dissolved nutrients and carbon, to provide information on the impact of the fertiliser on the environment.

The outcome of this work should not only help with the task of capturing atmospheric carbon dioxide in the soil, but also improve soil health and crop productivity.

Project participants:
CCM Technologies Limited, Cranfield University.

Funded amount:
£197,083

Developing a biopesticide for cabbage stem flea beetle

This project was a feasibility study to develop an innovative bio-pesticide technology for the control of cabbage stem flea beetle (CSFB) in oilseed rape (OSR). The OSR area grown in the UK has declined significantly since 2012 followed a ban on neonicotinoid insecticides, which resulted in increased CSFB damage. The beetle also developed resistance to the pyrethroid insecticides, the only chemical control option available to farmers.

The feasibility study involved developing a fungal-based treatment, shown to have a 100% kill rate against early-stage larval CSFB after four days, and a mean of 82% kill rate for adults. The project focused on the development of different formulation types of the bio-pesticide to target the CSFB at different stages of the life cycle, especially the adults which can cause major crop losses as OSR emerges in late summer.

The work also involved end-user engagement through knowledge transfer workshops, with the aim of gathering feedback to ensure that the project aligns with user needs. This highlighted the fact that farmers are using a range of IPM techniques to overcome CSFB, as there are no suitable synthetic or biological pesticide control options currently available.

The outputs of this work will have a significant impact on the UK economy, by helping farmers to safeguard yields through enhanced CSFB control, whilst increasing the area of UK-grown OSR to supply domestic demand for rapeseed oil. The project also helps to reduce emissions, through the development of targeted bio-pesticide application systems, reducing the use of machinery required and replacing synthetic chemicals with biological treatments.

Project participants:
Crop Health and Protection Limited,
CAB International,
Russell Bio Solutions Limited

Funded amount:
£212,365

Development and field testing of the next generation of vision-guided weeding systems

Current crop production systems have been reliant on the wide-scale application of herbicides to control weeds. However, this approach is not sustainable, due to unprecedented regulatory and environmental pressures, which place new emphasis on the development of novel techniques to kill weeds. Precision hoeing equipment is a promising alternative, but the current systems cannot achieve the accuracy required to remove weeds completely from fields.

This project helped to develop next-generation robotic weeding machinery, which enables the selective and accurate treatment of weeds growing amongst crop plants. The technology involved combines a precision hoe, guided by a vision system and machine learning for precise detection and localisation of crop and weed plants. The system can be rapidly deployed and adapted for various plant types and environmental conditions.

The new weeding system can be deployed both as a tractor-mounted solution, and through an autonomous mobile robot. An autonomous weeder can operate 24/7 and offers a solution for farmers who grow crops in glasshouses or polytunnels where traditional implements cannot be deployed. This more efficient weeding equipment should result in better management of weeds and reduced use of herbicides.

Project participants:
Garford Farm Machinery Limited,
SAGA Robotics Limited,
University of Lincoln

Funded amount:
£ 697,058

A novel non-destructive solution to quantify and qualify potato crops during growth to realise maximum marketable yield and help to reduce waste – TUBERSCAN

Determining the correct date on which to harvest potatoes is one of the most critical decisions that potato growers must make. If they lift their potatoes too early they may be below the optimum size, resulting in less than the maximum potential output being produced. If they lift them too late, they may be too large to meet buyer specifications, significantly devaluing them. Either way the grower loses potential income.

This project built on research carried out previously, which showed that it is possible to use new technologies to measure the total biomass of potato tubers in the soil, non-invasively. Other ongoing research also showed that it might be possible to process images of potato plants, to determine the number of tubers that each potato plant will produce.

The aim of this project was to develop and test an innovative prototype system to measure and map average potato sizes and potato biomass throughout fields. This enables early interventions and/ or selective harvesting to take place, thereby optimising crop yield and resource use. It is anticipated that this technology could generate an estimated 5 - 10% increase in UK marketable potato production at little or no extra cost, whilst helping to reduce waste throughout the supply chain.

Project participants:
B-Hive Innovations Limited,
Harper Adams University

Funded amount:
£374,876

iAgriWatch – intelligent remote sensing for smart farm

As the world's population continues to grow, it is imperative that food production increases. Yet as available land is diminishing and innovation in agriculture is slow, there is evidence that crop yields are stagnating. There is a need to develop new methods to inform farmers and other stakeholders in the food chain of the health and productivity of crops.

The iAgriWatch project used in-situ sensors and high-precision location-based sensors, combined with Earth observation data at various scales. The farm data produced is combined with information from the Web (about weather, market trends etc) using an innovative cloud-computing platform powered by artificial intelligence algorithms.

The project applied this technology to wheat, rice and other crops, to provide a better understanding of canopy growth and ageing. Using unique crop growth models, smart sensors and processing algorithms developed with partners in China, advance notice can be provided of the need for timely interventions to irrigate, fertilise or protect crops, to improve marketable yield. The iAgriWatch system is fully automated, requiring no technical expertise, and the outputs could be sent directly to agri-vehicles in the fields.

Project participants:
Ubipos UK Limited,
University of Nottingham

Funded amount:
£490,000

A holistic non-destructive data driven demonstrator to quantify potato crops during growth to realise maximum marketable yield and help reduce waste, contributing to net zero emissions - TUBERSCAN-DEMO

This project built on a recent proof-of-concept Innovate UK project (TUBERSCAN), which showed that it is possible to use new technologies to measure the total biomass of potato tubers in the soil, non-invasively. Combining this with above-ground data on potato plants, the number of tubers per potato plant can be accurately determined.

The project used the findings from TUBERSCAN to develop and test an innovative demonstrator system, to measure and map average tuber sizes and yield throughout potato fields. This data will provide insights to enable early interventions and/ or selective harvesting to take place, thereby optimising crop yield and resource use. It is anticipated that this technology could generate an estimated 5-10% increase in UK marketable potato production, whilst helping to reduce waste throughout the supply chain, working towards net zero emissions in the potato industry.

Project participants:
B-Hive Innovations Limited, Branston Limited, Harper Adams University, University of Manchester

Funded amount:
£1,921,229

Peptide insecticides: new targets and commercialisation

This project aimed to provide a disruptive solution to the global problem of destruction of food crops by insect pests, where current conventional insecticides are beset with sustainability and environmental problems.

The project was focused on insecticides based on peptides (small proteins), which target unique features of insect physiology to provide safe, effective insect pest control for food crops. These new bioinsecticides do not harm beneficial insect species and have the potential to replace current synthetic chemicals, benefitting both the environment and end-consumer health.

The project made use of an innovative, targeted discovery and design platform which does away with the costly, inefficient and time-consuming random screening of large libraries of compounds (which takes up to three years in a traditional discovery programme). It has the added advantage of being faster and more agile in finding new pest targets.

The project involved using the discovery platform to target new insect pests and new markets. The project will also support the validation of peptide candidates for current markets, development of peptide synthesis capacity, and evaluation of the effectiveness and toxicity of candidate bioinsecticides.

Project participants:
SOLASTA Bio Limited

Funded amount:
£1,128,056

A 'Smart Storage' solution for the potato sector to reduce waste by 110kt and improve packer profitability by £108 million per annum

Throughout the UK, over 5.5 million tonnes of potatoes are grown every year. Potatoes grow in different sizes and shapes and there is vast variability across the field.

Currently there is no full set of quality and size data available at the time of harvest, to maximise marketable yield. Only sample data is available, which does not cover the crop variability across the field. This also leads to crop imbalance during the packing process. Potatoes are packed together that may not meet a customer's specifications, because they are too big or too small.

This project involved gathering the whole data at harvest regarding size and yield, to allow the grower to make informed decisions about their crop, and potentially increase the marketable yield and revenue by selecting the right crop at the right time.

In order to maximise marketable yield by minimising crop losses due to potato imbalance, the project developed a 'smart storage' solution for potatoes. Growers are able to select boxes for cold storage based on the size of the potato, helping to ensure that a higher proportion of the crop meets the size profile of a given customer order.

Project participants:
B-Hive Innovations Limited,
AHDB Limited, Branston Limited

Funded amount:
£510,663

Radical and environmentally-friendly agricultural sprayer technology using ultra-fine bubbles

Emerging technology based around ultra-fine bubbles (UFBs), also known as nanobubbles, offers potential for significant change and benefits across the economy. These UFBs are less than a millionth of a centimetre in diameter (1,000 times smaller than the width of a human hair), and they exhibit a range of remarkable properties. They are notable for their longevity (the period of time they remain as bubbles), and importantly their capability for carrying gases of various kinds, and other chemicals that stick to the bubble surface.

The versatility of UFBs, and their properties, mean that they have significant potential in agriculture. They can make spraying and irrigation much more effective, and so can lead to a significant reduction in the inputs (of water, chemicals etc) that are needed to provide crops with nutrients, or for pest control or control of plant diseases.

The aim of this project was to establish the feasibility of integrating UFBs in a generic platform that can be used for a range of applications, and as the basis for new, economically viable and environmentally-friendly products and services. The project represents a significant step towards new economic and employment opportunities in the UK.

Project participants:
Maggrow U.K. Limited,
Agri-Epi Centre Limited,
Crop Health and Protection Limited

Funded amount:
£212,240

Developing an early-warning system for harmful algae blooms to improve productivity on salmon farms

Aquaculture is an important industry for sustainable protein production, with salmon farming being particularly important in the UK.

Harmful algal blooms (HABs) occur when, due to certain environmental conditions, microscopic algae or phytoplankton populations can become very large and form blooms. Not all phytoplankton are harmful, but some species produce harmful toxins, while others deplete dissolved oxygen in the water, or have physical features that can damage fish gills. A HAB that forms in close proximity to a salmon farm can cause major problems for fish health and welfare, with increased incidences of disease and mortality. HAB events seem to be increasing as a result of climate change, and can be extremely economically and environmentally costly for aquaculture producers.

HAB monitoring is part of the daily routine for many aquaculture farmers, but it can have high energy costs. This project developed an early warning technology to notify farmers of potential and imminent HABs. The technology continuously monitors the environmental conditions on and around farms through the use of wireless sensors in the water and machine learning algorithms in the cloud. It alerts farmers when conditions that promote blooms occur in real time, enabling them to respond quickly to mitigate any detrimental impacts. This system will ultimately increase food production, while reducing energy consumption and the carbon footprint of fish farming.

Project participants:
R. S. Aqua Limited

Funded amount:
£103,807

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