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Animal Health, Agri-tech and Aquaculture (AAA): Improving Awareness and Links for Innovation Capacity in Scotland

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Life Sciences in
SCOTLAND

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(AAA): Improving Awareness and Links for
Innovation Capacity in Scotland**

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Contents	
EXECUTIVE SUMMARY.....	1
INTRODUCTION.....	3
FELLOWSHIP AIMS AND METHODOLOGY.....	4
CURRENT AAA LANDSCAPE IN SCOTLAND.....	5
ACADEMIC EXCELLENCE.....	7
INDUSTRY LANDSCAPE.....	17
INNOVATION CENTRES.....	32
NETWORKS, CONSORTIUMS & CO-OPERATIVES.....	33
SCIENCE PARKS.....	35
GOVERNMENT & DEVELOPMENT AGENCIES.....	35
CHARITIES.....	36
BUSINESS GATEWAYS AND VENTURE STUDIOS.....	36
FUTURE AAA LANDSCAPE.....	37
SURVEY TO KEY STAKEHOLDERS.....	38
OBJECTIVES, METHODOLOGY AND DATA COLLECTED.....	38
RESULTS.....	38
DEMOGRAPHIC INFORMATION.....	38
FACILITIES/RESOURCES.....	39
COLLABORATIONS AND INTERNATIONAL LINKS.....	42
OPPORTUNITIES.....	43
CHALLENGES.....	46
SURVEY RECOMMENDATIONS.....	49
AAA INNOVATION REGULATION.....	50
Appendix 1. Stakeholder Inventory.....	52
Appendix 2. Survey – Strengths, Opportunities and Challenges in the AAA sector in Scotland.....	52



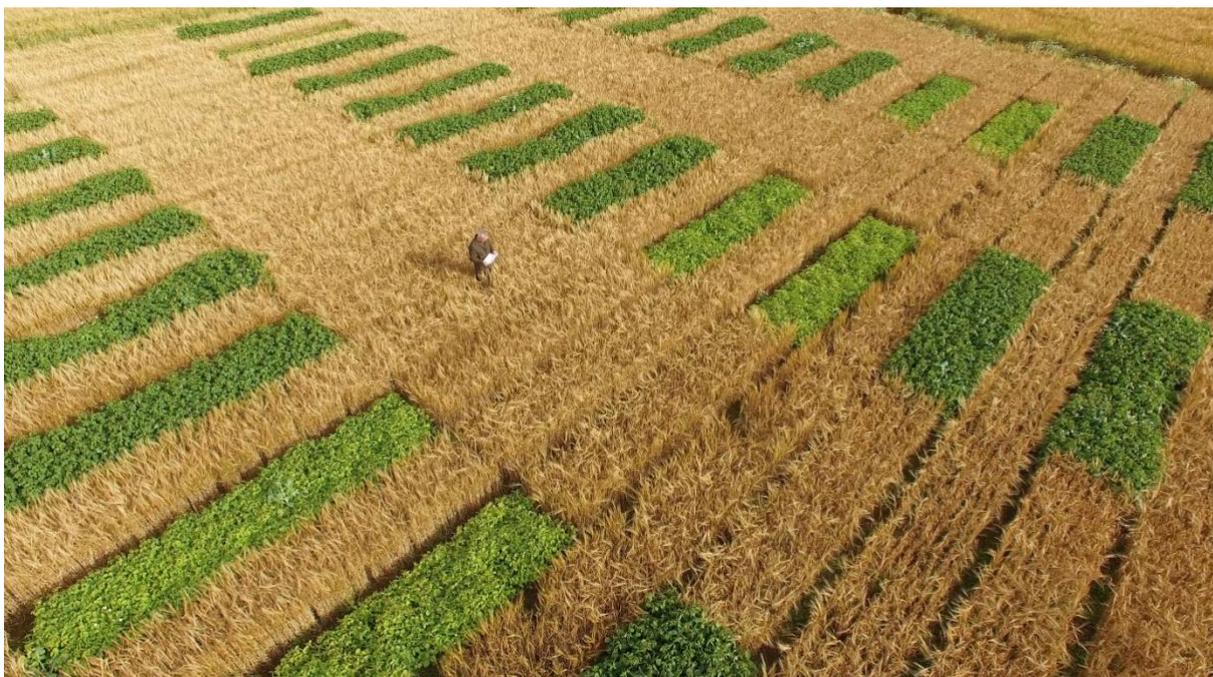
EXECUTIVE SUMMARY

The aims of this fellowship were to increase the understanding of the animal health, agri-tech and aquaculture (AAA) sector in Scotland and improve understanding of opportunities and challenges facing the sector. This was achieved through creation of an inventory mapping key stakeholders in the sector across Scotland and a survey to key stakeholders. The breadth of the sector, its dynamism and the constraints of a short duration Fellowship mean that this report should be read as platform from which further exploration of the sectors can build on. Whilst beyond the remit of this current project an up-to-date scoping exercise on impact of gross value added (GVA) on the sector would be beneficial.

The inventory created (up to date as of October 2021), and described in further detail in the report below, provides an overview of the vast breadth and expertise within the sector across academic institutes, companies, innovation centres, networks and consortiums, charities, government and development agencies, and business gateways and venture studios. A large proportion of identified stakeholders are based in and around the Easter Bush Campus which is the European epicentre for animal biosciences. The future AAA landscape was also explored, with multiple new centres, hubs and new trial facilities, developing and planned, over the coming years, showing the vast expansion and investment in this area. The report also includes the extensive

trial facilities, both animal and crop, which exist across Scotland and contribute to Scotland's world leading research within the AAA Sector.

An online survey was circulated to key stakeholders aiming to identify key resources and facilities, international links, and opinions on current opportunities and challenges to the sector (including impacts of COVID-19, BREXIT and green recovery). Throughout the survey, responses identifying skills, expertise and research facilities were consistently identified as key assets and unique selling points of the sector. Expertise were particularly noted in genetics and breeding, animal health and agri-tech for use across all farmed animals. Strong links were identified with other academic institutes, companies and collaborators within Scotland, the wider UK and across the world. Sustainable production systems, agri-tech and digital innovations and novel/alternative production systems were identified as the main opportunities presented to the sector. Respondents to the survey noted that they would like to see increased promotion of the sector and its impact and increased R&D funding and investment for retention of skills. The largest challenges currently facing the sector were lack of funding (including BREXIT's impact on limiting investment), increasing climate change and environmental pressures, and innovation regulation. Examples around innovation regulation within the sector were explored further within this report including the use of environmental DNA (eDNA), novel, next generation green insecticides and the use of insects for protein. Other challenges currently facing the sector include increased administrative burdens, reduced access to materials/issues with importing materials, labour shortages and the threat of food supply chain disruption caused by BREXIT. COVID-19 has also presented challenges including reduced research capacity.



INTRODUCTION

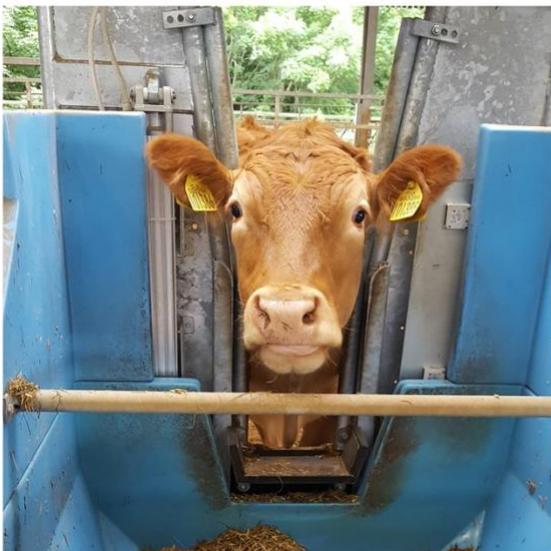
This SEFARI Fellowship was set up to understand the opportunities for the animal health, agri-tech and aquaculture (AAA) sector in Scotland, in collaboration with Life Science Scotland's Industry Leadership Group (AAA Subgroup) and Highlands and Islands Enterprise (HIE). Life Science Scotland's Industry Leadership Group is a joint group of industry, enterprise agencies and governmental strategy teams, the subgroup was established to champion the AAA sector, thereby leading a greater voice to the fast-growing sector which Scotland already excels at on an international level. The subgroup aims to build awareness and engagement within the life sciences community and promote its strengths. Highland and Islands Enterprise represents the Scottish enterprise agencies in the group and seeks to develop a highly successful, inclusive, and prosperous region, in which increasing numbers of people choose to live, work, study and invest and in which the AAA strategy fits. The breadth of the sector, its dynamism and the constraints of a short duration Fellowship mean that this report should be read as platform from which further exploration of the sectors can build on.

The rising global population means there is increased reliance on protein (both meat and fish) which must be produced in a more sustainable and environmentally friendly way. Advances in research and development to promote health and production efficiencies enable this goal to be met. The animal health, agri-tech and aquaculture sector in Scotland is important to both the life sciences and technology sectors and underpins the country's high performing food and drink industry. There is a large breadth of skills in animal health, agri-tech and aquaculture including academia, public sector and industry. However, to date there is little validated information that exists on Scotland's contributions to this sector and its global impact.

Scotland's world class AAA sector includes:

- One of the largest concentrations of expertise in animal and veterinary science in Europe and the world at Easter Bush Campus.
- Over 210 companies and stakeholders operating in the AAA sector in Scotland.
- Two internationally rated veterinary medicine schools, both in close proximity to each other, with a third planned in the near future. Currently almost 1/3 of UK vets are trained in Scotland each year.
- Scotland is global leader in veterinary science publications in comparison to level of GDP.
- Broad range of research excellence including nutrition and health, animal behaviour and welfare, genetics and breeding, agri-tech, disease diagnosis and therapeutic/vaccine developments.

- First commercial vaccine (Dictol) against parasitic disease in cattle developed at University of Glasgow, and more recently a breakthrough first-of-its-kind vaccine (Barbavax) for Barber's pole worm.
- First cloned mammal, Dolly the sheep, created at Roslin Institute.
- University of Edinburgh together with SRUC ranked top in the UK in the Research Excellence Framework for agricultural and veterinary research.
- The Institute of Aquaculture at University of Stirling is largest of its kind in the world.
- Several new developments planned in the AAA sector in the near future including a new agri-tech hub at Easter Bush, Dairy Nexus, SRUC's new vertical farm and vet school coinciding with the new Rural and Veterinary Innovation Centre (RAVIC), new James Hutton Institute's International Barley Hub and Advanced Plant Growth Centre and new Shetland shellfish facility.



FELLOWSHIP AIMS AND METHODOLOGY

The aim of this Fellowship was to map out the current landscape in Scotland in terms of what currently exists in the AAA sector in Scotland, including key companies, consortiums, research centres, academic partners and key facilities, along with identifying competitive strengths and opportunities. This report, and aligned inventory, provides a comprehensive but not exhaustive list of all stakeholders operating in the space. All stakeholders identified operated pre-farm gate. This was achieved via three tasks:

Task 1. Undertake a comprehensive review of the current AAA landscape in Scotland and identify upcoming advances in the sector. This was accomplished using existing literature and online searches. The below definitions of AAA were used to create an inventory to increase the understanding of the current AAA sector:

- *Animal health* “interventions that improve the health of livestock and companion animals. Such interventions include medication, vaccines, diagnostics and other relevant processes and technologies”.
- *Agri-tech* “the development of novel technology for agriculture ensuring improved productivity and sustainability. This includes technology applied to benefit both crop and animal-based agriculture. Also included are precision agriculture, data driven innovation, other relevant innovative technologies, crop breeding, vertical farming (or totally controlled environment farming) and crop protection”.
- *Aquaculture* “the breeding and rearing of fish, shellfish, plants, algae, and other organisms in water environments. This encompasses all aspects of the production process including breeding, nutrition, health and welfare, and other relevant technologies”.

Task 2. Identify strengths, opportunities, and challenges in the sector with a survey to key stakeholders.

Task 3. Undertake a mapping exercise of trial facilities (both animal and crop) across Scotland. This was achieved by searching publicly available documents, therefore may not be an exhaustive list of all facilities.

This report highlights the breadth, strengths, and competitive advantages of the AAA sector in Scotland.

CURRENT AAA LANDSCAPE IN SCOTLAND

Two hundred and sixteen key stakeholders in the AAA sector were identified. A map has been created in Figure 1, which shows the geographic breakdown (based on local authority areas) of each of these. The majority of the stakeholders were based around the central belt of Scotland and particularly around the City of Edinburgh (38) and Midlothian (39), and Highlands (23). Other key sites for stakeholders were Argyll and Bute (20), Glasgow (15), Dundee (11), Aberdeen (8), Stirling (9), Fife (7),

The below sections set out the current landscape separated into key stakeholder areas: academic excellence; industry landscape; innovation centres and centres of expertise; networks; consortiums, and co-operatives; science parks; government and development agencies; charities; and accelerators and venture studios. Whilst key facilities are listed within each stakeholder area below, a comprehensive list of trial facilities collated in this fellowship can be found in the inventory (Appendix 1). An existing database of trial facilities within the aquaculture sector exists on the [Scottish Government website](#).

ACADEMIC EXCELLENCE AND FACILITIES

Scotland is one of world leading locations for veterinary and animal science. This is especially true around Easter Bush Campus which holds the largest concentration of animal scientists in Europe and the world. Below is a list of academic partners in the AAA space, including areas of expertise and facilities.

[Biomathematics & Statistics Scotland \(BioSS\)](#) BioSS is funded by the Scottish Government's Rural and Environmental Science Analytical Services Division (RESAS) and provides statistical support across the AAA sector. Their specialism lies in the development and application of statistical methods (including biomathematics) to enhance knowledge and impact. They have a broad range of statistical and modelling expertise including animal health, big data, aquaculture, genomics and bioinformatics, and process and systems modelling.

[Data-Driven Innovation \(DDI\)](#) DDI is a cluster of innovation hubs bringing together academic disciplines to address grand challenges using data, including the use of "big-data" from agri-tech and genomics in both livestock and aquaculture sectors. DDI, led by University of Edinburgh and Heriot-Watt University, forms a major part of the Edinburgh and South-East Scotland City Region Deal. DDI hosts the Edinburgh International Data Facility offering high performance computing facilities for advanced data analytics, the facility provides analytics and storage services which support research and data driven innovation in Edinburgh, South-East Scotland and beyond.

[Edinburgh Napier University](#) Edinburgh Napier University offers expertise in multidisciplinary research including aquaculture environmental sustainability and health and welfare (for example parasitic infection).

[Heriot-Watt University](#) Heriot-Watt University is home to the Centre for Marine Biodiversity and Biotechnology. This is an interdisciplinary research centre with

research areas focussed on the blue economy including aquaculture, invertebrate biology, immunology and marine natural products. The Centre for Marine Biodiversity and Biotechnology hosts flexible laboratory facilities for physiological studies, spectroscopy, microscopy, molecular biology, ecotoxicological biomarkers, benthic biodiversity and sediment characteristics. Experimental facilities include a central aquarium facility comprising of seawater and filtered freshwater options. In addition, the centre hosts six constant temperature rooms, including one dedicated to ocean acidification. The centre also has its own research vessels and dedicated scientific dive team.

James Hutton Institute The James Hutton Institute (JHI) combines research and expertise in crops, soils, land use and environmental research to help address global challenges including food security. They have a broad range of expertise and resources including genome technologies, functional genomics, imaging technologies, Rubus and Ribes germplasm collections, National Soil Archives, Commonwealth Potato Collection, plant pest and pathogen collections, analytical equipment, national soils database and virtual landscape theatre. JHI's world leading facilities include:

- Research farms including trial facilities at Balruddery Research Farm (170ha arable research farm), Glensaugh Research Farm (upland livestock farm of >1000ha and automatic weather stations and hydrological data monitoring systems), and Glen Finglas (24 grazing enclosures measuring 3.3ha each).
- Glasshouses and Growth Facilities (137 glasshouses, 42 plant growth cabinets, 15 plant growth rooms, 19 cold stores, 19 polytunnels and 1200m³ standing-out-ground area)
- International Barley Hub and Advanced Plant Growth Centre, discussed further under "Future AAA Landscape".
- Sustainable feedstocks for animal and aquaculture at the Centre for Sustainable Cropping. This is the first test farm of its scale in the UK and delivers sustainable management practices and improved crop varieties. The farm operates at commercial scale to maintain yield using fewer agrochemicals, reducing GHG and nutrient leaching and enhance soil quality for commercially relevant crops (e.g., barley, wheat, oilseed rape, potato and faba bean).
- Genetics and genomics to elucidate the genomes of key and commercially relevant crops for livestock feeds (e.g., barley grain), and pathogens within the crop and livestock sector.
- Food safety including development of technology innovations to detect and diagnose pathogens, including food borne pathogens, and risk analysis to assess level of risk from food borne pathogens/toxins.
- Waste Utilisation from the aquaculture sector and its application in agriculture (e.g., fertiliser).

James Hutton Limited is the commercial arm of JHI and delivers a range of scientific services and expertise across crop breeding, bioscience, aquaculture and downstream food and drink products.

Moredun Research Institute The Moredun Research Institute carries out world leading research to improve animal health and welfare (both livestock and aquaculture) through the prevention and control of infectious diseases caused by viruses, bacteria, and parasites. The Moredun Research Institute has a broad range of expertise and facilities including:

- Research into infectious diseases of livestock and aquaculture, including zoonotic disease relevant to public health, including vaccine development.
- State-of-the-art animal and laboratory facilities which are equipped for handling a broad range of livestock pathogens (parasites, bacteria, viruses). This includes accommodation for all livestock species, including incorporated accommodation, post-mortem suite and incineration facilities, high containment facilities providing controlled environment conditions for large and small animal species (including specified pathogens up to Containment Level 3) and 150ha grazing land. Laboratory facilities are good laboratory practice (GLP) compliant.
- Disease surveillance, in partnership with SRUC's Veterinary Services, to monitor livestock disease outbreaks across Scotland. This includes dedicated virus surveillance units and pathology laboratory.
- Precision farming research to improve productivity of livestock production systems
- Proteomics bringing together molecular biology, biochemistry, and genetics for characterisation of proteins expressed by genes. This includes the Moredun Proteomics Facility which focusses on infectious diseases.
- Bioinformatics tools to develop novel methods/software to further understanding of complex biological data.

Moredun Scientific, the commercial arm of Moredun Research Institute, is a contract research organisation with expertise in provision of services to global animal health companies, offering efficacy and safety testing for veterinary medicines, vaccines, and feed additives for both livestock and aquaculture, thus allowing commercial outputs from research.

University of Edinburgh's Royal (Dick) School of Veterinary Science and Roslin Institute The Roslin Institute is one of the largest dedicated animal biosciences research institutes in Scotland, hosting and delivering the majority of the research

activity at University of Edinburgh's Royal (Dick) School of Veterinary Studies. Key expertise and facilities at these sites include:

- Genetics and genomics including those underpinning resistance to disease in livestock and markers for improved aquaculture broodstock in aquaculture. This includes Edinburgh Genomics, the largest academic DNA sequencing facility (by output) in the UK, and expertise in bioinformatics.
- Diseases and health including new and emerging zoonosis (including more recently COVID-19 research), and pathogens for improving food safety. This also includes tools, reagents and assays for veterinary immunology. The Roslin Institute also hosts the centre for comparative pathology, a collaborative centre focused on human and animal disease mechanisms, and TSE Resource Centre offering support to Transmissible Spongiform Encephalopathy research. There are also strengths in osteoarthritis and cancer in companion animals, linking to the dedicated Riddell-Swan Veterinary Cancer Centre and equine hospital at the University of Edinburgh.
- Strong links to the Roslin Innovation Centre, the business gateway for companies focussed on AAA at Easter Bush Campus.
- Behavioural sciences studying the optimum environment to enhance animal welfare.
- Biological research facility providing housing and care for rodents.
- Proteomics and metabolomics facility offering a range of mass spectrometry and analytical chromatography methods, and bioimaging and flow cytometry equipment including high-end microscopy and cell sorting.

The Royal (Dick) School of Veterinary Studies owns and operates a 250ha dairy research farm (including milking parlour) at Langhill and Dryden Research Farm. The Roslin Institute is home to specialist laboratories and bioimaging skills (including the Bioimaging and Flow Cytometry, Proteomic and Metabolomics Facility), and research facilities including:

- The National Avian Research Facility (NARF) consisting of two units (i) conventional and (ii) specified pathogen free and home to one of the largest number of transgenic chicken lines in the world.
- Livestock/Farm facilities including the recently opened Large Animal Research Imaging Facility (LARIF). LARIF hosts several facilities including:
 - Isolation suite for studying infectious diseases in animals including containment unit providing specialist animal holding areas and dedicated procedure rooms. Two containment units are available which operate at containment level 2.

- Range of imaging resources for large animals including computer tomography (CT), 3-Tesla magnetic resonance imaging (MRI) scanner, C-arm fluoroscopic X-ray system, ultrasound, mobile PET-CT imaging.
- Two operating theatres for surgery/general anaesthesia.
- Critical care unit specialising in prolonged anaesthesia and intensive care enabling up to six anaesthetised animals to be physiologically monitored simultaneously.
- Genetic modification of livestock including embryology facilities, bio-secure environments from implantation of engineered zygotes through to the rearing of breeding populations.

Scottish Association for Marine Science (SAMS) SAMS is Scotland's oldest and largest independent marine science organisation, delivering marine science research and development. SAMS work in partnership with academic business, government, regulatory and voluntary sectors, working with a wide portfolio of facilities and services:

- Scottish Marine Robotics Facility operating the latest smart technologies for marine research.
- Culture collection of algae and protozoa offering the most diverse collection of its kind in the world.
- SAMS operate a small fleet of research vessels.
- Sampling equipment and analytical facilities.
- Alan Ansell Research Aquarium consisting of 160m² indoor and outdoor facilities for studies including but not limited to biology of deep-sea coral, biological rhythms, feeding trials, larval studies, biology of non-native species and behavioural studies.
- Two experimental seaweed farms aiding to identify the most advantageous species to farm and harvest in Scotland, and identifying and controlling pathogens. This links closely to SAMS's recently completed expansion of their seaweed nursery.
- Experimental artificial reefs to research interactions between man-made structures and the marine environment.

SAMS Enterprise provide specialist marine consultancy and SAMS Ltd. is an academic partner of University of Highlands and Islands.

Scottish Universities Life Sciences Alliance (SULSA) SULSA is a strategic partnership between 11 Scottish universities which seeks to advance life sciences innovation and research.

Scottish Environmental, Food and Agriculture Research Institutes (SEFARI)

SEFARI is a consortium of six environmental, food and agricultural research institutes across Scotland, including SRUC, Moredun Research Institute, the Rowett Institute, BioSS, JHI and Royal Botanic Gardens Edinburgh. These institutes deliver the Scottish Government-funded Strategic Research Programme addressing grand challenges in agriculture, animal and plant health, environment, land use, food drink, and rural communities. SEFARI delivers knowledge exchange and impact through the SEFARI Gateway.

Scotland's Rural College (SRUC) SRUC combines and integrates research, education, and consultancy in the land-based sector, and is the largest institution of its type in Europe. It also has strong links to industry and policy, with sites present across Scotland within each faculty hub (Central, North and South West), SRUC also in preparation to achieve degree awarding powers. Key expertise include:

- Dedicated animal trial facilities in livestock production, and facilities for crop trials which underpin research capabilities (described further below).
- Animal behaviour and welfare, focussing on assessing behaviour and emotions, indicators of pain, and qualitative behavioural assessment.
- Breeding and genomics research to optimise health, welfare, productivity, and environmental impact leading to more sustainable production systems of livestock and capabilities for aquaculture. Additionally, delivery of national genetic and genomic evaluations through Edinburgh GENetic Evaluation Services (EGENES), and body composition estimation using dedicated mobile CT scanner.
- Disease systems including SRUC Veterinary Services providing disease surveillance and analytical testing, and epidemiology research unit, based at Inverness, focusing on development of models to describe disease transmission in animal populations.
- SAC Consulting delivers consultancy to over 12,000 customers with expertise in veterinary services, livestock and crops, environment design, farm diversification and rural business management.
- Strategic partner in new SeedPod development hub (led by Opportunity North East; ONE) which will be located at Craibstone (see Future AAA Landscape).
- Developing innovative solutions through SRUC's Commercial Group and Innovation hub.

SRUC is home to a large number of farms and research facilities which enables it to deliver high quality research in the land-based sector, including:

- Beef and Sheep Research Centre based at Easter Howgate Farm covering >1000ha including hill, upland and lowland, and home to 400 suckler cows and

>1400 sheep. The farm has world-leading facilities to weigh, monitor individual feed intake through feed bins for cattle (part investment from CIEL) and forage, concentrate and weigh crates for sheep (CIEL investment). The centre hosts the GreenCow facility which consists of six respiration chambers to monitor greenhouse gases from individual animals and newly invested portable accumulation chamber (PAC) for measuring sheep emissions. The farm has facilities for nutrition, feed efficiency trials and ground truthing agri-tech solutions (automated weigh systems, 3D imaging, animal mounted sensors, proxy technologies, EID etc.).

- Dairy Research and Innovation Centre based at Crichton Royal Farm (Dumfries) has two units based on 252ha farmland including the Langhill Breeding study with 50 years of selection for milk solids production (maximum and national average genetic lines). The farm houses facilities for nutrition, methane and precision livestock farming (PLF) research including a total of 270 milking cows, including automated milk recording, individual recording of feed and water intake, weighing facilities, calf respiration chambers and range of precision livestock tools. In addition, SRUC's dedicated calf research facilities are based in Dumfries, including bespoke equipment to allow for continuous assessment of individual calf growth, intake and behaviour (through Agri-Epi Centre investment). The centre also focuses work on soil and grassland including soil compaction, greenhouse gas emissions and controlled traffic farming.
- Monogastric Research Centre hosts both pig and poultry units. The poultry unit, Allermuir Avian Innovation Centre, encompasses all aspects of poultry production and facilities include raised-floor units, enriched housing layer facilities and large floor pen facilities allowing small scale to commercial conditions. The pig unit, based at Easter Howgate, is a 100 sow farrow to finish herd with facilities to monitor feed intake and growth, agritech (including 3D cameras), pathogen and parasite studies, and behaviour and welfare studies.
- Hill and Mountain Centre is based at Kirkton and Auchtertyre Farms near Crainlarich and consist of 2,200ha. The site has an established LoraWAN network and research focusses on how technology can help hill farmers to improve production including EID.
- Scottish National Equestrian Centre (SNEC) is a key education, training and events facility owned and operated by SRUC.

[University of Aberdeen](#) the University of Aberdeen has many expertise and international centres within the AAA sector including:

- The Rowett Institute of Nutrition and Health carries out studies of diet and health in both animals and humans. Areas of expertise include gut microbiome,

nutrition, and health to improve nutritional value of food products whilst reducing environmental impacts.

- International Centre for Aquaculture Research and Development (ICARD) offering extensive expertise in fish nutrition, feed formulations, infection trials, immunology and vaccine development, pathogen interactions.
- Scottish Fish Immunology Research Centre addressing both fundamental and applied issues for fish health including gene discovery and vaccine development in collaboration with University of Stirling and Marine Scotland Science.
- The School of Biological Sciences hosts recently refurbished aquarium facilities (freshwater and seawater facilities). The aquarium also has high biosecurity pathogen challenge facilities and independent zebrafish aquarium with isolated breeding tanks. This is in addition to laboratory equipment including multiple mass spectrometers, chromatographers and electron microscopes.

University of Dundee The University of Dundee is one of the leading universities in Europe delivering research in life sciences including through the Division of Plant Sciences which was established in 2007. This is an internationally recognised centre for molecular plant science including genes and processes underpinning traits (e.g. yield, disease resistance).

University of Edinburgh The University of Edinburgh is home to one of the UK's leading veterinary schools, the Royal (Dick) School of Veterinary Studies, and home to the Roslin Institute (both described in detail above). The University has other expertise across the AAA sector, including:

- Supporting Evidence-Based Interventions (SEBI) applies data and evidence to help smallholders and livestock communities make better investments and improve livelihoods in low- and middle-income countries.
- Global Academy of Agriculture and Food Safety is an interdisciplinary hub of expertise supporting decision-making to transform agri-food systems and improve food security.
- Centre for Tropical Livestock Genetics and Health (CTLGH) aims to improve livestock-based livelihoods in the tropics. Strategic partners include University of Edinburgh, the Roslin Institute, SRUC and International Livestock Research Institute (ILRI).
- Edinburgh Innovations is the University's commercialisation service with expertise across all aspects of animals, agriculture, data, and circular economy.

- Innogen, a collaboration between University of Edinburgh and the Open University, produced high quality research and supports delivery of innovation across the 3 As.
- Bayes Centre is the University's innovation hub for data science and artificial intelligence.

University of Glasgow the University of Glasgow is home to the College of Medicinal, Veterinary and Life Sciences (MVLS) bringing together internationally renowned experts. Research expertise include viral and parasitic diseases, livestock production and public health, ecology of infectious diseases, reproductive biology and research into companion animals. The MVLS also has strengths in fish biology including epidemiology and spread of disease. Research is carried out within several departments including School of Veterinary medicine, Institute of Biodiversity, Animal Health and Comparative Medicine, Institute of Infection, Inflammation and Immunology and Centre for Virus Research. The university is home to several trial facilities including:

- The Scottish Centre for Ecology and the Natural Environment (SCENE) which provides high quality wet and dry field laboratories, an aquarium and space for experimental studies.
- The Institute of Biodiversity, Animal Health and Comparative Medicine has eight temperature-controlled aquarium rooms (freshwater and seawater), aviaries to allow natural behaviours to be observed in captive birds, and the Glasgow Polyomics facility for analysis of genomes, transcriptomics, proteomes and metabolomes.
- Concho Fam and Research Centre which comprises of 344ha (including 42ha woodland), which aids in delivery of teaching and research activities including production systems, animal health, nutrition, breeding/reproduction and epidemiology. Facilities include basic surgery facility, laboratory suite, ruminant metabolism laboratory, feed mill and cattle and sheep handling/housing facilities.

University of Highlands and Islands (UHI) the University of Highlands and Islands is composed of 13 colleges and research institutes in the Highlands and Islands region of Scotland. There are several research centres within UHI which carry out AAA related research:

- SAMS (described in detail above).
- Environmental Research Institute at North Highland College activities include providing analytical services, consultancy and sediment analysis. Areas of

excellence include nutrition, salmonid migration, water quality, benthic surveys and tidal modelling.

- NAFC Marine Centre conducts research in fisheries science and the blue economy. It supports activities of production and food quality and safety.
- UHI Lipidomics Research Facility in Centre for Health Science performing lipidomic and proteomic analysis in fish and algae.
- UHI Rivers and Lochs Institute provides research, training and education focussed on freshwater biodiversity, including fish and fisheries genetics, biodiversity management, catchment management, aquaculture=environment interactions and biodiversity management and socioecology.

[University of St Andrews](#) the University of St Andrews has expertise in the blue economy including the marine environment, aquaculture, marine biotechnology. The University is home to the Scottish Oceans Institute researching a wide range of topics including fish biology, marine ecology, conservation biology, fish physiology and endocrinology, genomics, behaviour and bioacoustics. The Scottish Oceans Institute is home to the Gatty Marine Laboratory consisting of a seawater aquarium, seal pool and molecular laboratories.

[University of Stirling](#) the University of Stirling has expertise in sustainable aquaculture and food security through its Institute of Aquaculture. The Institute of Aquaculture is home to one of the largest concentrations of aquaculture expertise in Europe and one of the largest of its kind in the world. The Institute has a range of scientific expertise including genetics, sustainable aquaculture, disease and health, genetics and reproduction and nutrition. Specialist facilities include:

- Machrihanish Marine Environmental Research Laboratory, a purpose-built facility containing a commercial scale marine hatchery nursery and growing unit. This facility has a total of 151 flow through recirculating tanks including a dedicated quarantine tank and linked laboratory.
- Niall Bromage Freshwater Research Unit for freshwater studies, including Atlantic salmon smolt production, under GLP standards. The unit has a total of 42 flow through holding units and dedicated sterile room for live fish work in addition the GLP laboratory.
- Howietoun Fishery operating as a commercial fishery and hatchery for brown trout, salmonids and smolt.

[University of Strathclyde](#) the University's Electronic, Electrical and Engineering (EEE) department has expertise in engineering and agri-tech development including

the Silent Herdsman (now AfiMilk) collar for oestrus detection and health. The department also collaborate on many agri-tech grants.

INDUSTRY LANDSCAPE

Scotland offers a range of research, supply and manufacturing across the 3 As. Whilst this list below is not exhaustive, it includes start-ups, small and medium enterprises (SMEs) and multinational corporations (MNCs).

ANIMAL HEALTH

The industry animal health sector offers a wide range of expertise including consultancy, genetics and genomics, veterinary (including diagnostics, surveillance, treatments, vaccines and imaging), nutrition, gene therapy, cell cultures, drug development and production, contract research organisations and water treatment systems. These are discussed in further detail below:

Consultancy

[Food Chain Enterprises Ltd](#) Food Chain Enterprises are experts in the poultry supply chain offering consultancy and training to support poultry production.

[AbacusBio Ltd](#) AbacusBio, a science and technology consulting firm based in New Zealand and the UK, deliver solutions for clients across the agribusiness landscape, including both livestock and aquaculture.

[Supply Chain In-Sites \(SCI\)](#) SCI is a provider of services to the food supply chain and animal welfare sectors offering bespoke programs including governance, complete supply chain assessments, traceability and provenance and risk management.

Genetics/Genomics

[AB Europe](#) AB Europe, a cattle breeding and genetics company, offer solutions using reproductive technologies to the UK livestock sector.

[Roslin Technologies](#) Roslin Technologies focus on applying new biotechnologies (including stem cell and genomics) to improve sustainable protein production across both livestock and aquaculture sectors.

[Semex UK](#) Semex are a world leader in bovine genetics, reproduction and artificial insemination, covering both the dairy and beef sectors.

Wobble Genomics Wobble Genomics specialise in sequencing (RNA and DNA) and bioinformatics for discovery and detection of novel biomarkers.

Veterinary

AfiMilk Ltd AfiMilk are a global leader in developing, manufacturing and marketing advanced systems for dairy farms and herd management, including heat (oestrus) detection and health monitoring in cattle.

BDSL Irvine Ltd BDSL Irvine supply veterinary diagnostics kits which diagnose various diseases in animals.

BioBest BioBest are one of the UK's leading full service veterinary laboratories, offers research, contract and laboratory support services in infectious diseases and pathology.

Bioemitter Farming Systems Bioemitter Farming Systems offer biodynamic parasite control in livestock systems using vibration energy.

BioReliance Ltd BioReliance provide testing and manufacturing services to pharmaceutical and biopharmaceutical companies, with a focus on gene therapy and vaccine manufacturing in Scotland.

Carus Animal Health Carus Animal Health is focused on identifying and developing novel technologies which have applications in animal health with particular interests in improving care for companion animals through cutting edge innovation.

Cojengo Cojengo provide Africa's first integrated livestock disease diagnosis surveillance platform using mobile apps to enable disease diagnostics.

Fixed Phage Fixed Phage use targeted phage solutions to improve health of livestock and companion animals.

GALVmed GALVmed provide livestock health solutions including vaccines, medicines and diagnostics, making them accessible and affordable to millions in developing countries.

Herd Advance Herd Advance, a start-up company in digital agriculture, deliver an improved herd management app in the beef sector including real time health monitoring of the herd.

IceRobotics IceRobotics develop and deliver livestock behaviour monitoring systems used to detect ill health and heat (oestrus).

IMV Imaging IMV Imaging provide veterinary imaging systems for both livestock and companion animals. BCF technology, who design ultrasound for on-farm use recently joined the IMV Technologies Group.

Ingenza Ltd Ingenza are a biotechnology company specialising in high value industrial products and therapeutic proteins.

MiRNA Diagnostics Ltd MiRNA are a veterinary diagnostics company specialising in development of testing technologies for veterinary disease using microRNA (miRNA).

MV Diagnostics Ltd MV Diagnostics are an R&D company developing veterinary diagnostic kits and reagents for animal health.

NCIMB Ltd NCIMB, a microbiological and chemical analysis company, specialise in all things microbiology (bacteria, yeast, bacteriophages, plasmids etc.) and microbial/pathogen identification.

Neemco Ltd Neemco formulate and provide natural pest control, their products are livestock for control of biting and egg laying flies.

NEOGEN NEOGEN provide a comprehensive range of solutions and services focussing on improving food and animal safety, including animal and aquaculture protein production.

Novarum DX Ltd Novarum technology transforms a smartphone into a diagnostic platform for animal health (livestock and companion animal).

Vertebrate Antibodies Vertebrate Antibodies is an emerging biotechnology company providing antibody solutions for livestock, companion animals and fish to improve animal health.

Vetsina Animal Diagnostics Vetsina Animal Diagnostics are a new company formed by DESTINA Genomic and Roslin Technologies providing veterinary diagnostics (RNA & microRNA) for animal health and veterinary use.

Wyoming Interactive Wyoming Interactive are a full-service digital agency providing consultancy, development and design across multiple sectors, including digital technologies in veterinary science.

Nutrition

Roslin Nutrition Roslin Nutrition are a monogastric nutrition company focussed on formulating and manufacturing trial diets, including those to improve animal health.

Gene therapy

AskBio Ltd AskBio are a leading biotechnology company specialising in gene therapy.

BioReliance Ltd BioReliance provide testing and manufacturing services to pharmaceutical and biopharmaceutical companies, with a focus on gene therapy and vaccine manufacturing in Scotland.

Cell cultures

Cellexus Cellexus are an R&D company which develop and manufacture bioreactor systems for cell culture and fermentation applications including phages to reduce antimicrobial usage.

Contract research Organisations

Argenta Argenta are the world's only combined global Contract Research Organisation and Contract Manufacturing Organisation specialising in animal health.

BioBest BioBest are one of the UK's leading full service veterinary laboratories, offers research, contract and laboratory support services in infectious diseases and pathology. They are also UKAS, Good Laboratory Practice and Good Manufacturing Practice accredited.

EPP Ltd EPP are a Good Laboratory Practice Contract Research Organisation specialising in analytics, screening and environmental sciences.

Drug development and production

Charles River Charles River are a drug development, animal health product and agro-chemical testing facility for wide range of animal species including livestock and companion animals.

N2 Pharmaceuticals N2 Pharmaceuticals are a veterinary drug production company specialising in unique injectable medicines derived from blue mussels.

Water Treatment systems

Pure Water International Ltd Pure Water International provide advanced water filtration systems including aquaculture and livestock.

Scotmas Scotmas provide water treatment systems for use in both aquaculture and livestock.

AGRI-TECH

The industrial agri-tech sector offers a wide range of expertise including consultancy, sensors/robotics/cameras, IoT and intelligent systems, drones/unmanned aerial vehicles/satellites, material suppliers, software/mobile apps, vertical/controlled environment farming, molecular technologies and alternative systems. These are discussed in further detail below:

Consultancy

[AbacusBio Ltd](#) AbacusBio, a science and technology consulting firm based in New Zealand and the UK, deliver solutions for clients across the agribusiness landscape, including both livestock and aquaculture.

[Wyoming Interactive](#) Wyoming Interactive are a full-service digital agency providing consultancy, development and design across multiple sectors, including digital technologies in veterinary science.

Sensors/Robotics/Cameras

[AfiMilk Ltd](#) AfiMilk are a global leader in developing, manufacturing and marketing advanced systems for dairy farms and herd management, including heat (oestrus) detection and health monitoring in cattle.

[Crover](#) Crover offers unique grain storage solutions to automate monitoring for optimal storage conditions.

[IceRobotics](#) IceRobotics develop and deliver livestock behaviour monitoring systems used to detect ill health and heat (oestrus).

[IMV Imaging](#) IMV Imaging provide veterinary imaging systems for both livestock and companion animals. BCF technology, who design ultrasound for on-farm use recently joined the IMV Technologies Group.

[Innovent Technology Ltd](#) Innovent Technology develop agri-tech solutions for livestock (PLF) applications including software and imaging.

[SoilEssentials](#) SoilEssentials provide precision farming solutions for farmers by farmers.

[Spectrolytic Ltd](#) Spectrolytic provide spectroscopy solutions across multiple sectors including milk analysis in the dairy sector and phosphate and nitrate sensors during crop spraying.

Syngenta Syngenta are a global agri-tech company, focussed on arable. Syngenta are headquartered in Switzerland but have a manufacturing plant in Scotland.

Taylor Technologies Ltd. Taylor Technologies are an R&D agri-tech company developing spraying automation in the arable sector.

ZIVA Robotics ZIVA provide robotic vehicles to help monitor crop health and growth in polytunnels. ZIVA were previously known as CASTA SPES Technologies Ltd.

Internet of Things (IoT) and intelligent systems

Celestia UK Celestia specialise in terrestrial and space borne IoT devices including drone and unmanned aerial vehicles for crop spraying.

Greengage Enlightened Farming Ltd Greengage Enlightened Farming supply smart lighting solutions to improve animal welfare and productivity.

R3 IoT R3 IoT combine satellite technology with IoT, applications include remote environment monitoring through satellite imaging.

Data/Artificial Intelligence

Arc-Net Arc-Net improve traceability, transparency and security to supply chains via blockchain, this system is used in to improve traceability in the arable sector.

Dyneval Ltd Dyneval provide automated technology solutions for pen-side semen analysis using artificial intelligence.

Global Surface Intelligence Global Surface Intelligence combine big data analytics and imaging from satellites, drones and unmanned aerial vehicles to changing land use, forestry and agriculture.

Drones/UAVs/Satellites

Apem Ltd APEM is Europe's leading environmental consultancy service specialising in marine and land-based aquaculture, ecology and aerial surveys.

Astrosat Astrostat are an earth observation company utilising satellite technology, applications in agriculture include soil moisture monitoring.

Ecometrica Ecometrica provide environmental monitoring solutions to improve resource management and build resilience, including monitoring impacts of climate change (water and land).

Global Surface Intelligence Global Surface Intelligence combine big data analytics and imaging from satellites, drones and unmanned aerial vehicles to changing land use, forestry and agriculture.

Space Intelligence Space Intelligence supply landscape mapping using satellite images. Applications in agriculture include above ground carbon storage, land cover and land use changes, and habitat loss.

Material suppliers

NoPollution Industrial Systems Ltd. NoPollution are experts in mechanical and electrical engineering, including in the agriculture sector. Specialisms include environmentally controlled chambers (e.g., SRUC's GreenCow GHG facility).

Pentland Material Supply Pentland Material Supply specialise in engineering providing solutions to agriculture - projects have included GreenCow at SRUC and Intelligent Growth Solution's vertical farming system.

Ritchie Agricultural Ritchie are providers of agricultural equipment in Scotland including specialised agri-tech equipment (e.g. BeefMonitor water trough/weigh crate).

Software/Apps

Cojengo Cojengo provide Africa's first integrated livestock disease diagnosis surveillance platform using mobile apps to enable disease diagnostics.

Datamars Livestock Datamars provide platforms and tools for farm and livestock management.

Farm-Hand Farm-Hand provide data driven farm management solutions for sensor-free precision irrigation allowing improved farm management for small-medium holders globally.

Herd Advance Herd Advance, a start-up company in digital agriculture, deliver an improved herd management app in the beef sector including real time health monitoring of the herd.

iLivestock iLivestock provide farm management software for the livestock sector. eWeigh addition allows for fully integrated system to weigh cattle.

Novarum DX Ltd Novarum technology transforms a smartphone into a diagnostic platform for animal health (livestock and companion animal).

Peacock Technology Peacock specialise in engineering, robotics/automation and machine vision/artificial intelligence, with uses in the agriculture sector.

Controlled Environment Farming

Intelligent Growth Solutions Intelligent Growth Solutions are experts in controlled environment agriculture, installing the first vertical farm in Scotland.

Liberty Produce Future Farming Hub Liberty Produce Future Farming Hub, based at the James Hutton Institute, is a state-of-the-art fully contained and controlled vertical farming system.

Shockingly Fresh Shockingly Fresh are experts in vertical farming including hydroponic farming.

The Aquaponics Garden The Aquaponics Garden provide scalable aquaponics and vertical farming systems.

Vertegrow Vertegrow provide vertical farming and controlled environment farming solutions.

Molecular technologies

AskBio Ltd AskBio are a leading biotechnology company specialising in gene therapy.

BeeBytes Analytics CIC BeeBytes Analytics specialise in honeybee genetics and DNA analysis.

Cellexus Cellexus develop and manufacture cell culture and fermentation technologies including phage use to reduce antimicrobial usage.

Charles River Charles River are a drug development, animal health product and agro-chemical testing facility for wide range of animal species including livestock and companion animals.

Edinburgh Genomics Edinburgh Genomics are the largest academic DNA sequencing facility (by output) in the UK, with expertise in post-processing/bioinformatics

Green Bioactives Ltd Green Bioactives create sustainable sources of plant biomolecules and extracts to supply agriculture industries.

Ingenza Ltd Ingenza are a biotechnology company specialising in high value industrial products and therapeutic proteins.

Semex UK Semex are a world leader in bovine genetics, reproduction and artificial insemination, covering both the dairy and beef sectors.

Wobble Genomics Wobble Genomics specialise in sequencing (RNA and DNA) and bioinformatics for discovery and detection of novel biomarkers.

Alternative Systems

BetaBugs Ltd BetaBugs are an insect genetics company developing and distributing black soldier fly breeds within the insect farming sector.

SEM SEM pioneer disruptive new technologies that process co-products helping achieve a circular economy.

Solasta Bio Solasta Bio develop targeted and pollinator friendly bioinsecticides which are safe for non-target organisms.

AQUACULTURE

The industry aquaculture sector offers a wide range of expertise including breeding and genetics, production, nutrition, health and welfare, water quality, technological solutions and consultancy. These are discussed in further detail below:

Breeding/genetics

Aquagen Aquagen, headquartered in Norway, are an aquaculture breeding and genetics company.

Cryogenetics Technologies UK Ltd Cryogenetics Technologies provide cryopreservation and fertilisation services within the aquaculture sector.

Landcatch Ltd/Hendrix Genetics Landcatch provide innovative genetic and breeding solutions to the aquaculture sector.

Roslin Technologies Roslin Technologies focus on applying new biotechnologies (including stem cell and genomics) to improve sustainable protein production across both livestock and aquaculture sectors.

Wobble Genomics Wobble Genomics specialise in sequencing (RNA and DNA) and bioinformatics for discovery and detection of novel biomarkers.

Xelect Ltd Xelect are specialists in genetics and provide genetic solutions for the aquaculture sector.

Production

Aggreko Aggreko provide heating, colling and power supply chain rental in the aquaculture sector.

Aqua Innovation Ltd Aqua Innovation provide practical solutions for aquaculture, including production and construction of recirculating aquaculture systems.

Aquamoor Ltd Aquamoor deliver sustainable mooring solutions, including for applications in aquaculture and seaweed farming.

Brow Well Fisheries/Ae Fishery Fishery (trout) based in Dumfries and Galloway.

Cooke Aquaculture Scotland Cooke Aquaculture is one of the leading Scottish salmon producers.

Fass Fern Mussels Producers of rope grown mussels.

Feamainn Feamainn are a start-up in the aquaculture sector commercially growing seaweed.

FiiZK FiiZK are a supplier of semi-closed- and closed- cage systems for aquaculture. They also specialise in software development and treatment tarps for cages.

Fishfrom Fishfrom are a salmon farming business using and developing scalable recirculating systems.

Gael Force Group Gael Force Group are an equipment and technology provider, supplying all aspects of aquaculture production.

Green Sea Solutions Green Sea Solutions are developing and cultivating a sustainable seaweed farming system.

Inverlussa Marine Services Inverlussa Marine Services is one of Scotland's leading workboat operators, with a fleet of modern vessels servicing aquaculture businesses throughout the UK and Europe.

Inverlussa Shellfish Company Inverlussa Shellfish Company is a large mussel producer.

Invicta Trout Invicta Trout, a trout farming business, provide aquaculture consultancy and advisory services to land based trout farmers, covering all aspects of freshwater trout farming.

Isle of Skye Mussel Company Isle of Skye Mussel Company are a sustainable mussel farming operation.

Kames Fish Farming Kames are a large trout fish farming operation and also a supplier of aquaculture equipment.

Load Monitoring Systems Load Monitoring Systems design and manufacture in load monitoring equipment in the aquaculture sector.

[Loch Duart](#) Loch Duart are a Scottish salmon producer.

[Loch Fyne Oysters](#) Loch Fyne Oysters are a Scottish seafood producer

[MiAlgae](#) MiAlgae harnesses microalgae as a source of Omega-3 as an alternative to wild-caught fish.

[Mowi Scotland](#) Mowi are the UK's largest supplier of farm-raised salmon.

Namara Projects Ltd Namara Projects are an aquaculture R&D company.

[EFC Scotland Ltd](#) EFC Scotland (formerly Niri Scotland) provide recirculating aquaculture systems for salmon farming.

[Norfab Equipment Ltd](#) Norfab are a bespoke equipment supplier in aquaculture sector.

[North Bay Innovations Limited](#) North Bay Innovations, previously North Bay Shellfish Ltd., provide sustainable solutions for aquaculture.

[Organic Sea Harvest](#) Organic Sea Harvest are a Scottish organic farmed salmon producer.

[Orkney Shellfish Hatchery](#) Orkney Shellfish Hatchery are a land-based oyster hatchery.

[Otter Ferry Seafish](#) Otter Ferry Seafish, one of the longest established Aquaculture businesses in the UK, specialises in lumpfish and wrasse and is UK's only halibut hatchery operating in conjunction with Gigha Halibut which grows on halibut juveniles.

[ScaleAQ](#) ScaleAQ, an international aquaculture company, specialising in engineering and production of aquaculture solutions. This was formed after a merger of Steinsvik UK, Aqualine and AquaOptima.

[Salmon Scotland](#) Salmon Scotland (previously Scottish Salmon Producers Organisation) help create conditions for the long-term and sustainable growth of the Scottish salmon sector, representing all salmon farming companies in Scotland.

[Scottish Sea Farms](#) Scottish Sea Farms are a major producer of Scottish farmed salmon.

Shetland Mussels Ltd Shetland Mussels are a mussel producer.

[The Scottish Salmon Company](#) The Scottish Salmon Company are a major producer of Scottish farmed salmon.

[Todd Fish Tech Ltd](#) Todd Fish Tech design and manufacture shellfish systems, specialising in those used in research aquaria. Recently merged with Fisheries Enhance.

[Wester Ross Fisheries](#) Wester Ross Fisheries are a small Scottish salmon producer

Xanthella Xanthella design and manufacture photobioreactors to grow photosynthetic products on both lab and industrial scale, this includes growing high-value micro-algae in Scotland (Oban).

Nutrition

BioMar BioMar are a global leader in aquaculture feed supplying high performance diets within the aquaculture sector.

Cargill Aqua Nutrition (EWOS) EWOS, an international leader in aquaculture nutrition, supply feed to the aquaculture sector. EWOS have recent investment in salmoNIR, a handheld fat scanner for salmon.

Mowi Scotland Mowi are the UK's largest supplier of farm-raised salmon, Mowi Scotland also operates a new state-of-the-art feed mill on the Isle of Skye.

Northeast Nutrition Scotland, owned and operated by Cooke Aquaculture, operate a salmon feed mill at Invergordon.

GlycoMar Limited GlycoMar have expertise in discovery and development of glycomolecules from microalgae, which are subsequently used in aquaculture (feed).

Health and welfare

Aqualife Services Aqualife are a global leader in fish care and vaccination services after a merger with Salmovac.

Aquatic Diagnostics Ltd Aquatic Diagnostics develop and manufacture reagents and kits to improve fish health.

Benchmark Animal Health Benchmark develop solutions in genetics, health and nutrition to improve performance and fish health and welfare.

Bioemitter Farming Systems Bioemitter Farming Systems offer biodynamic parasite control in aquaculture using vibration energy.

EPP Ltd EPP are a Good Laboratory Practice Contract Research Organisation specialising in analytics, screening and environmental sciences.

Fixed Phage Fixed Phage use targeted phage solutions to improve health of farmed fish.

GenusWave Ltd GenusWave provide breakthrough acoustic technology to deter seals thus improving welfare and salmon health.

Highland Aqua Team Highland Aqua Team provide vaccination services and net refurbishment in the fin fish aquaculture sector.

Kelpring Kelpring uses natural kelp to clean fish habitats in salmon farming, achieved by providing a natural kelp forest for wrasse and lumpfish within the lice zone in salmon pens.

Mørenot Scotland Mørenot provide innovative solutions to improve fish health and efficiency fish farming and aquaculture.

Neemco Ltd Neemco formulate and provide natural pest control, their products are used in aquaculture for sea lice control.

NEOGEN NEOGEN provide a comprehensive range of solutions and services focussing on improving food and animal safety, including animal/aquaculture protein production.

Nevis Marine Ltd Nevis Marine are specialists in applied fish welfare, pest management and innovation in the aquaculture sector.

Nordic Cover AS Nordic Cover design and develop cleaner fish habitats and lice skirts in the aquaculture sector.

Patogen Patogen are fish health R&D experts focussing on preventing infection, disease and injury. Patogen have recently been acquired by Fürst Medical Laboratory and recently established a new laboratory for preventative and diagnostic services based in Oban.

PHARMAQ Analytiq UK PHARMAQ Analytiq applies research and analysis techniques to safeguard fish health and welfare in the aquaculture sector. Previously branded as FishVet Group under ownership of Benchmark Holdings.

Pulcea Ltd Pulcea use technical innovations to improve fish health, welfare, and productivity.

SMIR Scotland Ltd SMIR Scotland, part of Norwegian Company SMIR, optimise fish health and welfare including delousing of salmon. SMIT Scotland was previously branded as Hydrolicer Scotland Ltd.

STIM STIM provide health and welfare solutions, including bacteriophage technology, in the aquaculture. STIM was formed with merger of sister companies Europharma, Fishguard and ACD Pharma.

Vertebrate Antibodies Vertebrate Antibodies is an emerging biotechnology company providing antibody solutions for livestock, companion animals and fish to improve animal health.

Water Quality

[Aqualution Systems Ltd](#) Aqualution Systems manufacture hygiene solutions (hypochlorous acid) for agriculture and aquaculture uses.

[Aquatiq Hygiene Systems Ltd](#) Aquatiq Hygiene Systems (previously Hygiene Teknikk) specialise in the production of cleaning systems for aquaculture dosing.

[Clean Water Wave Ltd](#) Clean Water Wave provide cost-effective water treatment systems to transform polluted into clean water.

[Dryden Aqua Ltd](#) Dryden Aqua specialise in sustainable solutions for water treatment of aquatic life support systems.

[I & C Process Solutions](#) I & C Process Solutions specialise in water and waste water optimisation, treatment and recovery.

[Pure Water International Ltd](#) Pure Water International provide advanced water filtration systems including aquaculture.

[Russell Mainstream Supply Ltd](#) Russell Mainstream Supply specialise in hygiene and water treatments, supplying instruments to measure dissolved O₂, temperature and pH to the aquaculture sector.

[Scotmas](#) Scotmas provide water treatment systems for use in both aquaculture and livestock.

[Sternor Aquatech](#) Sternor Aquatech provide water treatment and electrical engineering solutions for the aquaculture sector.

[Trimara Services](#) Trimara is a provider of automated cleaning machines for aquaculture systems.

[Triogen Ltd \(Suez Group\)](#) Triogen specialise in ozone, UV and advanced oxidation process for water treatment, including applications in aquaculture.

Technological innovations

[Ace Aquatec](#) Ace Aquatec are leading experts providing breakthrough technologies to the marine and aquaculture sector.

[AKVA Group](#) AKVA are a global aquaculture and technology service provider for both land- and offshore- aquaculture.

[Algacraft](#) Algacraft are an emerging provider of fully automated analysis of algae growth using cutting-edge photobioreactors.

[Gael Force Group](#) Gael Force Group are an equipment and technology provider, supplying all aspects of aquaculture production.

HonuWorx HonuWorx are a sub-sea robotics company specialising in robotic operations in offshore aquaculture.

Imenco Imenco provide subsea camera, light, laser, acoustic and electronic technologies in aquaculture and other offshore sectors.

Lallemand Aquapharm Ltd Lallemand are a marine bio-technology company screening marine organisms to improve aquaculture systems using their patented SeaRch™ technology.

OTAQ Ltd OTAQ Ltd, and OTAQ Aquaculture, provide innovative technology and engineering solutions to optimise aquaculture operations globally.

Precision Subsea Precision subsea are a mechanical and engineering company specialising in subsea cameras, offering expertise in aquaculture, fisheries and oceanography, among others.

Rastech Research CIC Rastech design technology to improve sustainability of aquaculture including novel recirculation aquaculture systems.

SalmoSim SalmoSim is a start-up from the University of Glasgow offering in vitro systems and facilities for aquafeed nutrition, veterinary pharmaceuticals and microbiome assessments using an innovation simulator of the salmon gastro-intestinal tract.

Spectis Robotics Spectis Robotics provide and manufacture world-leading robotic crawler and camera systems for underwater and aquaculture applications.

Tritech International Limited Tritech offers innovative technologies for underwater applications including imaging and acoustic systems.

Tritonia Scientific Tritonia provide specialist diving services for advanced scientific operations including underwater observations using photogrammetric 3D digital monitoring allowing autonomous and remote monitoring.

Vaki Scotland Ltd VAKI Scotland delivers technologies to monitor and estimate stock and biomass in aquaculture systems.

Consultancy

Aquatera (Environmental Services and Products) Aquatera operates a global environment consultancy operation with specialism in aquaculture, and other offshore, coastal and land-based blue economies.

Invicta Trout Invicta Trout provide aquaculture consultancy and advisory services to land based trout farmers, covering all aspects of freshwater trout farming.

Simply Blue Aquaculture (Simply Blue Group) Simply Blue Aquaculture, part of the Simply Blue Group, are a salmon farming consultancy contracting and installation provider helping to deliver low impact aquaculture in the blue economy.

INNOVATION CENTRES & CENTRES OF EXPERTISE

Four of Scotland's eight Scottish Government funded innovation centres are linked to the AAA sector.

Agri-Epi Centre Agri-Epi Centre, one of 4 InnovateUK agri-tech innovation centres, focusses on collaborations using innovation, technology and precision engineering for UK farming. There is also a satellite farm network acting as a test-bed for agri-tech research and development on commercial farms.

CENSIS CENSIS, one of eight innovation centres, focusses on sensing, imaging and IoT technologies. They offer independent trusted advice and support to private businesses and public sector organisations to accelerate innovation.

Centre for Innovation Excellence in Livestock (CIEL) CIEL, one of four InnovateUK agri-tech innovation centres, focusses on livestock production including innovative technologies. CIEL has a network of academic and industry members encompassing all aspects of the supply chain.

ClimateXChange (CXC) CXC offer advice research and analysis to support policy development on climate change for the Scottish Government, including through improving emissions from livestock and crop and soils.

Centre of Expertise for Waters (CREW) CREW is a Scottish Government funded partnership between the James Hutton Institute and all Scottish Higher Education Institutes and Research Institutes supported by Marine Alliance for Science and Technology for Scotland. CREW informs all areas of water policy in Scotland, by delivering objective and robust research and expert opinion.

DataLab DataLab, one of eight innovation centres based on data and artificial intelligence, supports Scotland to maximise value from data strengthening the thriving data science community.

Epidemiology, Population Health and Infectious Disease Control (EPIC) EPIC, the Scottish Government funded centre of expertise on animal disease outbreaks, brings together a consortium of expertise in the field. The consortium consists of University of Glasgow, the James Hutton Institute, SRUC, BioSS, Moredun Research Institute, Roslin Institute and the Global Academy of Agriculture and Food Security.

Industrial Biotechnology Innovation Centre (IBioIC) IBioIC, one of eight Scottish innovation centres, connects industry, academia and government, providing support to companies to growth the Scottish biotechnology sector.

Innovation Hub for Controlled Environment Agriculture (IHCEA) Liberty Produce and Crop Health and Protection (CHAP) have partnered to establish the Innovation Hub for Controlled Environment Agriculture which is housed at the James Hutton Institute, Invergowrie. IHCEA develop test and research next-generation technologies to improve the cultivation of indoor and protected crops.

James Hutton Institute International Barley Hub and Advanced Plant Growth Centre Two new innovation projects, totalling £62m, funded by the UK Government and Scottish Government (through Tay Cities Region Deal) have recently started operating (main infrastructure will be complete in 2023) and attracting new start-ups and investment. The International Barley Hub will develop new varieties and growing systems to future proof the barley sector against climate change. The Advanced Plant Growth Centre (APGC) will revolutionise crop productions including the use of indoor vertical farms ultimately reducing cop productions environmental impact. APGC's key foci are pre-and post-harvest technologies and solutions to support, develop and create plant and crop-based industries. This places the APGC at the centre of the emerging disruptive global technologies of total controlled environment agriculture including vertical farming.

Plant Health Centre (PHC) PHC is a virtual centre of expertise funded by Scottish Government though RESAS aiming to tackle plant health challenges. The centre is led by James Hutton Institute with sector leads from SRUC, Royal Botanic Garden Edinburgh and Forest Research.

Scotland 5G Centre The Scotland 5G Centre, in partnership with University of Strathclyde, University of Glasgow, Scottish Government and Scottish Futures Trust, is the national centre for 5G which will accelerate deployment and adoption of 5G in Scotland, which enables many rural communities and farms connectivity enabling greater uptake of technology innovations.

Sustainable Aquaculture Innovation Centre (SAIC) SAIC, previously Scottish Aquaculture Innovation Centre, provides funding and support for commercially relevant and collaborative research in the aquaculture sector by connecting businesses and academics. SAIC is one of eight Scottish innovation centres to drive growth in key economic and social importance and has >150 consortium members.

NETWORKS, CONSORTIUMS & CO-OPERATIVES

BioDundee BioDundee is a partnership between public, private, academic and third sector organisations in Dundee and the surrounding areas. The BioDundee community includes stakeholders in life sciences, research services, digital, education and skills, medical technology and design, and professional services.

Centre for Tropical Livestock Genetics and Health Partnership between SRUC and International Livestock Research Institute (ILRI) and funded by Bill and Melinda Gates Foundation and Department for International Development. The aim of this partnership is to improve health and productivity of livestock to alleviate hunger, malnutrition and poverty through genetic selection.

Easter Bush Research Consortium EBRC is a consortium of key players in the animal and veterinary science sector and consists of the Roslin Institute, SRUC, R(D)SVS, and Moredun Research Institute.

EIT Food EIT Food is Europe's leading knowledge and innovation community, making food system more sustainable. This is achieved through innovation, education, entrepreneurship, and public engagement.

Global Scot The Global Scot network provides an international network of Scottish businesses, entrepreneurs and professionals, offering skills, expertise and connections to support Scottish businesses.

IoT Scotland IoT Scotland, launched in 2018 as a partnership between Scottish Government, Scottish Enterprise, Highland and Islands Enterprise and North, is Scotland's national IoT network and the most advanced network in the UK.

James Hutton Institute Open Science Campus JHI operate an Open Science Campus at Craigiebuckler, Aberdeen and Invergowrie, nr Dundee. Twelve life science and agri-tech organisations are co-located here including MycoNourish, Bloom Biotechnologies, Intelligent Growth Solutions and Liberty Produce.

Knowledge Transfer Network (KTN) The UK Knowledge Transfer Network for biosciences, is at the interface of UK funding, scientific capacity, and industrial need. KTN connect innovators with new partners and new opportunities, with expertise in the agri-food sector.

Marine Alliance for Science and Technology for Scotland (MASTS) MASTS, formed in 2009, is a consortium of organisations involved in marine science, representing the majority of Scotland's research capacity.

Midlothian Science Zone Midlothian Science Zone is a world-leading centre of research excellence in animal health and life sciences based in the Easter Bush Campus. The cluster consists of academia, innovative companies, spin outs and start-ups.

Smart Rural Co-Op Smart rural co-op, a subsidiary of SAOS, is a Scottish agri-tech farming co-op using technology to improve sustainability, efficiency and profitability of

farming systems. Technologies are focussed on livestock, arable, environmental monitoring and safety.

SCIENCE PARKS

[European Marine Science Park](#) Located in Oban, the European Marine Science Park is a cluster of emerging marine businesses. The Park offers laboratory and office space.

[Inverness Campus](#) Inverness campus, developed by Highlands and Islands Enterprise, brings together businesses, researchers, academia and scientists operating in life sciences, digital healthcare and technology into one location.

[Pentlands Science Park Ltd](#) Pentlands Science Park provides a supported environment for >20 commercial tenants involved in life science R&D.

[Roslin Innovation Centre](#) The Roslin Innovation Centre, the business gateway for companies at Easter Bush Campus, offers flexible office and lab space to help grow and accelerate opportunities in a collaborative community. The Innovation centre is situated at the heart of the Easter Bush Campus. Tenants in the centre have a focus on animal and veterinary science, agri-tech, aquaculture and animal health.

GOVERNMENT & DEVELOPMENT AGENCIES

[Animal & Plant Health Agency \(APHA\)](#) APHA, the executive agency of DEFRA, provide research, consultancy and, diagnosis and surveillance on farm animal diseases.

[Highlands and Islands Enterprise \(HIE\)](#) HIE are the economic and community development agency, providing funding and investment in the Highlands and Islands. Regional projects in the AAA sector include:

- European Marine Science Park – business cluster providing laboratory and office accommodation in marine sciences.
- Inverness Campus – cluster of stakeholders in the life sciences sector, including businesses, academics (University of Highlands and Islands and SRUC), and research institutions.

[Interface](#) Interface connects national and international industries to Scotland's universities, research institutes and colleges, working across all sectors.

[Marine Scotland Science](#) Marine Scotland Science, the scientific division of the Marine Scotland Directorate, provides advice and services relating to aquaculture and provides evidence to support policies and regulation.

Science & Advice for Scottish Agriculture (SASA) SASA, a division of the Scottish Government, provide scientific services and advice to support Scottish agriculture.

ScotEID ScotEID works closely with the Scottish livestock sector and Scottish Government to record animal movements (e.g. births, deaths, movement) to improve traceability across the sector, including new regulation around electronic identification of animals.

Scottish Agricultural Organisation Society (SAOS) SAOS are Scotland's experts on farmer co-ops and collaborations in the food sector. They provide a range of development and consultancy services including technology innovations and data.

Scottish Development International (SDI) SDI is Scotland's trade and inward investment agency, with a network of >30 offices globally.

Scottish Enterprise Scottish Enterprise is an economic development agency and a non-departmental public body of the Scottish Government. Investments include Intelligent Growth Solutions.

South of Scotland Enterprise (SOSE) SOSE, launched in 2020, is the economic and community development agency for Dumfries and Galloway and the Scottish Borders. SOSE are a partner in the dairy nexus project (see below).

CHARITIES

Equine Grass Sickness Fund The Moredun Foundation's Equine Grass Sickness fund is a registered charity (the only of its kind in the UK) which raises funds specifically for grass sickness research.

St Abbs Marine Station St Abbs Marine Station is a registered charity dedicated to marine science, conservation, and education. It has recently started a partnership with University of Edinburgh to increase sustainability in marine and sea ecosystems. The station consists of a laboratory, adjoining research aquarium, and mesocosm facility.

ACCELERATORS AND VENTURE STUDIOS

Agri-Epi Centre Business Incubation Agri-Epi Centre offer office space and practical technology business incubator workshop spaces to aid product and company incubation.

DDI AI Accelerator The DDI AI Accelerator, financed through the Scottish Funding Council and DDI programme, aims to scale up and accelerate data-driven AI start-ups.

Food & Agriculture Science Transformer (FAST) FAST, Scotland's first venture studio, is a collaboration between the University of Edinburgh and Deep Science Ventures. The programme will create high growth technology start-ups in the agriculture sector.

HIE Pathfinder HIE's Pathfinder provides opportunities for entrepreneurs to accelerate their new product or business in four months including training, mentoring and networking opportunities. In March 2022, a new dedicated animal health (animal livestock and aquaculture) cohort begun, the first of its kind in Scotland.

FUTURE AAA LANDSCAPE

Dairy Nexus and Digital Dairy Value Chain The dairy nexus, situated at SRUC's Barony campus, will be a start-of-the-art facility to decarbonise the dairy industry gaining more than £21m in funding. This forms part of the Borderlands Inclusive Growth Deal, with additional funded from UKRI's Strength in Places Fund and South of Scotland Enterprise (partners including CENSIS, University of Strathclyde and University of West of Scotland, Afimilk among others).

Easter Bush Agri-tech Hub The Easter Bush Agri-Tech hub, funded through Edinburgh and South East Scotland City Region Deal (£74m), aims to establish Edinburgh as the data capital of the world. The new hub, which will be based at Easter Bush, will use data to develop health and genetic innovations in the agri-science space to transform the sector to reach net-zero and achieve sustainable food production systems.

SeedPod SeedPod a new £21m development hub, led by Opportunity North East (ONE) and funded by the UK Government and Scottish Government (Aberdeen City Region Deal), is due to open in 2022 on SRUC's Craibstone Campus. SeedPod will place businesses in the region at the forefront of innovation and sustainability driving Scotland's green recovery.

SRUC Rural and Veterinary Innovation Centre (RAVIC) This £9m innovation centre, based on the Highlands and Islands Enterprise Inverness Campus, will create and support the development of new and existing small to medium size businesses to grow job and the economy. The centre will focus on SRUC's, SAC Consulting's and SRUC Veterinary Service's existing expertise in animal health, infectious disease control and zoonotic disease research.

SRUC Vertical farm The new vertical farm, funded by the Scottish Government and dedicated to research, education and knowledge exchange, will be the first of its kind in a higher education institute in Scotland. The new facility will be built at the King's Buildings Campus in 2022.

SRUC Vet school SRUC's new veterinary school, based in Aberdeen and Inverness, will be Scotland's first new school of veterinary medicine in >150 years. The new school is expected to add £26 million and create 238 jobs in Scotland by 2030.

Royal DSM Bovaer will create a new production site for their novel methane reducing feed additive for ruminants in Dalry. The new plant plans to be operational in 2025.

Centre for Agricultural Sustainability and Innovation (CASI) funded under the Angus Deal with a location at the James Hutton Institute Balruddery LEAF Innovation Centre will provide a field platform and facilities for testing new agri-tech technologies.

SURVEY TO KEY STAKEHOLDERS

OBJECTIVES, METHODOLOGY AND DATA COLLECTED

An online survey (Google Forms) was created and circulated to key stakeholders in the AAA sector. The survey was circulated through Life Science Scotland's Industry Advisory Group (AAA Subgroup) and related contacts, social media, and regional news/press releases. The survey was open to responses between 12th April 2021 and 31st May 2021 and was fully approved by both SRUC's Social Science Ethics Committee and Scottish Government's Rural & Environmental Sciences and Analytical Services (RESAS) prior to circulation. Data collected in this survey included basic demographic information (e.g. geographical location, company type, sector area), key facilities/recourses, collaborations and international links, and opinions on current opportunities and challenges to the sector, particularly around COVID-19, BREXIT and green recovery. A copy of the circulated survey form can be found in Appendix 2.

RESULTS

There were 21 responses in total to this survey. Two responses were removed – one respondent did not complete the survey fully and one respondent completed it from a post-farm gate perspective.

DEMOGRAPHIC INFORMATION

Of the 19 responses, seven respondents were from research/innovation centres, six from the private sector, five from academia, three from the public sector, four from research/innovation centres and two responses for "other" (trade body and consultancy). Fifteen respondents worked in the aquaculture sector, 14 in agri-tech and 11 in the animal health sector, note that respondents had the option to select more than one of the three As. The majority of respondents had headquarters in the central belt of Scotland, particularly centred in Midlothian (Midlothian, 10; Highland, 3; City of Edinburgh, 2; Glasgow City, 2; Argyll and Bute, 1; Perth and Kinross, 1). Respondents

were asked to provide information on other sites out with headquarters/main office. These included Argyll and Bute (3), Highland (3), Aberdeenshire (2), City of Edinburgh (2), Comhairle nan Eilean Siar (2), Glasgow City (2), Moray (2), Orkney (2), Shetland Islands (2), Aberdeen City (2), Angus (1), Dumfries and Galloway (1), East Lothian (1), Fife (1), Scottish Borders (1) and Midlothian (1). A summary of this can be found in Figure 2.

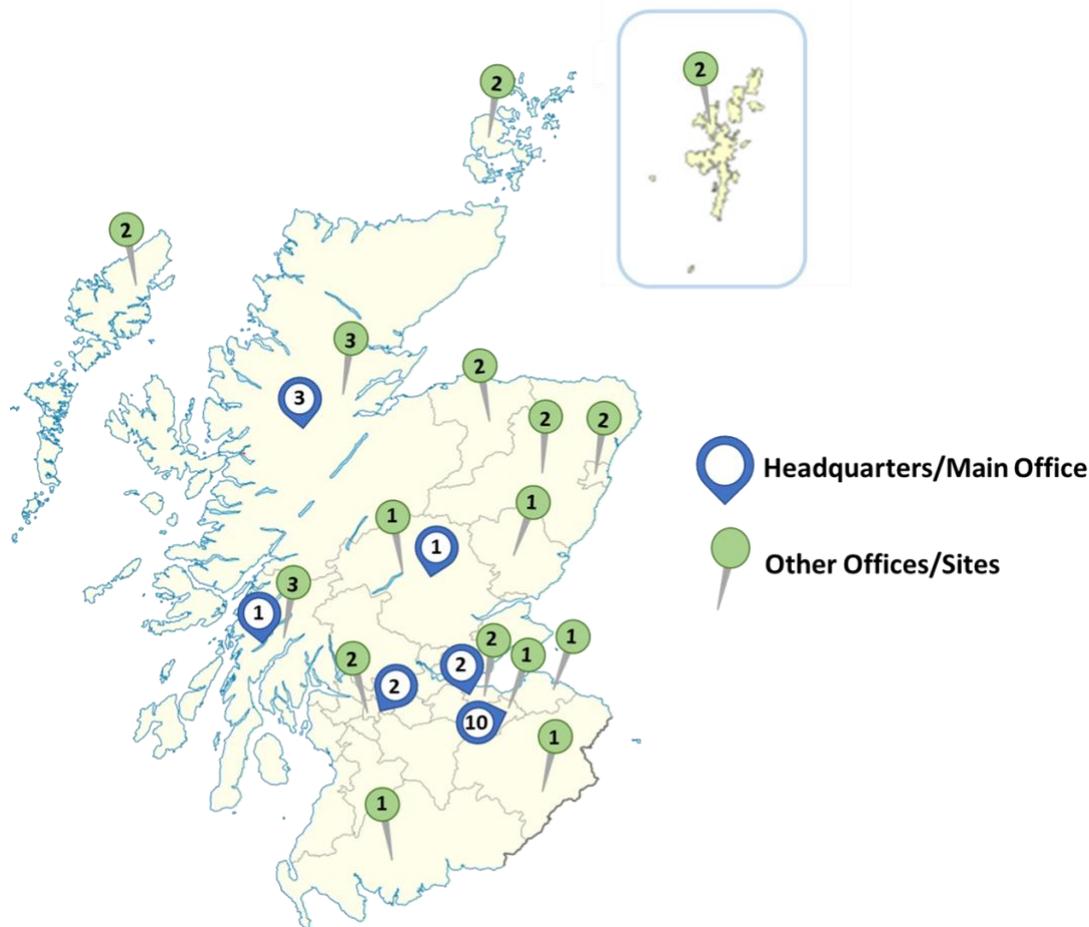


Figure 2 – Geographic location of headquarters and other sites/offices of survey respondents. Map edited from National Library of Scotland’s map of Scotland.

FACILITIES/RESOURCES

This section of the survey aimed to highlight key assets, facilities and resources within the AAA sector in Scotland.

Key assets, resources, and facilities

Skills and expertise were identified as the top (58%) asset/resource, responses noted particular expertise and skills in “big data” and Internet of Things (IoT) (16%),

intellectual property (16%) and disease models, diagnostic and surveillance serves and immunological expertise (5%). Research facilities were also identified as being key assets and facilities within the AAA sector (53%). This includes both animal/field facilities (37%) and lab facilities (37%), with several respondents noting good laboratory practice (GLP) compliance (11%). Eleven percent of respondents did not respond to the question.

Strategic expertise

Survey respondents were asked to identify and provide information on their top three themes for their strategic expertise. The top two themes identified were genetics and breeding (37%) within both livestock and aquaculture sectors, and animal health (37%). Within animal health, respondents noted expertise in one health (16%), disease diagnostics, investigations and control (16%), disease modelling (11%) and vaccines/therapeutics (11%). Other themes included agri-tech (26%) including “big-data” and engineering expertise, aquaculture (16%), analytical services (11%), stakeholder engagement, links to policy and regulation (11%), economic development (11%) and insect pests (5%). Five percent of respondents did not answer the question. This is summarized in Figure 3.



Figure 3 – Word Cloud of strategic expertise in the AAA sector in Scotland.

Strongest asset/unique selling point

Expertise within the sector was identified as the greatest asset (53%), this included cross-sector and multidisciplinary expertise (21%), expertise in data and data analytics (21%), animal health and disease modelling (11%) and genetics (5%). Other assets included facilities (26%), both laboratory-based facilities (11%) and animal/trial facilities (5%). Further responses included strong networks (32%) including “*national and international networks*” (16%), being at the “*epi-centre of the highest concentration of animal related expertise in Europe*” (Easter Bush Campus; 5%) and business support and economic development (11%). This is summarized in Figure 4.

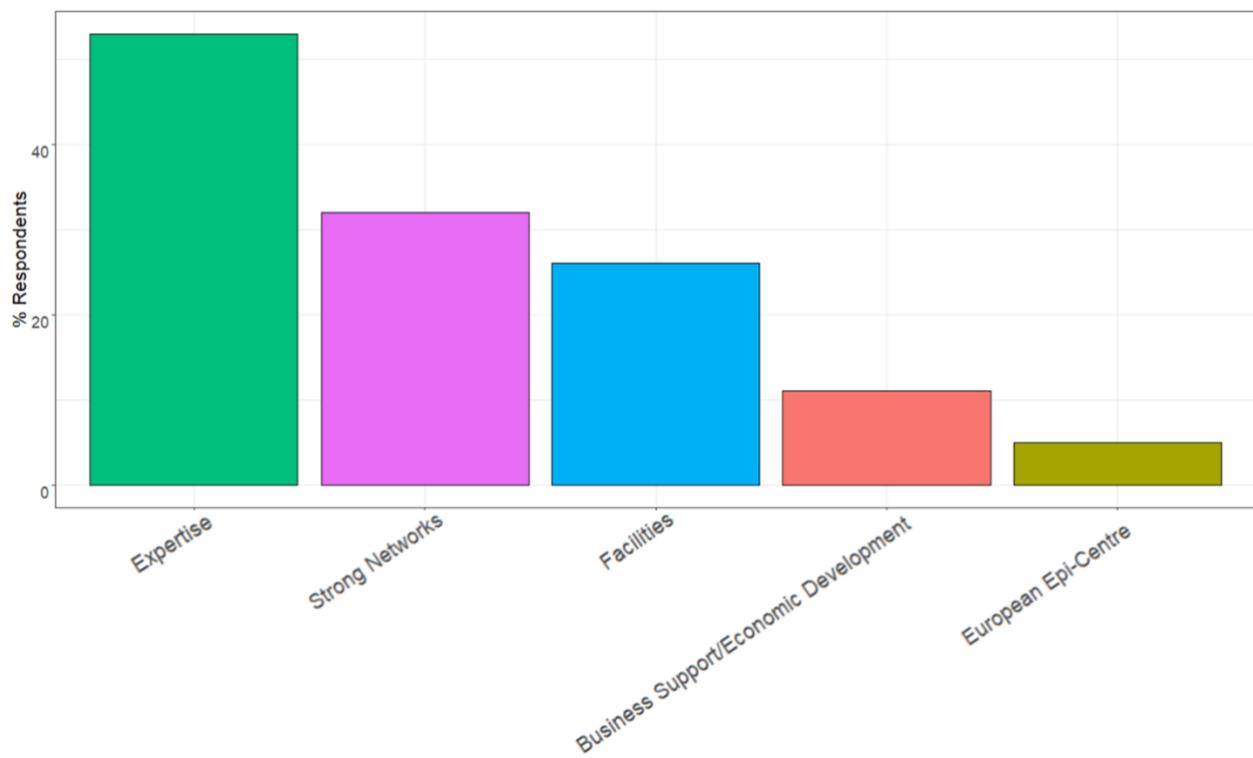


Figure 4 – Strongest asset/unique selling point of the AAA sector in Scotland

Unique AAA sector

This question aimed to identify what respondents thought made the AAA sector in Scotland unique. Responses included the expertise and scientific strength of the sector (32%), being based the European epi-centre for animal bioscience (Easter Bush Campus; 32%), the multidisciplinary nature of the sector (16%), strong collaborations (nationally and internationally; 16%) and international reputation (16%).

Other responses included our natural assets (16%) including “*Scotland’s vast coastline and healthy water bodies*”, the scale of the sector (5%) and current infrastructure (5%). Five percent responded that they were “*unsure*” what made the AAA sector unique and a further 5% responded that it is not unique.

COLLABORATIONS AND INTERNATIONAL LINKS

This section of the survey aimed to explore collaborations and links both within Scotland, wider within the UK and internationally.

Collaborations (Scotland)

Most responses noted collaborations with academic institutes within Scotland (53%). Strong links and collaborations were noted with innovation centres (32%), companies (26%) including contract research organisations, biocampuses/science parks (11%), trade bodies (11%), manufacturing partners (5%), co-ops (5%), city and region deals (5%) and Scottish Government (5%). Six percent of respondents did not answer the question.

Collaborations (outside Scotland/Internationally)

Strong links were noted within Europe (58%), including links to the UK (i.e., Wales, England, Northern Ireland; 32%), France (5%), Denmark (5%), Sweden (5%) and the Netherlands (5%). In addition, respondents recorded strong links with North America (21%) including the USA (11%), Canada (5%) and the Caribbean (5%), and South America (16%) including Chile (5%) and Mexico (5%). Collaborations were also noted with Asia (16%), for instance China (5%), Japan (5%) and India (5%), and Africa (11%) including Kenya (11%) and South Africa (5%). Furthermore, links and collaborations with Australia (5%) and New Zealand (5%) were evident. Eleven percent identified that they did have collaborations outside Scotland but provided no further response and 26% did not respond to this question.

Spin-out companies in AAA sector

Respondents noted multiple spin out companies including MycoNourish, Roslin Technologies Ltd, Green Bioactives Ltd, Wobble Genetics Ltd, Censo Biotechnologies Ltd, Ingenza Ltd, Vetsina Ltd, Wormvax Australia, BioBest, Bells Isolators, SAMS Enterprise and SOLASTA Bio. A full description of each of these companies (those which are based in Scotland/relevant to AAA) can be found in the stakeholder inventory (see appendix 1). Several respondents also noted that they are able to

provide funding to incubate start-ups and spin-out companies, including the Food and Agriculture Science Transformer (FAST) venture studio.

OPPORTUNITIES

This section of the survey aimed to identify opportunities presented to the sector, including how current events (e.g. BREXIT, COVID-19, green recovery) open opportunities.

New opportunities becoming available

Sustainable production systems (37%) were identified as the greatest opportunity, particularly for aquaculture (26%), agriculture (16%) and renewable energy (5%). Other opportunities identified included the use of agri-tech and digital innovations (32%) to promote and achieve net zero targets (5%) and increase automation of systems (5%), green recovery and net zero targets (responses not mentioning use of agri-tech/digital innovations; 21%), big data and analytics (21%) including the potential for artificial intelligence (AI) and machine learning (11%) and potential of the new University of Edinburgh's new supercomputer (5%). Novel and alternative production systems (11%) were also identified as opportunities particularly the use of vertical farming (5%), in addition to opportunities associated with the circular economy (16%), the blue economy (16%) and new venture studios (e.g. FAST; 11%) allowing development of new companies. Genetic technologies (11%) including microbiome and gene therapy, animal health (5%) including zoonosis, disease infection/control, immunostimulants and antimicrobial resistance, food security (5%) and knowledge exchange/experience sharing were also identified as new opportunities. Five percent of respondents did not respond to this question. This is summarised in Figure 5.

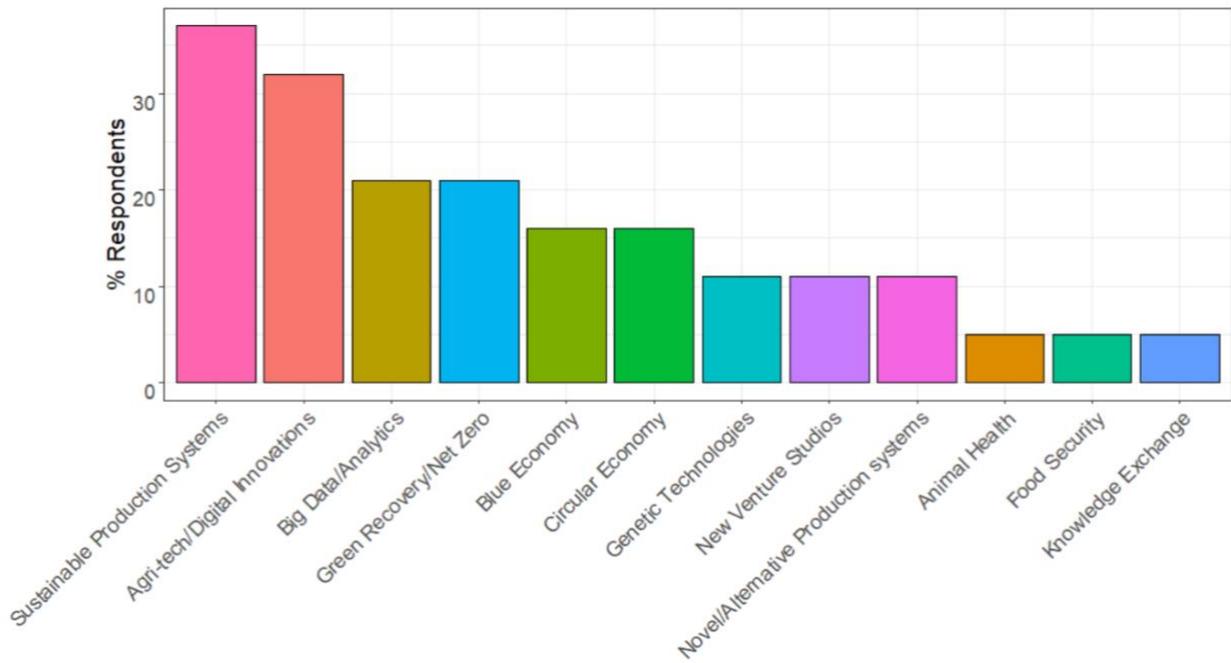


Figure 5 – New opportunities coming available to the AAA sector in Scotland

Opportunities would like to see

The aim of this question was to identify opportunities respondents would like to see becoming available. Responses included increased promotion of the sector and its impact (26%) especially in the areas of wastewater treatment (11%), increased R&D (21%) particularly in the following areas:

- Aquaculture (11%)
- Gene therapy and the microbiome (5%)
- Sustainability (5%)
- Agriculture (5%)
- Companion animals (5%)
- Animal health (5%)
- Zoonosis (5%)
- IoT, machine learning and AI (5%)

Increased funding and financial support (16%), training and upskilling in the sector (11%) particularly around data/data handling/data analysis (5%), increase in exchanging and sharing of data (16%) and greater distribution of infrastructure across the sector (5%) were also acknowledged as areas to provide opportunities. Eleven percent of respondents did not provide a response.

Support would like to see available

Respondents were asked to provide details of what support they would like to see becoming available. By far the largest response was increased funding opportunities (68%), particularly increased funding dedicated to the AAA sector (16%), translational research (11%), collaborative projects (5%) and private and public sector co-funding for “the “D” part of R&D, this is a bottleneck” (5%). Increased support for communications and networking (21%) both within the science community and to the wider public, increased investment (16%) for retention and upskilling of technical skills and staff (11%) and early career researchers (5%), and the need for a dynamic regulatory body within the AAA sector to “work closely with innovation companies and institutes, in order to fully realise AAA potential” (11%) were also identified as areas for further support. Note that innovation regulation is discussed further in the “AAA innovation regulation” section below. In addition, “a focussed strategy/plan” within the sector (5%) and cluster/working group to identify funding opportunities and collaborations (5%). These results are summarised in Figure 6.

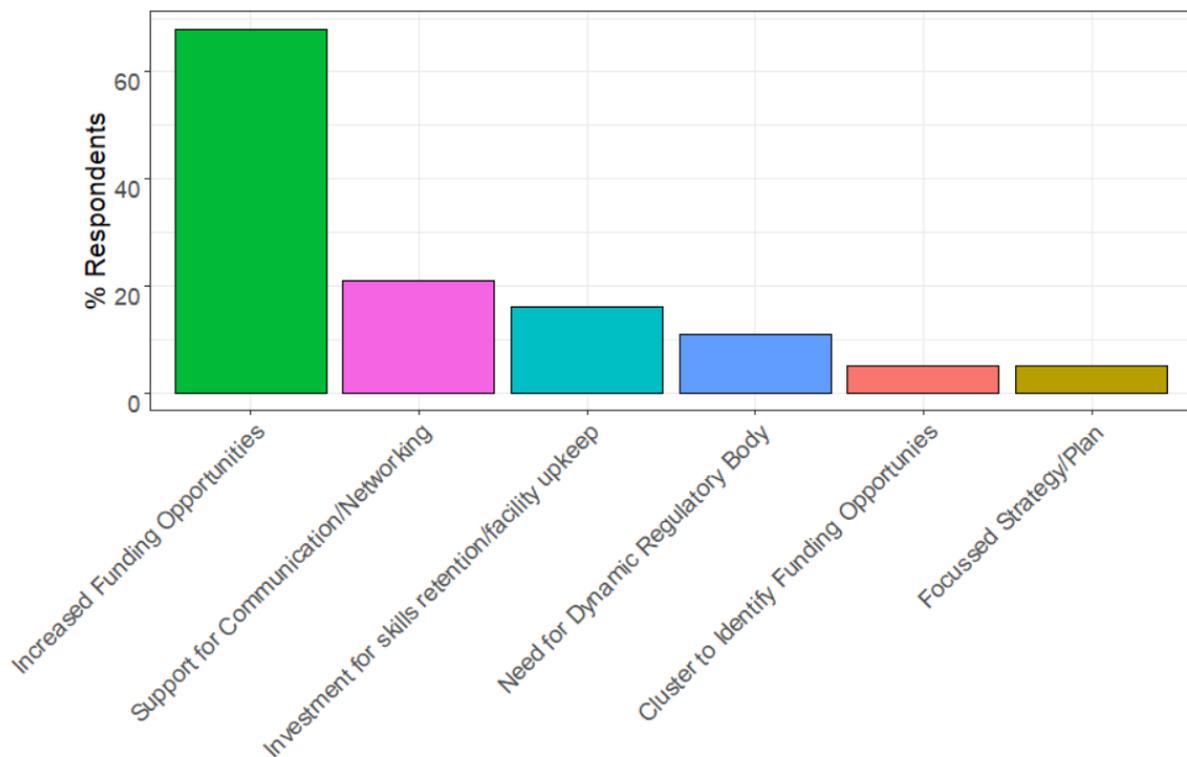


Figure 6 – Areas where the AAA sector require greater support.

Opportunities around current events

The aim of this question was to identify if current events (e.g. COVID-19, BREXIT, Green Recovery etc.) open opportunities within the AAA sector, and if so how. Green

recovery was identified as the largest opportunity (42%), with opportunities in using agri-tech (“*agri-tech should be at the centre of green recovery funding*”; 16%), circular economy (5%), economic incentives for “low carbon” technologies (5%), marine initiatives (5%) and collaborations (5%). COVID-19 was identified as having large opportunities (32%), including opening up opportunities for greater zoonosis/emerging disease research (11%), new business models and adapted ways of working (11%), and remote monitoring (5%). BREXIT opens opportunities to develop regulatory systems to enable innovation including genetic technologies to be regulated at the Scottish or UK level (5%) and potential for increased investment in agri-tech (5%). Current events (not specified which) enables diversification of activities and refocusing of research activities (16%) including increased data sharing (5%), enables crisis driven innovation (5%), greater impact driven investment (5%) and greater international collaborations (5%). Five percent of respondents said that it was too early to say if there have been or are any opportunities. Sixteen percent of respondents did not provide a response to this question.

Countries/companies/academics would like to work with

This survey question identified if there are any countries/companies/academic institutes that respondents would like links to be established with. Twenty-one percent of respondents answered yes but did not provide specific detail or noted that they are open to work with all. Other responses included working worldwide/international clusters (21%), including New Zealand, Australia, Israel, Netherlands, Singapore, South Korea, Canada and Latin America, and academic institutions in Scotland (16%), specifically noting Roslin Institute, SRUC, SAMS, James Hutton Institute and SAIC. Forty-two percent of respondents did not respond to the question.

CHALLENGES

This section of the survey aimed to identify challenges presented to the sector, including from current events (e.g. BREXIT, COVID-19, green recovery).

Challenges in the sector

This survey question aimed to identify the top 3 challenges facing the AAA sector in Scotland at present. The largest challenges identified were lack of funding (47%), increasing climate change and environmental pressures (26%), Brexit (21%) including Brexit’s impact on limiting investment (5%), administrative burdens (5%) and issues importing raw materials/access to markets (5%), AAA regulation (16%) and missing out on opportunities/falling behind on competition (11%) particularly caused by “*slow decision making [on funding applications]*”. Other challenges include the potential of Scottish Independence (11%) which “*may result in lower research funding if access to UK gov funding will no longer be possible*”, lack of visibility/disjointed nature of the sector (11%) and lack of co-ordination of funding and resources (11%). Further

challenges included COVID-19 impacting businesses and customers (5%), lack of skills and lack of retention of skilled workers (5%), low number of farmers uptake of agri-tech (5%) and public perception of the agricultural/livestock sector and lack of perceived value (5%). Eleven percent of respondents did not respond to the question. A word cloud of responses provided can be found in Figure 7.



Figure 7 – Word Cloud of challenges facing the sector.

Resources/facilities lacking

Respondents were asked to identify which resources, facilities and expertise are lacking within the sector. Dedicated AAA funding (21%) for future infrastructure and maintenance of current infrastructure was identified as the main resource lacking. Sixteen percent noted that the AAA sector has adequate facilities, however respondents did note that facilities could be improve with further and on-going investment. Other responses included lacking leadership and organisation (16%), lacking collaborations (16%) including “*perhaps more agri innovation centres which act as catalysts for SMEs/academia to develop cutting edge technologies for the sector which enhances Scotland’s international competitiveness in this sector*”, technical and data skills (11%) including bioinformatics, knowledge on use/maintenance of specialist equipment and “*greater understanding of all players in the sector*”, innovation test sites and trial facilities (11%), translational research and expertise (11%), access to skills in rural Scotland (5%) and lack of public engagement (5%). Eleven percent did not provide a response.

Areas for improvement

Largest responses related to improving collaborations and partnerships within the sector (37%), one respondent noted “*collaboration between industry and the public sector to drive green growth and COVID-19 economic recovery*”, and communication (26%) including “*communication and showcasing Scotland’s strengths and assets to itself and the rest of the world*”. Other responses including funding and impact, specifically in the AAA sector (11%), appreciation of the value of science “*within government and the wider public*” (11%), attracting skills and work to Scotland (5%), research commercialisation, internationalisation and entrepreneurship (5%), regulation and licencing (5%), prioritising issues (5%) “*to provide resilience for Scottish economy in the coming decades*” and a stronger private sector base (5%). Sixteen percent of respondents did not provide a response. A summary of this can be found in Figure 8.

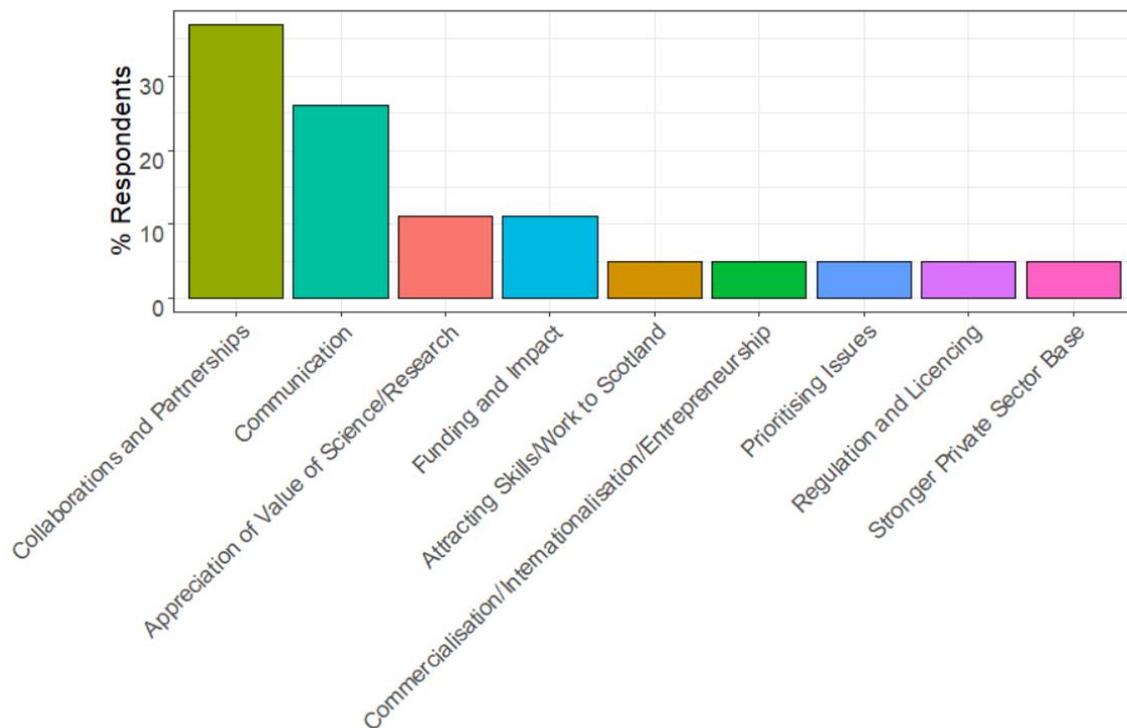


Figure 8 – Areas for improvement in the AAA sector in Scotland.

Challenges during current events

This question aimed to identify if current events (e.g. COVID-19, BREXIT etc.) negatively impacted the sector or prevented opportunities. Brexit was identified as the main challenge (42%) including issues with importing/exporting goods and materials (11%), labour shortages (11%), increased administrative burden and “red-tape” (11%), threatening of the food supply chain/disruption to markets (11%), loss of access to funding and (5%), damaging confidence with colleagues across Europe (5%) and increases in costs (5%). Similarly, COVID-19 was noted as negatively impacting the

sector (11%) by reducing research capacity in laboratory-based work (due to social distancing; 5%), thereby either increasing the cost due to increased space required (5%) or reducing the pace of research (5%). Green recovery may “*focus on a single factor of greenhouse gas reduction rather than the wider issues of resource use reduction*” (5%). Eleven percent of respondents notes that current events create opportunities rather than challenges, and 5% responded that businesses are surviving over growing: “*level of change is impacting business capacity to respond to opportunities as they correctly prioritise remaining in business over growth*”. Eleven percent did not respond to this question.

SURVEY RECOMMENDATIONS

This survey highlighted strengths, opportunities and challenges within the AAA sector, whilst survey uptake was lower than expected the responses collated did provide great insight into the sector. The survey highlights skills, expertise and research facilities (both animal/field and laboratory) are key assets within the AAA sector in Scotland. The sector has many strategic expertise, the main ones identified in this survey were genetics and breeding, animal health, agri-tech and aquaculture. This expertise, along with facilities, are the sector’s greatest resource. A large proportion of this expertise is based in and around Easter Bush Campus, the European epicentre for animal bioscience. The sector has strong links and collaborations within Scotland, the wider UK, and worldwide. Respondents noted that current events open many opportunities, including the use of/research into novel and alternative production systems, agri-tech, digital innovations, low carbon technologies and advanced data analytics (e.g. machine learning and AI) to create sustainable systems for green recovery and to allow Scotland to achieve net zero GHG emissions targets by 2045. However, there are also lots of challenges associated with current events, particularly Brexit, including limiting investment, increased administrative burdens, reduced access to materials/issues with importing materials, labour shortages and the threat of food supply chain disruption. COVID-19 also presents challenges including reducing research capacity, especially in laboratory-based work/research.

Below we set out recommendations for support from challenges highlighted in this survey:

- Increased research and development, funding opportunities and financial support dedicated to the AAA sector. This is by far the largest challenge facing the sector.
- Increased support for communication and promotion of the sector and its impact, both within the science community and wider public. A specific target for this may be the private sector which can aid in attracting enabling investment. There is a need for improved collaboration and partnerships within the sector.

- Increased training and upskilling, especially around data/data handling/data analytics.
- There is a need for a dynamic regulatory body for new innovations which can allow AAA to reach its full potential (see full description in “AAA Innovation Regulation” section).
- There is a lack of co-ordination of funding and resources leading to a disjointed AAA sector, leading to a need for a more organised approach. This includes greater understanding of the sector to allow for increased collaborations.
- There is a lack of dedicated test sites and trial facilities for new innovations.

AAA INNOVATION REGULATION

As noted in the survey results section above, one of the challenges facing the sector is regulation around new innovations. There is an increased interest for the UK, as well as devolved nations, to change regulation and legislation to ensure innovations, which can help improve efficiencies, reduce waste, and contribute to green recovery, are delivered to the sector. This is now possible post-Brexit as the UK is not governed by EU legislation on these matters. There have been historic occasions when innovation has happened in response to policy and heightened concerns for the environment, for example SOLASTA BIO and their novel next generation green insecticide which target insect pests alone and not beneficial pollinators. However, there have also been examples of legislation barriers in recent years, which has impacted Scotland’s ability to develop and adopt new technologies/innovations, some examples in aquaculture:

- **Environmental DNA (eDNA).** The framework which regulates emissions from marine fish farms requires farmers to monitor potential impacts on the seabed both beneath and surrounding the farm. This has previously been achieved by assessing biodiversity using benthic taxonomy (e.g., manually identifying and counting individual organisms) which is a time consuming and labour-intensive process often taking several months for samples to be reported. Often, by this time, fish farms have restocked and results therefore do not provide real-time results for that current production cycle. In 2015, the sector was approached by researchers interested in investigating the use of eDNA as an alternative to the traditional benthic taxonomy approach. Initially the regulator was unwilling to consider alternatives to the traditional benthic approach, however, the following year the regulator changed their position allowing two “proof of concept” projects focusing on eDNA and a further project confirming the potential of using eDNA. Currently the technology is sufficiently robust to be used as a screening tool for benthic regulatory compliance gaining £2 million funding to further develop the work into a full regulatory and on-farm (and in cycle)

environmental assessment tool, with hopes it will be operational within the next three years.

- **Innovation Farms.** There has long been a desire and need to develop innovation farms which support the development and trialling of innovative technologies. However, the current regulatory system provides no incentives for such farms despite the many benefits, both short and long term, including environmental protection, fish health and welfare and climate change mitigations. A review of the regulatory system governing marine aquaculture is underway under the Griggs Review. This review aims to make Scottish aquaculture legislation one of the most effective and transparent in the world.

Other examples of technologies and innovations facing regulatory barriers include gene editing, genetic modification, phage technologies and probiotics in aquaculture, and the use of insect protein (especially as an alternative protein in ruminant and monogastric production systems). More recently, it was announced that regulation of gene-edited crops would be relaxed¹ in England, however, it is also important to note that innovation acceptance in destined markets (e.g. EU) is also crucial to adoption.

[1<https://www.theguardian.com/environment/2021/sep/29/genetically-modified-food-a-step-closer-in-england-as-laws-relaxed>](https://www.theguardian.com/environment/2021/sep/29/genetically-modified-food-a-step-closer-in-england-as-laws-relaxed)

Appendix 1. Stakeholder Inventory

[LINK TO ONLINE INVENTORY](#)

Appendix 2. Survey – Strengths, Opportunities and Challenges in the AAA sector in Scotland

You are invited to participate in this online survey to identify strengths and opportunities within the animal health, agri-tech and aquaculture (AAA) sector in Scotland. The AAA sector in Scotland is important to both life sciences and technology sectors and underpins its high performing food and drink industry. However, to date little validated information exists on Scotland's contributions to this sector and its global impact. The information collected in this survey will be used to increase the understanding of the AAA landscape within Scotland including strengths, opportunities, and challenges. This includes creation of an inventory of current companies and facilities along with creation of promotional material to raise awareness of this sector. This research is funded by the Scottish Environment, Food and Agriculture Research Institutes (SEFARI) and the Scottish Government in collaboration with Life Science Scotland's Industry Leadership Group (AAA subgroup) and Highlands and Islands Enterprise.

We understand that some information may be confidential, so providing details for each question is optional. You will receive no direct benefits from participating in this research study. However, your responses will help us to understand the current AAA landscape and identify strengths and challenges, and map current sectoral opportunities. Your participation in this study is entirely voluntary and you can withdraw at any time, even after completion. By agreeing to participate in this survey you have the option to complete this anonymously, however, anonymous responses cannot be withdrawn.

This survey should take no more than 15 minutes to complete.

Responses to the survey will be stored in a password protected electronic format with access to responses restricted via a 2-step verification process. There are no known risks associated with this survey; however, as with any online related activity the risk of a breach is always possible. We will minimize any risks by storing survey data securely on a remote server with restricted access, email addresses will be stored separate to individual responses. For further information or queries please contact Jenna Bowen (Jenna.Bowen@sruc.ac.uk)

I agree to participate in this survey

Yes/No

SECTION 1 – BASIC COMPANY INFORMATION

We understand that some information may be confidential, so providing details for each question is optional. However, your responses will help us to understand the current AAA landscape and identify strengths, opportunities, and challenges.

What is your company/institute name?

Please select your sector. Select all that apply, if selecting "other" please provide more information in the box below.

- Academic
- Private Sector
- Public Sector
- Research Centre
- Prefer not to say

Please select your sector, note that you can select more than one option.

- Animal Health
- Agri-tech
- Aquaculture
- Prefer not to say

In which Scottish local authority are your headquarters based?

- Aberdeen City
- Aberdeenshire
- Angus
- Argyll and Bute
- City of Edinburgh
- Clackmannanshire
- Comhairle nan Eilean Siar
- Dumfries and Galloway
- Dundee
- East Ayrshire
- East Dunbartonshire
- East Lothian
- East Renfrewshire
- Falkirk
- Fife
- Glasgow City
- Highland
- Inverclyde

- Midlothian
- Moray
- North Ayrshire
- North Lanarkshire
- Orkney
- Perth and Kinross
- Renfrewshire
- Scottish Borders
- Shetland Islands
- South Ayrshire
- South Lanarkshire
- Stirling
- West Dunbartonshire
- West Lothian

Do you have other sites out with your headquarters? If so, please select all that apply.

- Aberdeen City
- Aberdeenshire
- Angus
- Argyll and Bute
- City of Edinburgh
- Clackmannanshire
- Comhairle nan Eilean Siar
- Dumfries and Galloway
- Dundee
- East Ayrshire
- East Dunbartonshire
- East Lothian
- East Renfrewshire
- Falkirk
- Fife
- Glasgow City
- Highland
- Inverclyde
- Midlothian
- Moray
- North Ayrshire

- North Lanarkshire
- Orkney
- Perth and Kinross
- Renfrewshire
- Scottish Borders
- Shetland Islands
- South Ayrshire
- South Lanarkshire
- Stirling
- West Dunbartonshire
- West Lothian

SECTION 2 – FACILITIES/RESOURCES

We understand that some information may be confidential, so providing details for each question is optional. However, your responses will help us to understand the current AAA landscape and identify strengths, opportunities, and challenges.

What are your company's key assets, resources and facilities within the AAA space?

What are your strategic expertise (e.g. vaccines, genetics etc.) - please provide information on your top 3 themes.

What is your strongest asset or unique selling point?

What do you think makes the AAA sector in Scotland unique?

SECTION 3 – COLLABORATIONS AND INTERNATIONAL LINKS

We understand that some information may be confidential, so providing details for each question is optional. However, your responses will help us to understand the current AAA landscape and identify strengths, opportunities, and challenges.

Do you have collaborations with other companies/institutes within Scotland? If so, and you are willing to expand on these, please list which companies and the nature of these links.

Do you have collaborations with external companies outside Scotland or internationally? If so, and you are willing to expand on these, please list which companies and the nature of these links.

Do you have any spin-out companies relevant to the AAA sector? If so, please provide more information.

SECTION 4 – OPPORTUNITIES

We understand that some information may be confidential, so providing details for each question is optional. However, your responses will help us to understand the current AAA landscape and identify strengths, opportunities, and challenges.

In your opinion, what new opportunities are becoming available to the AAA sector in Scotland?

What opportunities would you like to see become available?

What support would you like to see?

Do current events (e.g. COVID-19, Brexit, green recovery) open opportunities? If so, how?

Are there any countries/companies/academic institutes that would like to work with?

SECTION 5 – CHALLENGES

We understand that some information may be confidential, so providing details for each question is optional. However, your responses will help us to understand the current AAA landscape and identify strengths, opportunities, and challenges.

What are the top 3 challenges facing the AAA sector in Scotland at present?

What resources/facilities/expertise do we lack?

What areas do we need to improve on?

Do current events (e.g. COVID-19, Brexit, green recovery) negatively affect this sector or prevent opportunities? If so, how?

SECTION 5 – THANK YOU

Thank you for your participation in this survey. If you are willing to be contacted about your responses in the future please tick the below box and provide preferred contact details below.

[Tick-box]

Name and email address, or preferred contact details (leave empty if you wish to remain anonymous).