Strategy for Environment, Natural Resources and Agriculture Research

2022-2027

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Ministerial Foreword

Our natural environment is central to our identity as a nation, to our health, quality of life and our economy. Over the past year as we witnessed Covid-19 fundamentally change our way of life, the importance of being able to enjoy Scotland's natural environment, and the health and wellbeing impacts this brings, were made clearer than ever. As we look forward, how we use our land and other natural assets will all need to be re-imagined in order to build Scotland's green recovery and address the twin threats of biodiversity loss and climate change.

Scotland is playing a central role in developing environmental solutions to the global climate and nature crises, and our response is based on the strongest possible scientific evidence. Our Environment, Natural Resources and Agriculture research programme is central to achieving this. We invest nearly £50 million a year in our research programme, so it is a major commitment for us.

I recognise the dedicated work that has gone into our funded science over the current funding cycle. It has guided policy development, both in my own portfolio and that of my colleague the Cabinet Secretary for Rural Economy and Tourism. It has also provided evidence and research which has supported economic development in Scotland in the urban as well as the rural economy and helped policy makers across the Scottish public sector. This is work we need to build on and refocus to meet the challenges we face now, including the need for a green recovery, responding to the global climate and nature crises and the UK's exit from the European Union. These drivers will fundamentally change our approach to conserving Scotland's environment and how we use our fantastic natural assets in Scotland in a sustainable way.

This research strategy sets out our priority research topics for the coming years as: climate change; land use; biodiversity; the rural economy; animal and plant disease; water and flooding. This strategy also sets out our plans for funding research on topics not previously included in the programme including: air quality; the circular economy; and land reform.

Along with the evolution of the research programme into new areas and responding to new challenges, this strategy sets out how we will enhance the programme to maximise its impact. This includes plans to establish a Scottish Centre of Expertise in Biodiversity. This centre will advise policymakers in government, local authorities and our public bodies on how best to combat biodiversity loss.

I am proud of the progress that we have made in Scotland in responding to the global climate emergency and enhancing our natural environment. However, there is still much to do, and it is vital that our future policy decisions are rooted in evidence. The research priorities and plans set out in this strategy will be central to this approach.

Roseanna Cunningham
Cabinet Secretary for Environment, Climate Change and Land Reform

Contents

1. Overview

The Environment, Natural Resources and Agriculture Research Programme is a large scale, multidisciplinary programme with a budget of around £50 million a year. Its primary purpose is to provide science and evidence to support policymakers within Scottish Government and its delivery partners. In doing so it also maintains long-term research programmes and science facilities which directly support Scotland's academic research base, and allows research institutes to leverage in additional funding from other UK and international funders.

The programme covers a wide spectrum of topics including:

- Plant and animal health
- Sustainable food system and supply
- Human impacts on the environment
- Natural resources
- Rural futures

The Scottish Government's vision for the research programme is:

> **"to support research that is relevant, respected and responsive to Scotland's environment, communities, its people and to the rural economy"**

This vision places the science that we invest in at the heart of Scottish society, and looks to those engaged in the research to visibly and proactively contribute to the health, wealth and wellbeing of the nation, by applying their collective talents for the benefit of all of Scotland's people. The relationship between our research, government policies, and National Outcomes for Scotland is illustrated in Figure 1.

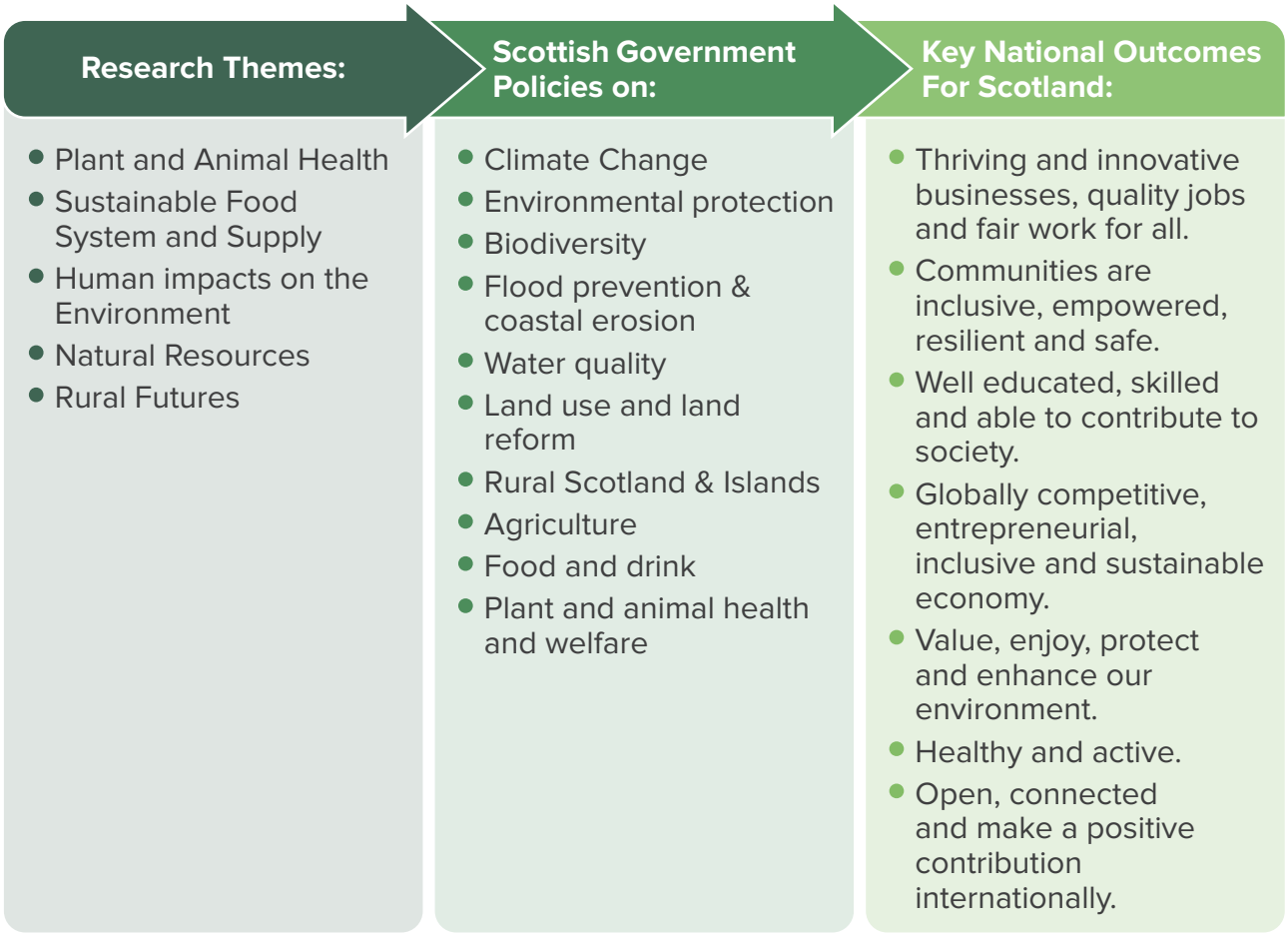


Figure 1. Relationship between research, policy and National Outcomes for Scotland.

This Strategy sets out how we will achieve this vision. It highlights our research priorities, and the principles and processes behind the investment we will make between 2022 and 2027. It explains how we expect our research to achieve impact, the mechanisms we will use to fund research, and the operational changes to our governance and reporting mechanisms which will be made during the next cycle.

The Strategy has been informed by consultation with a broad range of stakeholders including the independent Strategic Advisory Board which oversees the research programme, universities and research institutes, as well as multiple agricultural & farming bodies, NGOs and Local Authorities. A high volume of responses was received and many of these have been incorporated into the Strategy, or will be used to inform the subsequent implementation stages of the programme.

Our research must produce excellent scientific outputs which are useful, accessible and influential for government and other end users. This requires a strong focus on engagement and knowledge exchange to ensure that research outputs fully inform the policy making process and are accessible and useable by a wide range of external stakeholders. Some examples of impact from the current research programme are given in the boxes below. To achieve this, we fund:

- Long-term research with strategic objectives. This is currently delivered through our Strategic Research Programme and associated investment in Underpinning Capacity.
- Short-term research on more applied problems.
- Expert advice and opinion. This is primarily delivered through our Centres of Expertise[1] which provide specialist advice and knowledge on subjects where demand is highest.
- Knowledge exchange with stakeholders, including co-construction of new research.

During the current funding cycle, around 88%[2] of the funding was used to support research at six Main Research Providers (MRPs)[3], a group of Scottish research organisations with specialist expertise in areas directly relevant to the research programme. The MRPs have developed a collective identity as SEFARI (Scottish Environment, Food and Agriculture Research Institutes) in part through a joint Knowledge Exchange centre, the SEFARI Gateway.

The SEFARI institutes are not the only source from which expertise is drawn, nor does the work they do represent the full extent of our science needs. Our funding also supports research at a wide range of other Higher Education Institutes and other organisations.

Building strong partnerships is key to our approach. The SEFARI institutes through which we make much of our investment in research cannot cover the vast array of topics that are contained in the rural economy and environment portfolios, nor can they be expected to have the expertise in all areas. Therefore during this funding cycle, we will continue to broaden the supply base for our research, working with an expanding range of research providers to meet our needs. In particular we will better connect the research we support with the wider Scottish and UK public sector, businesses, Scottish Universities and the UK Research Councils and expect this collaboration throughout the whole research programme.

1 There are currently four Centres of Expertise, on: Animal Disease Outbreaks (EPIC), Water (CREW), Climate Change (ClimateXChange) and Plant Health (Plant Health Centre).
2 The remainder was spent on research funded at other institutions via the Contract Research Fund, the Centres of Expertise or the rural or economic surveys budgets which fund the Agricultural Census and the Farm Business Survey.
3 James Hutton Institute, Scotland's Rural College, Moredun Research Institute, Royal Botanic Garden Edinburgh, Biomathematics and Statistics Scotland and Rowett Institute

Research & Economic Impact:

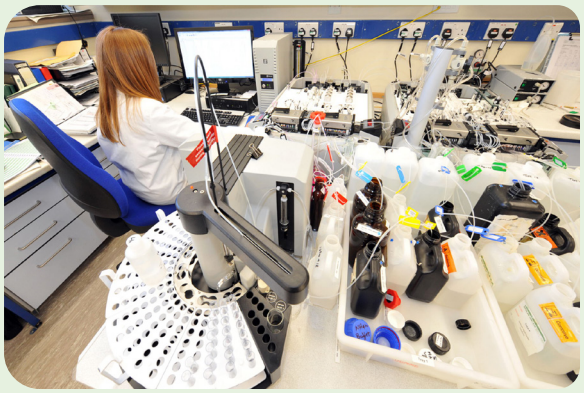
The Scottish Government's Environment, Natural Resources and Agriculture research programme plays a key role in ensuring that scientific evidence is embedded within policy development across a range of government portfolios. For example the outputs from the programme have been central to designing the Scottish Government's approach to responding to the Global Climate Emergency. It has provided the evidence to ensure that policies are focused on areas where emission reductions will be maximised and that the decisions made are based on the latest scientific evidence. However, its impact is far broader and goes well beyond the development of government policy.

A 2017 study[4] of previous research cycles estimated that the programme contributed £151.8 million GVA to the Scottish economy a year and supported nearly 1,500 jobs.

These impacts were achieved through a wide range of channels. For example, the deployment and utilisation of research funded through previous programme cycles has led to improvements in plant and animal health and genetics, which in turn have boosted agricultural productivity. A number of projects funded via the programme have also led to the creation of spinout companies and wider commercialisation activity which has had wider economic benefits.

The research programme also directly supports Scotland's academic research base. It supports hundreds of highly skilled research jobs and also provides a stable funding base that enables institutes to lever in significant additional funding from other UK and international funders into the Scottish economy. In 2018-19, external income leveraged as a result of the research programme was £28 million, equivalent to c. £0.60 returned for each £1 invested.

4 Strategic Research Programme 2011-2016: economic impact. **https://www.gov.scot/publications/economic-impact-strategic-research-programme-2011-2016/**



Research Impact – Covid-19

Covid-19 has forced governments and publics worldwide to build the capacity and the expertise to tackle the pandemic. It has shone a spotlight on the role of experts across a wide range of academic disciplines, and demonstrated the need for scientific knowledge and skills from people and organisations who can bring their expertise into policymaking and public services.

Our long-term investments in science and research capacity across Scotland have meant that our Main Research Providers and Centres of Expertise could contribute to the Scottish Government response to this crisis at short notice. Their contributions drew upon the existing expertise of the researchers within our research programmes on animal and plant disease, food and rural economics, and also upon the laboratory facilities and staff which support those programmes.

Our Centre of Expertise on Water (CREW) funded a rapid project to test for the viral RNA in waste-water (sewage) with SEPA and academic partners. This is now a nationwide programme and is being used by Local Health Boards to help target community testing.

Researchers from Scotland's Rural College, the Moredun Research Institute, our national Centre of Expertise on Animal Disease Outbreaks (EPIC), working with BioSS, have taken their knowledge of zoonotic and animal disease and worked to test samples for Covid-19 and model the outbreak in the Scottish population, forming the Scottish Covid Research Consortium.

Other parts of our research programme have contributed widely to the Covid-19 response, and shown the value of our long-term investments in science and research capacity across Scotland. For example, the PCR machines funded via the research programme, which are used to detect microscopic amounts of DNA and RNA at the Rowett Institute and James Hutton Institute, were used for diagnostic testing of Covid-19 by the NHS in patient samples.

The SEFARI-Gateway has worked with all of its partners including the Royal Botanic Garden Edinburgh to put together educational materials to support home schooling.

Research Impact – Coastal Flooding and Erosion

The Dynamic Coast project is an award-winning, pan-government partnership that has transformed Scotland's public sector's understanding of coastal change and the risks from coastal flooding and erosion under a changing climate.

Funded through the Centre of Expertise on Water (CREW) and supported by key agencies, the project has established a national evidence base of coastal change. This summarises the last 130 years of coastal change across all of Scotland's erodible shores (beaches, dunes and saltmarshes) and projects the changes forward to 2050. It has been used to identify areas which are, or may become, susceptible to erosion in the coming decades.

The identification of such susceptible areas, backed by an objective evidence base and interactive maps is now being used by government, agencies, Scottish Water, Adaptation Scotland, Local Authorities, developers, landowners and community groups to develop management policies and adaptation plans to tackle coastal erosion and flood risk.

Research Impact – Combating Raspberry Root Rot

Genetic research into raspberry root rot disease is helping to alleviate the economic damage of the disease, and improve the viability of raspberry production for Scottish soft fruit producers.

The disease, which is caused by *Phytophthora fragariae* var. *rubi*, is currently the most economically damaging of all pests and diseases that affect raspberries in the UK. The raspberry is an iconic Scottish product known worldwide for its superior taste and quality, and the industry requires new commercially acceptable varieties that are resistant to *Phytophthora*.

With funding from the Strategic Research Programme, researchers at the James Hutton Institute have spent over a decade developing the first genetic linkage map for raspberry and subsequently identifying molecular markers to link important traits to genetic regions. Deployed early in the breeding process, these research techniques have speeded up the development of new varieties. In August 2020 a new resistant variety, Glen Mor, was launched by James Hutton Limited.

New resistant varieties such as Glen Mor will improve the viability of raspberry production for many fruit growers, as they can return to land which carries the disease but is otherwise ideally suited to raspberry production, and away from more expensive pot-based growth systems, whilst also reducing the use and cost of fungicides.

Research Impact – Peatland Restoration

In recognition that peatland restoration is one of the most effective ways of locking in carbon, the Scottish Government has committed to restoring peatland as part of its climate change policy agenda.

Peatlands research in the programme has many elements and aims to provide an evidence base for the wider costs and benefits of Scottish peatlands restoration. This includes improving methods for calculating carbon stores and establishing the extent to which peatland restoration will help Scotland and the UK meet their emissions reduction targets.

Working in partnership with others on the **RSPB Scotland Forsinard Flows Reserve**, SEFARI researchers have monitored the GHG fluxes at several sites and have shown how restored peatland can significantly help store more GHGs. They are also developing methods to more accurately evaluate the cost-effectiveness of peatland restoration and evaluate the condition of peatland.

This research has played an important role in helping Scotland assess progress towards the statutory GHG emission reduction targets. It has also informed how to better incorporate the effects of draining and the rewetting of peatlands into calculations for **UK GHG inventories**.

2. Strategic Drivers for the Next Programme

Across the programme as a whole there are three overarching drivers which will play a key role in shaping our priorities and research needs in future years. We expect many of the research projects that we will support over the next funding cycle to support these areas:

- **Global climate and nature crises** – Achieving net zero greenhouse gas emissions and responding to biodiversity loss are inextricably linked and will fundamentally shape the choices which we face in areas such as land-use, environmental and agricultural policy for decades to come. Changes to our climate and wider environment will also be a key driver of future work on plant and animal health, the management of our natural resources and the economic challenges and opportunities faced by rural communities. Biodiversity loss in particular is a growing problem and Scotland has a key role in combating it, especially in relation to fragile upland ecologies, peatlands and coastal and marine ecosystems.
- **EU exit** – The UK's exit from the EU will have a significant impact across the research programme. For example, the UK's future trading relationship with the EU and other countries will change, which will impact on Scottish companies, particularly in agriculture and the food and drink sectors. The future of farming support in Scotland, and the successor to the Common Agricultural Policy, which the Scottish Government will need to design, will also cut across all elements of the research programme.

- **Sustainable economic growth and wellbeing** – The economic impact of the Covid-19 pandemic and the subsequent recovery will have far-reaching consequences for all parts of society. The Advisory Group on Economic Recovery, which the Scottish Government established to advise on the recovery from the crisis, emphasised the importance of green growth and maximising the benefits of Scotland's natural capital as part of the recovery.[5] These drivers will impact on all elements of the research programme. Simultaneously there is a growing focus on policy approaches aimed at enhancing wellbeing, of which environmental sustainability is a key element, either in place of or alongside more traditional measures of economic progress. This focus will inform the work across our research programme.

Another key need which has become apparent over the current research cycle is for more responsive and flexible research to reflect changing needs and priorities. Since the last research strategy was published in 2015 many events have occurred which have created new and unforeseen research needs. Some of these are national and global events such as the Covid-19 pandemic, the UK's exit from the EU and the Scottish Government's declaration of a global climate emergency. Others are more discrete and impact on specific elements of the programme. Our research programme must be dynamic and capable of adapting to a changing and evolving policy landscape, ensuring that funding can be directed to support new priorities, and where the impact of the investment can be maximised while avoiding unnecessary disruption to the skills, expertise and underpinning capacity residing in research organisations.

The Strategic Advisory Board, which oversees the research programme, published its recommendations for the next cycle of research funding in May 2019. Their report[6] recommended that the research programme needs to evolve in order to remain fit-for-purpose; there should be better alignment with Scottish Government's needs, more flexibility to reposition resource when required, a wider range of research providers, and continued commitment to protect the research capacity and data that are unique to, and essential for, meeting Scottish needs.

5 **https://www.gov.scot/publications/economic-recovery-implementation-plan-scottish-government-response-to-the-advisory-group-on-economic-recovery/pages/6/**

6 **https://www.gov.scot/publications/summary-report-conclusions-strategic-advisory-board-resas-funded-science/**

3. Our Objectives

In responding to these strategic drivers of the research programme, we will work to the following objectives:

- We will refresh the research programme to ensure that it better captures new and growing policy priorities.
- We will continue to support the underpinning research capacity, the platform of skilled and connected researchers, data and infrastructure upon which more responsive research can be developed.
- We will provide the Scottish Government with greater flexibility to respond to emerging needs, through more short-term, responsive research.
- We will access the best research available by engaging a wider range of research providers, by collaborating with other funders, and by fostering an interdisciplinary approach.
- We will maximise the impact of our research through engagement with stakeholders and horizon scanning.
- We will update our funding and governance mechanisms, to ensure that they support these objectives throughout the funding cycle.

4. Our Research Priorities

The high-level drivers of global climate and nature crises, EU exit and economic growth and wellbeing outlined in **Section 2**, will drive the Scottish Government's needs for research and evidence during the lifetime of this strategy.

With this in mind, the following research areas have been identified for funding and are presented here under five themes. Every theme will be expected to deliver research and evidence which will help to meet the challenges posed by one or more of the high-level drivers. These themes will be used as a single conceptual structure to steer research across our entire research portfolio and all funding streams, whether that is through our Main Research Providers, our Centres of Expertise, or other contractors.

The five **research themes** are:

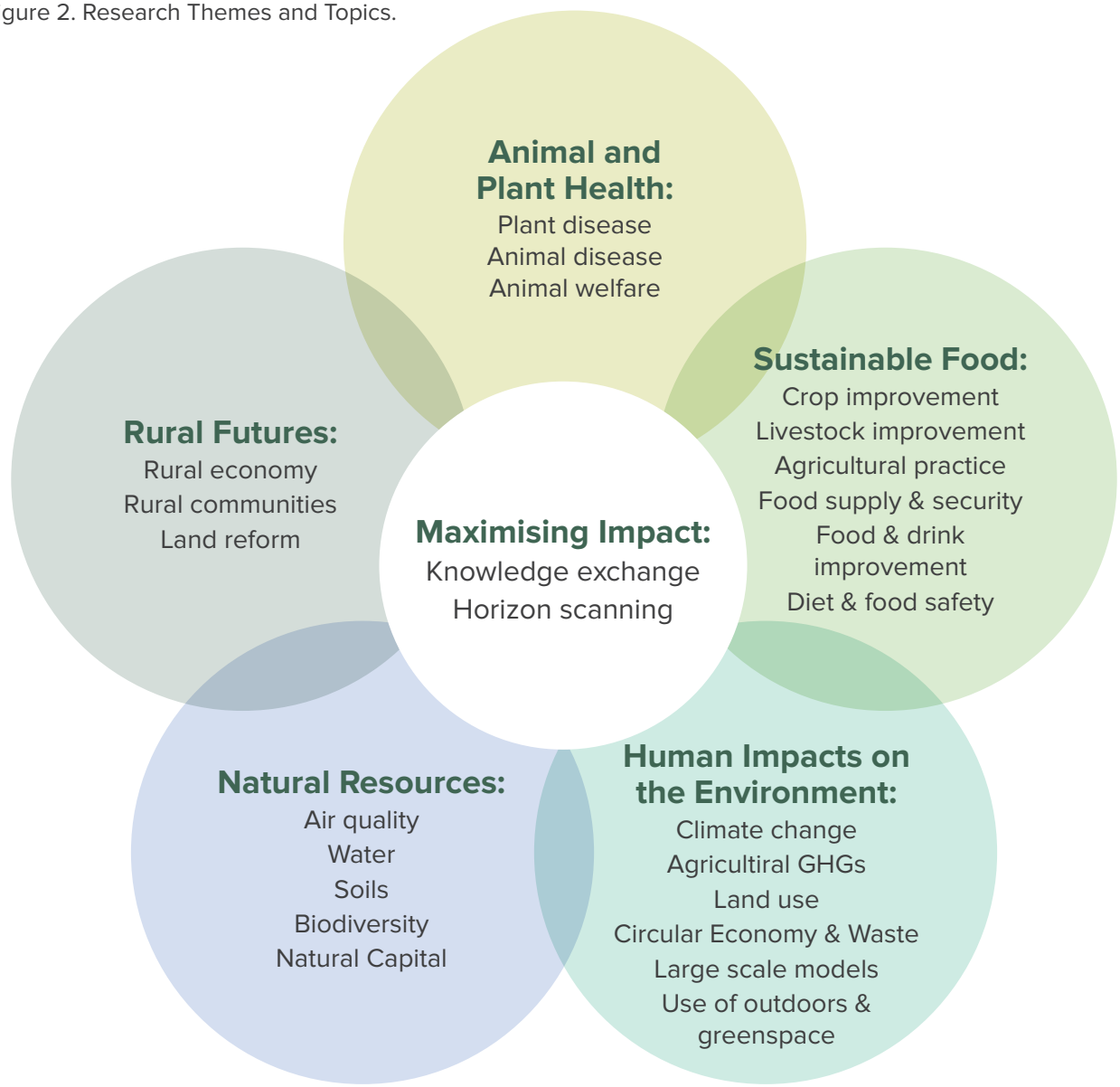
- Theme A: Plant and Animal Health
- Theme B: Sustainable Food System and Supply
- Theme C: Human Impacts on the Environment
- Theme D: Natural Resources
- Theme E: Rural Futures

The five themes, and the constituent **research topics** which sit within them are illustrated in Figure 2. More information on each component is set out in **Annex A**. **Further detail on each will be provided as work is commissioned to implement this strategy**.

The Scottish Government expects to support research across all of the research topics, though we will prioritise and allocate resources between them, in line with the Strategic Advisory Board's consistent challenge. Our high-level drivers require a particularly early focus on land use, the rural economy and natural capital, including biodiversity and water.

In addition, we will prioritise research with other funding partners on animal and plant disease and climate change. The high-level drivers are relevant across many research areas, as are the cross-cutting themes (data science and behaviour change); hence proposals from any theme that best align with those drivers will be prioritised during evaluation. Moreover, the areas identified here present ongoing strategic research needs. The timing for project delivery will be outlined in more detailed documents, for example in the invitations to tender. Portfolio-wide prioritisation will remain an important signal to research providers and potential funding partners. The scientific strand of governance will update the prioritisation over the next funding cycle (see **Section 7**).

Figure 2. Research Themes and Topics.



The themes and topics are helpful to give structure to the programme and are not intended to create boundaries between research areas. Co-ordination and exchange of information and ideas between themes is often necessary, and mechanisms will be needed to drive

and manage such interconnections. Some linkages are best informed by researchers, for example SEFARI's broad interpretation of 'One Health' research including ecological, plant, animal and human health. Government policies such as the Regional Land Use Partnerships[7] will also catalyse new research linkages across our themes to match their need for integrated evidence and decision support. We also continue to expect multidisciplinary approaches to bring together a fertile mix of natural science, social research and economics, which is necessary if we are to address the complexities and realities of policy challenges in the real world.

This structure reflects a number of changes in our research priorities compared to the current funding cycle. For example, climate change is now recognised in the programme as a discrete research topic rather than as an element of other topics. Whilst many of these topics reflect the continuing need for evidence in existing policy areas, following the advice of the Strategic Advisory Board and broader consultation, we will introduce four research topics which were not previously included in the programme, with a corresponding reduction in research priorities in other areas.

- **Air quality**. This is an important environmental issue with impacts upon life and health outcomes. Scotland's strategy to reduce air pollution in Scotland is due to be revised and is likely to increase the focus on this issue, and the corresponding need for additional research.
- **Land reform**. Previous research cycles have not had a specific research programme on land reform, but with ongoing changes in Scottish land policy this new element will ensure that we can cement expertise in this important policy area into the programme.
- **Circular economy and waste.** New funding on this area addresses previous gaps in the programme. This is a naturally cross-cutting policy challenge, working across behavioural, social, economic, and environmental issues, to drive down Scotland's overall negative environmental impacts, and we expect it will be of wide policy and industry interest in the years to come.
- **Large-scale modelling.** Opportunities from new data sources and modelling applications are emerging across the UK, and evidence needs are arising within a number of Scottish Government policy areas. Given the technical skills and challenges involved, we anticipate benefits from taking a strategic approach to data integration and modelling at scale. This work should contribute across policy areas, and will likely involve collaborative projects with other funders.

Two further, cross-cutting activities have emerged, in the methods of data science and in understanding behavioural change. Past and current funding has supported skills and expertise in these areas, for example providing dedicated support from BioSS for data-rich research, modelling and machine learning. Both activities seem likely to become a natural part of high-quality research delivery across our programme. We therefore expect to fund these activities throughout the research themes, remaining open to opportunities that broaden their adoption, for example informed by the science strand of governance.

7 Protecting Scotland's Future: The Government's Programme for Scotland 2019-20. **https://www.gov.scot/publications/protecting-scotlands-future-governments-programme-scotland-2019-20/**

5. Maximising Impact

Our research must produce outputs which are useful, accessible and influential for government and other users, thereby maximising the impact of our research upon the strategic drivers identified earlier.

We recognise that there is not a simple journey from the design and production of scientific evidence to its subsequent impact upon policy and practice, and that there are a number of ways in which this can be achieved.

Early discussions with stakeholders to identify their needs and constraints are critical to shaping research and products which can subsequently be used to drive change and achieve impact. We will therefore ensure that stakeholders are involved in the early stages of co-constructing research wherever possible. As an example, stakeholders have already offered detailed ideas on specific subjects and questions as part of the public consultation on this Strategy, and we will use these as **work is commissioned to implement this Strategy.**

There is also a need for intermediary researchers, gatekeepers and other experts to act as a bridge in communicating the outputs of the research programme to stakeholders and wider society. To do this we will continue to support a Centre for Knowledge Exchange to help facilitate interaction and communication with stakeholders, and which will complement the Knowledge Exchange activities embedded within the wider research programme.

Within the research process itself, we will drive a culture of openness by improving the visibility of the research, and embedding open science and open data approaches. Research results funded through the programme, and the associated data, should be freely available by default (see **Section 7**).

We recognise that scientific research and technical innovation can also reveal emerging challenges, and new opportunities, which would have otherwise been unforeseen by government and policy makers. The horizon-scanning element of the research programme is a new initiative, specifically designed to support the identification of early-warnings for environment, natural assets, agriculture and rural communities.

Further details on both knowledge exchange and horizon scanning are provided in **Annex B**.

6. Delivering Our Investment

The diversity of our research needs requires correspondingly diverse funding mechanisms. There will be five key mechanisms through which our investment will be directed in order to take this strategy forward in 2022-27 (listed below).

Longer term grant-supported research will continue across core areas of the programme. Similarly, the commitment to services supported by underpinning capacity will remain, for example, call-down advice, maintenance of biological collections and long-term field studies. However, the share of funding which currently goes to longer term strategic research will fall from the current 66% of spend at present to around 57% of spend (Figure 3).

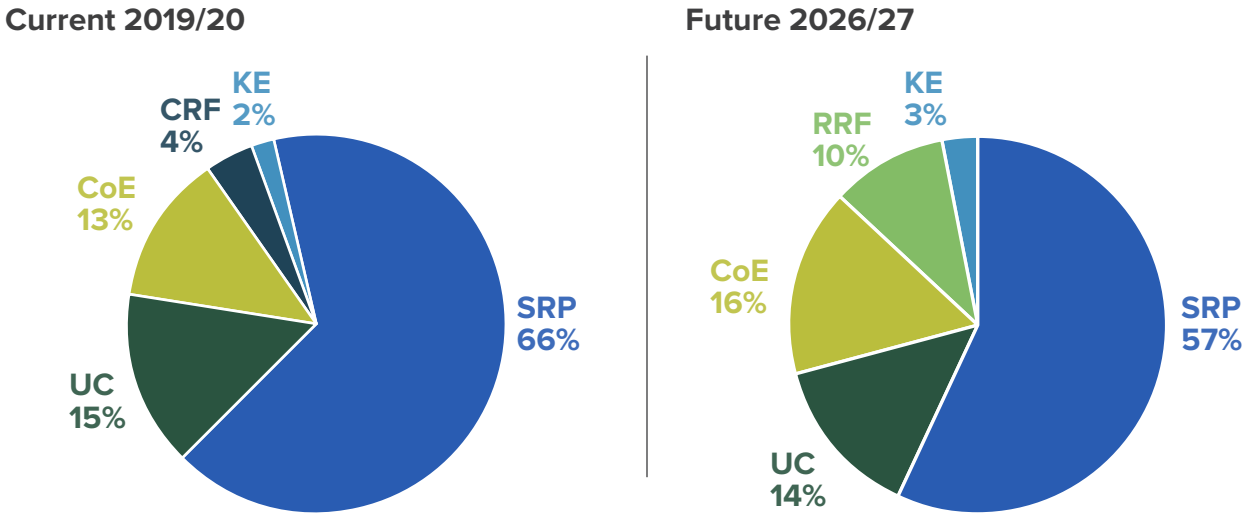


Figure 3. Comparison of current and future distribution of research spend by type.

This change will allow us to introduce a Responsive Research Fund (RRF). This is a new fund designed to ensure that the research programme can respond more flexibly to changes in research needs and analysis as we proceed through the research cycle. The RRF will be reactive to new, emerging policy needs across the whole programme, and will enable the procurement of short and medium-term (up to 3 years) research through open competition.

We will also continue to pursue collaborations with other science funders both within Scotland and across the UK to maximise the impact of our investment. We will liaise with other funders, and identify priority areas for collaboration where there is opportunity to strengthen our programme and build added value to topics with particular relevance to Scotland.

Overall our investment will be delivered through the five funding mechanisms outlined below:

Strategic Research Programme (SRP)

- Longer-term (3-5 years) research which provides new knowledge which is relevant to government policy.
- We will continue to use the SEFARI institutes as providers of the strategic research programme, and will allocate available resources accordingly.

Responsive Research Fund (RRF)

The flexibility to commission short-term policy-led projects has significant impact for policy making and was previously delivered through the Contract Research Fund. This function will be maintained as part of the RRF fund in 2022-2027.

Medium-term research (up to 3 years) responding to new, unforeseen policy needs which emerge after the initial commissioning period. Aims, objectives and mechanisms will need to be developed, and options such as staged, “challenge” funding will be considered.

This funding will be awarded under open competition and will therefore be open to a far greater range of organisations to help foster innovation and creativity in the types of work funded by the programme.

Centres of Expertise (CoEs)

We will continue to support the existing policy-facing Centres of Expertise for Climate Change, Water, Animal Disease Outbreaks and Plant Health. It is envisaged that the proportion of the budget allocated to these centres will be increased slightly to reflect the growing demand for their outputs.

A new Centre of Expertise on Biodiversity will be established to reflect the growing demand for evidence in this subject area (see **Annex A** Theme D.4 for further detail).

Underpinning Capacity (UC)

The Underpinning Capacity funding stream will continue to be available to ensure key assets are maintained and their long-term sustainability is secured for Scotland.

Encouraging access to, and availability of, the range of science resources supported by this funding will be a key focus of this funding for 2022-2027. This is in line with trends for increased accessibility of publicly-funded data and facilities.

Knowledge Exchange (KE)

We will continue to support a Centre for Knowledge Exchange, which will promote engagement with users to co-construct new research, communicate research findings and raise impact.

7. Governance and Reporting

Governance

The governance of the research programme has evolved over time, and will be refreshed for the next funding cycle. An independent external review[8] recommended that additional value would be gained by avoiding barriers between the different funding mechanisms used. This is consistent with the recommendations of the Strategic Advisory Board[9]. The Strategic Advisory Board discussed the options for future governance of the programme in 2020 and 2021, endorsing the structure outlined below.

A “Research Portfolio Board” will oversee the whole portfolio of research funded by the programme including the Centres of Expertise. Its members will represent the users of research in Scottish Government and external stakeholders, the research providers through an updated SEFARI, and independent advice from the Scientific Advisory Board. The Portfolio Board’s key role is to balance the aims of the programme, notably providing particular research evidence and sustaining national research capabilities. The board will be supported by three subgroups covering scientific, operational and institutional issues (Figure 4).

8 Structure-Function Analysis of SEFARI (2020). **https://www.gov.scot/publications/structure-function-analysis-sefari/**

9 Strategic Advisory Board for RESAS-funded science: summary report (May 2019). Includes recommendations for the next RESAS funding cycle. **https://www.gov.scot/publications/summary-report-conclusions-strategic-advisory-board-resas-funded-science/**

The SAB has recommended that the research programme would benefit from a more strategic approach. The scientific strand will embed this forward-looking work, for example, reviewing and updating this research strategy. The Centre for Knowledge Exchange, the proposed horizon scanning activity, the SAB and Theme Leaders from the research portfolio will be involved.

The operational strand will continue to oversee the allocation of funding and post-award reporting as is undertaken at present.

The institutional strand will address non-science strategy and major financial issues that arise, systemically or for specific research organisations.

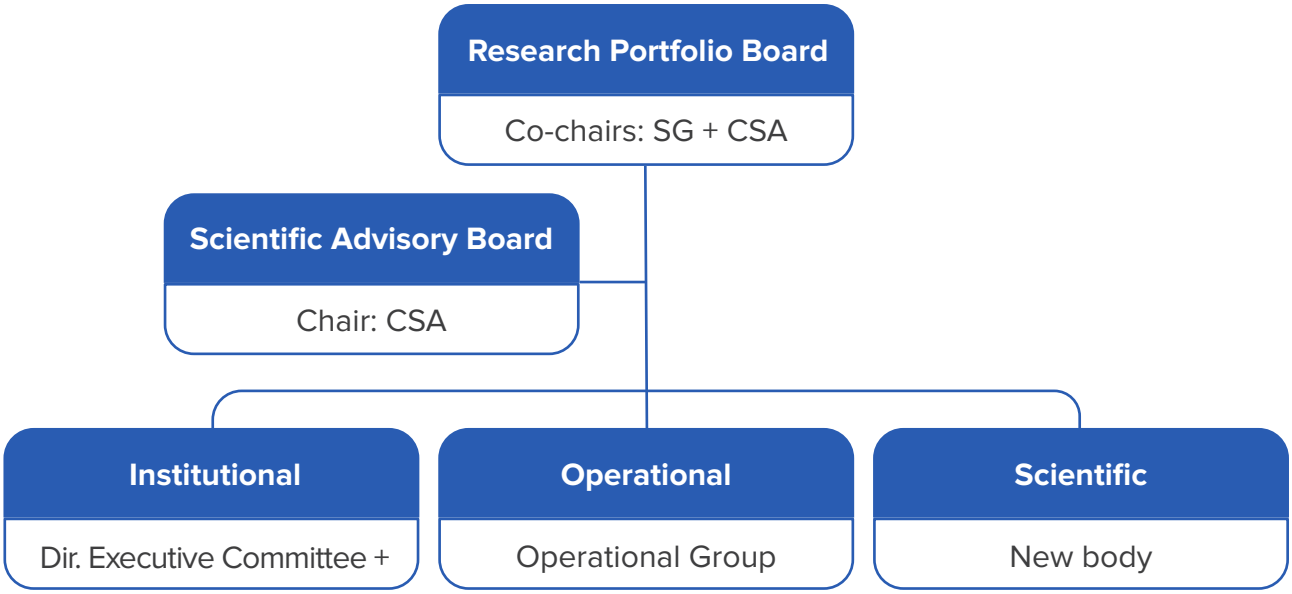


Figure 4: Proposed governance structure.

The Research Portfolio Board will be co-chaired by a senior Scottish Government official (SG) and the Chief Scientific Advisor for Environment, Natural Resources and Agriculture (CSA). The three governance strands will bring government and research providers together to address different aspects of the research. Two existing bodies are noted, the Operational Group (of Scottish Government officials and research providers) and Directors Executive Committee (the SEFARI Directors). The latter will be expanded to include directors of the Centres of Expertise.

As part of our initiative to drive a culture of openness in the next research portfolio, we have developed a policy on open research and FAIR data sharing that will apply across the portfolio, aligned with other relevant funders. We will also establish reporting mechanisms which are, as far as possible, comparable to UK Research and Innovation (UKRI), making available maximum visibility on the work carried out and capturing the benefits that have accrued.

How we will monitor progress

We already monitor and evaluate our investment in research, requiring deliverables from every project. We will develop this further by taking the following measures:

- For the work within the Strategic Research Programme we will collect, and make public, measures of science excellence, benchmarked against other research funders on the basis of scientific quality measures that are appropriate to the range of research that we fund.
- Immediate delivery measures will continue to be reviewed in the operational strand of governance on an ongoing basis with timing appropriate to the research timescales, and with summary reports to the Scientific Advisory Board and proposed Research Portfolio Board.
- We will continue to undertake an independent mid-term review of the portfolio of research activity, engaging fully with stakeholders of the research as part of this.
- For all research we fund, we will collect and make public information based upon case studies, user testimonies and, where possible, economic valuations, to demonstrate the impact and value of research on an economic and societal basis.
- The six objectives described in **Section 3** will be reviewed in turn, along with science quality and impact, by the science or institutional strands of governance (summarised to Scientific Advisory Board and Research Portfolio Board) to inform the summative mid-term review.
- Throughout 2022 - 2027 we will continue to develop and refine the indicators we collect, recognising that detecting and understanding the impact of strategic research may take place over longer timescales than the more immediate and policy-focused research.

Annex A: Research Themes and Topics

Theme A: Plant and Animal Health

High quality agricultural crops and livestock underpin Scotland's growing food sector and our ambition to be a Good Food Nation, with products consumed in Scotland, the UK and exported that are known for their provenance and quality. Research and development are required to provide confidence against a background of uncertainty generated by climate change, shifting world trade patterns and the spread of diseases and pests.

Diseases of plants and animals cause direct production losses which reduce the quality of products, the viability of businesses and increase environmental burden through increased resource use. Our policies, policy delivery partners and producers need evidence, tools and resources to detect, prevent and control diseases and pests. Our objective is to protect our primary production systems and ensure that they are as economically and environmentally efficient as possible.

The threats of diseases and pests come from a range of sources: some are endemic in Scotland and currently constrain production; others may arrive with products that are traded internationally. They include pests and diseases that move between hosts such as between wildlife and livestock, between imported products and the natural environment, or between livestock, the environment and people. Maintaining the skills, expertise and capability to detect and deal with the endemic diseases, the 'exotic' threats and zoonotic infections, is a core function of our research.

A1. Plant Disease

Plants sustain life, mitigate climate change, enrich landscapes and underpin our rural industries. However, they are subject to an ever-increasing range of pest and disease threats, due primarily to trade and travel globalisation and the effects of climate change.

For example, the bacterial pathogen, Xylella, has over 500 host species, many of which are found across Scotland. Legislative controls would require destruction of host species up to 5km from the site of an infected plant. A Scottish outbreak could therefore devastate our natural environment.

Another pest, Potato Cyst Nematode (PCN), causes significant yield losses but, more importantly, the amount of infested agricultural land increases every year. If the loss of land continues at the current rate, our £100 million seed potato industry will be in jeopardy in the next 30 years.

The Scottish Plant Health Strategy aims to work collectively with stakeholders to minimise the impact of plant pests and diseases and will be revised in 2021. With an evolving landscape, policy decisions need to be underpinned by scientific evidence in order to best support Scotland's rural industries, the environment and our biodiversity. More than ever, behavioural change tools are required to support industry changes that will help safeguard Scotland's future plant health resilience.

Goals:
Working collaboratively across science, industry and policy, we have the potential to reduce the burden of detrimental impacts from pests and diseases to safeguard our environment and economy, and improve our plant health resilience.

To achieve this we aim to:

- Understand pest and disease infection routes and plant resistance mechanisms in order to develop effective and sustainable control strategies, including integrated pest management strategies.
- Identify key trade risks and potential solutions to prevent introduction of non-indigenous pests and diseases.
- Support development of plant disease diagnoses to allow rapid identification of infected plants, particularly at points of entry and in the field.
- Model the impacts of climate change to inform policy decisions aimed at responding to and mitigating future plant health threats.
- Engage with stakeholders to ensure a joined-up approach to our evidence needs.

Connections:
Future of Scottish Agriculture discussion document, Scottish Biodiversity Strategy, Scottish Plant Health Strategy, Scottish Climate Change Adaptation Programme Action Plan, Environment Strategy, Defra Animal and Plant Health Agency, bacterial disease programme led by UKRI-BBSRC, AHDB research programme, Euphresco research.

A2. Animal disease

This topic includes diseases that affect livestock, principally cattle, sheep, pigs and poultry, and depending on circumstances it may extend to include diseases of other animals (e.g. equines, honey bees, camelids and cervids). Whilst the majority of the research will be on non-notifiable endemic disease (research on notifiable diseases is funded elsewhere), there is a some need to explore the specific impacts of notifiable disease threats in Scotland. It covers the prevention, detection, and control of animal disease, from both existing and emerging diseases. The protection of public health through a One Health approach – including tackling zoonoses and antimicrobial resistance – is also a priority.

Drivers for this work include the SG's Animal Health and Welfare Strategy (currently under review), the Scotland One Health National Antimicrobial Resistance Action Plan (SOHNAAP) (in preparation) and the new EU Animal Health Regulation (Scotland will be broadly aligned to this). Future changes in agricultural and rural support mechanisms, the economic effects of EU exit and new trade deals will also mean changes in the livestock sector in Scotland. Animal health controls will need to address such change, and improved data systems such as ScotEID, the Scottish multispecies livestock database, will be increasingly important. Novel disease control programmes may be needed, requiring evidence to help design these, monitor progress and drive behaviour change in the livestock sector.

Goals:
Scientific evidence is developed and used to improve disease prevention, surveillance and control systems in order to reduce the impacts of animal disease upon the productivity and biological efficiency of the livestock sectors in Scotland.

To achieve this we aim to:

- Inform improvements in surveillance policy so that disease threats and resistance to treatments are detected early.
- Provide robust scientific evidence to inform contingency plans for disease threats and responses.
- Develop diagnostics & vaccines for the detection and control of endemic and new and emerging infections, this requires understanding of disease mechanisms and a pathway to deployment.
- Develop data resources to inform disease prevention and control which are reactive and accessible to policy makers, research groups and collaborators. Based on core datasets collected by ScotEID and Scottish Government together with data from other parts of the UK.

Connections:
Links to other research topics on animal welfare, plant health, livestock improvement, food supply and security, food and drink improvements, diet, climate change, agricultural GHGs, land use. Key partnerships are with Defra Animal and Plant Health Agency (APHA) and contracted projects, with UKRI-BBSRC programmes and Institutes and with EU research programmes.

A3. Animal welfare

This topic includes the welfare of livestock, companion animals and of wildlife. The importance of animal welfare and protection in Scotland is underlined by new powers established by Scottish Ministers under the recent Animals and Wildlife (Penalties, Protections and Powers) Bill, and the creation of the Scottish Animal Welfare Commission which will focus on protecting the welfare of wild and companion animals. The current Animal Health and Welfare Strategy is also under review, and may lead to the formation of a new Scottish Veterinary Service combining regulatory and enforcement roles in the sectors.

These changes in legislation and strategy, the work of the new Commission, and ongoing changes in livestock production coupled with public concern about welfare of animals in agricultural systems will generate demands for research into veterinary, legal and ethical issues. Unforeseen research needs are also likely to stem from EU Exit, international trade deals, new agricultural support mechanisms, climate change and the emerging “One Welfare” initiative.

Goals:
Animals in Scotland have the highest possible standards of welfare, with legislation, guidance and advice to Ministers, animal keepers and the public based on evidence derived from high quality science.

To achieve this we aim to:

- Develop methods to assess welfare, improve animal husbandry and reduce the use of painful procedures in sustainable farming systems.
- Inform policy responses to livestock welfare issues that arise from EU exit and support commitments made to improving the welfare of laying hens.
- Understand how to influence the behaviour of those working with animals to maximise uptake of measures to improve health and welfare standards of livestock, pets and exotic species.

Connections:
Links to other research topics on animal disease, livestock improvement, food supply and security, food and drink improvements, biodiversity, behaviour change. Key partnerships with Defra Animal and Plant Health Agency (APHA) and contracted projects, with UKRI-BBSRC programmes and institutes and with EU programmes.

Theme B: Sustainable Food System and Supply

This theme brings together research on sustainable food production from domestic agriculture through to sustainable and secure supplies of food, as well as supporting a safe and healthy diet. It will provide elements of research relevant right through from farm to fork in order to contribute to the economy, people's livelihoods and the health of the nation.

One of the primary focuses of the research is in developing resilient, high-quality crop, livestock and food and drink industries that capture market value and contribute to Scotland's economy. There is also a focus on improving agricultural practices to develop a resilient, productive sector that is abreast of transformative opportunities. In order for the research to have impact, ultimately it must all be positioned in a way to benefit the industry.

Particular connections will exist between the crop and livestock improvements research in this theme and the plant and animal disease research. Any research identifying improvements will also have potentially beneficial knock-on effects for climate change and other environmental issues (Themes C and D). As agriculture is such a significant contributor of greenhouse gases (GHGs), there should also be clear links demonstrating and quantifying the potential emissions and land use savings associated with the research.

B1. Crop improvement

There are many challenges affecting the sustainability of crop production in Scotland including climate change, declining soil health, loss of key agro-chemicals and pest and disease threats. However, with a growing global population and environmental challenges to consider, there is an immediate need to produce more food on less land, with less water and with lower environmental impacts. As we go forward, we increasingly need our crops to be resilient, nutritious, high yielding, environmentally-friendly and competitive in global markets.

Cutting-edge research in this area will help safeguard rural industries by supporting farmers to adapt to, and mitigate, the trade and production challenges that lie ahead in order to thrive as outlined in the Future of Scottish Agriculture policy document. This work will include the potato, barley and soft fruit crops that are traditionally important in Scotland, as well as new, emerging crops.

Goals:
To create resilient, sustainable, high quality crop production systems that support the rural economy, climate change mitigation and adaptation, food security and the circular economy.

To achieve this we aim to:

- Support innovative crop improvement research, including crop breeding and fast-track selection of desirable traits, to facilitate high quality crop production.
- Support farmers to adapt to future trade and production challenges so that they can continue to produce quality crops as part of a thriving rural economy.
- Ensure scientific evidence underpins policy decisions to improve and support the crop production sector and our rural economy.
- Maintain collaborative approach across policy and scientific areas dealing with the challenges of climate change, food security, plant health, and the circular economy to best support continuation of a strong crop production sector.

Connections:
Future of Scottish Agriculture Discussion Document, Scottish Plant Health Strategy, Scottish Climate Change Adaptation Programme Action Plan, Scottish Environment Strategy, UKRI-BBSRC's bacterial disease programme, AHDB and Defra research programmes.

B2. Livestock improvement

The livestock improvement theme will focus on the major livestock species that contribute to Scotland's primary production sector and its Good Food Nation ambitions – cattle, sheep, poultry and pigs. The sector has economic value as an employer and a supplier to our food sector, is also part of our culture and heritage, and interacts with biodiversity and the wider environment. We need to improve our livestock farming to enhance profitability and sustainability, with a direct focus on outputs that contribute to Scotland's climate targets and support biodiversity.

Research needs include the genetic improvement and conservation of genetic diversity in livestock, reduction of greenhouse gas emissions through more efficient use of food/feed, and environmentally sustainable livestock systems which also support biodiversity. Other needs include understanding the drivers of, and barriers to, behaviour change in businesses to inform policy decisions on the future of rural and agricultural support mechanisms.

SG aims to support digital approaches across the livestock sector, where the use of data and digital transactions is expanding rapidly. Many thousands of small businesses could use their own data to drive productivity and efficiency, and research is needed to inform policies and to drive and support this change. Scotland is well-placed to advance this area because SG has invested in a multi-species livestock database, the ScotEID system, which can both underpin research and assist delivery of research outputs.

The diversity of business types and the connections between players in the livestock supply chain (breeders, finishers, marts and abattoirs) must be taken account of in research design and delivery throughout this topic in order to maximise the impact of research outputs.

Goals:
Research outputs that inform and drive a change in policies, businesses and the supply chain towards sustainability, productivity and GHG reduction.

To achieve this we aim to:

- Build a body of evidence, expertise and knowledge to inform development and implementation of livestock improvement policies that mitigate climate change and enhance biodiversity.
- Develop tools, innovations and methods that can be taken up by livestock businesses that enhance economic performance and deliver against sustainability targets.
- Explore the benefits of whole chain approaches to the use of data in the livestock supply chain.

Connections:
Links to other areas of the strategy including: animal disease; animal welfare; improving agricultural practice; land use; agricultural GHGs; food supply and security; biodiversity; rural economy; knowledge economy.

B3. Improving agricultural practice

This research topic will be key to informing work on the future of food and farming in Scotland, post-2024 farming support and the uptake of measures, policies and practices required to meet policy goals, as well as developing the underlying resilience of the sector. Departure from the EU, and therefore Common Agricultural Policy, in conjunction with the increased focus on the climate emergency will lead to substantial changes in agricultural subsidy system and policy.

Positively influencing farmer behaviour is a long-standing issue with a wide range of examples in the industry of challenges around the uptake of best, and even basic, practice. In order to deliver policy outcomes in the most effective way it is essential for the Scottish Government to understand the barriers to uptake of basic and best practice, new technology and how to develop policy to better incentivise uptake.

Goals:
Better uptake of basic and best practice by farmers leading to a more productive and less vulnerable sector overall.

To achieve this we aim to:

- Develop approaches to influence farmer behaviour and effect change on the ground with respect to soils, land management, air quality, flood prevention and climate change.
- Understand the barriers to uptake of basic and best practice in Scottish agriculture.
- Understand and quantify where possible the likely scale of costs and benefits of the approaches identified.

Connections:
Behavioural change is an area cutting across nearly every policy area of interest identified in the research portfolio. It is essential that this work package operates in conjunction with these other areas to identify and quantify specific cost-effective techniques for increasing the uptake to benefit all areas of agriculture.

B4. Food supply and security

The purpose of this research topic is to equip policy makers with the knowledge to ensure that domestic food production in Scotland can fulfil the goals of providing good, high-value jobs domestically, and contribute to a healthy Scottish diet and the circular economy. Ensuring that we effectively leverage new and existing technology and data to maximise our capacity to produce and add value is a key concern here.

Goals:
To identify opportunities for change to Scotland's food supply chains to meet the nation's needs and to maximise the efficiency, value, sustainability and resilience of our food supply.

To achieve this we aim to:

- Produce a detailed set of scenarios and recommendations about the scope and potential value for increasing soft fruit and vegetable production in Scotland, drawing on international examples and the scope for emerging and current technology to maximise our capacity and minimise waste.
- Research the most effective support models for encouraging innovation within a high-value, high-productivity food sector.
- Review the Scottish supply chain and protein bioeconomy, exploring where supply chain investment could improve the resilience and reduce the fragility of primary production sectors in relation to external shock.
- Review and assess what scope there is to build food security within Scotland and increase capacity to respond to food insecurity.

Connections:
Many Scottish organisations contribute to understanding the food system; the UKRI-BBSRC-led Transforming Food Production and Global Food Security programmes will be among the external partners.

B5. Food and Drink Improvement

This topic will support the greater understanding of Scotland's food and drink industries, identify opportunities to expand and capture greater market value, as well as consider the interactions with and impacts upon wider Scottish Government objectives such as the climate change emergency and inclusive growth.

Goals:

- Evidence on how to develop both existing and new export markets, and to support the development of new brands.
- Innovations which improve the sustainability of food processing and distribution.
- Business models which promote collaboration between farmers, growers and other workers in order to maximise the circulation of value within the food system.

To achieve this we aim to:

- Analyse potential and high-return opportunities in order to identify the barriers and limitations which food products face in new markets, with an emphasis on building capacity to add greater value to our exports and accessing new markets via technological innovation.
- Identify points within key Scottish food and drink supply chains where bottlenecks exist and/or value opportunities are missed or where there are opportunities to recapture value.
- Review the scope for reducing the environmental impact of Scotland's food and drink products, including the processes and materials used, to reduce waste, improve against wider-environmental goals and support the Scotland brand.
- Collect baseline and monitoring data in order to benchmark food and drink processors on non-traditional metrics (i.e. energy use, GHG emissions).
- Review the pros and cons of higher value (i.e. PGI, PDO, organic) status for Scottish products.

Connections:
Links to other research topics on food safety, waste and circular economy, and rural economy.

B6. Diet & Food Safety

This topic will support Scottish Government's commitment to the concept of Scotland as a 'Good Food Nation', where our population takes pride and pleasure in, and benefits from, the food they produce, buy, cook, serve, and eat each day.

The importance of a safe, healthy, nutritious and environmentally sustainable food and drink environment in Scotland is a critical part of our culture and is fundamental to our economic growth and public health. It is vital that actions support achievement of the Scottish Dietary Goals and maintain a focus on reducing health inequalities in the population.

Goals:

- Interventions which reduce food-borne disease and health risks.
- Innovations which improve the traceability of food and feed origins.
- Approaches to persuade consumers improve their diet and food safety.

To achieve this we aim to:

- Build understanding on the sources and epidemiology of foodborne disease in Scotland to identify interventions and reduce foodborne disease.
- Develop state-of-the-art scientific methods to identify and tackle emerging microbiological, chemical and nutrient risks in food for Scottish consumers and businesses.
- Establish an understanding of the flow of bacterial antimicrobial resistance (AMR) genes through soil, animals and humans.
- Develop methodologies and build data that can identify and track the origin of Scottish food products.
- Develop work on behaviour change interventions so that we can understand how to influence consumers to make long-term changes with respect to their diet and food safety and that reduce or minimise health inequalities.
- Research protein alternatives (e.g. legumes), vegetable and fruit production that can be reared and/or grown in Scotland, to support climate change targets and sustainability at reduced costs to consumers.

Connections:
Links to research topics on rural economy, agricultural practice, crop improvement.

Theme C: Human impacts on the Environment

This Theme brings together research on activities that have a direct environmental impact including on the climate, land use and resource use. Research on agricultural greenhouse gases, circular economy, land use and climate change, are all needed to inform the transition to net zero by 2045 and the range of policies that will be required to get us there. Large-scale, coordinated changes to our economy, agricultural and land use practices are required to reduce our impact on the environment and to make the most of the economic and social opportunities of this transition.

As well as looking at the high-level, long-term strategic direction, this research theme looks at the individual and community level to understand how people, families, organisations and businesses can each best be supported to reduce their environmental impact. There is a focus on understanding individual behaviours and consumption practices and encouraging more sustainable business models, land uses and behaviours. It is anticipated that these behavioural changes will both reduce environmental impact but could also improve individual wellbeing. This is particularly the case in the research into use of outdoors and greenspace which aims to get more people visiting and benefiting from nature.

This theme is highly crosscutting with particular connections to research on Natural Resources, Food system, and Rural Futures.

C1. Climate Change

The Climate Change Act 2019 set new targets for the reduction of greenhouse gas emissions. These targets, which apply annually from now through to Net Zero in 2045, are among the most demanding in the world. This reflects both the severity of the challenge but also our view that Scotland has the right range of assets to make a success of the transition to Net Zero. We will publish an update to our Climate Change Plan in December 2020. This document will set out across all sectors of the economy how we intend to meet our emissions reduction goals, consistent with Net Zero, through to 2032.

Goals:
We need an evidence process that supports an effective policy response, across all sectors, to the ongoing challenges of our Net Zero goal. It needs to support both long run and responsive decisions on our use of resources and help us to design policies where we make the most of potential co-benefits and opportunities for growth in green jobs to support our communities.

To achieve this we aim to:

Achieving our Net Zero target will require substantial effort across all sectors and a wide range of supporting policy measures. We expect to work with other funders especially in this area. Some specific areas of focus include (but are not limited to):

- Understanding the impact of land-use change and land management: on emissions and carbon sequestration; on risk and resilience; and, on our ability to respond and adapt to climate change.
- Technical and economic analysis to inform the challenge of decarbonising food production.
- Approaches to develop and review a national Nitrogen Balance Sheet.
- Analysis of the economic impacts of policy options, for example around the potential employment and supply chain benefits of different technology pathways.
- Research into the social aspects of climate change policy, including public attitudes, behaviour change, and equity and social justice.
- Improving the evidence base to support policies to decarbonise heat and transport.

Connections:
Research on climate change must connect with a range of other research on our land use and natural assets. This includes biodiversity, circular economy, rural economy, land-use, agriculture, natural capital, public health, flooding and soils.

C2. Agricultural GHGs

This research topic will support the development of new options for: reducing emissions, improvements to the design and implementation of existing GHG reduction measures (including incentivising behavioural change); how best to monitor these; and, increasing our capacity to model the emissions from the beef, sheep and dairy sectors under a range of land use and farming scenarios.

This work will be key to informing work on the future of food and farming in Scotland, post-2024 farming support and the broader measures required to meet the agriculture GHG targets in the forthcoming Climate Change Plan. The Scottish Government firmly believe that agriculture has a key role to play in being part of Scotland's solution to meeting our Net Zero target.

Goals:

- Agriculture plays its full role in tackling the global climate emergency and limiting temperature rise to 1.5°C; i.e. meets each of its envelopes under the Climate Change Plan.
- We are responsible global citizens with a sustainable international footprint; i.e. we do not contribute to the global climate emergency by offshoring emissions.

To achieve this we aim to:

- Produce science-based and quantified estimates of the mitigation potential of new and existing measures to reduce emissions from agricultural GHG's.
- Understand the extent to which these measures would be captured and reflected in the Greenhouse Gas Inventory and develop approaches to incorporate those that are not.
- Develop workable, practical approaches to increase uptake of basic and best practice and influence future behavioural change.
- Compare Scottish agricultural emissions internationally at a sectoral, farm and unit level in order to understand what the impact of increased imports could be.
- Measure and monitor our progress and performance over time at appropriate levels, such as benchmarked farm or commodity levels.

Connections:

This topic is connected to other research topics on Animal Disease, Livestock Improvement, Improving Agricultural Practice, Air Quality and Climate Change. All actions under those topics have the potential to impact agricultural emissions so it is essential that the work is joined up and that research in those areas understands and can demonstrate the consequential impact on GHG's as well.

This topic is heavily connected to research carried out by ClimateXChange, and to work undertaken by OCEA, TIMES modellers and the Climate Change Plan policy teams as well as having wider UK connections with both research and inventory work by, for example, Defra and Rothamstead.

C3. Land Use

Rural land use involves many economic activities such as forestry, agriculture and tourism, but we also need to recognise that there are wider social and environmental values (e.g. cultural heritage, biodiversity) which should be taken into account by decision makers and planners. Land and the way it is used can also contribute to the release or storage of greenhouse gases, and we must ensure that land use is optimised to make the maximum contribution to tackling climate change. All this requires a more strategic and joined-up approach, as outlined in Scotland's Land Use Strategy, and supported by suitable data. Scottish Government is committed to the establishment of new governance frameworks and partnerships for future land use planning at multiple levels from local to regional levels.

Goals:

- Planning of different land uses is fully integrated and joined up across sectors and scales.
- Planning decisions take full account of the wider social and environmental benefits which come from land use, and not just economic benefits.
- Changes in land use are optimised to reduce greenhouse gas emissions.

To achieve this we aim to:

- Recommendations for effective governance and planning processes to integrate land use across sectors, and at local to regional scales.
- Develop more timely, affordable and accessible data and metrics for land use across Scotland.
- Evaluation of potential fiscal measures to encourage more diverse and productive land use.
- Improved methods of valuing land and land-uses that capture the wider social and environmental benefits which are not recognised by the traditional cost-benefit approach.

Connections:

Links to other research topics on land reform, climate change, natural capital and biodiversity and rural futures, and to complementary research from UKRI-NERC.

C4. Circular Economy and Waste

We want to create a more circular economy in Scotland – an economy in which products and materials are kept in high-value use for as long as possible. This concept builds on Scotland's progress in the zero waste and efficiency agendas. Developing a more circular economy will benefit both the environment (cutting waste and greenhouse gas emissions) and the economy (improving productivity and opening up new markets).

In our existing economy, we "take, make and dispose". We take resources from the ground, air and water; we make them into products and structures; then we dispose of them. In a circular economy, systems are designed to make better use of valuable products and materials – changing the way they are produced and managed to have less impact on finite natural resources, and create greater economic benefit.

A circular economy approach is linked to all areas of government and all sectors of our economy. This topic overlaps Theme B, on the sustainable food system.

Goals:
Evidence to help us build new behaviours and skills, and prioritise targets for action towards a circular economy.

To achieve this we aim to:

- Better understand the behaviours that influence adoption of circular economy approaches (including from businesses and consumers, and in understanding what barriers exists to prevent adoption of circular economy approaches, and how best to communicate with different groups).
- Develop an understanding of the skills needed to move towards a more circular economy – to support new green jobs.
- Understand which specific items of waste produce the largest environmental concern, and what can be done to reduce waste of these items. (Items of initial interest include: textiles, mattresses, batteries and electrical equipment.)
- Understand how materials flow through our economy and the emissions impacts of different materials. We need to understand which materials have the biggest overall environmental impact (considering their manufacture, life and disposal) in order to understand how best to tackle these materials.

Connections:
Work on reducing waste and moving towards a more circular economy has links to work on climate change and natural resources. Work in this topic will link to complementary work in Zero Waste Scotland, and the UKRI-EPSRC Circular Economy research centres, amongst others.

C5. Large Scale Modelling

Many of the research topics in this strategy involve significant modelling requirements to help us understand how complex, landscape or sectoral-scale systems behave, and how this can be projected into the future. This topic seeks to bring these modelling requirements together in a strategic approach to modelling at scale. It is expected that this will involve a number of specific modelling outputs, but also work to collate and coordinate these models to provide more strategic evidence for agriculture policy, land use strategy, post-EU exit planning, and developing strategies to meet net zero emission targets.

Goals:

- To build a coherent and strategic view of interactions at the landscape or sectoral scale, through large scale and linked-up modelling.
- To understand the limits and possibilities of various interventions to reduce GHG emissions, control nitrogen flows and enhance carbon storage in various agricultural sectors, and land uses.

To achieve this we aim to:

Large scale modelling appears under various topics and the following are a summary of the key modelling requirements. This is not an exhaustive list but reflects known priorities:

- Coordinate the various data sources available, investigating new technologies such as remote sensing, and incorporating modelling techniques.
- Model the GHG emissions from the beef, sheep and dairy sectors, and develop a single projection model to project GHG emissions under a range of Scottish farming/land scenarios (including grasslands and moorlands), to include changes in land use, agriculture and forestry under different business and emissions scenarios.
- Model potential trade and economic impacts upon agriculture, to inform post-EU exit planning and replacement of Common Agriculture Policy.
- Model the impacts of climate change and adaptation upon crop production, to improve plant health and resilience, and inform plant biosecurity advice and plant health policies.
- Develop more detailed and flexible waste and circular economy emissions modelling, to feed into future Climate Change Plans.

Connections:

This is a cross-cutting topic with links to several themes, and complementary work ongoing in multiple Scottish, UK and international organisations.

C6. Use of Outdoors and Greenspace

The use of the outdoors for leisure and recreation is enjoyable in its own right but outdoor visits can also deliver a range of social, environmental and economic benefits. Valuing nature is also a driver for biodiversity conservation. Increasing the proportion of adults visiting the outdoors for recreation at least once a week has been a Scottish Government National Indicator since 2006. There has been a steady and significant increase in outdoor recreation by most adults in recent years, though some population groups have shown no significant change.

Goals:
We want to establish a comprehensive picture of the mechanisms through which different population groups derive benefits from greenspace. This is particularly relevant in the context of Covid-19 when we have seen increased use of the outdoors. Equally, we also want to understand the barriers that limit access for some population groups and the incentives that might help promote behavioural/attitudinal shift in them.

To achieve this we aim to:

- Understand the mechanisms by which greenspace influences positive (or negative) outcomes (e.g. in health, wellbeing, etc). This would allow us to understand what specifically about the greenspace leads to certain outcomes and how or what parts of these could be replicated.
- Develop an understanding and metrics of greenspace quality. Evidence suggests that quality of greenspace is vital in ensuring that the desired health and wellbeing benefits are achieved. There is however lack of adequate knowledge or consensus on what constitutes as ‘quality’ and this needs further research (linked to the mechanisms noted above).
- Provide better economic appraisals of the costs and impact of greenspace provision and use. Current cost-benefit appraisals underestimate the wider benefits of investing in greenspaces, and new methods will help with making vital investment decisions and give a better indication of the preventative spend on health arising from investment in greenspaces.
- Understand the key barriers faced by people in accessing the outdoors and how these can be addressed.
- Understand behaviours amongst different population groups in relation to outdoor recreation and use of greenspace and how these link to wider environmental values and people’s ‘connection with nature’. Equally, what drives behaviours on sustainable use of the outdoors.
- Test whether access to greenspace in early years accounts for benefits later in life.

Connections:
This is multidisciplinary research that links to environmental attitudes and behaviours towards circular economy and waste, early years education, and place making.

Theme D: Natural Resources

Scotland's natural resources (air, soil, water, biodiversity) provide many essential ecosystem services which benefit human health, safety and wellbeing. They are also key to tackling the challenges of climate change and biodiversity decline, and in promoting sustainable land use and a green economy. To protect, enhance and optimise the benefits we receive from our natural resources, we need better information about their status and quality, how and why they are changing, and how best to manage and protect them.

We already have much information about our natural resources, but there are still gaps, and a need to improve the way in which we make decisions about their use and management, particularly where there are trade-offs to be made to achieve multiple benefits. We need ways to properly value natural resources and the services which they provide, so that decision makers and planners can fully take Natural Capital (both market and non-market values) into account, and to drive the changes in behaviour needed to manage and protect them.

This theme will inform decision-makers across a range of policy areas including the rural economy, environment and biodiversity protection, land management, water industry and regulation, and climate change.

Natural resources interact with each other in many ways, and it is important that the component parts of the Theme work together to make these connections and exchange information. There will also be links with work on human interactions with the environment, including climate change, GHG emissions, greenspace, and land use.

D1. Air Quality

Cleaner air provides multiple benefits including to human health, the environment, climate change and the economy. Despite reductions in air pollutants over recent years in Scotland, poor air quality still harms human health and the environment, and has a complex interrelationship with climate change.

The Cleaner Air For Scotland 2 (CAFS 2) Strategy is the main policy driver for SG and partners to work together to reduce air pollution, generate efficiencies and cost savings, and foster better policy integration. The strategy was revised following consultation in 2020. Currently, the six policy objectives relate to transport, health, place-making, legislation and policy, communication and climate change. A 2019 Independent Steering Group review recommended strengthening of evidence on public knowledge, attitudes and behaviours, both for the general population but also for under-regulated areas such as domestic biomass burning and agriculture.

Much air quality research takes place at UK level, but there is still a need for tailored evidence at Scotland level, to support Scotland-specific policies and interventions.

Goals:
Scotland has the cleanest air in Europe; policy areas are well-integrated and the public are well-informed, engaged and empowered to contribute.

To achieve this we aim to:

- Assess risks, impacts and mitigation of air pollution in Scottish urban landscapes (biomass burning); identify opportunities to influence behaviours and strengthen regulation.
- Positively influence farmer and land manager behaviour change via tools and guidance to achieve sustained reductions in site-level air pollution.
- Improve models of air quality for agricultural emissions and domestic burning, by improving data availability and associated monitoring protocols (to improve ability to anticipate problems, mitigate and respond quickly).

Connections:
Climate Change Plan, National Planning Framework 4, Routemap for Renewable Energy, Forestry and Land Scotland; multiple research Themes, especially agriculture/ GHGs, climate change and Natural Capital (economic impacts).

D2. Water

This topic will support the management of Scotland's rural and urban water resources, under the challenges of changing climate and land use.

It will inform a range of policies which concern the quality and availability of water for human consumption, water's role in the wider environment and in supporting biodiversity, and our adaption to the impacts of climate change including flood risk.

Some challenges are well recognised, and research will continue to inform the development of policy options to tackle, for example, pollution, flood risk, and to evaluate the effectiveness of water management. Other challenges are less well understood, or more uncertain, for example, the governance of water use under drought conditions, opportunities around regional land use planning, future changes and uncertainty in water quality and quantity (including flood risk), combined risks such as coastal and surface water flooding, and new risks from emerging pollutants.

Goals:

- Understanding future changes in water resources and flood risk, and the associated challenges, to aid long-term planning.
- Identify how to build resilience into our water resources, and to adapt the ways which we manage and use them as we respond to change.
- Effective approaches to govern the use of water resources.

To achieve this we aim to:

- Develop methods for predicting future changes to the quality and quantity of water resources and flood risk, to inform forward management strategies.
- Develop more flexible, adaptive water management options for Scotland which can be adjusted to respond as new evidence emerges.
- Design interventions to adapt to and/or mitigate the impacts of increasing risk from drought, flood and warmer rivers.
- Develop the role of new regional land use planning approaches in the governance and management of water resources and flood risk.
- Develop innovative management and governance systems for urban water.

Connections:

To other water research funded by UKRI, Defra, EA, SEPA, and NatureScot. Connection with soil health research within the research portfolio. Scotland's Hydro Nation agenda.

D3. Soils

Soils provide many benefits, from growing food and trees to less obvious functions such as filtering water, regulating water flow and, particularly for peatlands, storing carbon. However, soils remain threatened by factors such as erosion, compaction and loss of organic matter; which also have wider consequences for the environment, society and the economy. Policymakers and other decision makers therefore require robust analyses to understand the environmental, economic and societal benefits we get from soils and peatlands in a wide range of contexts.

Whilst there is no single soils policy for Scotland, the Climate Change Plan (including the Peatland Plan and the Land Use Strategy) and Scottish Climate Change Adaptation Programme are key policy drivers, as protecting and enhancing soil health and restoring peatlands are key to reaching net zero GHGs by 2050.

Natural Capital approaches are already adopted by Scottish Government and NatureScot to support policymaking (e.g. for potential agricultural support 'payment by results' schemes, biodiversity protection, water quality). These would benefit from more evidence on how soils contribute, including their monetary and non-monetary value. More real world data is needed, both to validate scientific models of climate change impacts and to monitor impacts of interventions. There is also a need for tools to encourage behaviour change and uptake of incentives for peatland restoration and sustainable soil management.

Goals:
Maximise the contribution of Scotland's soil and peatlands to reduce GHG emissions and other ecosystem services. Optimal uptake of sustainable soil and peatland management practices, with strong stakeholder engagement.

To achieve this we aim to:

- Understand the role and estimate monetary/non-monetary value of soils and peatlands in delivering net GHG reductions and other key ecosystem services.
- Model how peatlands and managed soils may be impacted by future climate change, to explore policy options for minimising soil degradation (e.g. under extreme events). This could benefit Regional Land Use Partnerships, and the design of agricultural support measures.
- Identify options for strategic and systematic soil and peatland monitoring, based on best use of available and novel data, with effectiveness of interventions assessed, to allow timely, cost-effective and appropriate responses to changing conditions.
- Develop user-friendly 'packaged' soil and peatland metrics and indicators to support land based businesses and policymakers.

Connections:
UK GHG inventory reporting, Climate Change Plan, Peatland ACTION project, Regional Land Use Partnerships, Scottish Climate Change Adaptation Programme Action Plan, Land Use Plan, Environment Strategy 2020, future agriculture strategy and agri-support mechanisms, Natural Capital.

D4. Biodiversity

Biodiversity is the variety of life on the planet: ecosystems, species and variation within species. Ecosystems, including the soils which support them, provide us with services including food, water quality, carbon capture, flood management, energy and enjoyment. Species are key components of these ecosystems, with their genetic composition and functioning giving the resilience they need to adapt to climate change, pollution and new pests and pathogens. As well as being important in its own right, biodiversity has important social dimensions, contributing positively to our mental and physical wellbeing.

The biodiversity and climate change crises are linked. They share many of the same drivers, but also many of the same solutions. Biodiversity is essential for sustaining the living ecosystems that provide us with food, fibre, water, energy, and medicines. It is also important when considering climate change, pollution, water quality, flood control and has important social dimensions, contributing positively to our mental and physical wellbeing.

The protection of Scotland's biodiversity and ecosystems is a key priority for Scottish Government and we are committed to doing more to protect and enhance our species and habitat diversity (at spatial, compositional and genetic scales).

At the international level, the Convention on Biological Diversity (CBD) is currently developing the post-2020 Global Biodiversity Framework (GBF) as a stepping stone towards the **2050 Vision of "Living in harmony with nature"**. This will be adopted at the CBD Conference of the Parties (COP 15) in Kunming, China, and will include development of a monitoring framework. In Scotland, the policy position is currently being developed to support these drivers.

Goals:
Research on the function, services, and resilience of ecosystems, on valuing and accessing nature, and on biodiversity management will help to deliver our aspirations for biodiversity conservation and associated national and international targets. Whilst the specific goals are yet to be agreed, Scotland is committed to playing our part in international efforts to safeguard biodiversity.

To achieve this we aim to:

- Improve knowledge on the distinctiveness and state of nature in Scotland in terms of species, genetics, habitats and ecosystem functionality and resilience (including health of soils), and viability of and risks to nature.
- Develop evidence on the benefits of nature, notably through nature-based solutions to societal challenges (health and wellbeing, climate change, biodiversity loss, resilience, economic pressures, poverty and inequality).
- Develop evidence of the pressures upon biodiversity in Scotland and their impacts, especially the indirect and direct drivers of biodiversity loss identified by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Understanding mechanisms of resilience in the face of these pressures, particularly the role of agri-environment incentive schemes and climate change, is a key evidence need.
- Develop evidence-based solutions that enhance nature and biodiversity, across a range of policies, practice and scales (including green infrastructure, farming, protected areas, habitat connectivity and ancient woodland restoration) while recognising the connections to other sectors.
- Enhance our evidence base of effective conservation action, to recognise which interventions are working and why. This is particularly important where Scotland has international responsibility, such as in marine and coastal habitats, temperate rainforest, peatlands, oceanic arctic-alpine heaths, and specifically for seabirds, lichens and bryophytes.
- Develop techniques and results that are internationally applicable, allowing us to be good global citizens. The **Edinburgh Declaration** gives a special impetus, as does the implementation of elements of the Scottish Biodiversity Information Forum recommendations by building capacity of local record centres and new ways of gathering and sharing data.
- Establish a new, time-limited Centre of Expertise on Biodiversity to support actions around the developing SG's Biodiversity Plan. This will focus on providing short term policy relevant evidence and research and will complement longer term research carried out through the Strategic Research Programme.

Connections:
This topic has significant linkages to the topics on crop disease, food security, water, air quality, soil health, natural capital, access to green spaces and improving agricultural practice.

D5. Natural Capital

Natural Capital is the world's stock of natural resources. This includes air, water, minerals and all living things. Scotland's rich and diverse natural environment is one of our most important national assets. It is fundamental to our health, our way of life and our economy.

Protecting and enhancing our natural capital is of central importance to Scotland's response to the global economic crisis caused by the Covid-19 pandemic, and will play a vital role in future land-use and agricultural policies in Scotland.

Scotland has a range of excellent natural capital measurement and monitoring tools and programmes. However, a joined-up systematic approach to measuring our natural assets would allow decision makers in government and other sectors to take potential impacts on natural capital into account.

Goals:
We want to establish a more comprehensive picture of the quantity and quality of all natural assets in Scotland, and how these interact with one another. This work will allow policy makers, planners and businesses to better assess the potential impact that changes may have on natural assets and their ability to provide ecosystem services.

To achieve this we aim to:

- Review all existing evidence on natural assets in Scotland and identify any key gaps.
- Undertake additional research to gather data on assets for which little evidence is currently available, in order to establish timely and comprehensive assessments of natural assets in Scotland.
- Better understand the relationship between natural capital and climate change – both by understanding which natural assets are most at risk from climate changes in Scotland, and by better understanding the ways in which our natural environment can mitigate and adapt to climate change impacts through nature based solutions.
- Explore the dependencies upon Natural Capital, and clarify the associated risks and implications for policy, the economy and business from any declines in Natural Capital.
- Develop resources to provide these data to economists, policymakers, and wider audiences.

Connections:
Research on natural capital must connect with a range of other research on our land use and natural assets, their resilience in future, and integrate with economic research on Scotland's other capital stocks. Research partners will include Defra, JNCC, ESRC and UKRI-NERC.

Theme E: Rural Futures

Rural Scotland comprises 98% of Scotland's land mass and is home to 17% of Scotland's people. In 2018, the GVA of the rural economy was reported to be £37.6 billion which represents 26% of Scotland's total.

Key longstanding issues for Scotland's rural and island areas are depopulation, limited or seasonal opportunities for employment, constraints on services (education, housing, childcare, broadband access and fuel poverty), and community empowerment. Considerable attention is currently being given to economic recovery in light of the Covid-19 pandemic and it is recognised that the economic consequences of EU exit are expected to be strongly felt in rural communities. A focus on green recovery may offer considerable opportunities for rural areas.

The Scottish Government is committed to sustainable rural development and ensuring that rural and island communities are treated fairly in policy making. Other commitments include sustainable economic growth, environmental protection, diversification of land ownership and support for community ownership of land. The intention is that communities should become better involved in decisions made about land and other aspects of their areas, with 'place based' policies growing in importance. As well as research in Scotland, there is considerable opportunity to learn from, and collaborate with, rural communities around the world.

E1. Rural Economy

This research topic is concerned with providing evidence to policymakers to support the effective development of the rural economy. The rural economy is diverse and more than 90% is outside of the traditional primary industries of agriculture, fisheries and forestry. It includes a wide range of activity including food and drink manufacturing and accommodation services linked to tourism. Self-employment is more common in rural areas than urban areas. Growing interest in a green economic recovery offers particular opportunities for rural economies to capitalise on.

Goals:

- Identify improvements to the support mechanisms for rural businesses, including those which sit outside of agriculture and those linked to the 'green economy'.
- Tools to embed rural policy across national government policies.
- Evidence to drive improvements in equality and inclusion in rural businesses.

To achieve this we aim to:

- Review the extent to which current approaches to business support meet the needs of the rural economy, how these might be improved and the implications for adopting a national approach to rural business support.
- Identify and develop evidence for rural funding programmes outside of agriculture.
- Develop evidence on a wide range of rural equality issues to support rural workers, including but not limited to: the lack of participation of women in agriculture, health and safety on farms, and other protected characteristics.
- Design a set of rural social data indicators, which can be used to ensure that rural need is embedded throughout the development of national policy.
- Learn from others internationally.

Connections:

Links to other research topics on rural communities, land use, natural capital and to research in UKRI-ESRC.

E2. Rural Communities

Rural and island communities have experienced long-standing issues relating to population and demographic change, sustainable rural development, public service delivery, equalities and socioeconomic opportunities. The key policy drivers include: rural depopulation, employment, education and skills, housing and infrastructure, community empowerment and ensuring that island and rural priorities are accounted for throughout government's policy and legislation.

Goals:
Better understanding of the issues around, and solutions to mitigate depopulation in rural Scotland.

To achieve this we aim to:

- Gather evidence to develop policy interventions in rural areas facing critical levels of depopulation, with the aim to encourage inward migration and increase local opportunities for young people.
- Develop case studies of innovative solutions to childcare and afterschool provision in rural Scotland, with the aim to increase labour market opportunities for parents.
- Address the equalities knowledge gap by collecting evidence on the size, and lived experience, of minority groups in rural Scotland. This will be used when carrying out Equality Impact Assessments during the policy making process.
- Explore ways in which the capacity and impact of the Scottish Rural Parliament can be increased in order to build communities' opportunities for collaboration and participation in decision making.

Connections:
Links to the research topic on rural economy. Rural childcare research is closely connected to ongoing work conducted by the Women in Agriculture Taskforce.

E3. Land Reform

Land reform in Scotland includes matters relating to the ownership, use and management of land and associated rights and responsibilities. The Scottish Land Rights and Responsibilities Statement, published in 2017, sets out the key policy drivers of diversifying land ownership, and increasing community engagement in decisions about land. The Statement's commitment to environmental stewardship is also now heightened by the climate emergency and the setting of Net Zero emission targets, and this will draw in issues around the rights and responsibilities of land ownership in relation to land use and greenhouse gas emissions. The Scottish Land Commission is also developing advice and guidance around the Statement, and will advise Scottish Government on land reform.

Goals:
Evidence to support policies around the development of community ownership, community engagement, and better understanding of the role of land ownership in achieving net zero emissions and reversing biodiversity decline for Scotland.

To achieve this we aim to:

- Compare Scottish governance structures and those elsewhere in Europe to identify the scope for change and benefits of alternative approaches. This should also contribute to the development of regional land use partnerships.
- Assess the effectiveness of community ownership strategies.
- Review the fiscal measures that may be used to address concentrated land ownership, their legal basis, how they relate to ownership patterns and structures in Scotland, and an analysis of the likely impacts of different measures on the current situation.
- Review the effects of diversified land ownership. This should also consider a better approach for valuing land and land use.
- Analyse and identify the best approaches to forestry to address the climate emergency and biodiversity loss, in the context of Scotland's current land ownership pattern.

Connections:
Links to research on land use within this strategy, and also to the work and supporting research undertaken by the Scottish Land Commission.

Annex B: Knowledge Exchange and Horizon Scanning

Knowledge Exchange

Knowledge Exchange (KE) is a specific discipline, and an activity which is necessary for the research portfolio. The KE intent substantially distinguishes our funding from, for example, UKRI funding. There should be as far as possible a direct line to policy impact for each section of the research portfolio. In practice however there are a wide range of ways of improving the research impact of the portfolio. Focusing on the questions that are most important to Scottish policy in relation to environment, natural assets, agriculture and rural communities is clearly important for impact. However, here are important and unavoidable differences between evidence making and policy making as activities. Relationships of trust and respect between researchers and KE professionals have been critical for this area. This section of the portfolio will both develop strategies and approaches that support impact; and also practically support and develop the social infrastructure needed for useful knowledge exchange.

We expect that this will mean funding a wide range of activities, both traditional knowledge exchange, such as through fellowships, fast-action KE workshops and reports etc. and also working to improve the KE skills of the people we fund across the research portfolio.

We see KE into the Scottish Government as a target for the evidence produced by our research portfolio, but our research must also seek out impact with: our agencies; independent NGOs; industry and commercial organisations; the Scottish Parliament; and the wider public in Scotland, where relevant.

Goals:
We want the maximum impact from our research and from our researchers. We will support organisations and staff who span the relevant sectors, and are equipped with effective KE skills and approaches.

To achieve this we aim to:

- Produce influential reports as a result of workshops and rapid KE events.
- Support boundary-spanning experts, through fellowships in industry and government.
- Support training in KE and policymaking for researchers and organisations funded via the programme.
- Support wider KE opportunities through the Centre for Knowledge Exchange.

Connections:
This should connect to all of the remainder of the portfolio, coordinated with the KE that Centres of Expertise will continue to undertake within their domains. The Royal Society of Edinburgh runs substantial KE and KE training events such as The Scottish Crucible, which we could mirror or support.

Horizon Scanning

More than ever in the age of EU exit, Covid-19 and future uncertainty around climate change, we recognise the need for our research to identify emergent systemic risks and opportunities. These could be the so-called 'Black Swan' events (rare but with outsize consequences), or new evidence, technologies and innovations concerning well-established but still challenging problems such as climate change.

By definition horizon scanning means it is not possible to put together a detailed research programme in advance, but we can be clear about the methods. We expect the horizon scanning will cut across all disciplines, and all parts of the research portfolio. Similar to KE, skills and methodologies are being developed for horizon scanning that are distinct from research skills. We expect this activity to be adaptive and proactive in identifying new issues, and to lead into solutions, or ways to enhance the benefits.

Goals:
We want to have regular outputs on the emerging threats and opportunities for Scotland's environment, natural resources, agriculture and rural communities. Multidisciplinary thinking should lead to identification of Black Swans and high-risk edge cases.

To achieve this we aim to:

- Produce influential reports on emerging systemic high-risk issues, and identify potential mitigations.
- Report on emerging disruptive technologies and innovations, and identify potential policy or legislative support.
- Directly influence the national risk picture, and influence the national risk register.
- Ensure Scotland's policymakers are well informed about new innovations and opportunities.

Connections:
This activity should connect to all of the portfolio, and should inform updates of this research strategy by the scientific strand of governance (**Section 7**). UKRI and GO-Science run UK-level horizon scanning programmes; this activity should link to them where relevant.

Annex C: List of Abbreviations and Acronyms

AHDB	Agriculture and Horticulture Development Board
AMR	Antimicrobial resistance
APHA	Defra Animal and Plant Health Agency
BBSRC	Biotechnology and Biological Sciences Research Council
BioSS	Biomathematics and Statistics Scotland
CAFS	Cleaner Air For Scotland Strategy
CBD	Convention on Biological Diversity
CoE	Centre of Expertise
CRF	Contract Research Fund
CSA	Chief Scientific Advisor for Environment, Natural Resources and Agriculture
Defra	Department for Environment, Food and Rural Affairs
DNA	Deoxyribonucleic acid
EA	Environment Agency
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
Euphresco	European Phytosanitary Research and Coordination network
FAIR	Findability, Accessibility, Interoperability, and Reusability
GBF	Global Biodiversity Framework
GHG	Greenhouse gas
GIS	Geographic Information System
GO-Science	Government Office for Science
GVA	Gross Value Added
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

JNCC	Joint Nature Conservation Council
KE	Knowledge Exchange
MRPs	Main Research Providers
NERC	Natural Environment Research Council
NGO	Non-Governmental Organisation
OCEA	Office of the Chief Economic Adviser
PCN	Potato Cyst Nematode
PCR	Polymerase chain reaction
PDO	Protected Designation of Origin
PGI	Protected Geographical Indication
RNA	Ribonucleic acid
RRF	Responsive Research Fund
RSPB	Royal Society for the Protection of Birds
ScotEID	Scottish livestock traceability research team
SEFARI	Scottish Environment, Food and Agriculture Research Institutes
SEPA	Scottish Environment Protection Agency
SG	Scottish Government
SOHNAAP	Scotland One Health National Antimicrobial Resistance Action Plan
SRP	Strategic Research Programme
UC	Underpinning Capacity
UKRI	UK Research and Innovation

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