Government Office for Science



UK CROSS-GOVERNMENT FOOD RESEARCH AND INNOVATION STRATEGY



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BIS Department for Business Innovation & Skills
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Llywodraeth Cymru Welsh Assembly Government
BBSRC
MRC Medical Research Council
DH Department of Health
FOOD STANDARDS AGENCY
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UK Cross-Government Strategy for Food Research and Innovation

Foreword: Professor John Beddington, Government Chief Scientific Adviser

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The 2007/08 food price rises shocked many in the developed world from the belief that stable or declining food prices and assured supplies could be taken for granted. In the developing world the impact of higher prices came on top of existing levels of food insecurity, making the impacts far more severe, particularly on the poorest and most vulnerable in society.

Whilst the events of 2007/08 were driven mainly by short term factors, they highlighted the challenge mankind faces to feed – equitably, sustainably and healthily – a global population approaching 9bn by mid-century.

At the same time, policy makers in the UK and internationally, and increasingly in the major emerging economies, are grappling with the problem of rising levels of obesity and diet related disease. It is a grim irony that 1 billion adults globally are overweight, and 300m are obese, whilst in the developing world a billion people remain malnourished and under-nourishment plays a part in more than half of all child deaths.

But it would be wrong to see food policy only as a series of challenges. The agri-food sector in the UK and globally is vast, presenting huge opportunities for those businesses able to thrive and innovate, including to meet the increasingly sophisticated demands of UK consumers who place high value on the quality, taste and provenance of the food they eat.

This strategy addresses the contribution of research and innovation to meeting these and the many other challenges on food. It links closely to the shared vision set out in *Food 2030* of a sustainable and secure food system, and to achieving the UK's planned aid in the developing world.

For the first time, it represents a joint research strategy for food research and innovation that extends across the UK public sector – and in doing so fulfils a commitment from the Cabinet Office's 2008 *Food Matters* report, as well as the collective agreement of Food Ministers across the UK.

As set out in this strategy, the issues surrounding food are frequently complex, inter-connected and multi-faceted. Often they extend across organisational responsibilities. Solutions must take account of this complexity to be coherent, and if they are to succeed need to draw on the breadth of knowledge and understanding that is available from many disciplines, organisations and sectors.

With this in mind, a core aim of this strategy is to provide a framework to facilitate a more coordinated and collaborative approach between those public sector bodies involved in funding, commissioning and delivering research in the UK, linking with the private sector, consumer and other organisations wherever relevant.

In 2008/09, public investment in research and innovation across the UK amounted to some £400m. It is clearly critical, not least in the current economic climate, that we secure best value from this investment.

I am enormously grateful to the many organisations and individuals who have contributed to the development of this strategy. A number of important new actions are set out within it. However, of equal value I believe is the commitment to new levels of cooperation that its development has helped secure across government, including the Devolved Administrations in Scotland, Wales and Northern Ireland.

Summary

The UK has a world leading science base which can contribute substantially to achieving the vision of the Government food strategy - *Food 2030* - for a sustainable and secure food system, linking social, environmental, health and economic factors, and in developing the policies to deliver this.

Indeed, the Government's goals for the food system can only be achieved through a strong contribution from research and innovation, to provide the evidence to support effective, joined-up policies and to ensure the development and dissemination of new knowledge, technologies and skills. The topic of food is inherently complex and multi-faceted, and the research and innovation landscape reflects this complexity.

This Strategy provides, for the first time, an overarching government framework for food research and innovation across the UK.[1] Current programmes are placed within the context of broader policy goals and research challenges. Highlighted throughout are examples of past successes, good practice and where joint working is already strong, on specific research and on cross-cutting issues. However, the Strategy also recognises the need for further commitment to co-ordination and sets out how this will be pursued.

There are real challenges ahead for policy makers and researchers, and for the food industry from producers to retailers, with pressures on our food system set to increase sharply in the decades ahead. However, the UK has great strengths in its science base and in industry on which it can draw to meet these challenges, and to exploit the opportunities for innovation and new markets that exist. Innovation in a commercial context clearly takes place predominantly in industry. However, Government has a key role in stimulating this not only through the impact of its research investments but also by investing in education and skills, and through effective regulation, procurement policies and setting of product standards.

Key initiatives highlighted in this Strategy include:

- a new multi-partner food security research programme, co-ordinated by BBSRC and delivered jointly with relevant Research Councils and government departments, and including close engagement with industry and the third sector. Key aims include strengthening research coordination and partnerships, building a more integrated community of researchers, funders and users that extends across disciplines, organisations and sectors, to provide multi-disciplinary research to ensure a sustainable and secure food system; [Section 6.6]

- a new Technology Strategy Board led Sustainable Agriculture and Food Innovation Platform, co-funded by Defra and BBSRC with up to £90M over 5 years, to fund innovative technological research and development in areas such as crop productivity, sustainable livestock production, waste reduction and management, and greenhouse gas reduction; [Section 6.6]

- a doubling of research investment in agriculture by DFID over the next five years to provide farmers in developing countries with access to technologies and to help national governments with more effective agricultural policies,

[1] Reference to Government in this document will refer to the UK Government, unless otherwise specified

based on a robust evidence base. Important progress is also being made towards strengthening the institutional arrangements at international level that will help maximise the value of these investments; [Section 4.1]

- to exploit opportunities in the European Research Area through co-ordination mechanisms such as ERA-NETs and Joint Programmes, and collaboration through the Research and Technology Development (RTD) Framework Programme more generally; [Section 6.6]

- a major Foresight study looking over the long term at the ability of global food systems to feed the predicted future world population of 9 billion healthily and sustainably, set to launch its findings in October 2010; [Section 4.7]

- a new BBSRC Advanced Training Partnership scheme to provide a range of specialist high level training (masters, professional doctorate and continuous professional development) to meet industry needs in partnership with the higher and further education sectors; [Section 7.4]

- the development of new indicators to monitor research collaboration, innovation and skills within the suite of indicators being introduced by Defra for a sustainable and secure food system; [Section 8.3]

This Strategy was developed by a cross-government group under the chairmanship of the Government's Chief Scientific Adviser, Professor John Beddington. The Food Research Group (FRG),[2] including representatives from the Devolved Administrations in Scotland, Wales and Northern Ireland, aims to provide leadership in addressing the issues set out in the Strategy, and will oversee its implementation. The Group's wider links have been strengthened through the new Food Research Partnership (FRP) established to bring FRG members together with senior representatives and experts from industry, the research community and others outside government. The FRP has provided further valuable input to the development of the Strategy to promote a more coherent and coordinated approach on food research and innovation across the UK.

[2] Further information on the Food Research Group and the Food Research Partnership is provided in Section 6.4

1. Introduction

1.1 Aims, Audience and Scope

The challenge set by the Cabinet Office *Food Matters*[3] report in 2008 was for Government to join up its efforts on food policy looking at health, food safety, the economy and the environment. It noted that many of the elements required for a comprehensive food policy already existed but that central Government needed to better integrate them, and work with the public, food chain businesses and other stakeholders to put a new policy framework in place.

This Strategy sets out how the Government plans to maximise the contribution of research and innovation to meeting its goals on food, responding to the need for stronger links between research activities across the public sector.

A joined-up approach on food research and innovation is vital: to underpin coherent policy making, to maximise the contribution of UK research in addressing domestic and global goals, and to help the UK benefit from opportunities of vast global markets.

From both a policy and research perspective the topic of food is highly complex. There are many interests across Government Departments and Research Councils, a large and diverse industry sector, and an extensive range of scientific disciplines that are relevant, ranging from biotechnology through to behavioural research. Yet the importance of bringing these strands together is clear, to support the overarching goal of:

- a sustainable diet, which is affordable, safe and healthy, in the UK and globally, with a thriving UK agri-food business sector.

This document does not set out to replicate or replace those strategies and research plans developed by individual organisations. Rather, it aims to draw more strongly the links between these, and to focus on cross-cutting issues where cooperation is beneficial, for example on skills and infrastructure issues.

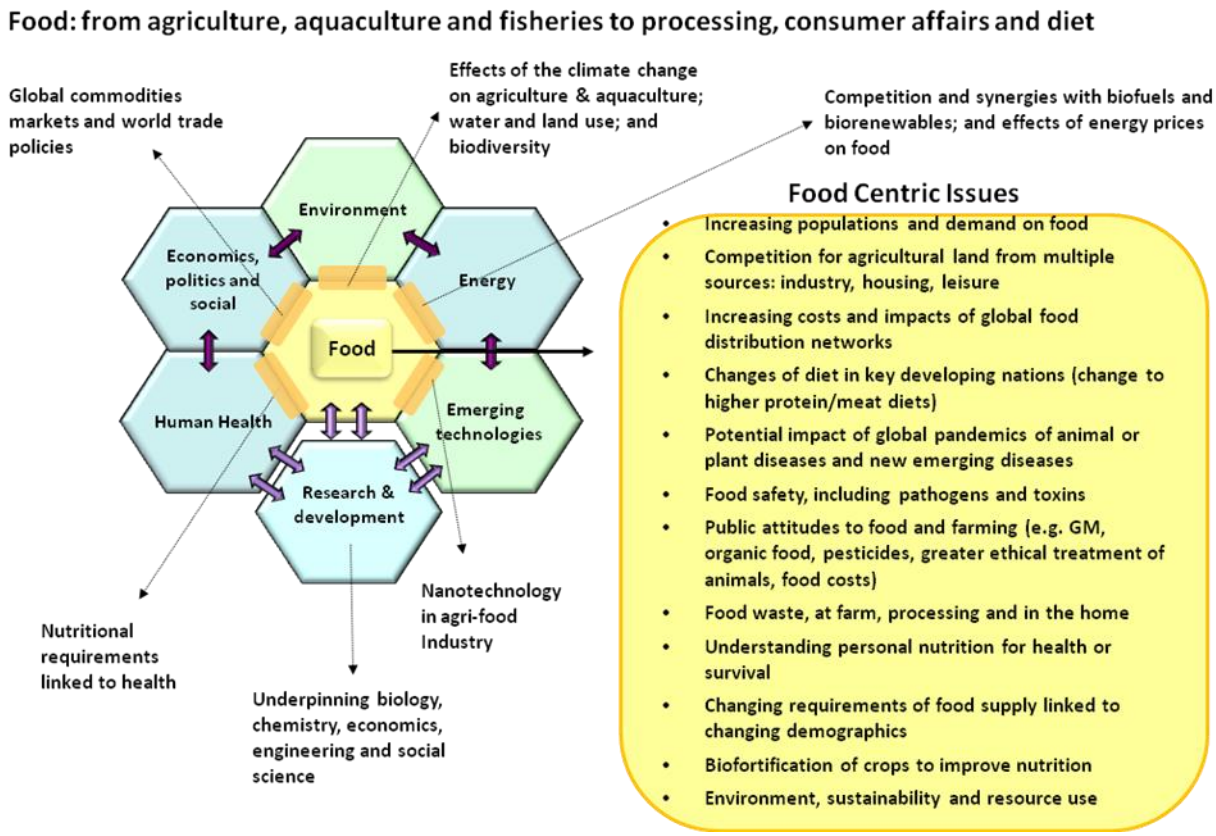
The Strategy is centred on the contribution of the public sector, but it also considers the important links and shared interests with the wider research communities and users, in industry and elsewhere.

Definitions

It is challenging and probably artificial to arrive at a single definition of food research, given the strong links and interactions with a range of other areas, from the environment to human health, from biofuels to global trade policies. This document does not attempt it. However, its dominant focus can be seen as being broadly in the central space illustrated in the diagram below:

[3] http://www.cabinetoffice.gov.uk/strategy/work_areas/food_policy.aspx

Figure 1: The food space and its interactions with other areas



This Strategy comprises broadly three parts:

Chapters 1-5 set out the context and the overarching policy, funding and delivery framework for food research and innovation, including: the Government's vision for a sustainable food system; the role and priorities for research linked to major UK and global challenges; a review of the current landscape of organisations and programmes; and an assessment of key research challenges.

Chapters 6 and 7 set out the Government's plans for strengthening future impacts and joint working, including mechanisms to improve collaboration across the public sector and with other funders and stakeholders, and to enhance cooperation on cross-cutting issues such as research infrastructure, skills and the translation of research into use.

Chapter 8 then explains how outcomes will be monitored and assessed.

2. Policy Goals and Vision

2.1 Policy Goals

Major challenges lie ahead, both for the UK and globally, in the way we produce and consume food.

The UK Government and Devolved Administrations are strengthening their approaches to food policy, including by developing a shared understanding of their goals and priorities for the food system.[4] To strengthen cross-government leadership, Defra has a new Departmental Strategic Objective, to ensure sustainable, secure and healthy food supplies.

In August 2009, Defra published its UK Food Security Assessment, analysing the challenges and risks to UK food security and the resilience of supplies. It also describes the Government's plans for ensuring that the UK remains food secure, with sufficient supplies of safe and nutritious food in the face of the challenges ahead.[5]

The overall vision of the Government food strategy: '*Food 2030*' for a sustainable and secure food system (see box 2.2) identifies what an economically, environmentally and socially sustainable food system should look like in 2030. It builds on four established strategic policy objectives for food, which are to secure:

- fair prices, choice, access to food and food security through promotion of open and competitive markets;
- continuous improvement in food safety;
- changes needed to deliver healthier diets; and
- a more environmentally sustainable food chain.

Investment in science and technology is an integral component to achieving this vision, and to meeting the challenges on food security identified, as well as promoting a thriving business sector to increase economic productivity and sustainability.

The Government is equally committed to addressing poverty and hunger and to promoting sustainable food systems in the developing world. This includes meeting the Millennium Development Goal (MDG) to halve the proportion of people who suffer from hunger by 2015. The food crisis of 2008 highlighted the volatility of international food markets, the need for increased global food production and the inter-connectedness of food issues in the UK to events globally. Whilst the price of the supermarket shopping basket increased in the UK, in developing countries the crisis meant hunger for an additional 110 million people, and permanent health damage for more than 40 million malnourished children.[6]

Support for agriculture and related research and innovation in developing countries is a central part of the Government's approach for tackling hunger globally as well as for a more sustainable food system. The UK also has an important role in making the

[4] The term "food system" is used to mean the food supply chain in terms of both land- and water-based production, processing, manufacturing, distribution, retail, catering and consumption and their environmental, economic and societal impacts.

[5] http://www.defra.gov.uk/foodfarm/food/security/assessment.htm

[6] DFID 2009. White Paper – Chapter 2: Promoting Economic Recovery and Greener Growth. http://www.dfid.gov.uk/Documents/whitepaper/wp-ch2.pdf

case for increased investment in food and agriculture research internationally, mobilising global resources e.g. in the G20 and through the United Nations.

2.2 Vision

The Government's food strategy: '*Food 2030*' sets out a vision for a more sustainable food system as follows:

What we want by 2030…....

- *Consumers are informed, can choose, and afford, healthy, sustainable food. This demand is met by profitable, competitive, highly skilled and resilient farming, fishing and food businesses, supported by first class research and development.*
- *Food is produced, processed, and distributed to feed a growing global population in ways which:*

  - use global natural resources sustainably;

  - enable the continuing provision of the benefits and services that a healthy natural environment provides;

  - promote high standards of animal health and welfare;

  - protect food safety;

  - make a significant contribution to rural communities, and;

  - allow us to show global leadership on food sustainability.
- *Our food security is ensured through strong UK agriculture and food sectors, and international trade links with EU and global partners, which support developing economies.*
- *The UK has a low carbon food system and the food chain is efficient with resources – any waste is reused, recycled and used for energy generation.*

The above goals were developed following extensive consultation[7] with stakeholders, including via an online discussion "*Food 2030*", and alongside a linked consultation on key indicators for a healthy, sustainable and resilient food system.

Many of the elements required for comprehensive and fully joined up food policy are already in place, but there is scope to strengthen policy coordination and delivery, and – as this Strategy aims to do – to promote a more coherent approach on research and innovation to support these goals.

[7] http://www.defra.gov.uk/foodfarm/food/security/

3. Context and Role for Research

3.1 Global challenges

Climate change, population growth and the inexorable rise in global demand for food, energy and water, combined with rising affluence, threaten to create conditions for a 'perfect storm' of inter-related challenges, impacting strongly at the global level but with implications for all countries.

Food security[8] is affected by many physical, economic, environmental, political, social and other factors, including poverty, health, food production and distribution, consumption patterns, infrastructure and access to markets, and is undermined by events such as natural disasters and conflicts. Improved food security is important for global reduction of hunger and poverty, and for economic development. One aim of the Millennium Development Goals is to reduce by half the proportion of people suffering from hunger by 2015. The number of people chronically affected by hunger rose in 2008 from 700 million to over one billion largely as a result of increased food prices.

The resilience and sustainability of the global food system will be severely tested by the need to sustain a population projected to reach around 9 billion in 2050, within the constraints of available land, energy and water, and while protecting the natural environment and coping with unavoidable climate change. Food security, poverty eradication, climate change and the environment are all inextricably linked, and understanding this interrelationship will be crucial to delivering the necessary increases in food production required in a sustainable way.

The UN has predicted that food demand will rise by around 50% by 2030, with global population set to reach around 8.3 billion on this timescale and consumption patterns changing as people move out of poverty around the world. The growing trend towards more "western style" diets in emerging economies, with higher levels of meat, fish[9] and dairy consumption, will significantly increase the pressures on land and water resources. There will be both threats and opportunities for traditional food industries and food supply.

Climate Change and Africa

The current dependence of most of Africa on rain-fed agriculture leaves millions of people highly vulnerable to minor changes in climate. The risks of increasing variability and unpredictability of rainfall are much greater than any increase or decline in overall rainfall. A new study[10] has found that by 2050 hotter conditions, coupled with shifting rainfall patterns, could make anywhere from 500,000 to one million square kilometres of marginal African farmland no longer able to support even a subsistence level of food crops, although the land, on which some 20 to 35 million people currently live, may still support livestock.

Increasing food production to meet this rising demand will present major environmental challenges, both at a global level, via the contribution of agricultural and food systems to greenhouse gas emissions, and more locally, such as through

[8] Defined by the FAO as being achieved when all people at all times have physical and economic access to sufficient, safe and nutritious food for a healthy and active life.
[9] Globally, fish provides protein for a billion people. In the UK, people are encouraged to eat more fish (target of two portions a week), while the UK currently imports 75% of the fish it eats, and exports 50% of fish it catches.
[10] Nairobi-based International Livestock Research Institute (ILRI) and the United Kingdom's Waen Associates.

pressures on biodiversity, ecosystems, soil and water. At the same time, global climate change will exacerbate these factors and bring added pressures on food production in many countries. Despite policies to mitigate climate change and adapt to its impacts, an increasing dominance of negative over positive impacts can be expected in all regions over time, such as through droughts, chronic water scarcity, increasing temperatures, changes in prevalence of animal and plant diseases, and frequency of extreme events such as floods.

Looking to the oceans, attention will be needed to manage world fish stocks, with threats to marine ecosystems from unsustainable exploitation, climate change, acidification and other pressures such as tourism and heavy industry.

A projected increase of 45% in energy demand by 2030 and the need to reduce greenhouse gas (GHG) emissions will put upward pressure on energy prices, which will impact directly on food supplies through increasing running costs of agricultural machinery, processing plants and transport, and indirectly e.g. through increased costs for energy intensive fertilisers and pesticides. Availability of some key inorganic nutrients (especially nitrogen, phosphate and potassium) will also be an issue.

By 2050, agriculture will still be the largest user of freshwater resources in most regions, although its share is expected to decline relative to industrial and domestic uses. Under current water use practices, increases in population and changes in diet are projected to increase water consumption in food and fibre production by 70-90%.[11] The risk of regional conflict is expected to increase as a result of greater competition for water resources from major river systems, particularly the Nile.

A rising and increasingly urbanised population will bring greater pressures on land for industrial, housing and other municipal uses. There is also potential for loss of land due to rising sea levels and salinification of major alluvial floodplains (e.g. in Bangladesh and the Nile delta). Pressures to preserve natural habitats and ecosystems, and carbon sinks such as forests, limit the scope to expand land for agricultural production. For example, the OECD estimates that there is potential for an additional 1.6bn hectares of land in Africa to be used for agricultural production, but this would have major implications for GHG emissions since much of it is forest. Higher food prices and demand for biofuels may add to the pressures, along with the purchase of land in developing countries by richer nations for their own food production in poorer nations.

A further challenge comes as obesity and other diet-related diseases are increasingly important national and global health issues. The WHO projects that by 2015 approximately 2.3 billion adults will be overweight and more than 700 million will be obese[12], and obesity is growing rapidly in low and middle income countries, particularly in urban areas.

3.2 The UK food system

The UK food and drink supply chain accounts for 7% of GDP and employs 3.7 million people. It is intimately linked to global markets, and although advanced and efficient by world standards the UK will need to respond to the same global challenges and

[11] Comprehensive Assessment of Water Management in Agriculture http://www.iwmi.cgiar.org/Assessment/
[12] http://www.who.int/mediacentre/factsheets/fs311/en/index.html

pressures outlined above, through both coherent policies and a broad spectrum of research.[13]

For example, farmers will need to adapt and innovate to deal with climate changes, biodiversity action plans and farming regulations, particularly extended nitrate vulnerable zones, revised fertiliser rules, mycotoxin appraisal for grain assurance, and tighter restrictions in licensing and use of pesticides. Food manufacturers, processors, distributors and retailers will need to be more resource efficient and tackle waste throughout the food system, and to further reduce food safety hazards and risks (including from imports). Rising food and input prices have sharpened attention on the need for more efficient resource use throughout farming and food systems to increase productivity.

The food system as a whole is responsible for around 18% of UK greenhouse gas emissions, and will need to contribute to the UK Government and Devolved Administrations' target, set in statute, to reduce UK emissions by at least 80% by 2050, with challenging interim targets en route.

Currently, food wasted in UK homes costs the average household £480 a year.[14] Eliminating this waste would equate to the carbon saved by taking 1 car in every 5 off the road in the UK. It would also be the equivalent of increasing primary food production by 66% in terms of the volume of food available for consumption.

Patterns of consumption are changing and having significant effects on the health of the population. An estimated 70,000 premature deaths could be avoided each year if UK diets matched nutritional guidelines. Although consumers are better informed and more demanding about the food they eat than previous generations, obesity is rising in the UK. If no action is taken, predictions suggest that by 2015 60% of men and 50% of women will be obese.[15] Being overweight or obese increases the risk of developing heart disease, Type 2 diabetes, high blood pressure and osteoarthritis. Poor diet also contributes to a number of other health conditions, such as anaemia. In this regard, there is a need to better understand consumer behaviour and the factors throughout the supply chain influencing food and lifestyle choices.

Working with business on diet and health

In 2007, the Government Office for Science's Foresight team published a major study examining the complexities of the problem and reviewing future trends and possible solutions. The report *Tackling Obesities, Future Choices'* brought fresh insights into the growing social, economic and medical threat of obesity. Importantly, the study developed a novel system-based approach to the challenge and set out the key components of a strategy to meet it. The study provided the underpinning scientific evidence to inform the Government's response, and in January 2008 DH and DCSF jointly published *Healthy Weight, Healthy Lives: a cross-government strategy for England*, including an additional investment of £372 million in tackling the problem over the period 2008-11.

[13] Defra July 2009. The Future of our Farming. http://www.defra.gov.uk/foodfarm/policy/farming-future/documents/farm-future-leaflet090709.pdf

[14] WRAP, 2009. Household Food and Drink Waste in the UK. http://www.wrap.org.uk/downloads/Household_food_and_drink_waste_in_the_UK_-_report.4cc106b2.8048.pdf

[15] At present, body mass index (BMI) is routinely used to measure for overweight and obesity. BMI = weight (kg) divided by height (m2). The following figures are based on a report by the International Obesity Task Force (IOTF) and refer to a Caucasian population. Underweight <18.5; Normal range 18.5–24.9; Overweight: ≥25.0; Pre-obese 25.0–29.9; Obese class I 30–34.9; Obese class II 35–39.9; and Obese class III ≥40.0. Although BMI is useful on a population scale, it has limitations on an individual level, where more specific means of body composition measurement may be more useful and accurate. Foresight Obesity study. http://www.foresight.gov.uk/OurWork/ActiveProjects/Obesity/Obesity.asp

The Government is not alone in being concerned about the issue. The problems of obesity, coronary heart disease and diabetes, and the benefits of 'healthy eating', has moved to centre stage for food manufacturers. Whilst simplistic answers are advocated by some, in practice the development of effective solutions is challenging and a strong underpinning of research evidence is needed, ranging from the basic science of nutrition to behavioural studies. It is not a problem that can be tackled by any one organisation or policy in isolation, and the research needs are similarly complex and multi-dimensional.

Recognising the shared public and private sector interests, a joint industry-research council fund (DRINC) has been set up by BBSRC to support research in nutrition. Its first call for proposals in 2007 was oversubscribed ten-fold.

Separately, the FSA is working on a number of initiatives with industry, including to reduce the level of salt and saturated fat, and to help them provide better information to consumers on their products.

3.3 Importance of Research and Innovation

A broad portfolio of evidence will be vital to meeting the Government's goals for a secure, healthy and sustainable food system, in the UK and globally. Research will be essential, for example, to increase sustainable food production, to better protect against the constantly evolving threats to agriculture from pests and diseases, to reduce waste, to safeguard human health and to promote better nutrition.

Research investment helps to improve policy and public services and the performance of business, also creating new business opportunities. The research and innovation system therefore needs to be well integrated with the food system to make sure that the potential of new scientific advances is realised, and that the research needs of the food system are communicated to the research community. This will be important for helping to create a business environment which is innovative, resilient to shocks and internationally competitive.

The UK Government and Devolved Administrations fund a wide range of research directly relevant to food, from biosciences and medical research to economic and social studies. This research falls broadly into six categories: policy, strategic, basic, applied, experimental development and horizon scanning.

For research related to evidence-based policy making, the benefit comes from developing and implementing more effective policies, grounded on the best available evidence, and in their evaluation. This mitigates the occurrence of unintended consequences of policies and ensures that policy goals and targets will be met. Departments seek expert advice through Scientific Advisory Councils[16] / Committees (SACs) and other expert panels to provide an independent 'challenge function' to help inform policy development, research strategies and priorities, and to assist horizon scanning. Below are examples of the remits and contributions of some of the Scientific Advisory Committees.

The **Scientific Advisory Committee on Nutrition** (SACN)[17] provides advice to the FSA, DH and other bodies on issues such as the nutrient content of foods, advice on diet and people's nutritional status.

[16] Defra Scientific Advisory Council http://www.defra.gov.uk/evidence/science/how/sac/about/index.htm
[17] Scientific Advisory Committee on Nutrition http://www.sacn.gov.uk/

The **Spongiform Encephalopathy Advisory Committee** (SEAC)[18], sponsored jointly by DEFRA, DH and the FSA, provides independent advice on transmissible spongiform encephalopathies such as BSE, CJD and Scrapie. Its remit is wide-ranging, covering public health, food safety and animal health issues, providing advice on research priorities to reduce scientific uncertainties and assessment of risks.

The Council of Food Policy Advisors, established by Defra, provides independent advice on food policy with key stakeholder expertise, and has recently made recommendations[19] to Government which contribute to making steps towards a sustainable, secure and healthy food supply.

Use of Evidence to Inform Policy Advice in Pregnancy[20]

Peanut allergies

In 2008, the Committee on Toxicity[21] considered a review of the latest scientific evidence on exposure to peanuts in early life and the development of peanut allergy. It concluded[22] that:

- there is no clear evidence that eating or not eating peanuts (or foods containing peanuts) during pregnancy, whilst breastfeeding or during early life influences the chances of a child developing peanut allergy; and
- that the previous dietary recommendations are no longer appropriate because of a shift in the evidence base since previous advice was issued in 1998.

Government advice was revised to reflect the latest scientific evidence and this new advice[23] was issued in August 2009, following trials with consumers and health professionals to ensure that it is clear and understandable.

Caffeine intakes

Recognising the need for more robust basis for advice on caffeine consumption in pregnancy, the FSA completed in March 2008 a major study on the issue, involving around 2500 pregnant women. Evaluating this and other studies published since it last assessed the health risks of caffeine in 2001[24], the Committee on Toxicity recommended that earlier advice to limit caffeine intake below 300mg per day[25] be revised. The new advice, issued in November 2008[26], is to try to keep intake below 200mg per day during pregnancy, as high levels of caffeine might result in babies having a low birth weight, increasing the risk of some health conditions in the baby and in later life, or possibly even miscarriage.

The 'innovation system' in the agri-food chain describes the progression of an idea or concept from basic research through the various stages of applied research and development to use in the field, factory or home. As in other sectors, innovation occurs only with the successful exploitation of new ideas – encompassing everything from incremental improvements to existing processes to major developments that might transform an industry. Although most innovation in a commercial context takes place in the private sector, government has a key role in stimulating this. For example, by investing in education and skills; through effective regulation, procurement policies and setting of product standards; and through the impact of its research investments.

[18] Spongiform Encephalopathy Advisory Committee http://www.seac.gov.uk/
[19] Defra 2009. First Report of the Council of Food Policy Advisors. http://www.defra.gov.uk/foodfarm/food/policy/council/pdf/cfpa-rpt-090914.pdf
[20] FSA Chief Scientists Annual Report http://www.food.gov.uk/news/newsarchive/2009/sep/scirep09
[21] Committee on Toxicity of Chemicals in Food, Consumer Products and Environment (COT) is an independent scientific committee that provides advice to the FSA, DH and other government bodies on matters concerning the toxicity of chemicals. http://cot.food.gov.uk/
[22] http://cot.food.gov.uk/cotstatements/cotstatementsyrs/cotstatements2008/cot200807peanut
[23] http://www.food.gov.uk/safereating/allergyintol/peanutspregnancy
[24] http://cot.food.gov.uk/cotstatements/cotstatementsyrs/cotstatements2001/caffeine
[25] http://www.food.gov.uk/news/newsarchive/2001/oct/caffeinepregnancy
[26] http://www.food.gov.uk/news/pressreleases/2008/nov/caffeineadvice

Reduced water use in strawberry production – East Malling Research, through a Defra funded LINK project, are improving water use efficiency and fruit quality in strawberries. Research shows that a 70% reduction in water use can be achieved through better scheduling of irrigation, with improvements in flavour and shelf-life potential. Results are now being transferred to potatoes - another crop with high water demand.

Tackling safety risks in Bangladesh – Children traditionally catch fish in rice fields in Bangladesh. However 80% of the 16,000 tonnes of insecticides used in Bangladesh every year are applied to rice, mainly to control stem borers. A DFID-funded project involving the Natural Resources Institute, Bangladesh Rice Research Institute and agro-chemical company Syngenta, is trialling a new pheromone based mass trapping approach as an alternative to insecticides. The technology has really caught the farmers' imagination and even local pesticide dealers are united in calling for it to be made available to the farming community.

It is also important to recognise the international benefits of research undertaken in the UK. Much knowledge generated from UK research, especially at the more fundamental level, has global relevance, and research results generated in one country can be used in another. A study of the impact of agricultural research in developed and developing countries indicated economic rates of return of around 40%. On a global scale also, models show that without the contributions from the Consultative Group on International Agricultural Research (CGIAR) poor countries would have produced 7-8% less food, and world food prices would be 18-21% higher, leading to a 5% average decrease in per capita food consumption in developing countries.[27]

Impacts of International Wheat Breeding Research
A review of the economic impact of efforts since 1973 by the International Maize and Wheat Improvement Center[28] (CIMMYT) to develop spring bread wheat varieties resistant to leaf rust found that every 1990 US dollar invested in CIMMYT's wheat genetic improvement over 40 years has generated at least 27 times its value in benefits from leaf rust resistance in spring bread wheat alone. The findings emphasis the importance of maintenance research in crop breeding programmes.[29]

Deploying new technologies, processes and knowledge that make our food businesses more sustainable and efficient will be critical in meeting our economic, environmental and social goals, including promotion of a thriving food sector. The timescales to impact for research vary from the (almost) immediate to the long term (years) depending on the area of work funded and the complexity of the issue being addressed. The uptake of both biological and mechanical innovations in agriculture may take many years, with a long lag of perhaps 15 – 25 years between research expenditures and widespread implementation at farm level.[30] Once benefits have been demonstrated in trials, farmers need to be able to find and use these innovations effectively. Thus it is vital to take a long term, strategic view and to conduct research now to meet the future challenges, as well as developing approaches to facilitate the timely transfer of new knowledge and technologies into practical application.

[27] CGIAR 2009. CGIAR Impact. http://www.cgiar.org/pdf/pub_cg_corp_folder_inserts_IMPACT_10_09.pdf
[28] The UK was a founder member of the Consultative Group on International Agriculture in 1972 and has funded CIMMYT since then.
[29] Marasas, C.N., M. Smale, and R.P. Singh. 2004. *The Economic Impact in Developing Countries of Leaf Rust Resistance Breeding in CIMMYT-Related Spring Bread Wheat.* Economics Program Paper 04-01. Mexico. D.F.: CIMMYT. http://www.cimmyt.org/english/docs/eco_paper/pp0401.pdf
[30] Note similar lag times have been observed in the translation of medical research: D. G. Contopoulos-Ioannidis, G. A. Alexiou, T. C. Gouvias, J. P. A. Ioannidis (2008). Life Cycle of Translational Research for Medical Interventions Science, 321 (5894), 1298-1299 DOI: 10.1126/science.1160622

IMPACT OF RESEARCH

A number of studies have estimated the benefits of UK Research Institute programmes:

- **John Innes Centre**: Current JIC research has the potential to make a significant contribution to reducing Septoria leaf blotch in wheat, the economic losses of which can be up to £36 million in any one year in the UK alone.
- The **Institute of Food Research** saves consumer wastage of food products estimated at £25 million per year through research which has led to extended shelf lives for food products..
- Savings to farmers through research at **Rothamsted Research** into sulphur nutrition for crops have been estimated at £50 million per year.
- Joint DFID/BBSRC funding of disease research at the **Institute of Grassland and Environmental Research** (now the Institute of Biological, Environmental and Rural Sciences IBERS) has led, through collaboration with researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Patancheru, India, to the development of a new variety of pearl millet that is resistant to attack by downy mildew disease, a fungal disease that can reduce harvest yields by up to 80%. Poor farmers in Haryana and Rajasthan now grow these hybrids over 150,000 hectares, both as food grain and for animal feed.
- The economic benefit of long-term support for research facilities was demonstrated by an independent report by DTZ consultants, estimating that the **Institute for Animal Health** work on bluetongue virus potentially saved the UK economy £485M and 10,000 jobs[31]
- An independent assessment of economic impact of the **Scottish Crops Research Institute** estimated a figure of £160 million per year return to the UK economy from an annual investment of approximately £13 million.

[31] http://www.iah.bbsrc.ac.uk/press_release/2009/2009_9.htm

4. Research and Innovation Landscape

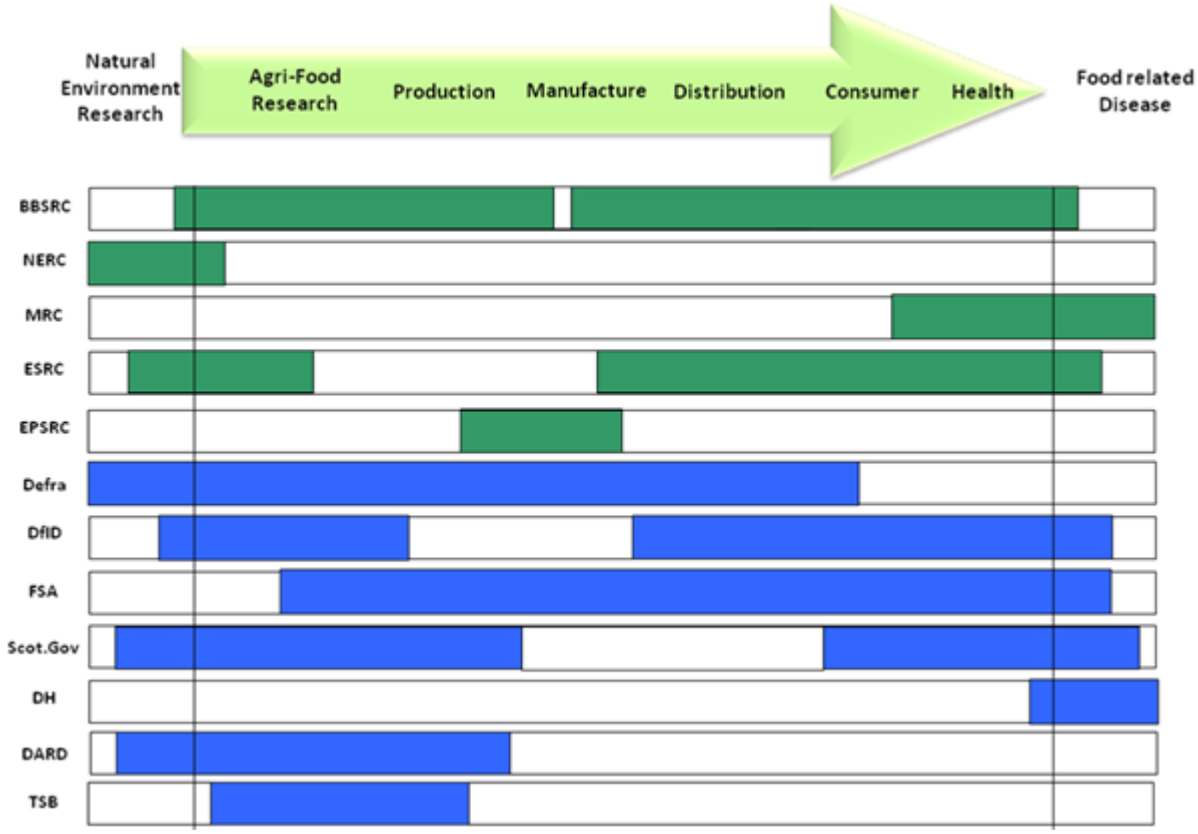
4.1 Organisations and Remits

Main Funders

The food research and innovation landscape encompasses a range of Government departments, Devolved Administrations and other public bodies, including the majority of Research Councils (RCs), the Technology Strategy Board (TSB), the Higher Education Funding Councils, and a diverse industrial base.

The diagram below gives a broad view of departmental and Research Council responsibilities across the different aspects of the production, supply and consumption of food.

Figure 2: Food responsibilities across Government, Devolved Administrations and Research Councils



- The ***Department for Business, Innovation and Skills (BIS)*** is responsible for the overall direction of UK research, innovation and skills policy, and provides funding through the Research Councils (supporting basic and early stage applied research and postgraduate skills) and the business-focused Technology Strategy Board. It also provides support for the English higher education sector and the Sector Skills Councils.

- The ***Department for Environment, Food and Rural Affairs (Defra)*** has primary responsibility for UK food and agriculture policies with the strategic objective of "ensuring a thriving farming and food sector with an improving net environmental

impact and a sustainable, healthy and secure food supply". Defra's evidence portfolio spans the food chain from primary production to consumption (including fisheries and aquaculture), and addresses the need for a resource efficient, productive, secure and sustainable food system.

- The ***Food Standards Agency (FSA)*** protects the public's health and consumers' other interests in relation to food (as defined in the Food Safety Act 1990). It has a wide remit for microbiological and chemical food safety across the whole food chain, from farm to fork. It shares responsibility for nutrition with UK health departments and has a particular role in helping consumers achieve and maintain a healthier diet. It also has a role in ensuring consumers have the information they need to make informed and effective choices about the food they eat, including protection from food fraud and illegal practices.

- The **Department of Health** (DH) aims to improve the health and well-being of people in England. It is responsible for developing policies for health protection, health improvement and to address health inequalities. This includes promoting healthier living and addressing food related disease, especially obesity and diabetes and coronary heart disease. DH works across Government, with the food industry and with other stakeholders, to help people improve their diets. Programmes include: '5 a day' (FSA-led), healthier food initiatives for schools (Department for Children, Schools and Families -led), better hospital food and 'Healthy Start' to help low income families access milk, fruit, vegetables and vitamins.

- The ***Department for International Development (DFID)*** promotes development and poverty reduction in poorer countries, in particular through achieving the Millennium Development Goals (MDGs). Its remit in relation to agriculture includes providing poor farmers with access to technologies and helping national governments make better policies. It supports the Consultative Group on International Agricultural Research (CGIAR), regional research organisations in Africa, and responsive programmes of research with BBSRC on crop science and animal health. In order to get existing research and technology into widespread use, DFID supports two Public Private Partnerships, and a 'Research into Use' programme. DFID plans to double its own spending on agricultural research over the next five years, as well as pressing the case internationally for increased research funding in Africa through its work on the Comprehensive Africa Agriculture Development Programme (CAADP) and more widely through the Global Partnership for Agriculture and Food Security (GPAFS).

- ***Scottish Government*** – through the Scottish Rural and Environment Research and Analysis Directorate (RERAD), funds strategic research on sustainable and profitable agriculture for plants, animals, land management and impacts on human health, mainly in its five Main Research Providers (MRPs).[32] RERAD has a unique position in the UK in commissioning four policy-relevant five-year programmes of research from its five MRPs alongside acting as a 'broker' for policy led research to meet more immediate needs of policy customers in the Scottish Government. Marine Scotland funds research in support of policies on the marine environment, capture fisheries and aquaculture. Scotland's national food and drink policy

[32] Macaulay, Moredun and Scottish Crop Research Institutes, Rowett Institute of Nutrition and Health, Scottish Agricultural College.

'Recipe for Success[33] was published in June 2009. Its aim is to promote Scotland's sustainable economic growth by ensuring that the Scottish Government's focus on food and drink, and its work with Scotland's food and drink industry, addresses quality, health and wellbeing and environmental sustainability, recognising the need to ensure access and affordability at the same time.

- ***Northern Ireland*** – the Department of Agriculture and Rural Development (DARD) aims to promote sustainable economic growth and the development of the countryside, and to assist the competitive development of the agri-food, fishing and forestry sectors, taking into account the needs of consumers, welfare of animals, and conservation and enhancement of the environment. New arrangements have been established in Northern Ireland to support industry engagement with government, including a revised strategic vision for the food sector.

- The ***Welsh Assembly Government*** – The Rural Affairs Department, seeks to support thriving rural communities where people live and work and enjoy a high quality of life, through helping farming become more sustainable economically, socially and environmentally. The Department is also responsible for fisheries and sponsors the work of the Forestry Commission in Wales. The Welsh Assembly Government has published its Farming, Food and Countryside Strategy[34] in May 2009. The strategy sets out an action plan for a sustainable and profitable future for farming families and businesses through the production and processing of farm and forestry products. It has set targets to reduce GHG emissions by 3% per year by 2011 and is working to develop dairy and red meat road maps for Wales to promote best practice in reducing energy and water use and costs along the food chain. Defra manage their research programmes and budget on an England and Wales basis. Welsh Assembly Government officials liaise with Defra to ensure that Welsh research needs are considered.

The **Research Councils** are executive Non-Departmental Public Bodies, established to fund basic, strategic and applied research and related postgraduate training.

  - ***Biotechnology and Biological Sciences Research Council (BBSRC)*** is the lead research council on food, with responsibilities for bioscience research spanning the food chain from basic plant, soil and animal science to food science and human nutrition. Funding is primarily through HEI and research council institutes, but BBSRC also funds industrial collaborative schemes, international collaborations and public engagement which help to add value to the research and increase its impact. In addition, BBSRC is the primary funder of postgraduate studentships in this area. A key initiative is the development of a cross-funder road map for research priorities to address food security.

  - ***Economic and Social Research Council (ESRC)*** research also spans the food chain, with a focus on the social sciences and economics from understanding farm management and modelling world food supplies to gaining insights into food choice.

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[33] Scottish Government (2009). *Recipe for Success – Scotland's National Food and Drink Policy.* http://www.scotland.gov.uk/Publications/2009/06/25133322/0

[34] Welsh Assembly Government (2009). *Farming, Food and Countryside: Building a Secure Future* *http://wales.gov.uk/topics/environmentcountryside/farmingandcountryside/ffcbuildingasecurefuture/ffcstrategydocs/anewstrategyforfarming/?lang=en*

- ***Engineering and Physical Sciences Research Council (EPSRC)*** funds fundamental engineering and chemistry, which has implications for food manufacturing and processing.

- ***Medical Research Council (MRC)*** funds research into human health and disease and therefore has an interest in nutrition, and especially how it relates to ageing and obesity. MRC recently commissioned a nutrition research review.[35]

- ***Natural Environment Research Council (NERC)*** has responsibility for environmental sciences which intersect agriculture in issues of land and water use, environmental sustainability and the effects of climate change.

Other relevant ***Non-Departmental Public Bodies*** include:

- The ***Technology Strategy Board (TSB)*** assists businesses to develop new products and services based on technology. It also assists in knowledge transfer for the benefit of the UK economy through knowledge transfer partnerships (KTP) and knowledge transfer networks (KTNs). Building on the success of the existing collaborations with the TSB, the Research Councils agreed in 2007[36] to align £120M of their funding with the TSB over the 2008-11 Spending Review period, and food is a key area for support. The TSB Sustainable Agriculture and Food Innovation Platform (SAF IP) will address agricultural productivity (crops and livestock), food processing and waste (from farm-to-fork); and includes technology development, product introduction and good practice. The Detection and Identification of Infectious Agents (DIIA) Innovation Platform is mostly focused on human disease but is also investing in the development of tests for the rapid detection of certain animal diseases which will help the livestock industry. More information is provided in Section 7.

- The **Agriculture and Horticulture Development Board** (AHDB) helps improve the efficiency and competitiveness of these sectors within the UK. This encompasses meat and livestock (cattle, sheep and pigs) in England; horticulture, milk and potatoes in England, Scotland and Wales; and cereals and oilseeds for the UK as a whole. Six sector divisions are responsible for setting and delivering strategies to deploy AHDB levy income for funding near-market research and providing information on advances in research and development.

- The ***Higher Education Funding Council for England (HEFCE)*** provides money to universities and colleges for teaching, research, infrastructure and related activities, and therefore funds food research and training through general Higher Education Institutes (HEIs) and Full Economic Cost core grant funds, although no specific programmes exist for food.

- The ***Scottish Further and Higher Education Funding Council***[37] (SFC – Scottish Funding Council) is responsible for funding teaching and learning provision,

[35] DN: Ref
[36] Lord Sainsbury 2007. Sainsbury Review of Science and Innovation. http://www.hm-treasury.gov.uk/sainsbury_index.htm
[37] http://www.sfc.ac.uk/

research and other activities (including areas related to food) in Scotland's 43 colleges and 20 higher education institutions.

- The ***Higher Education Funding Council for Wales***[38] (HEFCW) promotes internationally excellent higher education in Wales by funding education, research and other activities in Welsh higher education institutions, for the benefit of individuals, society and the economy, in Wales and more widely, and would include the food sector generally.

Research Providers

The UK has a strong and diverse research base with many world class facilities in Government, Devolved Administration and Research Council funded agencies and institutes, as well as key strengths in Higher Education Institutes.

4.2 UK Research Strengths

The UK is recognised internationally for its research in many disciplines related agriculture and food. Examples of key UK research strengths include:

- ***Agriculture*** –The UK has a strong science base in support of sustainable land management and its environmental impact. Its scientific research ranges from studies of soil processes to investigations at the ecosystem and landscape scale.
- ***Animal health and welfare*** – The UK is an international leader in research into exotic and endemic diseases of livestock, and provides the World / EU Reference Laboratories for surveillance, research and diagnosis of many such diseases.
- ***Aquaculture and fisheries*** - The UK aquaculture industry, though relatively small, has international strengths in disease identification and environmental management; and there are strong links between the research base and industry both in the UK and internationally.
- ***Climate change*** - UK climate science and modelling is world-leading, and the Climate Impacts Programme provides increasingly refined information and projections to support adaptation and planning at a regional and local level. The UK also has strengths in research to reduce food chain emissions.
- ***Economic and social modelling*** - in the UK is world class, putting the UK in a strong position to apply these strengths to predicting changes in world food markets, creating more stable supply chain economies, and understanding consumer behaviour and attitudes to food.
- ***Food safety*** - The UK has world leading strengths in the microbiological sciences underpinning food safety.
- ***International development*** - The UK has a long history of support for research in developing countries, including supporting partnerships between UK researchers and institutions with developing country counterparts, to deliver better and more relevant research to improve local capacity. The UK works in collaboration with a wide range of bilateral and multilateral partners including the World Bank, the

[38] http://www.hefcw.ac.uk/home/home.aspx

European Commission, Regional Development Banks, as well as other donor countries and is generally seen as an international leader linked both to its domestic actions and its efforts to mobilise global investment in agriculture and food security.

- ***Multi-disciplinary research*** - There are good examples of existing multi-disciplinary food system studies, e.g. the Rural Economy and Land Use (RELU) [39] programme has shown that wider multi-disciplinary approaches can work and deliver outputs when the funders and researchers from different topics work together towards a common goal to deliver benefits to UK agriculture.

- ***National datasets*** - Long term, spatially extensive datasets (soils, water, biodiversity, demographics, sociological) exist and underpin understanding of ecosystems, land-use, environmental change and other areas, such as dietary monitoring (where the National Diet and Nutrition Survey is a key resource) and, the Food Expenditure Survey (which looks at national household food purchasing and expenditure).

- ***Nutrition, healthier food and effective food choice*** - UK scientists are world leaders in the study of early life nutrition and its impact on later health outcomes, understanding diet and health interactions, and diet/gene interactions. The UK has a key strength in cohort studies with relevance to nutrition research and its impact of health research and a competitive advantage based on good systems for follow-up, National Health Service (NHS) databases and integration into cutting-edge biomedical science departments. Underpinning this it has important strengths in epidemiology, genetics, molecular biology, biochemistry, micronutrient research and national surveys of health, food consumption and nutritional status.

- ***Plant sciences*** – The UK has an internationally recognized plant science research base, with key strengths including genetics, genomics, cytogenetics, biochemistry and physiology, multi-site trialling and germplasm improvement.

- ***Technology and process engineering*** – Development of innovative technologies for the agri-food industry to support a sustainable and resource efficient food supply chain.

4.3 Funding

Public Sector

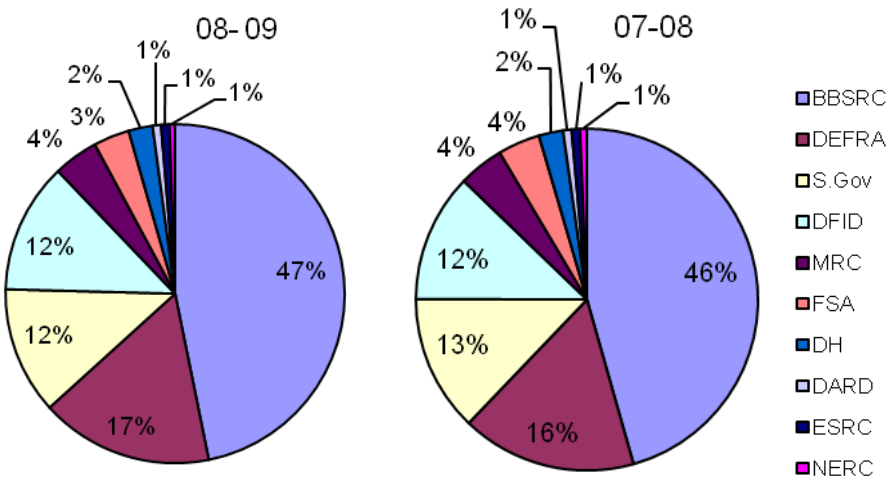
Government and Devolved Administration spend on food research in FY08/09 is estimated to have been £415m and in FY07/08 was £408m, allocated by individual funders as shown in Figure 3 below. More detailed figures are given in Annex 4.

The dominant funders are BBSRC, Defra, DFID and the Scottish Government. BBSRC is the highest funder by some margin, given its responsibility for underpinning and strategic research in agriculture, food and health aspects of diet. It has six research institutes, four of which are primarily dedicated to food (Institute of

[39] The Rural Economy and Land Use Programme (2004-2010) aims to advance understanding of key drivers and challenges, to inform future policy and practice with choices on how to manage the countryside and rural economies. http://www.relu.ac.uk

Food Research, Institute for Animal Health, Rothamsted Research and John Innes Centre). In addition, BBSRC continues to support two former institutes, primarily in food related areas – the Roslin Institute and the Institute of Biological, Environmental and Rural Sciences, which are now part of the Higher Education Institutions (HEI) sector. BBSRC also supports the Genome Analysis Centre, established in July 2009 to further the UK's capacity in genomics, with much of its work relating to applications in food and agriculture.

Figure 3: Food Research Spend [40]



Defra's spend links to its role as lead department for food and farming, and in addition has three agencies: the Veterinary Laboratories Agency (VLA), the Food and Environment Research Agency (FERA), and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). In addition, Defra has an important role in national disease surveillance.

Looking ahead, the Technology Strategy Board has made a commitment of £10m per annum towards a Sustainable Agriculture and Food Innovation Platform, with co-funding from Defra and BBSRC.

DFID's responsibilities for food security and poverty alleviation in developing countries make it a significant funder of agriculture and food-related research both in the UK and overseas.

The Scottish Government spend reflects the strong emphasis placed on research and innovation as part of its approach on food, sustaining a long track record of support for excellent science from basic to applied. Programme funding is directed via its main research providers (Macaulay, Moredun and the Scottish Crop Research Institutes), as well as the Rowett Institute for Nutrition and Health, and the Scottish Agricultural College.

The FSA spend is smaller but research represents a significant proportion of its overall budget, consistent with its remit. Although, other funder contributions are smaller, they are not insignificant, especially in fostering translation of knowledge into and between the key sectors they support in the agri-food chain.

[40] Note: Data were submitted by funders based on funding of food research as defined by Figure 1 and do not include non-research activities (e.g. surveillance) or related research primarily focused on other areas (e.g. climate modelling, human disease). Further information is provided in Annex 4.

Data shows that in 07/08 over 68% (£266m) of public investment supported applied/strategic/policy research (based on ONS Frascati coding),[41] with the remainder for basic research.

Private Sector

The food industry across Europe is the largest manufacturing sector, with a combined turnover of €870 billion, but is dominated by small and medium-sized enterprises (SMEs) (i.e. 99.1 % of 300,000 companies). The UK agri-food sector comprises an enormous range of companies, including over 200,000 farm holdings and 6900 food processing companies, involved at varying stages of the food chain "from farm to fork", and divided between a number of sub-sectors.

The private sector predominantly supports near market research. Spend by the private sector on research is low overall, with Research and Development (R&D) accounting for only 0.24% of total food industry expenditure across the EU15 in 2004. The equivalent R&D expenditure for the food sector in the US is 0.35%, and in Australia is 0.40%; while Japan is the highest at 1.21%. A report in 2005 ranked the food and drink industry as 15th out of 19 sectors in terms of innovation. Innovation is concentrated in the bigger companies. In 2005, the top 15 food companies in the EU spent a total of €3bn on R&D.

The UK food processing sector encompasses a small number of very large food companies and numerous smaller firms. The 21 largest UK food producer and processor companies spend an average of 1.4 % of sales on R&D, although the majority of spending is from one large company.[42]

Modern UK farming encompasses a wide variety of business models, from outsourced contracting of arable cropping to the large number of small farms run on a hobby basis. There are wide variations in farm profitability with farmers' incomes more diversified that in the past.[43] In June 2008, there were 530,000 people involved in agriculture in England.[44]

Quality Meat Scotland works with the Scottish red meat industry to improve its efficiency and profitability and to maximise its contribution to Scotland's economy. It funds a range of initiatives from pure science projects, such as the caseous lymphadenitis (CLA) genotyping, through to very applied activities such as the comparative consumer testing of different beef and lamb products.

Seafish[45] works across all sectors of the seafood industry (fishermen, processors, wholesalers, seafood farmers, fish friers, caterers, retailers and the import/export trade) to promote good quality, sustainable seafood. Research and projects are aimed at raising standards, improving efficiency and ensuring that the UK seafish industry develops in a viable way. Seafish is a Non-Departmental Public Body, sponsored by the four UK government fisheries departments and funded by a levy on seafood.

[41] Frascati code definition.
[42] Food Matters – Towards a Strategy for the 21st Century – The Strategy Unit. July 2008.
[43] These include the following number of holdings (thousand) by farm type: dairy 10.6, grazing livestock 45.8, cereals 23.6, general cropping 8.6, specialist pigs 2.5, specialist poultry 6.200, horticulture 8.9, mixed 9.3, and other 92.7.Source: Agriculture in the UK 2008.
https://statistics.defra.gov.uk/esg/publications/auk/2008/default.asp

[44] See factsheet: Global Development Program: Agricultural Development
http://www.gatesfoundation.org/topics/Documents/agricultural-development-fact-sheet.pdf
[45] http://www.seafish.org/indexns.asp

Charities and NGOs.

Charities and non-governmental organisations (NGOs) also support significant food related research activities within the UK and in developing countries. Some examples are shown below.

The Bill and Melinda Gates Foundation
The Gates Foundation supports agricultural development research through its Global Development programme (spend of about $2billion since 1994, not all on research), with a mission to "Increase opportunities for people in developing countries to overcome hunger and poverty"[46]. The Foundation's approach on agricultural development targets smallholder farmers in Sub-Saharan Africa and South Asia, aiming to reduce subsistence poverty, hunger and child under-nutrition. The Foundation aims to invest in:

- *Science & technology*: focusing on crop science, crop improvement, crop strategies for livestock, and crop management strategies;
- *Farmer productivity*: focusing on locally adapted production, inputs/technologies and supporting systems to reach farmers;
- *Market access*: focusing on cash crops, livestock, staple crops, structured demand, and enabling mechanisms; and
- *Policy & statistics*: focusing on data systems, policy analysis and learning, with the emphasis on two cross-cutting areas: risk management and key emerging trends.

The Gatsby Charitable Foundation supports plant sciences through three initiatives:

- The *Sainsbury Laboratory - Norwich*, located at the John Innes Centre on the Norwich Research Park, with a scientific focus on plant molecular pathology and disease resistance.
- The *Sainsbury Laboratory – Cambridge*, being developed in the Botanic Gardens, will represent the latest thinking in effective laboratory design, and house over 120 scientists whose focus will be plant growth and development.
- The *Plant Science Network and Science and Plants for Schools (SAPS)*, which provides support for post-16 plant science education, and focus on securing and strengthening the plant science content of the biological curriculum.

4.4 Cross-Government Programmes

All seven Research Councils work together through cross-government programmes focused on major global challenges, with food having some relevance to all those listed below. The programmes include non-Council partners (for example, 21 partners in the case of Living With Environmental Change) and involve interdisciplinary research and policy partnerships with Government departments and Devolved Administrations:

- **Global Uncertainties; security for all in a changing world** – addresses five inter-related global threats to security - poverty (and inequality and injustice), conflict, transnational crime, environmental stress and terrorism. Research will be pursued that seeks to understand how crime, terror, environmental stress, and poverty create vicious circles through positive feedback.[47]

- **Living With Environmental Change** (LWEC) - aims to provide: the knowledge, tools, predictions, solutions and business opportunities needed to increase resilience to, and reduce economic costs of, environmental changes such as more severe weather and reduced biodiversity; and the best information to enable sustainable management and protection of vital ecosystem services -

[46] Global Uncertainties: security for all in a changing world http://www.rcuk.ac.uk/research/ccprog/security.htm
[47] Living With Environmental Change http://www.lwec.org.uk/

such as clean air, fresh water, healthy soils, and flood and disease protection - on the time and space scales on which the economy is managed.[48]

- **Ageing: Lifelong Health and Wellbeing** - provides longer term funding for new interdisciplinary centres targeting themes of healthy ageing and factors over the whole life course that may be major determinants of health and well being in later life.[49]

- **Energy** - is looking at new technologies to address the UK energy needs of the future. One key component to this programme is the potential of bioenergy, not as competition for food resources but in harmony with them especially by using biomass from agricultural waste. The new £27 million BBSRC Sustainable Bioenergy Centre combines the knowledge base from agri-food sectors to address these new challenges in a synergistic way with agriculture.

- **Nanotechnology** - aims to exploit the potential of technologies at a nanoscale. There are potential applications for the food industry e.g. in relation to novel packaging, food safety and contamination in the food chain, and the delivery of beneficial nutrients.

- **Food Security** – will align research priorities with the Government's key policy goals, and aim to strengthen research coordination and partnerships extending across the public sector, and with industry and the third sector.

4.5 Supporting business

Opportunities and benefits for business arise from much of the research undertaken across the public sector. A number of programmes are targeted specifically at companies to support research and innovation within the agri-food sector. These include:

- **Sustainable Agriculture and Food Innovation Platform** managed by the Technology Strategy Board (TSB), together with Defra[50] and BBSRC, involving a total public sector investment of £90 million over five years with match funding from industry. This supports innovative collaborative research and development with business and researchers to stimulate the development of new technologies that will increase food productivity whilst decreasing the environmental impact of the food and farming industries. Theme areas include: crop productivity, sustainable livestock production, waste reduction and management, and greenhouse gas reduction.

- The former four **Farming and Food Science LINK** programmes[51] on food, horticulture, sustainable arable and sustainable livestock were sponsored by Defra, BBSRC and the Scottish Government. These are now closed to new proposals but current projects will continue until completion. Project participants range from large retailers and agrochemical companies to small

[48] Ageing: Lifelong Health and Wellbeing http://www.rcuk.ac.uk/research/ccprog/ageing.htm
[49] Farming and Food Link Programmes
http://defrafarmingandfoodscience.csl.gov.uk/linkprogrammeoverview.cfm
[50] Defra will reinvest funding previously intended for its four Farming and Food Science LINK programmes on food, horticulture, sustainable arable and sustainable livestock in the new Innovation Platform.
[51] 'Stand-alone' LINK http://www.bbsrc.ac.uk/business/collaborative_research/link/stand_alone_link.html

manufacturers of specialist instruments and machinery, and individual farmers and growers, as well as industry levy bodies.

- A further **stand-alone LINK** scheme[52] sponsored by BBSRC promotes exploitation of research for the benefit of the industry. This will continue to run through responsive mode and is open to eligible applicants covering all areas of the BBSRC remit.

Reduced pesticide use in controlling wheat blossom midge - A LINK collaboration between ADAS, Rothamsted Research and John Innes Centre involving plant breeders and agrochemical and cereal industry partners is researching novel approaches to dealing with wheat blossom midge, a pest that causes serious loss in quality and yield in some years. The project has enabled more effective integrated pest management and reduced pesticide use.

Reduced nitrogen fertiliser use for oilseed rape - A LINK project with ADAS has identified genetic markers to help develop oilseed rape varieties with lower requirements of nitrogen fertiliser. Existing varieties that are more N-use efficient have been identified, promising that N requirements for future commercial varieties could be substantially reduced without compromising yield.

- The **Biosciences Knowledge Transfer Network**[53] funded through the TSB brings together three former KTNs - food processing, bioscience for business, and Genesis (genetics in animal husbandry), aiming to increase the breadth and depth of knowledge exchange between companies and between business and academia in specific areas of technology.

- **Industrial Partnership Awards** funded by BBSRC are one of a number of industry funding schemes that are science-led, responsive mode grants where an industrial partner contributes in cash (not 'in-kind') at least 10% of the full economic cost of the project.

Novel targeted herbicides - An Industrial Partnership Award to scientists at the University of Sheffield and co-funded by the agrochemical company Syngenta is bringing together biology expertise with the company's development of potential new generation herbicides. The partnership advances understanding of how molecular structure determines the activity of herbicides, and offers the industry the opportunity of novel targeted compounds capable of killing weeds that have become resistant to conventional herbicides.

- The **Knowledge Transfer Partnership** (KTP)[54] scheme is a mechanism by which companies and academic institutions work together to tackle specific and strategic industrial problems through exchange of personnel. It facilitates the transfer of expertise to the industry, increased competitiveness for the company, enhanced research capabilities and knowledge sharing for the academic partner, and training / professional development for staff members on exchange. Government part-funds each partnership with 50% of the costs for large companies, and 60% for SMEs, and the company partner providing the remaining costs. A number of government departments, Research Councils and Regional Development Agencies (RDAs) provide support for KTP projects, covering a wide range of themes.

[53] Knowledge Transfer Networks http://www.ktnetworks.co.uk/epicentric_portal/site/KTN/?mode=0
[54] Knowledge Transfer Partnerships http://www.ktponline.org.uk/

- **A farming section on Business Link**,[55] recently launched by Defra, offers a complete range of guidance, information and online tools for farm businesses. Currently available are guides on livestock, crops, organic farming, and agricultural wages and tenancies. Next year the '*Whole Farm Approach*' will be available. In addition, **Farming Link**[56] is Defra's magazine for farmers and growers.

- The **Biosciences Technology Area**,[57] funded through the TSB, supports those biosciences which underpin industrial biotechnology e.g. biocatalysis, system modelling, sustainable processes for production of food, chemicals, materials and energy production.

- The **Industry Club** model establishes a joint collaborative programme with industry and the Research Councils to support innovative research projects within academia that address generic, pre-competitive research challenges facing club members. These have proved a successful mechanism to support research that underpins the needs of industry, and bring together academic and industrial communities with an interest in a specific area. Examples include:

  - ***Diet and Health Research Industry Club*** (DRINC) – a £10m, 5-year partnership between BBSRC and a consortium of leading companies (£1m), aimed at helping the food industry develop products that deliver enhanced health benefits for consumers.[58]

  - ***Crop Improvement Research and Technology Club*** – led by BBSRC, in partnership with Scottish Government, is currently being developed to support pre-competitive research of strategic importance for industry to improve the productivity and quality of crops whilst increasing the sustainability of production systems. The club will initially focus on wheat, barley and oilseed rape, and their use in food production for humans and animals, and in the longer term may also support research on other important food crops, e.g. vegetables and fruit.[59]

    Other clubs are under development in areas such as animal health.

- Scotland Food and Drink has recently launched a tender for an innovation hub based in Aberdeen to facilitate linkages between the academic sector and the large number of food related SMEs in the north east of Scotland.

[55] Farming Section on Business Link
http://www.businesslink.gov.uk/bdotg/action/layer?r.l1=1081597476&r.l3=1082184973&topicId=1082184851&r.lc=en&r.l2=1082184851&furlname=farming&furlparam=farming&ref=http%3A//www.defra.gov.uk/foodfarm/index.htm&domain=www.businesslink.gov.uk
[56] Farming Link - http://www.defra.gov.uk/foodfarm/policy/farminglink/index.htm
[57] Biosciences Technology Area http://www.innovateuk.org/ourstrategy/technology-areas/bioscience.ashx
[58] Diet and Health Research Industry Club
http://www.bbsrc.ac.uk/business/collaborative_research/industry_clubs/drinc/index.html
[59] Crop Improvement Research and Technology Club
http://www.bbsrc.ac.uk/business/collaborative_research/industry_clubs/crop/index.html

4.6 European Union and International Development

European Union

The concept of a **"**European Research Area**"** (ERA) was established in 2000 to create a more open and connected environment for research across Europe, including strong global links. It aims to promote an environment that stimulates research and the exploitation of results, and contributes to the EU goal to invest 3% of GDP in research. The ERA has been made operational principally through the Framework Programme, which supports collaborative research, fundamental research, researcher mobility, and capacity building across Europe.

The current seventh Framework Programme (FP7: 2007-2013) provides finance on a competitive, responsive basis to international consortia of research providers and industrial partners, through a number of instruments that collectively deliver a full range of research and technological development activities. For collaborative research €32.4 billion is available between ten themes of activity.[60] Detailed programmes of work define, on an annual basis, the topics to be delivered.

The Food, Agriculture and Fisheries, and Biotechnology theme (worth €1.9 billion over 7 years) offers significant research opportunities addressing not only food production, manufacture and safety but also health-related issues such as obesity. Joint and co-ordinated projects on cross-cutting issues are also conducted with other themes, including in the Environment, Health and Energy areas. UK research organisations have typically done well in what is a highly competitive process, obtaining over €2.3 billion in the sixth Framework Programme (FP6). In the FP6 theme on Food Safety and Quality, 533 of the proposals submitted had at least one UK participant, of which 121 contracts were signed - a success rate of 22.7%.

UK research funding organisations also participate in ERANETs, which aim to coordinate national research programmes and identify opportunities for collaboration and gaps in research and knowledge. Defra co-ordinates the EMIDA ERANET on emerging and major infectious diseases of livestock;[61] and BBSRC co-ordinates the plant genomics[62] and systems biology[63] ERANETS.[64] In the ERA-NET in plant genomics the UK was the single largest partner (14.7M €), with involvement in 61% of funded projects and a success rate in call A of 25%. The UK is currently involved in the development of an EU Joint Programme on food security.

In addition, the Institute of Food Research is a key player in the industry-led European Technology Platform Food for Life, aiming to strengthen European-wide innovation, improve knowledge transfer and stimulate European competitiveness across the food chain. For further details see Annex 2.

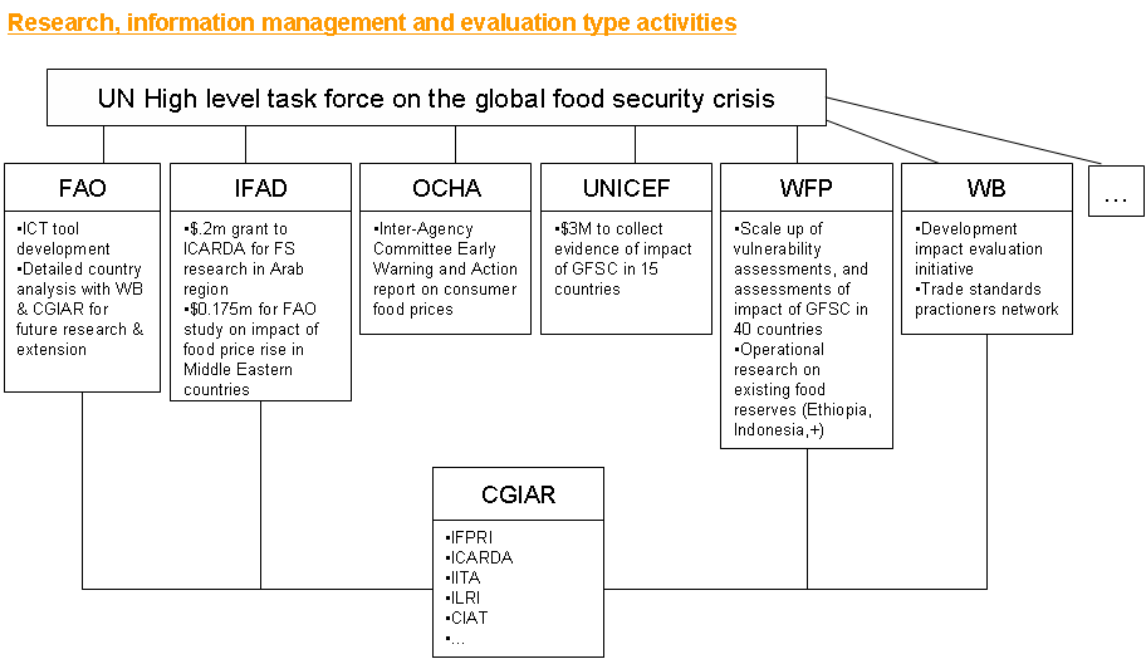
International Development

Linked to its international development goals, and in recognition of the key importance of agriculture to food security and wider economic development, a key

[60] The 'Cooperation' programme has 10 themes: Health, FFAB, ICT, NanoSci, Energy, Environment, Transport, Socio-Economics, Space, Security. .
[61] http://www.defra.gov.uk/evidence/science/how/documents/EU/alex-morrow.pdf
[62] Plant Genomics - http://www.bbsrc.ac.uk/science/international/eranet/era_pg.html
[63] Systems Biology - http://www.bbsrc.ac.uk/science/international/eranet/era_sys_bio.html
[64] Further details on UK links with EU - see Annex 2.

element of the Government's approach internationally is to support the **Consultative Group on International Agricultural Research** (CGIAR). This includes direct funding to CGIAR with opportunities for collaboration between UK research organisations and the 15 CGIAR research centres. With DFID support, significant progress has been made in reforming the CGIAR and creating a balanced partnership between the research centres, which are restructuring into a legal Consortium, and the donor community, that is establishing a new Global Trust Fund at the World Bank. In future, more funding will be directed towards key strategic research priorities through a small number of Mega Programmes. Accountability to stakeholders and beneficiaries has been made central to research prioritisation, planning and assessment of impact. A 6-year Strategic Results Framework is under development which will underpin the Mega-Programmes and all performance-based research contracts between the Fund and the Consortium.

Figure 4: International food security activities



DFID and the BBSRC have formed a strategic partnership to support high-quality basic and strategic biological and biotechnological research in crop science and animal health that has the potential to contribute to achieving the Millennium Development Goals, and which will establish productive partnerships between scientists in the UK and developing countries. Two calls have been launched to-date on: Sustainable Agriculture Research for International Development (SARID) and Combating Infectious Diseases of Livestock for International Development (CIDLID). Future initiatives are under discussion.

African regional research programmes: DFID supports three sub-regional research organisations (SROs) in east, west and southern Africa. This forms part of the UK commitment to agricultural development in Africa and to the Comprehensive African Agriculture Development Programme (CAADP). The SROs manage research programmes to tackle problems best addressed at a regional level, and direct resources to international and regional research partners best able to deliver research results.

An important part of these programmes is a focus on capacity building. DFID is already supporting the Forum for Agricultural Research in Africa (FARA) to implement a major capacity building programme. The purpose of the programme is to maximise the poverty reducing impact of interventions in the agricultural sector by supporting human and institutional capacity strengthening, including competencies and capacity in agricultural research management and the capacity for professional development in research and development.

DFID also provides support to the International Foundation for Science (IFS) whose mission is to contribute to strengthening the capacity of developing countries to conduct relevant and high quality research on the sustainable management of biological and water resources. IFS identifies young, talented scientists who have the potential for becoming the future research leaders and lead scientists in their nations, and to effectively support them in their early careers. More than 4,500 researchers in Africa, Asia and the Pacific, and Latin America and the Caribbean have been awarded research grants by IFS.

Getting agricultural research into use to reduce rural poverty: One of the key objectives of the DFID research strategy is to get the outputs of research into widespread use. The Research into Use (RIU) programme promotes the best results of past research funded by DFID and other donors in Africa and South Asia. The most promising outputs from past research investment have been selected for their potential to raise farmers' incomes, reduce poverty, halt environmental degradation, and increase food security, and using an "innovations system" approach are being promoted across Africa and Asia. Lessons from the programme are being collected and shared to show how best to get forestry, fishing, farming and livestock rearing technologies and policies into use to maximise their impact on reducing poverty.

The project has established strong links with the New Partnership for Africa's Development (NEPAD) secretariat and supported a range of innovative initiatives in Africa and Asia, to get existing technology into widespread use. It has established innovation platforms in a number of African countries, and by working with civil society, the private sector and public research and extension agencies, it is beginning to have real impact. By linking with NEPAD the programme has been able to support and influence the roll-out of CAADP across Africa, using evidence of best practice.

A range of initiatives exist on a bilateral basis. For example, BBSRC and Defra have set up a knowledge exchange partnership with senior Brazilian scientists visiting the key UK agriculture institutions, aiming to forge longer term strategic partnerships.

UK-China Sustainable Agriculture Innovation Network (SAIN).
SAIN is a new platform for UK-China collaboration on sustainable agriculture and the environment. It brings together researchers, policy experts, farmers and other stakeholders to undertake joint research and stimulate innovative thinking to ensure that policy and science is translated into practice on the ground. Launched in November 2008 by Defra Secretary of State Hilary Benn and Chinese Agriculture Minister Sun Zhengcai, it has already attracted the involvement of over 25 leading agricultural institutes in the UK and China. The first approved research projects are addressing issues around climate change mitigation and adaptation, nutrient management, bio-energy and resource efficient agriculture, with the overall aim of contributing to a resource efficient, low carbon economy and an environmentally friendly society.

Partnerships with the private sector:

DFID provides support to Public-Private Partnerships to develop products and technologies for use by farmers in developing countries using intellectual property made available from both the public and private sectors. DFID supports two partnerships: the *Global Alliance for Livestock Veterinary Medicines (GALVmed)* and the *African Agricultural Technology Foundation (AATF).* These partnerships are working closely to get existing technology into use, using the incentives and expertise which are in the private sector. Both have had considerable success in accessing intellectual property from the private sector, and making these widely available in Africa.

4.7 Horizon Scanning and Futures

Despite the wide-ranging evidence available on future issues and challenges, many uncertainties about the future will always remain. Strategies and plans that recognise this, and that take account of uncertainties, are more likely to be robust over the long term. Horizon scanning and futures research are used to systematically examine potential threats, opportunities and developments which are at the margins of current thinking and planning. Techniques involve exploring drivers of change, including novel and unexpected issues as well as persistent problems and trends, and their possible implications. The Government supports collaborative futures work embedded within policy development processes, to ensure that policies and strategies developed now will be more resilient to future uncertainties.

A wide range of horizon scanning and futures work is undertaken across Government. For example:

- The **Defra Horizon Scanning and Futures Team** regularly scans national and international scientific and non-scientific sources for information on change relevant to Defra, its delivery network and customers, including sources relevant to food research and innovation. Relevant insights are communicated via newsletters and discussed in monthly user club meetings and regular 'ground-truthing' workshop sessions. A collaborative impact analysis ensures that programmes, policy and strategy teams have the opportunity to identify implications, understand changes affecting their respective work areas and future proof their work.

- The **FSA General Advisory Committee on Science** (GACS)[65] provides independent advice on the Agency's governance and use of science. Its work includes horizon scanning, science governance, developing good practice and informing science priorities.

Notable examples of current major futures projects relevant to food include:

- **Foresight Land Use Futures**[66] is exploring how land use in the UK could change over the next 50 years. This includes examining society's future needs and values towards land use. It is using the latest evidence and expert opinion across the environmental, economic and social science disciplines to identify where the greatest pressures on land could be and to identify practices which

[65] http://gacs.food.gov.uk/
[66] http://www.foresight.gov.uk/OurWork/ActiveProjects/LandUse/LandUse.asp

encourage valued and sustainable land use practices. Findings are due to be published in February 2010.

- **Foresight Global Food and Farming Futures**[67] is looking at the challenge of how a global population of 9 billion can all be fed healthily and sustainably. The project is examining the food system, including issues of demand, production and supply, and broader environmental impacts, to strengthen understanding and analysis of the global uncertainties and interdependencies. It will consider the role of oceans, seas and lakes in food production, and assess the potential impact of future scientific and technological developments on the food system. Adopting a global perspective on the issues, it will look at potential threats and opportunities, and consider the implications of the analysis for policy and research in the UK, as well as internationally. Findings are due to be published in October 2010.

[67] http://www.foresight.gov.uk/OurWork/ActiveProjects/FoodandFarmingFutures/FoodandfarmingProjectHome.asp

5. Research for a sustainable and secure food system

5.1 Research challenges

Delivering the high-level policy challenges for the next 20 years as set out in *Food 2030* will require a combination of policy and research activities to address the key priorities.

In the last 20 years, technological advances in research have progressed rapidly; as evidenced for example by the step change in information technology and computers, and the revolution in understanding of biosciences and plant genomics. A challenge for any research programme will be to build on new and existing technologies and underpinning knowledge, to understand the food chain issues being addressed in a comprehensive, multi-disciplinary way.

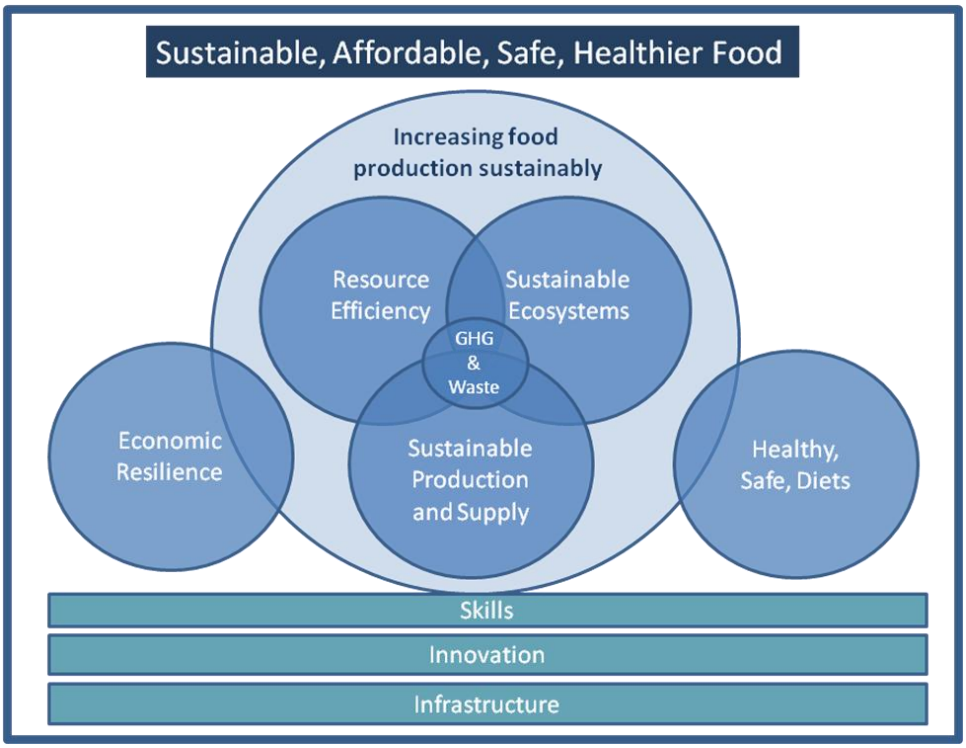
Individual research funders will each have, and regularly review, their own research strategies and priorities aligned with their respective roles and remits. Their priorities, and the balance between these, will develop over time as new challenges emerge. Some of these challenges will be long-term and high-risk/reward: so called "grand challenges". These are likely to be global in nature and give the UK research base an opportunity to engage in cutting edge research with other key global players. Ambitious goals might include e.g. nitrogen fixation or increased photosynthetic potential of crops,[68] or new vaccines for key livestock diseases. Clearly such ambitious targets will require sustained investments in research over a number of years, in coordination or partnership with other global stakeholders to maximise efficiency and the chances of success.

Set out below are key research areas and challenges relating to food, drawing from a range of sources,[69] noting that any such assessment is inevitably to an extent, a snapshot of current thinking. The challenges in many cases are global, although some are particular challenges for the UK or for developing countries. Whilst these are presented under five themes, it is important to recognise that all are (to varying extents) inter-related and overlapping, as summarised in the diagram. Alongside the broad research topics in Themes 1 to 5, cross-cutting issues that apply to all research areas are also shown. Those relating to skills, innovation and infrastructure are discussed in Chapter 7.

[68] Royal Society 2009. Reaping the benefits: Science and the sustainable intensification of global agriculture. UK scientists recommended that 'the Research Councils UK (RCUK) should develop a cross-council 'grand challenge' on global food crop security as a priority; including support for public sector crop breeding and genomics programmes to understand, preserve and enhance the germplasm of priority crops and train the next generation of plant breeders; and long-term high-risk approaches to high-return targets in genetic improvement of crops. http://royalsociety.org/Reapingthebenefits/

[69] These draw on a recent BBSRC led stakeholder meeting and consultation, a Food Research Partnership meeting, and other recent reviews.

Figure 5: Themes of Research Challenges for Sustainable, Affordable, Safe, Healthier Food[70]



A key principle underlying these themes is the cross-cutting multidisciplinary nature of the research required; and the need for integrated research that avoids silos of research activity undertaken in isolation from other relevant topics.

Themes:

Economic resilience - a sustainable food system is dependent upon efficient business throughout the production and supply chain. The economic sustainability of the agricultural sector requires that it is focussed on the needs of consumers through the market, with successful production in a more efficient way to help enhance the incomes and competitiveness of farm businesses. A competitive food sector is one that ensures fair prices for the consumer and is driven by productivity gains.

- ***Food supply, trade and prices*** – improved understanding of the critical factors controlling world trade and the global food supply and prices will be important, not least to predict consequences that affect UK food security**.** More rapid, reliable, cost-effective and generally accepted analytical methods to evaluate food authenticity and detect adulteration to enhance identification and traceability of food in the supply chain.

Resource efficiency - is achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource use intensity throughout the life-cycle to a level at least in line with the Earth's estimated carrying capacity. Key aspects of eco-efficiency include measures on waste, energy consumption, renewable energy usage and GHG emissions, as well as external costs (environmental, social and economic)

[70] Figure 5 is designed to show how the main research themes link to the Government Food Strategy '*Food 2030*' and it is appreciated that the diagram does not fully represent the overlaps and complexity of the interactions between the themes.

of food transport and food imports. Evaluation of environmental impact links into achieving a reduced carbon footprint across the food supply chain through increased resilience, resource efficiency and waste reduction; in addition to the need for improved understanding of the drivers of producers and consumers to enable more effective policy instruments to encourage behaviour changes.

- ***GHG*** – new technologies, management systems, and evaluation tools to reduce GHGs emissions from the agri-food chain including primary production, food manufacturing, retail, service sectors and domestic consumption (including related sources such as transport and refrigeration).

- ***Waste*** – prevention, re-use and disposal of agricultural waste; post-harvest technology to reduce crop-storage losses; use of commercial food waste in chemical and other industries; addressing consumer waste, including consumers' purchasing behaviours and their understanding of food storage requirements and food date labels; environmentally sustainable food processing; smarter packaging; and improved storage.

- ***Energy*** – off-farm generation of electricity from renewable agricultural sources (farm waste digestion, poultry litter, meat and bone combustion, straw, energy crops and paper/packaging); new technology for harnessing renewable energy sources on farm; and new technologies and management systems to reduce overall energy consumption in primary production, food processing and retail.

- ***Water*** – sustainable water management strategies for UK and global ecosystems; research into ways to reduce water usage through both new technologies (including plant and animal genetics) and practices in food production; and developing better tools for evaluation of the water footprint in primary production, manufacturing and distribution operations including retail and food service sectors.

- ***Nutrients*** – use of fertiliser (organic and inorganic) and other chemical inputs; and critical nutrients such as potassium, nitrogen, phosphorous, potassium and iron.

Sustainable ecosystems - the impact of the food system on vital and irreplaceable resources such as soil and water, air quality, and the biodiversity of plants and animals needs to be managed to maintain a healthy and well managed ecosystem to provide the ecosystem services needed.

- ***farming systems*** – whole systems approaches to land management practices that enhance biodiversity conservation in agricultural and associated ecosystems; maintenance of natural resources (e.g. structure and fertility of soils); management of competition for farm land (non-food / bioenergy crops, urban development); improved practices for local conditions - especially in developing countries; maintenance of ecosystem services e.g. carbon sequestration/flood management; management of agricultural waste; reduction in crop losses (field and post-harvest); and greater socio-economic understanding of farm practices and the supply chain.[71]

Sustainable food production and supply – Food production and supply targets are becoming wider and more demanding in the face of the need for food security (food demand will increase 70% by 2050 compared to 2006 to meet the needs of growing

[71] Note: the numerous interactions with resource use and food production.

world population[72]), predictions of faster climate warming, biodiversity action plans, farming regulations,[73] competing demands for land and adaptation to a low-carbon economy.

- ***Crop production –*** to enhance crop productivity with optimised efficiency of resource use (water, energy, chemical inputs); enhanced nutritional composition; better protection against losses to pests, diseases and weeds (responding also to tighter regulation of agrichemicals); enhancing tolerance to abiotic stresses (e.g. drought, high temperatures, salinity and flooding); effective use of advanced crop breeding programmes using genomic science and genetic markers (and biotechnology where appropriate, while strengthening the evidence base related to societal and environmental issues surrounding the acceptability of genetically modified crops);[74] improved technologies for monitoring and surveillance of crop diseases and insect pests; exploring potential for nitrogen fixation by non-legume crops and improved efficiency of photosynthesis; and understanding plant genomics and genetic diversity of plants.

- ***Soil –*** understanding soil processes; rhizosphere and plant-soil-microbe interactions, soil microbes; understanding carbon and nitrogen fluxes; and structural properties of soil, and the interactions with organic matter and inorganic nutrients.

- ***Livestock production –*** animal breeding for improved yield, quality and welfare; genetic diversity and use of rare breeds; vaccine development for endemic and exotic diseases (UK and global); improved diets and associated management systems to improve feed-conversion rates; management of threats from exotic and endemic animal disease; reduced impact of GHG emissions, and lower-intensity livestock farming especially in economically marginal areas; and improved monitoring and surveillance of animal diseases.

- ***Aquaculture and fisheries*** – sustainable management and use of wild fish stocks and managed fish production systems for key species; sustainable solutions (e.g. plant technologies) for use in fish feed; improving understanding of the nutritional and environmental impact of different farmed fish species; and management of fisheries and fish stocks.

Sustainable, healthy, safe, diets – food should be produced, processed, distributed and consumed in a society where people make informed choices to eat a healthy diet and are connected to the origins of their food and environmental sustainability, and treat food as a source of enjoyment and wellbeing through leisure activities such as growing and cooking food. A safe food supply which is accessible and affordable, needs to be maintained and secured, with consumers having confidence in the safety of food available to them.

- ***Healthier food and nutrition*** - improving understanding of the links between diet and health, and the implications arising from such links – in particular what constitutes an affordable, nutritious, healthy diet from available quality food sources; public health relevant nutrition; role of health assessments; potential

[72] http://www.fao.org/wsfs/forum2050/wsfs-background-documents/issues-briefs/en/
[73] particularly extended nitrate vulnerable zones, revision of RB209 fertiliser rules, mycotoxin appraisal for grain assurance and restrictions in licensing and application of pesticides
[74] Royal Society Report 2009. Reaping the Benefits – Science and the Sustainable Intensification of Global Agriculture. http://royalsociety.org/Reapingthebenefits/

interventions to improve nutritional well being; early markers of cancer to test the effect of diet on cancer risk at a population/group level; understanding better what consumers see as an "acceptable" diet; improving understanding of diet and chronic disease; closer linkage between basic nutrition and clinical research; tackling causes of obesity; understanding the potential of nutrient supplies from plants; personalised nutrition; new quality foods acceptable to consumers; optimisation of product formulation through new uses of existing ingredients, novel ingredients and novel formulations of ingredients – including ingredient replacement strategies.

- ***Sustainable consumption and healthy eating*** - understanding the complexities in the relationships and trade offs between sustainable production, consumption and healthy eating, including to improve understanding of what a healthy, low impact diet might comprise and how this can be promoted, supplied, measured (e.g. metrics of sustainability) and labelled.[75]

- ***Consumer attitudes and behaviours*** – improved understanding of the food supply chain by the public through better education and the timely provision of balanced information; an integrated approach (social, economic and biological knowledge) to improved understanding of what shapes consumers' attitudes to food and drink, and factors underlying consumption (e.g. the role of taste and texture in food preferences); understanding cultural barriers and behaviour linked to product choice and increasing interest in the convenience, taste, quality and origin of food; understanding issues that affect food availability and affordability; and exploring the barriers to healthy eating among the socially excluded.

- ***Food safety*** – addressing food safety in a global context across the agri-food chain; reduction of incidence of key foodborne pathogens (e.g. Campylobacter and Listeria) with potential increasing risk to human health; prediction and management of risks arising from new external factors (climate change, changing demographics, waste recycling, new regulations); improved knowledge of the causes and mechanisms involved in allergic reactions to food, to predict and reduce their incidence; understanding known, or assessing previously unknown or unrecognised, chemical hazards and risks; innovative technology capable of increasing shelf-life and maintaining food quality; more rapid, reliable, cost-effective and generally accepted analytical methods to evaluate authenticity, detect adulteration and detect agrochemicals; and reduction of safety hazards and risks by developing, improving and implementing proportionate, evidence-based controls for the whole supply chain.

More details of these research challenges can be found in the individual programmes of the different public funders, and in the new multi-partner food security programme.[76]

The cross-cutting issues of skills, innovation, and infrastructure will play a key role in the delivery of the research challenges and therefore have been discussed in more detail in Chapter 7.

[75] Sustainable Development Commission 2005. Delivering a Double Dividend: Better Nutrition for more Sustainable Diets. http://www.sd-commission.org.uk/pages/delivering-a-double-dividend-better-nutrition-for-more-sustainable-diets.html

[76] www.foodsecurity.ac.uk

An important element in meeting these research challenges will be improved co-operation, communications and sharing of knowledge, addressed in more detail in Chapter 6.

Tensions and trade-offs

It is comparatively easy to articulate individual challenges and research drivers. More difficult is the reconciliation of tensions and trade-offs, to develop coherent policies. For example:

- Livestock are a high source of GHGs and a reduction in livestock production could help to meet carbon targets - but – *in the UK livestock use grazing land less suitable for arable production, helping to maintain landscapes and avoiding the significant release of soil carbon that would arise from conversion to arable croplands; furthermore, livestock contribute to the livelihoods of the world's 1.3 billion people living in absolute poverty in developing countries, with more than a half using livestock are their principal means of a livelihood.*

- UK aquaculture is currently environmentally wasteful, relying on marine animal sources for fish feed at a 10:1 ratio of kg of fish used in feed to kg of fish produced – but – *increased fish consumption is needed to address low omega 3 levels in UK diet.*

- Consumers in the UK demand uniform shaped undamaged fruit and vegetables in the supermarkets – but *some packaging used to prevent damage and the food waste generated in removing mis-shaped produce can increase the environmental impact of the food chain.*

More examples of these tensions and challenges are presented in Annex 3.

It is in areas such as these that collaboration between funders and innovative, multi-disciplinary research will be most important.

5.2 Regulation

Regulation is an important tool in driving the agenda for a sustainable food chain.

The Environment Agency regulates environmental aspects of farming (with support through Cross-Compliance from Defra and WAG) through instruments such as Nitrate Vulnerable Zone (NVZ) compliance, water abstraction licences, discharge consents and farm waste regulations. In addition, the Agency provides support to farmers with best farming practice and environmental stewardship to make their business more efficient and greener.

The Government will need to draw on the best expert advice to work with and influence the EU and the international regulatory system, to ensure an effective regime that appropriately balances benefits and risks, including for emerging scientific developments such as genetic modification, new pesticides, nanotechnologies and irradiation, to improve the efficiency with which new technologies can be managed and where appropriate adopted, with relevant and proportionate safeguards. There will be opportunities to draw on evidence and experiences from the use of such technologies overseas. Early and improved consumer engagement on emerging technologies will also be important.

The importance of food provenance, especially to UK consumers, has caused retailers to modify labelling and advertising, linked to demands to source food more ethically (e.g. fair trade or free range) and to reflect different farm management systems (e.g. freedom foods or organic). Changes to legislative and regulatory requirements may also be needed to ensure branding and labelling match consumers expectations. Guidance on the use of terms such as “natural” have been issued by Government, while references to origin or health claims are also the subject of Government action to help ensure consumers are not misled. These are important issues that link to developments from research programmes.

6. Strengthening Links

6.1 Common Goal

This Strategy aims to support a secure, sustainable food chain which is safe, affordable and healthy, in the UK and globally, and a thriving UK agri-food sector, making best use of science and technology innovations. Many of the research issues which arise in pursuing this are, by their nature, complex and multi-disciplinary, and will often overlap departmental / organisational remits. Tackling these in an effective way requires strong links between funders, and innovative yet pragmatic co-operation, to promote a coherent, coordinated approach and to develop timely programmes to address the key questions, while making best use of (increasingly) pressured resources.

6.2 A Vision for Joining Up

Several reviews of publicly funded science have identified a need for a more joined-up approach between funders.[77] A commitment to working with others is often a part of organisations' research/science strategies, and there are good examples of funders working together to share information and ideas and to explore common research agendas, both in the food area and in areas where food is just one of several application areas. However, in practice, agreeing on joint funded projects / programmes has often proved challenging for a variety of reasons, including the way funders budget for, commission and manage their work. A key aim for this Strategy is to develop ways of working to ensure that, where it is the right choice, a joined up approach is also an easy and value for money choice.

Where issues are multi-factorial and cross organisational boundaries, funders acting in isolation to tackle only those elements falling within their remits risk developing a partial evidence base, missing key perspectives and leading to actions that are less effective, and that may even have unintended implications for others. An example is work on obesity – developing solutions based on research with only a dietary basis, without considering other elements of lifestyle such as exercise, could lead to limited conclusions and less effective interventions. It is therefore important to approach research needs in a more holistic way.

There are clear benefits of a more holistic and integrated approach including:

- *to support joined up, evidence based policies and delivery of coherent outcomes* (e.g. economic growth, mitigation of the climate change and its impacts, healthier diets) – avoiding policies/interventions that could impact detrimentally in other areas;
- *to develop a stronger and more coherent evidence base;*
- *to improve buy-in and exploitation of research*;
- *to address research gaps and avoid overlaps* – reducing the risk of duplication;
- *to improve the effectiveness and value of horizon scanning, in identifying emerging scientific, technical, market, regulatory and other issues*;

[77] MRC Strategic Review of Nutrition.
http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC005762;
BBSRC/HEFCE Study of Land Based Facilities and Resources
http://www.bbsrc.ac.uk/organisation/policies/reviews/operational/0905_landbased_facilities_report.html

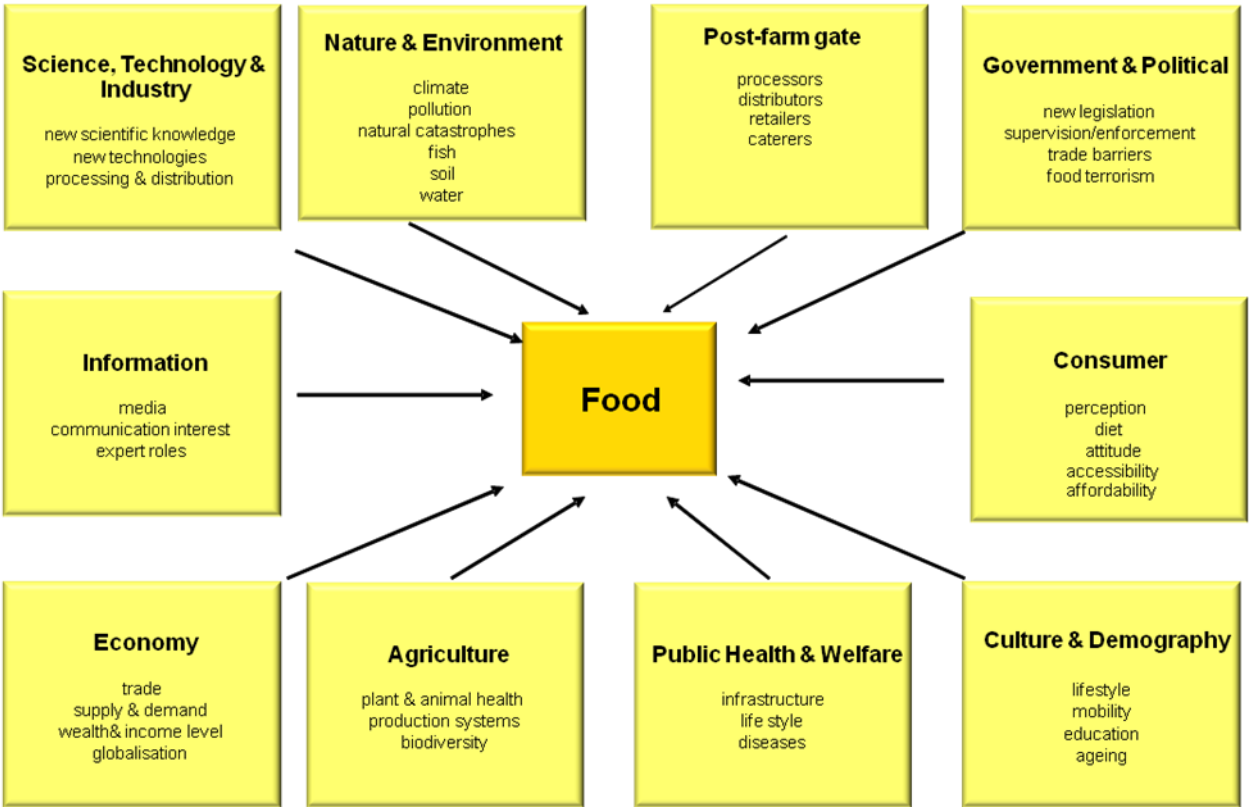
- *to better tackle system and interface issues* – including to promote the development of a research base providing the multidisciplinary evidence needed to support more coherent policy/innovation;
- *to make more efficient use of overall resources* – both within and between funders, and in the research base;
- *to build a more integrated community of researchers and users* extending across disciplines, organisations and sectors;
- *to facilitate shared views and strategies* – e.g. on institutional aspects of innovation and the continuum of research (from basic to applied) and the infrastructure requirements;
- *to identify opportunities to capitalise on the UK's infrastructure and capacity;*
- *to minimise unnecessary administration* for access by researchers to joint-funded projects with clear 'rules of engagement';
- *to link research priorities and outcomes better to the international development agenda, G8 commitments and Millennium Development Goals;*
- *to provide a more coherent UK approach to the emerging EU food security agenda;*
- *to share good practice*;
- *to provide a platform for closer collaboration with the private sector*; and
- *to maximise global impact and influence of UK research and UK research agencies***.**

6.3 **Links and Collaboration**

Improved co-ordination of food research requires not just the simple transfer of knowledge between related sectors but, more fundamentally, placing research in a wider context. Climate change data might lead farmers to seek water tolerant crops but there may be potential economic and environmental impacts if the solution from research is a new crop variety with more expensive seeds and requiring greater use of fertiliser and pesticide. Likewise, social and economic impacts could include whether the consumer will pay more for a local crop if cheaper imports are available, effects on farmers in developing countries, security of supply, long term dietary benefits, and whether people will actually want to eat it. Answers to questions like these require coordinated research across funders.

Figure 6 below offers a model for use in considering both the range of factors that might need to be taken into account when tackling an issue relevant to the food supply chain, and which other organisations may have an interest.

Figure 6: The various domains that exert influence on issues within the food chain[78]



This Strategy aims to provide a facilitative framework within which to strengthen collaboration in areas where there is added value for this approach. There is already much good practice on which to build, with examples including:

- The **UK TSE Research and Development Joint Funders' Co-ordination Group** has enabled members (DH, Defra, FSA, BBSRC, MRC and others) to coordinate £30M/year of public research funding on transmissible spongiform encephalopathies (TSEs). A joint human and animal health TSE research strategy 2005-2008[79] was published in 2005, and updated in 2008 for 2009-2011.[80] This co-ordinated effort has placed the UK as one of the top TSE researcher bases in the world and has gone a long way to support the reduction of BSE from the UK cattle population and in restoring UK exports of beef.[81]

- The **Microbiological Safety of Food Funders Group** (MSFFG)[82] co-ordinates publicly funded R&D on the microbiological safety of the food chain (including 'emerging' food-borne pathogens, and organisms of animal welfare and health

[78] The diagram has been adapted from a similar model developed by a 6th Framework Programme funded project called Periapt (see http://www.periapt.net/Document%20Library5/1/Final%20public%20report.pdf). The aim was to develop a model (the "host environment") for identifying the key domains, indicators and sources of information that would help identify where emerging risks may come from.
[79] TSE Research Strategy http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC003393
[80] TSE update 2009-2011 http://www.mrc.ac.uk/Ourresearch/Portfolios/TSE/Facts/index.htm
[81] UK TSE Joint Funders Group http://www.defra.gov.uk/foodfarm/farmanimal/diseases/atoz/bse/science-research/funders.htm
[82] The Microbial Safety of Food Funders Group includes: FSA, DEFRA, DoH, Dept of Agriculture and Rural Development for Northern Ireland, BBSRC, Meat and Livestock Commission, Food Safety Promotion Board, Medical Research Council, the Environment Agency and the Health Protection Agency.

significance with a food safety implication) with a view to informing the R&D effort, and identifying common research priorities, gaps and overlaps. Cross-funder reports present members' combined activities in a coherent manner, and knowledge sharing is supported by an open access searchable database of research funded by members.[83]

- ***Collaborative research and surveillance on mycotoxins in cereals*** – involving a collaborative research network and projects supported by Defra, FSA and HGCA.[84] In one initiative, research organisations and industry have assisted the development of risk assessment tools and risk management options for farmers and the food processing industry to minimise risk from *Fusarium* mycotoxins in cereals and ensure consumer safety.

- ***Coordinated Campylobacter research strategy*** – BBSRC, FSA, Defra, and other key stakeholders are working together to identify the key cross-cutting research priorities that will provide the evidence base to reduce UK Campylobacter levels.

- ***The Nanotechnology Research Coordination Group (NRCG)*** is coordinating publicly funded research into the potential risks presented by the products and applications of nanotechnologies. Defra chairs the NRCG and the members include departments, regulatory agencies and the Research Councils.[85]

- ***The Cross-Government Obesity Unit*** – based in DH but led jointly by DH and DCSF, with staff and resources from across government, has developed the 'Healthy weight, healthy lives' strategy as the first step in a programme to support people to maintain a healthy weight. It will continue to build the evidence base on tackling obesity by commissioning research to better understand the causes and consequences of the rise in unhealthy weight, and the evidence of what works to tackle it.

- ***The Environment Research Funders Forum*** – brings together the UK's major public sector sponsors of environmental science to co-operate for the best possible use of public funding for environmental research, monitoring (observation) and survey, and associated policy, regulation and training; in pursuit of the understanding, protection and enhancement of the natural environment.[86]

Another example of partnership between Government departments and Research Councils is the strategic partnership (established in 2008) between the FSA and ESRC, in part as a way of improving the FSA's access to food related social science evidence. Research has been commissioned as a result of a targeted call ('Understanding UK dietary decisions in the 21st century') and the FSA is contributing to the ESRC flagship survey 'Understanding Society'. The partnership will be further developed in the future.

Defra's research coordination group meets quarterly with other funders, including Devolved Administrations and WRAP, to exchange views on research developments,

[83] Microbiological Safety of Food Funders Group http://www.msffg.org.uk/
[84] Cereals levy sector of the Agriculture and Horticulture Development Board
[85] Nanotechnology Research Coordination Group
http://www.defra.gov.uk/environment/quality/nanotech/research.htm
[86] http://www.erff.org.uk

discuss common research priorities and areas of collaborative interest, and identify key gaps.

Within the Government analytical community (Government Economic Service, Government Social Research, Government Statistical Service, Government Operational Research Service, and Science and Engineering), joint working takes place across departments on key issues e.g. behaviour change.

Multi- partner programme on Food Security

A major new multi-partner food security research programme is being developed. This will be co-ordinated by BBSRC and delivered jointly with other Research Councils and government departments, and involve close engagement with industry and the third sector. Key aims include building a more integrated community of researchers, funders and users that extends across disciplines, organisations and sectors, to provide multi-disciplinary research to ensure a sustainable and secure food system.

6.4 Principles and mechanisms

In developing this Strategy, public funders have agreed a number of key principles to strengthen coordination, collaboration and dialogue across government, and with other key stakeholders.

These key principles are:

i. ***early engagement with potential collaborative partners and a consultative approach where decisions would have significant wider implications***, e.g. regarding support for major programmes. A more joined up, coherent approach will facilitate progress on long term science priorities and the maintenance of key institutional capability. In addition, when developing new ideas for research, funders will inform and consult with other funders and consider whether a joint approach would provide a more holistic evidence base and added value. Experience has shown that the more well developed a research requirement, the less amenable a funder is to adapting it to meet a joint need, highlighting the need to share research ideas at the earliest stages. If joint funding is not feasible or sufficiently advantageous, other avenues of joint/collaborative working should still be explored.

ii. an ***agreed focus on outcomes*** not inputs - Proposed work should have defined objectives in tackling the identified problem and, where possible, make reference to cross-government targets. Where a programme of work is needed there should be demonstrable coherence in the individual parts of the programme in tackling the evidence needs to address the desired outcome and clear plans on how the programme outcomes will be translated to serve key stakeholders.

iii. a ***high-level commitment*** and a "***can do" approach*** to making it work – Funders will provide a commitment to collaborate in a pragmatic fashion to deliver the work key to the desired outcome within the required timescales. If this approach is to be successful, there needs to be a "can-do" approach rather than a "we don't do things that way" approach. Different funders' mechanisms and reasons for undertaking research can often introduce barriers to working

together. If funders agree on the outcome desired, concerns over the mechanisms of achieving that should be of lesser importance.

iv. a ***range of models and mechanisms for collaboration*** are encompassed – A range of funding models and modes of collaborative working will be considered depending on the circumstances and funders involved – it will be for each funders' consortium to decide the best way to coordinate and collaborate for any proposed piece of work and the appropriate funding model.

v. A ***broad view of possible interests and perspectives*** in developing and consulting early on specific research questions / approaches – This will include ensuring a) natural, physical and social/economic sciences perspectives are addressed where relevant and appropriate; b) that programmes take due consideration of policy drivers, potential economic impact and the wider stakeholder benefits of the programme; and c) there is a commitment to *effective knowledge exchange* to deliver the research in an accessible and useful form to end-users (e.g. policy makers and businesses).

Examples of **supporting actions/mechanisms** to be explored include:

- the **identification of structural/administrative barriers to joint working** – developing solutions that draw on lessons learnt and good practice from joint calls in ERA NET projects (in an even more complex funding environment), and from previous cross-funder programmes.

- **involvement of other funders when undertaking programme/portfolio reviews** – to promote better awareness of the wider landscape (especially when performing gap analyses) and to help identify opportunities for closer working.

- **to set up a network of food research focal points within each funder** – to provide continuity and facilitate early engagement on ideas for cross-cutting research, and helping to set up cross-funder project teams as appropriate.

- **brokerage meetings between funders where new ideas for strategic initiatives could be tabled for early discussion** – using various methodologies (including "Open Space"[87]) to identify priority areas for strengthening links and facilitate collaboration between funders.

In addition, the cross-Government **Food Research Group** and public/private **Food Research Partnership**, both chaired by the Government's Chief Scientific Adviser, are high level fora to help strengthen coordination and collaboration and provide a further means to tackle problems where these arise.

[87] "Open Space" methodology aimed at tackling complex (and perhaps conflicting) problems, involving a diverse group of participants, in an innovative and productive way and achieving rapid meaningful results.

Food Research Group

The group brings together key public sector funders of food-related research including Research Councils, NDPBs and the Devolved Administrations. The group is served by a secretariat with membership from GO-Science, BBSRC, Defra and FSA.

The aims for the group are to:

- develop, and then support and oversee the implementation of, a cross-government research and innovation strategy for food;
- promote the coordination and coherence of food and agricultural research programmes and funding across departments and the wider the public sector;
- provide a forum where key cross-government food research and innovation issues and priorities can be discussed and addressed; and
- facilitate engagement with wider stakeholder groups, including research providers, funders and users.

Food Research Partnership

Established in April 2009, the 'Food Research Partnership' brings together members of the public sector Food Research Group with senior representatives from the research community, NGOs and the agri-food industry.

The FRP's aims are to:

- provide a high level forum to promote cross-sector dialogue and to jointly deliver enhanced leadership in addressing key strategic issues for food research and innovation;
- provide the opportunity of a challenge and "sounding board" function as individual organisation strategies and programmes are developed, and in relation to the functioning of the institutional landscape for food research as a whole; and
- forge links between member organisations, and encourage collaboration and a coherent approach to research across government (including the Devolved Administrations), the research community and the private sector.

The Partnership provided valuable input to inform the development of this Strategy, and in other early work is exploring the scope to improve the translation of research into use and to address skills and capacity issues across the food chain.

6.5 EU and International Links

Government departments and other public bodies regularly engage internationally on evidence and innovation to promote policy interests and to influence European and other international decisions. Such collaboration offers opportunities to address common policy challenges through a joint research response, exploit the complementary strengths of different national research programmes, and achieve the critical mass needed to fund large-scale projects.

There are many drivers for and barriers to collaboration in the EU and wider.[88] As part of this, departments support the developing European Research Area, primarily through participation in the EU's Framework Programmes for Research and Technological Development (FP), as described in Section 4. In terms of joining up national programmes, one of the more significant innovations in recent years has

[88] For example see, "Drivers, barriers, benefits and Government support of UK international engagement in science and innovation", Technopolis 2005. http://www.berr.gov.uk/files/file30064.pdf

been the FP's ERA-NET scheme, which supports an evolving set of activities from information exchange through to the joint funding of projects. A couple of these (plant genomics and systems biology) were mentioned in Section 4. Government departments and research councils are, or have been, involved in others of relevance, such as organic farming, plant health, animal diseases, food safety, fisheries, and agricultural research for development. The UK is also the joint lead in the development of an EU Joint Programme on Food Security.

In 2005, a Standing Committee on Agricultural Research (SCAR) was established with an updated remit, looking beyond the narrow aspects of research relating to production, and encompassing the farm to fork concept and sustainable agriculture, within the concept of a knowledge-based-economy. A major activity of the committee has been the establishment of Collaborative Working Groups, which provide a dynamic and flexible approach to national coordination, some of which have provided the basis for new ERA-NETs. The UK has participated in several of these, including the two most recently established in the agriculture/climate change and agriculture/energy areas.

UK coordinating committees such as the Global Science and Innovation Forum (GSIF) [89] play an important role to improve the coordination of UK engagement in international science and innovation. The Government also supports researcher collaboration and international mobility, particularly in the areas of agriculture and food, through the FP7 "People" programme, COST (European Co-operation in the field of Scientific and Technical Research) and the cooperative research programmes of the Organisation for Economic Co-operation and Development (OECD).

BIS are currently in the early stages of gathering evidence to inform the development of the EU Framework 8 Programme for 2012. This provides an important opportunity for departments, the Research Councils and other stakeholders to coordinate input, with a view to an agreed vision and definition of the challenges and remit for future EU funded food research and innovation. The UK Government and Devolved Administrations will also continue to strongly support and adopt an outward facing approach to research collaboration in the EU and wider, through participation in FP7, and by continuing to explore potential synergies through improved coordination of national programmes via the ERA-NETs and other mechanisms.

In addition, DFID currently chairs the European Initiative for Agriculture Research for Development (EIARD), a group for development agencies funding agriculture research which seeks to develop a common European position among EU funders on funding international agriculture research.

International collaboration is vital if the UK is to stay at the leading edge of world science and innovation, and benefit from the scientific output produced elsewhere. RCUK offices in key countries and the Government's international Science and Innovation Network[90] are key resources to help forge stronger links and collaborations.

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[89] Global Science and Innovation Forum (GSIF) is a vehicle for cross-government exchanges of information and ideas to improve co-ordination of the UK effort in international science and innovation collaboration. It provides strategic guidance and systematically scans the horizon for new and emerging issues.

[90] Supported jointly by BIS and the FCO, the Science and Innovation Network comprises 90 full time equivalent staff based in 39 cities worldwide, including all the major scientific nations and several emerging economies. The aim of the Science and Innovation Network is to promote scientific collaboration of UK laboratories and companies with the best counterparts abroad.

DFID have taken a leading role in reform of the CGIAR through their representation on the Transition Management Team.

6.6 **Key Activities**

- Development of a multi-partner food security research programme to co-ordinate research activities in agri-food across Research Councils and Government. *Lead: BBSRC*.

- Establishment of a new Sustainable Agriculture and Food Innovation Platform to fund innovative technological research and development in areas such as crop productivity, sustainable livestock production, waste reduction and management, and greenhouse gas reduction. *Lead: Technology Strategy Board.*

- Food Research Partnership to consider how to exploit opportunities in the European Research Area through co-ordination mechanisms such as ERA-NETS and Joint Programmes, and collaboration through the RTD Framework Programme more generally. *Lead: GCSA*.

- Food Research Group to provide public sector leadership to address key cross-government food research and innovation issues, including oversight in delivery of this Strategy. *Lead: GCSA*.

- Food Research Partnership to provide a high level forum to promote cross-sector dialogue and to jointly deliver enhanced leadership in addressing key strategic issues for food research and innovation. *Lead: GCSA*.

- Food Research Partnership to review the UK's international engagement on agri-food research and advise on priorities, opportunities and areas for strengthening and report by June 2010. *Lead: GCSA/GO-Science*.

7. Research Infrastructure, Skills Capacity and Translation of Research

7.1 Research Infrastructure

The UK has world-class facilities and resources which underpin agri-food research, and which bring benefits not only to the UK and internationally in addressing food security challenges. Major facilities and centres of expertise at Research Council, Government and Devolved Administration (DA) institutes are key parts of the national capability, as are strengths in the university sector and private sector.

Continuing to capitalise on the excellence of the UK's research base will require a strategic approach to sustaining and developing this essential infrastructure, with strong links between the different research funders and providers. The UK's research infrastructure has transformed in the last two decades, with radical re-organisations both of the landscape as a whole and at the level of individual bodies, including a number of closures / mergers of applied research institutes, and the move of some public sector institutes into the university sector. This is at a time when more commercially focused facilities have also been rationalised. Whilst these changes have brought benefits e.g. in terms of increased efficiency, reported consequences[91] have also included the loss of long-standing expertise and scientific support staff, and uncertainty over the distribution of responsibilities and information. Promotion of better communication and cooperation among the different research communities in Research Council, Government and DA institutes, and universities will be critical.

There have been calls also for funding schemes to be more coherent, with less fragmentation and a shift from solely short-term funding horizons[92] to some longer-term and more strategic support frameworks, which monitor change and identify trends. In the absence of long-term strategies on the part of funders and providers alike, research will tend to focus on more immediate objectives linked to individual projects. There is a risk that long-term research and policy goals will be compromised and that capability to research, monitor and provide emergency response in areas like animal health and welfare[93], sustainable farming and land use will be eroded. The actions outlined in Section 6 will provide important mechanisms for addressing these issues through strengthening existing initiatives and adding new approaches for promoting a more collaborative and strategic approach to ensure long-term sustainability of national research capacity.

[91] Donaldson, A. and Wilkinson, K. 2008. The delivery of animal health services in England. Newcastle University, Centre for Rural Economy.
[92] BBSRC 2004. Review of BBSRC-funded research relevant to crop science. A report for BBSRC Council, April, 2004.
[93] BBSRC 2009. Future directions in research related to food security. A consultation by the Biological Sciences Research Council.

7.2 **Skills Capacity**

The skills and expertise base associated with research facilities in academia, government agencies and industry is a key resource and vital to sustain.[94] The role of these facilities in training the next generation of researchers is also critically important. The sector is characterised by a diverse range of providers across research and education, and in recent years the number of these has decreased significantly. There is potential for gaps in training capacity in the future, and appropriate strategic planning and management processes responsive to national and local needs will be essential for each stakeholder.[95]

Perceived supply gaps in the research skills base identified by various studies[96] [97] [98] [99] include: c*rop production* (agronomy, forage crops, plant physiology, pathology and general botany, plant-soil interactions, weed science and entomology / pest biology, chemicals and pesticides (ecotoxicology, toxicology and risk assessment)), agricultural engineering, post-harvest storage, soil science and conservation, and agricultural economics); *livestock production* (ruminant and veterinary microbiologists/ pathologists/ parasitologists, animal genetics, animal physiology and nutrition), *fish production* (freshwater taxonomists/ecologists); *environmental science* (soil and water management, wildlife conservation), *food economics, nutrition, food quality, processing and manufacture* (through a lack of academic food science and manufacturing laboratories); *food retailing* (product design and innovation, product procurement and supply, business management and marketing) and *mathematical and computer sciences* (where qualified staff can be attracted to better paid jobs in other sectors). A gap in terms of experienced scientists who understand the policy process as well as having expertise in their fields has also been suggested.[100]

In addition, the availability of research expertise dedicated to international development has declined. This plays a key role in building scientific capability both in the UK and overseas in support of the Government's development and wider food security goals. The UK's potential role in training overseas scientists should not be underestimated in terms of the benefits to the UK science base, trade, security of world food supplies and international development.

To address these issues, the agri-food sector and research community will need to attract and train the next generation of researchers, and up-skill the existing workforce. Succession problems are already reported, with many experienced professionals nearing retirement. Yet attracting early-career researchers is a challenge, the negative perceptions of the industry, the limited opportunities for new researchers in Higher Education Institutions, and the limited longer-term career opportunities. In addition, the industry needs to provide clear demand signals and not only want these skills, but also up-skill and professionalise the workforce to meet these challenges.

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[94] Royal Society 2006. A degree of concern? UK first degrees in science, technology and mathematics.
[95] HEFCE 2008. Strategically important and vulnerable subjects.
[96] Royal Society 2009. UK-India Workshop on food-crop production. RS Policy Document 6 / 09.
[97] BBSRC 2004. Review of BBSRC funded research relevant to crop science. A report for BBSRC Council, April 2004.
[98] BBSRC 2009. Future directions in research relating to food security. A consultation by the Biotechnology and Biological Sciences Research Council.
[99] Arthur D Little. 2009. Survey of External Capabilities to meet Defra's Strategic Requirements. http://www.defra.gov.uk/evidence/science/how/documents/defra-external-capability-project-final-report.pdf
[100] Arthur D Little. 2009. Survey of External Capabilities to meet Defra's Strategic Requirements. http://www.defra.gov.uk/evidence/science/how/documents/defra-external-capability-project-final-report.pdf

The issue of perceived skills shortages is complex, potentially with global supply being sufficient to meet current demand but niche skills in short supply, and cannot be addressed by any single research funder or approach. It is important that food research funders work together with other relevant bodies in a systematic approach to monitor and maintain the health of the UK research and development community. This includes identifying where niche skills will be needed, and stimulating industry to seek appropriate high-level skills and continual professionalisation of the sector. This may mean reviewing current funding priorities.

Defra, BIS and BBSRC are working with the agriculture and horticulture industry in several schemes and initiatives to address the skills needs of the sector. These include the establishment by the Sector Skills Council (Lantra), in conjunction with Defra and industry of the Agri-Skills Forum, to develop a plan for skills development within the industry. The Rural Employer Engagement Development Network (REEDNet) is expanding support for work based staff development programmes in industry leading to recognised qualifications. Other schemes to encourage young entrants include apprenticeships and Young Farmers' Clubs.

DFID emphasises building the capacity of developing country research organisations in all its research projects and particularly supports regional research organisations in Africa.

7.3 **Translation of Research into Use**

Food research has strong relevance to a wide industrial base, from farming to catering, manufacturing and retail. The UK has significant business strength in these sectors, with the opportunity to exploit technology developed both in the UK and worldwide. The key to exploiting the combined strengths of the UK research base and industrial sectors is to ensure the effective translation of research outputs to application.

As a consequence of the diversity of sectors in the agri-food chain, the issues and challenges within each sector, at each stage of the food chain, and indeed between individual companies, will be equally wide ranging – in addition to considerations such as the different characteristics of sectors and companies in terms of preferred channels of communication and support networks. It is important to acknowledge this unique complexity in analysing where research translation problems might exist and in developing effective solutions.

Many companies will feel distant from the research community and may find it difficult to articulate their needs. SMEs in particular are typically less able to invest the time, and less likely to have the skills within the business, to engage directly with research services. Therefore, there is a need to look flexibly and creatively at how world-class research can be transferred to a large and diverse range of businesses, recognising that many organisations, not least companies themselves and industry representative bodies, will have important roles in this.

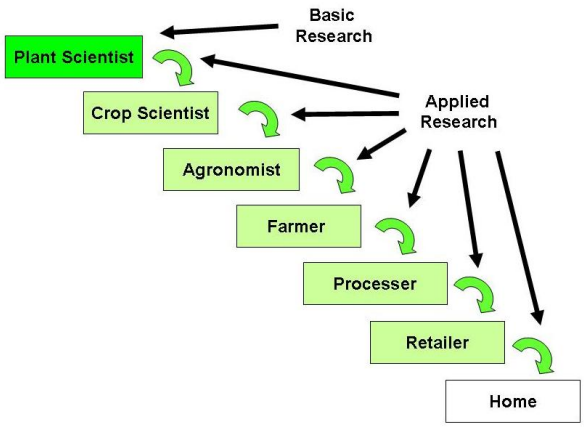
Section 4.5 highlights examples of the many schemes and initiatives that have been developed to strengthen research / industry links, encourage more sector led research and co-funding, and promote the efficient translation of research. The number and range of current interventions can be seen to reflect the diversity of user

needs, but more industry users could be encouraged to use and benefit from these schemes.

Research translation is nonetheless often cited as an area of systemic weakness, although good evidence on the exact nature and causes of the problem is limited, and sometimes conflicting. What is certainly clear is the benefit of further strengthening and extending partnerships across the communities of research funders, providers and users, to enhance dialogue and collaboration across all stakeholders.

This may for example involve better partnership between the agricultural colleges and universities (as the agricultural colleges have an important role in up-skilling the agricultural workforce).[101] Building stronger relationships between universities and businesses will also be important. This may involve dialogue related to products, technologies (including enabling technologies), processes, management techniques, knowledge and skills. More recognition in career progression/ promotion of translation skills and activities will also require a culture change.

In other sectors, classification systems have been used to define translation on a sliding scale to better delineate the degree of translation. However, the problem in defining applied research in the food sector is one of the number of industries in different parts of the food chain and not the type of scale e.g. applied research might be defined as the translation of basic plant research into a relevant crop, commercial scale seed production, use by farmers, or uptake by consumers; depending on the user at that stage of the chain.



The nature and operation of the research and innovation system will differ across the range of food research, and at different stages of the translation of basic research to the end user. ‘End-users’ include the primary producers in livestock, arable, horticulture and fisheries sectors, food processors and retailers, suppliers of equipment, seeds and machinery etc, health professionals and policy-makers. It is important to recognise that the flow of knowledge needs to be two-way, to ensure that users’ needs and problems are communicated to researchers. Capturing research outputs and providing available information to a range of potential users (from researchers to farmers) in an accessible format is also an increasing priority.

This diversity of users brings a complex relationship between public and private sectors. For example, in a UK wheat line, identification of an interesting yield trait might be immediately taken up by breeders and commercialised, whereas research showing a new crop has beneficial dietary effects might take years more research and investment before it is taken on by a commercial interest.

[101] BBSRC/HEFCE 2009. Study of land-based facilities and resources.

In improving partnerships between government, industry and research organisations, it will be important in each case to clarify through dialogue respective roles and funding responsibilities, to maximise the impact and coherence of investments overall. Where commercial benefits are clear there will be an increasing expectation on the private sector to contribute to research and translation activities, with the public sector funders focusing where the “market failure” is most apparent, e.g. in relation to SMEs.

In order to make step changes in agriculture, there is a need to scale-up resources made available to developing countries for human and institutional capacity building to enhance a research-based approach to agriculture development. In this context, it will be important to strengthen UK links for capacity building partnerships with National Agricultural Research Systems (NARS) and educational establishments, to ensure that the skills are in place in-country to harness the potential of existing technologies (while at the same time innovating), and to understand and support new technologies as they arise.

7.4 **Key Actions**

- Defra, BBSRC and the Scottish Government to establish a new group, engaging also more widely, to monitor and discuss UK agri-food research infrastructure issues: *Lead: Defra, BBSRC, Scottish Government*.

- As part of the Agri-Skills Strategy, create, implement, communicate, monitor and evaluate an action plan to promote the value and financial benefits from further professionalization and investment in high-level skills (through training, recruitment and the use of consultancy services). *Lead: Lantra and AHDB.*

- A new Advanced Training Partnership scheme to provide a range of specialist high level training (masters, professional doctorate and continuous professional development) to meet industry needs in partnership with the higher and further education sectors. *Lead: BBSRC.*

- Funders to clarify understanding of the process of translation of research findings and knowledge between the research base and the major UK primary production and food manufacturing sectors to establish opportunities and mechanisms for increased knowledge exchange, building on current initiatives and considering new methods of communication. *Lead: BBSRC and FRP.*

- Funders to assess areas of potential market failure where public intervention could be appropriate, through development of a balanced scorecard to measure progress, based on e.g. industry spend on research, productivity of the sectors, industry opinions etc. utilising the Defra food security indicators. *Lead: BBSRC and Defra.*

- Funders to collaborate and develop clear and robust set of common metrics for measuring progress in the up-skilling and the skills needed to support innovation in the agri-food sectors, working with REF, HESA, and HEFCE etc. *Lead: Defra, BIS, GO-Science.*

- DFID to fund a second phase of the Futures Agriculture Consortium (FAC) to promote more effective African agricultural policy processes by ensuring they are based on robust evidence. This aims to increase the impact of FAC by strengthening its work in African countries, linking the programme more closely with CAADP,[102] decentralising the Consortium in Africa, and launching a new set of themes around Science and Technology as well as new partnerships. *Lead: DFID.*

- DFID to continue funding the African Agricultural Technology Fund (AATF) – a not-for-profit organisation designed to facilitate and promote public/private partnerships for the access and delivery of appropriate proprietary agricultural technologies for use by resource-poor smallholder farmers in Sub-Saharan Africa. The aims are to negotiate the transfer of technologies held by public and private sector organisations, to manage their licensing, facilitates testing and regulatory approvals, and to ensure that the products reach farmers. *Lead DFID*.

- BBSRC has launched a consultation[103] on a proposed investment of over £1M in a new farm-scale research facility at North Wyke Research (Rothamsted Research) in Devon to determine how the platform can integrate with other funders and better utilise the breadth of expertise and infrastructure in the UK. Knowledge gained from the work will inform ways farmers can increase productivity and help to meet the growing food security challenge in a sustainable way. *Lead BBSRC.*

[102] CAADP is the AU-Nepad's Comprehensive African Agricultural Development Programme. CAADP was established by the African Union in 2003 at its summit of heads of state and government who agreed to invest 10% of their national budgets in raising agricultural productivity growth to 6% per year. CAADP provides a policy framework and a regional context for national and regional planning and investment for agricultural development. CAADP processes include regional and country-led roundtables that define national and regional strategies for halving hunger and increasing agricultural growth through policy reform and more and better investment.

[103] http://www.bbsrc.ac.uk/media/releases/2009/091126-consultation-investment-agricultural-research-facility.html

8. Making it Happen

8.1 Next Steps, Monitoring and Review

This Strategy sets out a range of ambitions and actions, including several major new initiatives, for strengthening the contribution of food research and innovation in achieving the Government's key goals on food, working where relevant with the Devolved Administrations.

The key test of the value of this Strategy will be the effectiveness with which it is delivered. Through the Food Research Group, the Government will review progress in implementing the Strategy in a year's time, including an assessment of key outcomes and achievements in strengthening links and co-ordination, and aim to complete this by March 2011.

8.2 Indicators for Measuring Progress

Defra is working with other departments in developing a suite of indicators for a sustainable food system. These indicators form a companion to the UK Food Security Assessment. They will not be targets, but instead will also form part of the evidence base for assessing progress in meeting Defra's Departmental Strategic Objective 7 (A sustainable, secure and healthy food supply).

The proposed indicators relating to skills and innovation are currently under development and will be a further test of the impact of this strategy. A challenge will be categorising research expenditure in a meaningful way to provide a useful measure for development and uptake of innovation. An assessment of potential for adaptability within the agri-food industry is also important, as is consideration of private sector funding of R&D.

8.3 Key Actions

- Funders to develop new indicators to monitor research, innovation and skills within the suite of indicators being introduced by Defra for a sustainable food system. *Lead: Defra, FRG.*

Annex 1

Summary Table of Actions Highlighted

No.	Section	Action	Lead
1	4.1	A doubling of research investment in agriculture by DFID over next five years to provide farmers in developing countries with access to technologies and to help national governments with more effective agricultural policies, based on a robust evidence base.	DFID
2	4.7	A major Foresight study looking over the long term at the ability of global food systems to feed a future world population healthily and sustainably, set to launch its findings in October 2010.	GO-Science
3	6.4	Public funder commitment to key principles to strengthen co-ordination, collaboration and dialogues across government, and with other key stakeholders.	FRG
4	6.6	Food Research Group to provide public sector leadership to address key cross-government food research and innovation issues, including oversight in delivery of this Strategy.	GCSA
5	6.6	Food Research Partnership to provide a high level forum to promote cross-sector dialogue and to jointly deliver enhanced leadership in addressing key strategic issues for food research and innovation.	GCSA
6	6.6	Development of a multi-partner food security programme to co-ordinate research activities in agri-food across Research Councils and Government.	BBSRC
7	6.6	Establishment of a new Sustainable Agriculture and Food Innovation Platform to fund innovative technological research and development in areas such as crop productivity, sustainable livestock production, waste reduction and management, and greenhouse gas reduction.	TSB
8	6.6	Food Research Partnership to consider how to exploit opportunities in the European Research Area through co-ordination mechanisms such as ERA-NETS and Joint Programmes, and collaboration through the RTD Framework Programme more generally.	GCSA GO-Science
9	6.6	Food Research Partnership to review the UK's international engagement on agri-food research and advise on priorities, opportunities and areas for strengthening and report by June 2010.	GCSA GO-Science
10	7.4	Defra, BBSRC and the Scottish Government to establish a new group, engaging also more widely, to monitor and discuss UK agri-food research infrastructure issues.	Defra, BBSRC Scottish Government
11	7.4	As part of the Agri-Skills Strategy, create, implement, communicate, monitor and evaluate an action plan to promote the value and financial benefits from further professionalization and investment in high-level skills (through training, recruitment and the use of consultancy services).	Lantra AHDB
12	7.4	A new Advanced Training Partnership scheme to provide a range of specialist high level training (masters, professional doctorate and continuous professional development) to meet industry needs in partnership with the higher and further education sectors.	BBSRC

13	7.4	Funders to clarify understanding of the process of translation of research findings and knowledge between the research base and the major UK primary production and food manufacturing sectors to establish opportunities and mechanisms for increased knowledge exchange, building on current initiatives and considering new methods of communication.	BBSRC FRP
14	7.4	Funders to assess areas of potential market failure where public intervention could be appropriate, through development of a balanced scorecard to measure progress, based on e.g. industry spend on research, productivity of the sectors, industry opinions etc. utilising the Defra food security indicators.	BBSRC Defra
15	7.4	Funders to collaborate and develop clear and robust set of common metrics for measuring progress in the up-skilling and the skills needed to support innovation in the agri-food sectors, working with REF, HESA, and HEFCE etc.	Defra, BIS, GO-Science
16	7.4	DFID to fund a second phase of the Futures Agriculture Consortium to promote more effective African agricultural policy processes by ensuring they are based on robust evidence and link the programme more closely with CAADP, decentralising the Consortium in Africa, and launching a new set of themes around Science and Technology as well as new partnerships.	DFID
17	7.4	DFID to continue funding the African Agricultural Technology Fund – a not-for-profit organisation designed to facilitate and promote public/private partnerships for the access and delivery of appropriate proprietary agricultural technologies for use by resource-poor smallholder farmers in Sub-Saharan Africa.	DFID
18	7.4	A consultation on a proposed investment of over £1m in a new farm-scale research facility at North Wyke Research (Rothamsted Research) in Devon to determine how the platform can integrate with other funders and better utilise the breadth of expertise and infrastructure in the UK.	BBSRC
19	8.3	Funders to develop new indicators to monitor research, innovation and skills within the suite of indicators being introduced by Defra for a sustainable and secure food system.	Defra FRG

Annex 2: Remits of Individual Government Departments, Devolved Administrations, Research Councils, and Non-Departmental Public Bodies

Biotechnology and Biological Sciences Research Council (BBSRC)

Mission:
BBSRC aims to promote and support, by any means, high-quality basic, strategic and applied research and related postgraduate training relating to the understanding and exploitation of biological systems. In addition, to advance knowledge and technology (including the promotion and support of the exploitation of research outcomes), and provide trained scientists and engineers, which meet the needs of users and beneficiaries (including the agriculture, bioprocessing, chemical, food, healthcare, pharmaceutical and other biotechnological related industries), and thereby contributing to the economic competitiveness of the UK and the quality of life. In relation to the Council's activities, and as the Council may see fit, to: generate public awareness; communicate research outcomes; encourage public engagement and dialogue; and disseminate knowledge

Remit in relation to Food:
BBSRC has a wide remit with respect to Food and is the research council that has primary responsibility for agriculture and food. BBSRC undertakes basic research into plants, microbes, animals, soil and modeling, from molecules to organism and ecosystem. This involves fundamental research on model species; basic and applied research on farmed species, (including disease and welfare); managed ecosystems (from soil-root interactions to farm-landscape scale); post harvest research including food safety, food chemistry and manufacturing; human diet including basic nutrition, psychology of food choice, diet and ageing, and maintenance of health through diet. BBSRC primarily funds academia through HEI and research council institutes but also funds industrial collaborative schemes, international collaborations and public engagement work. In addition, BBSRC is also the primary funder of postgraduate studentships in this area.

Overview of programmes related to food:
BBSRC programmes that relate to Food can be broadly broken into three areas: research led priorities, innovation led activities and institute strategic programmes. The majority of the ten research priorities for responsive mode grant proposals underpin aspects of food and food security including: global security, crop science, animal health, living with environmental change (effects on agricultural systems), ageing (dietary aspects), systems biology, and technology development. Food is also a significant part of four of the five BBSRC policy priorities including: increased international development, economic and social impact, welfare of managed animals, and impact on public policy.

BBSRC has a number of innovation schemes related to food including partnership in LINK programmes in collaboration with Defra, industry research and technology clubs e.g. diet and health. BBSRC also funds Industry co-funded research by responsive mode through its Industrial Partnership Awards and Stand-alone LINK.

BBSRC Institutes now package their research into Institute Strategic Programme Grants (ISPG). The majority of BBSRC institute programmes relate to food ranging from basic plant biology through to human health for example: at Rothamsted Research: Sustainable Pest and Disease Management; at John Innes Centre: Plant Perception and Response to the Environment (ENV); at Institute of Food Research: Food Structure and Health; at Institute for Animal Health: Understanding and control of livestock infectious diseases (LID); at Babraham: Immunology; and at North Wyke: Delivering Multifunctional Landscapes. In addition, BBSRC is funding a number of food related programmes at the former institutes at Roslin and IBERS.

Key interactions with other funders:
BBSRC has received co-funding or participated in joint funded schemes with EPSRC, ESRC, NERC, MRC and Defra, FSA, DFID, DH and Scottish Government. BBSRC also has extensive collaborations with EU partners through a variety of funding schemes and International collaborations with funding agencies/organisations from the US to Brazil.

Department of the Environment, Food and Rural Affairs (Defra)

Mission:
The overarching challenge for Defra is to secure a healthy environment in which current and future generations can prosper. Defra's Departmental Strategic Objectives include: A society that is adapting to the effects of climate change; a healthy, resilient, productive and diverse natural environment; sustainable, low carbon and resource efficient patterns of consumption and production; an economy and a society that are resilient to environmental risk; championing sustainable development; a thriving farming and food sector with an improving net environmental impact; a sustainable secure and healthy food supply; strong rural communities; and a respected department delivering efficient and high quality services and outcomes.

Remit in relation to Food:
Defra is the lead department responsible for agriculture and food and including the development and implementation of policy on the environment, rural affairs, farming and food production. Defra manage research programmes on an England and Wales basis and work closely with the Welsh Assembly Government to develop future research priorities. Defra's research portfolio on food spans the food chain from primary production to food in the home and addresses the need for a resource efficient, productive and sustainable food chain.

Overview of programmes related to food:
Food related programmes include research which contributes to policy development on sustainable farming and biodiversity, agriculture and climate change, water management, and efficiency and resilience in the food chain, together with work on plant and bee health and research to underpin GM risk assessment and policy development (annual budget £29M). Defra also jointly funds with industry innovative research which has a greater emphasis on competitiveness.

Defra's animal health and welfare programme supports research on exotic diseases of animals, Transmissible Spongiform Encephalopathies, bovine tuberculosis and control of zoonotic infections and endemic disease. In addition, Defra also supports research to reduce pathogenic diseases of UK fish and shellfish, improve animal welfare and support the work of the Veterinary Medicines Directorate.

Overall the Department's annual research budget across the food and farming sector (including animal health and welfare) exceeds £63M.

Key interactions with other funders:
Defra is closely involved in joint funding of food research with BBSRC, FSA, and Scottish Government (RERAD) and also has links with DH, DfID, FSA, WRAP and the Food and Drink Federation. Collaborative research partnerships with industry include those jointly funded by Defra, the RERAD, BBSRC and EPSRC e.g. projects in the Sustainable Arable, Sustainable Livestock, Horticulture, and Food LINK programmes which develop novel technologies and processes to support reductions in environmental impacts of the whole food chain, and knowledge transfer network partnerships. Internationally Defra is involved in European Research area networks (ERA-NETs) including a core international funding body network for organic farming. Defra also leads for UK on relevant parts of the EU 7th Framework Programme.

Department of Health (DH)

Mission:
DH exists to improve the health and wellbeing of people in England. DH is committed to improving the quality and convenience of care provided by the NHS and social services. Its work includes setting national standards, shaping the direction of health and social care services and promoting healthier living.

Remit in relation to Food:
DH works across Government, with the food industry, and stakeholders to establish a coherent national plan to help people in England improve their diets and create an environment which supports people to make healthier choices. Programmes include: '5 A Day' just eat more (fruit and veg); healthier food initiatives for schools – the School Fruit and Vegetable Scheme, Food Dudes and Free School Meals Pilots and 'Food in Schools'; 'Better Hospital Food' for consistent delivery of safe, good quality and nutritious food to patients; and the 'Healthy Start Scheme' to help low income families across the UK access a healthy diet. The Government's strategy for reducing the prevalance of obesity 'Health Weight, Healthy Lives includes a challenge to the food industry through the Healthy Food Code of Good Practice and a commitment to the Change4Live social marketing campaign to encourage people to 'eat well, move more and live longer'.

Overview of programmes related to food:
- ***Policy Research Programme*** provides research evidence to DH policy groups developing and formulating policy for NHS, public health and adult social care. Projects include the evaluation of the Healthy Community Challenge Fund, and a range of reviews of evidence on childhood obesity.
- Following publication of Best Research for Best Health – A new national health research strategy (2006) and the establishment of the National Institute for Health Research (NIHR), investments in research on nutrition, diet and lifestyle include:
  - ***Biomedical Research Centres*** (£468m – 12 centres – 5 years) in NHS and University partnerships provide NHS infrastructure for translational clinical research with patient benefit. Several Centres undertake research in nutrition and energy balance.
  - ***Biomedical Research Unit for Nutrition, Diet and Lifestyle (including Obesity)*** (£3.75m – 4 years) is a partnership between Southampton University Hospitals NHS Trust and Southampton University, enabling health researchers and clinicians to drive innovation in the prevention, diagnosis and treatment of ill-health related to nutrition, diet and lifestyle; and translate advances in medical research into benefits for patients.
  - **Diabetes Clinical Research Network** involves people with diabetes, carers and public in deciding research priorities, and generating a research portfolio by investigators from different disciplines, to encompass clinical studies with epidemiological studies and health services research, and interaction with basic, clinical science and translational research.
  - ***Programme Grants for Applied Research Scheme*** provides evidence to improve health outcomes, with a focus on research findings expected to impact on healthcare within a three to five year timescale. Diabetes was identified as a priority award (£7m - 5 years).
  - ***Health Technology Assessment Programme*** (HTA) supports independent research information on the effectiveness, costs and broader impact of healthcare treatments and tests for those who plan, provide or receive care in the NHS e.g. anti-obesity drugs in primary care, and themed calls with PHR for research on obesity.
  - ***Other Programmes*** that potentially include projects relating to nutrition include: Research for Innovation, Speculation and Creativity (RISC), Research for Patient Benefit (RfPB), and New and Emerging Applications of Technology.
  - ***Public Health Research*** (PHR) programme evaluates public health interventions, providing new knowledge on benefits, costs, acceptability and wider impacts of non-NHS interventions intended to improve health of the public and reduce inequalities in health.

Key interactions with other funders:
National Prevention Research Initiative (£12m – 5 years) – a collaboration of research funders from public and voluntary sectors with pooled funding to support research into risk factors (including obesity) relating to chronic heart disease, cancer and diabetes; and a Centre for Public Health Research Excellence in Diet and Physical Activity is one of the five new Public Health Centres for Excellence, funded through collaboration between major health research funders (£20m – 5 years). A collaboration by University of Cambridge, MRC, East of England Strategic Health Authority and University of East Anglia to build on existing research into diet and physical activity and established links of these lifestyle factors to diseases such as heart disease, stroke, osteoporosis and type 2 diabetes and expertise to help individuals change behaviour.

Department for International Development (DFID)

Mission:

DFID leads the UK government's effort to promote international development. DFID's overall aim is to reduce poverty in poorer countries, in particular through achieving the Millennium Development Goals (MDGs). The first MDG is to eradicate poverty and hunger, including "to reduce by half the proportion of people who suffer from hunger" between 1990 and 2015.

Remit in relation to Food:

DFID works across a number of agricultural sectors including forestry, fisheries, livestock and rural roads in addition to social protection and food aid. The DFID Research Strategy (2008-2013) and the supporting Agriculture Working Paper sets out DFID's approach to research on agriculture, fisheries and forestry. The Research Strategy has four results areas against which progress in implementation will be assessed. These are:

- New policy knowledge created for developing countries, the international community and DFID
- Existing and new evidence better informs decision-making about international development
- New technologies developed and used in developing countries
- Capability to do and use research strengthened

Overview of programmes related to food:

- DFID will double its support for agriculture to £400 million over the next five years. Expenditure will increase from £41 million in 2008-9, to £80 million in 2011-12. This will be spent in five areas:
    - International agricultural research organisations (£150m) (e.g. the Consultative Group on International Agricultural Research (CGIAR).
    - **Regional research organisations** (£50m) in West, East and Southern Africa, Andes and South Asia (e.g. ASARECA, CORAF, FARA). Initiatives include *Strengthening Capacity for Agricultural Research for Development in Africa* (SCARDA).
    - Responsive programmes (£12m) with the UK's Biotechnology and Biological Sciences Research Council (BBSRC) providing research grants to support basic and strategic biological or biotechnology research on crop sciences and animal health. (Sustainable Agriculture Research for International Development (SARID), and Combating Infectious Diseases of Livestock for International Development (CIDLID)).
    - Research into use and capacity building programmes (£50m). The *Research into Use* programme aims to maximise the poverty-reducing impact of past DFID funded research and other research, and by so doing, increase the understanding of how the promotion and widespread use of research can contribute to poverty reduction and economic growth. The Climate Change Adaptation Africa participatory action research programme managed by the International Development Research Centre (IDRC) to improve the pro-poor adaptive capacity of African societies. *Ecosystems for Poverty Alleviation* (ESPA) programme (managed by the Natural Environment Research Council (NERC)) to improve links with Research Councils and strengthen multidisciplinary investigation into under-researched poverty reducing potential of sustainable ecosystem management. *Water Research Programme Consortium: Research Inspired Policy and Practice Learning* (RIPPLE) to advance evidence-based learning on water and sanitation sector financing, delivery and sustainability that leads to measurable improvements in the equity of water and sanitation access for poor in Ethiopia and wider Nile region.
    - **Public-private partnerships** (£50m) to develop technologies for farmers (e.g. *Global Alliance for Livestock Vaccines and Medicines* – which is developing vaccines to benefit African livestock keepers; and grants to undertake **strategic programmes**, for example research on the control of avian flu). Also, the *Global Crop Diversity Trust* to ensure the long-term conservation and availability of plant genetic resources for food and agriculture.

Key interactions with other funders:

DFID provides funds to international agricultural research organisations and regional research organisations through multi-donor trust funds or initiatives managed by the World Bank. DFID leads cross-government PSA target on international poverty reduction with HMT, FCO and Defra.

Engineering and Physical Sciences Research Council (EPSRC)

Mission:
EPSRC aims to promote and support, by any means, high quality basic, strategic and applied research and related postgraduate training in engineering and the physical sciences. In addition, to advance knowledge and technology (including the promotion and support of the exploitation of research outcomes), and provide trained scientists and engineers, which meet the needs of users and beneficiaries (including the chemical, communications, construction, electrical, electronic, energy, engineering, information technology, pharmaceutical, process and other industries), thereby contributing to the economic competitiveness of the UK and the quality of life.
In relation to the activities above, as engaged in by the Council and in such manner as the Council may see fit, to: generate public awareness; communicate research outcomes; encourage public engagement and dialogue; disseminate knowledge; and provide advice.

Remit in relation to food:
Research of relevance includes food and drink products or ingredients: food proteins and carbohydrates, starch, milk, chocolate, sugars (sucrose, fructose etc.), lactic acid, grain, barley, dough, yeast (and any other obvious food stuffs). Food structure and properties: food colloids, lipids, non-Newtonian rheology, emulsions, phase inversion, oil/water dispersions, crystallisation. Food and drink manufacture and handling (including machinery, equipment and supply chain): extrusion, drying, spray drying, automation, boiling, baking, membranes (as in separation processes), ovens, freezing, distilling, milling, maturing, heat exchangers, fermentation, brewing, wort boiling, mashing, mixing, filters, centrifuge, cleaning, fouling, hygiene. Packaging (where relevant to food and drink properties or uses): cartons, smart packaging, barriers. Food modelling, functional foods (nutraceuticals), food waste or recycling, food chemistry (flavours), food sensors or analysis methods.

Overview of programmes related to food:
EPSRC has no specific programmes related to food other than co-funding contributions (on a case-by-case) basis to the BBSRC Diet and Health Industry Club (DRINC). EPSRC funding focuses on underpinning engineering and physical sciences through its standard funding mechanisms.

Economic and Social Research Council (ESRC)

Mission:
The ESRC helps to shape and defines society's sense of itself, guides the creation of new social knowledge and collaborates with those who make policy and executive decisions in government, business and the third sector. ESRC's mission is: to promote and support world class research and related postgraduate training in the social sciences; to advance knowledge and provide trained social scientists who meet the needs of users and beneficiaries, thereby contributing to the economic competitiveness of the UK, the effectiveness of public services and policy and the quality of life; and to disseminate knowledge about and promote public understanding of, the social sciences.

Remit in relation to food:
ESRC's aim is to support new and dynamic interdisciplinary research where it has the potential to drive forward breakthrough science or provide powerful innovative insights into complex applied problems. As part of this, extending partnerships with other Research Councils to embed social science at the heart of all collaborative work is key, particularly in the existing cross-council research challenges (including the new food security programme).

Overview of programmes related to food:
ESRC is identifying ways to secure safe, sustainable and affordable food supplies, particularly through the three following programmes:

- ***Supply / Demand Economies***
  - *Land use management*. Regulation effects on production demand. Supply and management. Acceptability of land use change, it's regulation and planning. Access to and or conflict over resources e.g. water. Tensioning with demands for housing/biofuels etc.
  - *Agricultural productivity*. Productivity modelling techniques (methodological research and substantive). Understanding how and why people respond to climate change in terms of crop choice, diet and resources use. Acceptability of novel production techniques e.g. GM.
  - *Global markets and trade*. Market regulation, better understanding of global markets and their distortions/market shocks. Improving trade flows (including examination of trade flows, regulation, purchasing practices and bulk buyers etc). Trends in demand (demographic, cultural and social - e.g. increased meat consumption in developing countries effects and future trajectory). Infrastructure investment economics e.g. ports, transport infrastructure and its resilience etc. Political sciences re international relations (e.g. trade agreements).

- ***Security***
  - *Food security* (which supplies and suppliers will be stable, for how long etc). How to respond to insecurity e.g. shortages in agricultural markets. Understanding how to manage enforced changes in diet. EU agricultural policy development, markets, economics. Political economy.

- ***Diet/Behaviour***
  - *Food safety.* Perceptions of food safety and ramifications of these (including nanotechnology, GM, new food stuffs etc.). Food safety and hygiene regulation and governance. Understanding effectiveness of campaigns/assurance schemes. Understanding how consumption patterns evolve and what they indicate about future patterns. Understanding and improving consumers' confidence in food.

Key interactions with other funders:
In 2008, ESRC entered into a strategic partnership with FSA, in part as a way of improving the FSA's access to food related social science evidence. Research has been commissioned as a result of a targeted call ('Understanding UK dietary decisions in the 21st century') and the FSA is contributing to the ESRC flagship survey 'Understanding Society'. The partnership will be further developed in the future.

European Union (EU)

Mission:
Funding collaborative and basic research to address key scientific and societal challenges. Helping research stakeholders communicate more efficiently and improving the way they coordinate their activities across Europe. In addition to continuous work to strengthen research institutions within the knowledge triangle, the European Research Area (ERA) addresses: researchers, knowledge transfer, joint programming, research infrastructures and international co-operation.

Remit in relation to Food:
The ERA addresses not only food production, manufacture and safety but also health-related issues such as obesity and societal issues related to food.

Overview of programmes related to food:
Those directly related to food include:

- **Framework programmes** are designed to support collaborative research by a wide range of participants: from universities, through public authorities to small enterprises and researchers in developing countries. Themes directly relevant to food include:
  - *Framework 7*: 'Food, Agriculture and Fisheries, and Biotechnology'; and 'Health', and basic science, via the European Research Council (ERC), in the 'Ideas' part of FP7.
  - *Framework 6*: 'Food Safety and Quality' (budget of € 685 million).
- **New Joint Technology Initiatives** which are industry driven, large-scale multi-financed actions, supported in certain cases by a mix of public and private funding.
- **ERANETs** are managed as a Funders Forum to identify opportunities for collaboration and gaps in research and knowledge, and fund joint research calls. The UK participates in ERA-NETS covering areas such as organic farming, food safety, agricultural research for development, and biodiversity. Those led in the UK include:
  - *Plant genomics* (BBSRC)
  - *Systems biology* (BBSRC)
  - *Emerging and major infectious diseases of livestock* (Defra)
  - *Statutory Plant Health* (Defra)
  - *Marine Fisheries* (Defra)
- **European Technology Platforms** are industry-led groups to strengthen European-wide innovation, to improve knowledge transfer and stimulate European competitiveness.
  - *Food for Life* addresses the entire food chain.
  - *Plants for the Future* addresses the plant sector including genetics and biotechnology.
  - *Farm Animal Breeding and Reproduction* major issues concerning sustainability, animal breeding and reproduction in Europe.
  - *Global Animal Health*
- **EARD-InfoSys+** provides an information and communication platform, in scientific development cooperation, through a network of National Nodes from member countries of the European Initiative for Agricultural Research for Development.
- Other initiatives with some relevance to food include:
- **Competitiveness and Innovation Framework Programme (CIP)** supports innovation activities (including eco-innovation), provides better access to finance and delivers business support services in regions (particularly for SMEs).

Food Standards Agency (FSA)

Mission:
The Agency's vision is "Safe Food and Healthy Eating for All", underpinned by the three core values of: putting the consumer first; openness and transparency; and science and evidence based.

Remit in relation to Food:
The FSA is a non-Ministerial Government department set up by an Act of Parliament in 2000 to protect the public's health and consumers' other interests in relation to food (as defined in the Food Safety Act 1990). It has a wide remit for microbiological and chemical food safety across the whole UK food chain, "farm to fork". It shares responsibility for nutrition with UK health departments and has a particular role in helping consumers achieve and maintain a healthier diet. It also has a role in ensuring consumers have the information they need to make informed and effective choices about the food they eat, including protection from food fraud and illegal practices.

Overview of programmes related to food:
As a science and evidence based organisation, the Agency uses evidence and commissions work where there are gaps in the evidence base, to help support development, implementation and evaluation of its policies. It has a broad portfolio of research, evidence-gathering and analysis programmes in the following thematic areas:

- Food safety – UK production and consumption
- Food safety – imports
- Healthier foods and diets
- Food behaviours and information
- Effective risk-based regulation
- Strategic and cross-cutting evidence and analysis

Key interactions with other funders:
Partnership is a key theme running through the Agency's Science and Evidence Strategy. The Agency works closely with other research funders in the UK and internationally, to ensure that its work is co-ordinated, and to add value by working together. FSA collaborate with a wide range of bodies in the UK, including other government departments, Research Councils e.g. in Funders groups which co-ordinate work in specific priority areas of common interest (e.g. TSE, microbiological safety, nutrition, nanotechnology). Work is co-funded by the Agency under the BBSRC Government Partnership Award Scheme. FSA also engage with the European Commission, helping to shape priorities in the EU's Seventh Framework Programme for Research (FP7), and through links with other funders in Europe and internationally. The Agency is also one of the partners in the National Prevention Research Initiative (NPRI) and in an EU-funded ERA-NET project, SAFEFOODERA, which covers 20 countries and regions across Europe, and co-funding projects from a recent joint call.

Medical Research Council (MRC)

Mission:

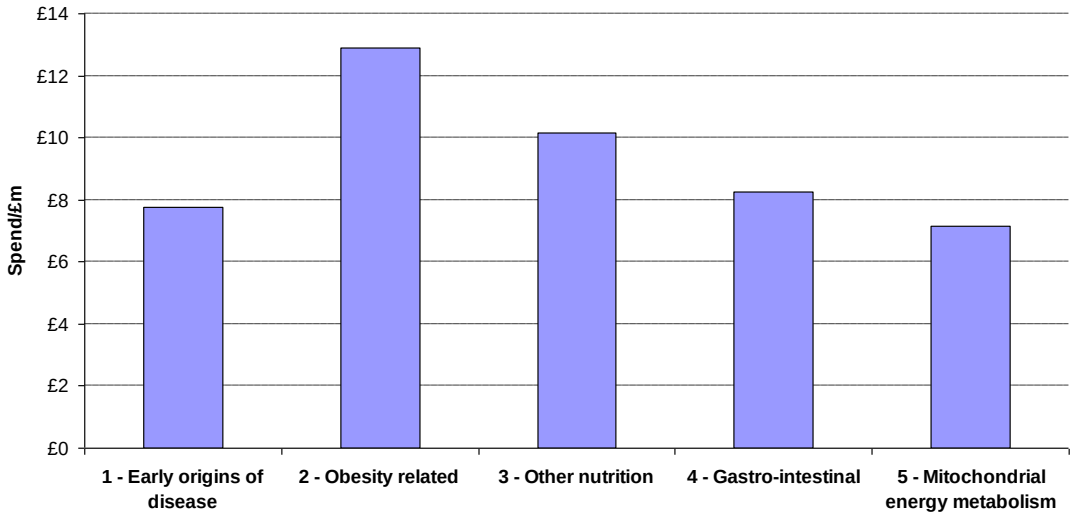
The heart of MRC's mission is to improve human health through world-class medical research by encouraging and supporting research to improve human health, producing skilled researchers, advancing and disseminating knowledge and technology to improve the quality of life and economic competitiveness of the UK, and promoting dialogue with the public about medical research. MRC supports research across the biomedical spectrum, from fundamental lab-based science to clinical trials, and in all major disease areas. MRC works closely with the NHS and the UK Health Departments to deliver their mission, and give a high priority to research that is likely to make a real difference to clinical practice and the health of the population.

Remit in relation to food:

The MRC's remit covers human nutritional requirements and the effects of food on health and disease (including allergies, food-borne diseases and toxicity).

Overview of programmes related to food:

In 2007/8 the MRC funded approximately £46m of research into nutrition, including obesity and mitochondrial energy metabolism. Of this, approximately £17m was directly relevant to "food research". The distribution across scientific areas is summarised in the graph below:



Notable MRC investments include:

- Collaborative Centre for Human Nutrition Research (Cambridge)
- Epidemiology Unit (Cambridge)
- Epidemiology Resource Centre (Southampton)
- International Nutrition Group (London School of Hygiene and Tropical Medicine).
- Mitochondrial Biology Unit, formerly the MRC Dunn Human Nutrition Unit (Cambridge)
- Centre for Obesity and Related Metabolic Disease (Cambridge)
- Centre for Nutritional Epidemiology in Cancer Prevention and Survival (Cambridge)

Key interactions with other funders:

The MRC interacts and co-invests in research funding initiatives with the BBSRC and ESRC, especially through the BBSRC-led DRINC scheme. There are strategic links between the FSA and MRC (as exemplified by recent contributions to development of the FSA). The MRC and National Institute for Health Research (NIHR) are partners under the Office for Strategic Coordination of Health Research (OSCHR), and NIHR take a strategic lead on obesity research under this partnership.

Natural Environment Research Council (NERC)

Mission:
NERC's mission is to gather and apply knowledge, create understanding and predict the behaviour of the natural environment and its resources, and communicate all aspects of their work.

Remit in relation to food:
NERC funds research on environmental systems, the pressures on those systems arising from natural processes and human activity and ways of strengthening the evidence base for managing the environment sustainably and productively. This includes research on agricultural and animal husbandry systems and the way in which these interact with environmental resources and processes such as biodiversity (including fish stocks and pest and disease ecology), soil, land-use patterns, pollution, surface water, groundwater and the seas. At this time of unprecedented rates and magnitudes of environmental change this expertise provides important input into a range of economically and socially important aspects of food production, supply and delivery. The outputs and outcomes from this research provide the food sector with the insight and foresight on environmental matters that business and the public need to plan for and make decisions about the future.

Overview of programmes related to food:
- ***Living With Environmental Change*** – NERC is the lead research council in the LWEC programme that has a number of strategic objectives relating to food supply. These include: ensuring a sustainable supply of food (and water), pests and diseases of plants and animals, and transport and urban systems (important as over half of humanity now live in urban areas).
- ***Insect Pollinators Initiative*** – NERC is a partner in the Insect Pollinators Initiative that was recently launched as part of LWEC.
- ***Rural Economy and Land Use Programme*** – NERC is a major partner in the RELU programme that has established a community of multi-disciplinary expertise able to address rural issues – many relevant to food.
- ***Research Centres*** – Several of its upcoming research programmes and national capability activities at its research centres deal with aspects of food-related research outlined in the previous paragraph.

Key interactions with other funders:
As a partner in Living With Environmental Change (LWEC) and through many other routes, such as work commissioned by government departments and externally funded and non-funded links with stakeholders in the public and private sector, NERC has a range of interactions with other bodies on food-related research. Principle research partners are Defra, DFID, BBSRC, ESRC, the Scottish Government, the Welsh Assembly Government, and the Wellcome Trust. Links to other bodies such as DH and MRC are developing as part of LWEC. NERC also supports staff working on regulatory committees such as the Advisory Committee on Releases to the Environment (ACRE) and Advisory Committee on Pesticides (ACP). Interactions with the private sector include farming consortia and funding from and advice to companies such as Unilever and Syngenta.

Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) and Marine Scotland

Mission:

RERAD promotes evidence based policy making by providing government with relevant, robust, timely and accessible scientific, socio-economic and statistical advice, research and horizon scanning on rural and environmental issues. Marine Scotland Science (MSS) provides the evidence base for marine policy and freshwater fisheries policy in Scotland. Both RERAD and MSS contribute to the single purpose of the Scottish Government which is to create a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth.

Remit in relation to food:

The Scottish Government launched its Food and Drink Policy in June 2008. RERAD staff work closely with the Policy staff responsible for delivery of the Policy to provide the appropriate evidence. RERAD's Research Strategy focuses primarily on production of food and the links between nutrition and health. RERAD also co-funds research in partnership with organisations in the food industry in response to appropriate requests.

Overview of programmes related to food:

There are 4 main Research Programmes with high level policy objectives as the drivers:

- ***Profitable and Sustainable Agriculture – Plants*** - delivers outputs such as knowledge and technology which help develop successful Scottish crop production in a changing environment. The research will exploit novelty in genetics resources (plant and pathogen) and will develop an improved understanding of how plants and pathogens react with their environment.
- ***Profitable and Sustainable Agriculture – Animals*** - helps Scottish livestock enterprises deliver high quality primary food products derived from animals that optimise benefits for human health and are produced in systems that promote the health and welfare of animals and enhance the environment.
- ***Environment – Land Use and Rural Stewardship*** - develops an appropriate balance between various land uses such as agriculture, environmental services, recreation and the preservation and enhancement of natural heritage.
- ***Impacts on Human Health*** - contributes to the delivery of information on how the food we eat and the way it is produced and consumed affects human health. Outputs should provide a robust basis for dietary and nutritional advice, and provide underpinning scientific evidence and sources of innovation for the health improving properties of our food. It will also consider the environmental health impacts of existing food production systems and changes in them. Outputs from this Programme should also inform the production of desirable food quality traits and be relevant to food processors.

In addition, there are 3 Cross-Cutting Themes (CCTs) of Climate Change, Biodiversity, and Social and Economic Sustainability to which each of the main Programmes contribute.

The RERAD Strategy for 2011-2016 will contain significant research on food, organised to deliver policy relevant outcomes which contribute to the overall Purpose of the Scottish Government. During 2010 research conducted through the Strategy will be commissioned.

Marine Scotland also funds research on marine and freshwater fisheries, and aquaculture; and is developing a science strategy due to be completed in 2010. It is expected to cover science supporting food production in both capture and culture fisheries but will primarily address the Scottish Government's purpose of growing the economy.

Both strategies are being developed in discussion with relevant government agencies namely: Food Standards Agency Scotland, Quality Meat Scotland, Scottish Natural Heritage, Scottish Environment Protection Agency where appropriate. The annual SG budget for food related research is approximately £34 Million.

Key interactions with other funders:

The Scottish Government is closely involved with joint funding with BBSRC and Defra. Funding strategies are discussed with Food Standards Agency Scotland and Quality Meat Scotland and with the Scottish National Heritage (SNH) and the Scottish Environment Protection Agency (SEPA) on environmental aspects of food production. The SG is also involved in ERA-NETS such as Emerging and Major Infectious Diseases of Livestock (EMIDA).

Welsh Assembly Government (WAG)

Mission:
The Welsh Assembly Government's vision is for a viable, sustainable food and drink sector in Wales, which best suits the needs of the Welsh people. It's strategic position paper 'Farming Food and Countryside: building a secure future' outlines the direction of the farming industry towards 2020. The Agri-Food Partnership for Food and Drink in Wales is working towards an over-arching strategy for the food chain in Wales, and will inform the work of sector specific groups taking forward strategies for dairy, red meat, horticulture and organics.

The partnership will gather evidence from a wide selection of sources to address the challenges and opportunities facing the sector. These will include the challenge of mitigating the damaging effects of climate change; protecting the environment; ensuring that carbon emissions are minimized and that natural resources are managed effectively. The need to ensure sufficient healthy food to meet consumer needs is to be balanced with the need for robust economic performance and strong rural communities.

Remit in relation to food:

The Food Fisheries and Market Development Unit is the lead Division in the Welsh Assembly Government's Rural Affairs (RA) Department on food policy. The Department as a whole is responsible for agriculture including policy on the environment, sustainability, rural development, farming, food production and research. The Division links with others throughout the Assembly as necessary in areas such as food tourism, food safety, caring for the environment, the health and nutrition agendas as well as education.

The 'Local Sourcing of Food and Drink Action Plan' is to be delivered as a partnership between key relevant divisions of the Welsh Assembly Government and industry stakeholders with the aim of increasing the level of local sourcing of food and drink in Wales and increasing the supply of local products to public sector organisations. It also recognises key elements of the new Wales Waste Strategy which supports the reduction of waste, emissions and increased energy efficiency throughout the whole food chain.'

The Welsh Assembly Government is also delivering the Food Tourism Action Plan 'Food and Drink for Wales', which brings together the areas of agriculture, food processing, tourism destinations, the food service sector, food festivals and food retail outlets, including farmers' markets.

Overview of programmes related to food:
As Defra manages research programmes and budgets on an England and Wales basis, the Welsh Assembly Government works closely with Defra to develop food related evidence, which contributes to policy development. This includes the sustainable farming and biodiversity, agriculture and climate change, water management and efficiency and resilience in the food chain, together with research on plant and bee health and animal health and welfare. It also includes innovative research that is jointly funded with industry via the LINK programmes, which includes food, arable, livestock and horticulture.

In addition, the Welsh Assembly Government contributes to the food research agenda at a strategic level via the Foresight programme and the Food Research Partnership (FRP).

Key interactions with other funders:
The Welsh Assembly Government works closely with Defra to ensure that Welsh research needs are considered as part of the Defra managed England and Wales programmes. In addition, the Welsh Assembly Government has developed links with wider UK evidence groups e.g. UK Research Councils, UK Research Institutes, Food Standards Agency (FSA), Agriculture and Horticulture Research Forum (AHRF), Living with Environmental Change (LWEC), Environmental Research Funders' Forum (ERFF), Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) and the Department of Agriculture and Rural Development Northern Ireland (DARDNI).

Department of Agriculture and Rural Development (DARD) for Northern Ireland

Mission:
DARD's vision is to create and maintain a thriving and sustainable rural community and environment in Northern Ireland. This mission is underpinned by four strategic objectives: to improve performance in the market place; to strengthen the social and economic infrastructure of rural areas by working to create a strong rural community with more businesses and jobs than before; to improve animal, fish and plant health and welfare by working towards a reduction in diseases; and to develop a more sustainable environment.

Remit in relation to food:
DARD sponsors a comprehensive research programme across the agri-food sector in Northern Ireland to provide a sound, scientific basis for government policy on agriculture and the environment and to underpin development in the agri-food private sector. Research is primarily commissioned through the Agri-Food and Biosciences Institute (AFBI).

Overview of programmes related to food:
DARD research funding is primarily concentrated on applied and experimental development research activities. The research programme includes work on: food industry sustainability, (quality and consumer choice, novel processes and products), consumer confidence, (food safety and traceability); sustainable food and farming including sustainable forage and crop systems, sustainable and competitive livestock systems (dairy, beef, sheep, pigs and poultry systems); and animal health, management and protection of natural resources and agriculture and food economics.
Important programmes include:

- **Improving performance in the market place** – supporting the sustainable economic development of the local agri-food, fisheries and forestry industries. Economic modelling work of the Food and Agricultural Policy Research Institute (FAPRI) - UK Partnership, helps to inform policy development and delivery of the complex social, political and economic interactions which shape the operating environment in which the agri-food, fisheries and forestry industries function.
- **Strengthening the social and economic infrastructure of rural areas -** focusing on the specific status, problems and opportunities of rural communities. Key research interests include: baseline and trend data on the socio-economic characteristics of different types of rural areas; the evolving role of agri-food, fishing and forestry in the rural economy; the role of the rural economy in the broader Northern Ireland economy; and socio-economic linkages and interdependencies between rural and urban areas.
- **Enhancing animal health and welfare, fish and plant health -** endemic animal diseases, including surveillance and diagnosis of animal diseases, notably bovine Tuberculosis (TB) and Brucellosis. Faster, more accurate and less costly detection of such diseases will ultimately assist in disease eradication programmes and the early detection and prevention of the spread of new diseases. Research in animal welfare aims to understand public perceptions and the benefits accruing to society from improved animal welfare relative to the costs and to explore the most efficient means of responding to higher animal welfare standards.
- **Developing a more sustainable environment -** gaining a better understanding of the interaction between land- and marine- based industries and the natural environment. This, together with an improved understanding of attitudes to regulatory compliance in these industries, will inform better policy making and regulation. At the same time, concern for environmental sustainability, including the need to mitigate the impact of climate change is opening up new opportunities for the land-based sector, for example in renewable energy production. A better understanding of the value attached to sustainable land and marine management may also provide the opportunity to create and exploit market differentiation for the products of the agri-food sector.

Key interactions with other funders:
DARD is closely involved in joint funding with Defra and Northern Ireland levy bodies such as AgriSearch. Funding of research is also discussed with a wide range of local stakeholder groups.

Technology Strategy Board

Mission:
The Technology Strategy Board aims to make the UK a global leader in innovation by promoting and investing in innovation enabled by technology for the benefit of business, to increase sustainable economic growth and to improve quality of life.

Remit in relation to food:
The TSB assists business in the development of new products and services, and knowledge transfer across all sectors of industry for the benefit of the UK economy. It does this through a number of mechanisms, including collaborative R&D, knowledge transfer partnerships (KTP), knowledge transfer networks (KTNs), Feasibility projects, Fast-Track projects and SBRI. It helps business build capability in underpinning areas and respond to market opportunities; works with Government as they address societal challenges, and helps businesses benefit; and builds networks within communities where knowledge about needs and capabilities can be exchanged. Many of these activities are appropriate for providing support to business in the agri-food sector.

Overview of programmes related to food:

Those TSB activities directly related to food include:

- ***Sustainable Agriculture and Food Innovation Platform (SAF IP)*** – This new Innovation Platform will work to develop technologies to increase food production whilst reducing the environmental impact of the supply chain. The principle themes are crop productivity, sustainable livestock production, waste reduction and management and GHG reduction technologies and methodologies. It is anticipated that over £90M will be invested in the programme over five years.
- ***Detection and Identification of Infectious Agents Innovation Platform (DIIA IP)*** although primarily focused on human health, is also investing in the development of tests for the rapid / point of care detection of targeted animal diseases which will help the livestock industry. Animal diseases currently in scope are Foot and Mouth (FMD) virus, Swine Vesicular Disease (SVD) virus, *Mycobacterium bovis* (in live cattle only), bluetongue virus, Classical Swine Fever (CSF) virus, African Swine Fever (ASF) virus, Avian Influenza virus (H5 and H7).
- ***Biosciences Knowledge Transfer Network*** – brings together three former KTNs food processing, bioscience for business, and genesis (genetics in animal husbandry) and aims to increase the breadth and depth of knowledge exchange between companies and between business and academia in specific areas of technology. It is also intended to set up a Special Interest Group (SIG) to support the networking requirements of the new SAF IP.

Other programmes where technologies of relevance to the agri-food chain industry may be developed include:

- ***Technology Area*** – there are six technology areas, several of which are relevant to the agri-food sector. The Biosciences strategy identifies a number of areas for future investment including industrial biotechnology and genomics. Other relevant technology areas include: advanced materials, nanotechnology, high value manufacturing, and information and communication technology (ICT).
- ***Application Areas*** – the TSB develops technology strategies in a number of broad market areas where the UK has a world-leading position. These include: energy generation and supply, medicines and healthcare, environmental sustainability, creative industries and high value services. The Resource Efficiency Strategy in particular contains themes that are relevant to the sector.

Key interactions with other funders:
TSB works closely with government departments and their agencies, devolved administrations and regional development agencies, and the research councils. The research councils and the English Regional Development Agencies (RDAs) have committed £120M and £180M respectively in alignment with Technology Strategy Board activities over a three year period. Some Government Departments also co-fund Innovation Platforms.
Food Processing Faraday Partnership - Previously supported through TSB by Defra and BIS (until Sept 2009). FPFP is now a business offering technology expertise and consultancy to the food industry.

Annex 3

Challenge Matrix: Examples of Competing Pressures in the Food System

As discussed in chapter 5, it is comparatively easy to articulate individual challenges and research drivers, but more difficult to reconcile tensions and trade-offs, in the development of coherent policies. Some more examples of conflicting challenges in the agri-food system which will need cross-government collaboration include:

Challenges and Research Drivers	Tensions and Trade-Offs
Aquaculture is currently environmentally wasteful and relies on marine animal sources for fish feed at a 10:1 ratio of kg of fish used in feed per kg of fish produced.	Given that Omega 3 levels are too low in the UK diet and oily fish is the only significant source, increased fish intake is recommended.
Lower red meat consumption would reduce health risks for many individuals, through reduced saturated fat consumption.	Forty percent of women have iron deficiencies and an increasing number of people show low levels of vitamins B6, B12 - red meat is one of the best sources of these nutrients.
Thinning chicken flocks prior to slaughter helps to supply a market need for a range of bird sizes in a more economic way for industry.	Thinning has been shown to increase the levels of Campylobacter contamination in chicken flocks by eight times thus reducing the safety of the food and increasing the risk to consumers.
GM technology has the potential to deliver a range of benefits (e.g. crops requiring less pesticide use, or crops which are drought-tolerant or have enhanced nutritional attributes).	There are issues with public perception of GM crops, which acts as a disincentive to research and uptake of GM technology.
Free range birds are more publically acceptable and potentially increase aspects of animal welfare.	Free range systems are at greater risk of disease especially transmitted from wild birds including zoonotic diseases such as avian influenza.
Reducing poverty and increasing affluence in the third world is a key developmental driver.	Increased affluence creates changes in food consumption to higher meat/protein diets which increases the amount of land needed for livestock production and has associated environmental impacts.
Excessive packaging is generally viewed by the consumer as wasteful and has an additional carbon footprint of its own.	The embedded carbon/water in food is often higher than that in the packaging, and in many cases, smarter packaging that reduces spoilage and waste of the food has a net benefit to overall carbon and water footprints.
Sustaining wild fish stocks is essential and quotas prevent over fishing of key species.	Quotas produce significant environmental waste through discarding of fish over the quota.
Animal disease research is expensive, requiring complex containment facilities and many different research programmes to address the range of possible threats.	Disease outbreaks have cost the UK economy billions, and effective research programmes have been shown to be cost effective in reducing outbreaks.
A reduction in the use of pesticides is potentially beneficial for health and has strong regulatory drivers.	Pesticide bans reduce yields and potentially make some crops economically unviable by increasing production costs and reducing availability.

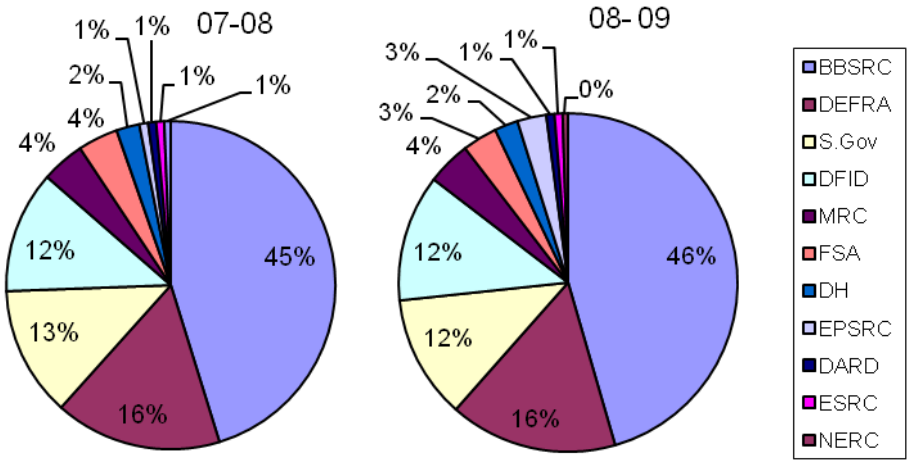
Annex 4

Breakdown of Research Funding Data:

A breakdown of the spend data (£M) from 07/08 and 08/09 used to generate the pie-charts in Figure 3 is shown below. This data (with specific caveats as detailed) was provided directly from the funders based on the currently available data for individual programmes.

Total Food Research Spend

Funder	*07/08*	*% of Total*	*08/09*	*% of total*
BBSRC	184.50	45.22	188.91	45.52
DEFRA	66.90	16.40	66.42	16.00
Scottish Govt.	52.23	12.80	48.97	11.80
DFID	49.10	12.04	50.24	12.11
MRC	17.30	4.24	17.30	4.17
FSA	16.12	3.95	13.80	3.33
DH	9.27	2.27	9.27	2.23
EPSRC	3.50	0.86	11.52	2.78
DARD	3.25	0.80	3.25	0.78
ESRC	3.18	0.78	3.18	0.77
NERC	2.63	0.64	2.15	0.52
Total	**407.98**		**415.01**	



BBSRC

Category (title)	***07/08***	***08/09***
Plant & Crop Science	66.4	65.6
Animal Health	45.5	54.5
Studentships	18.9	18.6
Diet & Health	14.1	12.2
Food Safety	10.9	11.2
Agricultural Systems	7.2	4.0
Environmental Change and Agri-Systems	6.6	6.8
Soil Science	6.3	5.9
Food Manufacturing	5.3	4.6
Animal Welfare	2.2	3.9
Aquaculture	1.1	1.6
Total	**184.6**	**188.9**

Note: This data does not include overlaps in spend between different programmes which is more accurate for estimating the spend in an individual area

Defra

Programme	***07/08***	***08/09***
Farming and Food science: Agriculture and climate change	5.25	5.61
Plant health and bee health	0.80	0.74
Research Efficient and Resilient food Chain (RERFC)	5.38	4.69
Water Quality and Use	3.47	4.41
Sustainable Farming systems and biodiversity	13.90	12.85
Genetically modified Organisms	0.38	0.40
Salmon and fisheries programme SF02	0.72	0.72
Livestock health/welfare programmes (related to food-excluding work on Crypto, pets and exotic viruses (£2M))	37.00	37.00
Total	**66.90**	**66.42**

Note: This data does not currently include capital expenditure at the Veterinary Laboratory Agency (VLA) associated with food research. Surveillance spend is excluded from this data as it is not research but it should be acknowledged that surveillance is an important underpinning activity supporting the food supply chain.

DFID

Programme	***07/08***	***08/09***
Support to Sub-regional Agriculture Research Organisations in Africa	3.0	5.0
Core support to the Forum for Agriculture Research in Africa (FARA)	0.4	0.5
Strengthening Capacity for Agriculture Research for Development in Africa (SCARDA)	1.0	2.6
Global Crop Diversity Fund	5.0	0
Research Into Use Programme (RIUP)	6.0	8.0
Sustainable Agriculture for International Development (SARID)	1.0	1.0
GALVmed – the Global Alliance for Livestock Vaccine and Medicines	0.9	0.9
Pro-Poor Policy Options for Control of Highly Pathogenic Avian Influenza (HPAI) in Africa and Southeast Asia	1.0	1.0
Support to the International Agricultural Research Centres and Challenge Programmes to support international public good research	22.5	25.0
Combating Infectious Diseases of Livestock for International Development (CIDLID)	0.1	1.5
Climate Change Adaptation Africa	4.5	4.0
Ecosystems for Poverty Alleviation (ESPA)	3.0	0.0
Water Research Programme Consortium : Research Inspired Policy and Practice Learning (RiPPLE)	0.7	0.7
Total	**49.1**	**50.2**

Scottish Government

Programme	***07/08***	***08/09***
Programme 1: Profitable & Sustainable Agriculture – Plants	10.45	10.45
Programme 2: Profitable & Sustainable Agriculture – Animals	10.46	10.05
Programme 3: Environment – Land use and Rural Stewardship	9.78	9.79
Programme 4: Impacts on Human Health	10.05	8.79
Contract Research Fund	6.50	4.90
Fish stocks and aquaculture research (based on estimates for Fisheries Research Services)	5.00	5.00
Total	**52.23**	**48.97**

MRC

Programme	***07/08***	***08/09***
MRC Collaborative Centre for Human Nutrition Research	6.0	6.0
MRC International Nutrition Group	1.6	1.6
MRC Epidemiology Resource Centre	2.5	2.5
MRC Epidemiology Unit	6.1	6.1
MRC Social and Public Health Sciences Unit	3.5	3.5
Grant and fellowship funding (response mode) - early origins of disease	2.0	2.0
Grant and fellowship funding (response mode) - obesity related	3.0	3.0
Grant and fellowship funding (response mode) - gastrointestinal disease	1.4	1.4
Grant and fellowship funding (response mode) - other nutrition	2.1	2.1
Total	**28.2**	**28.2**

FSA

Programme	***07/08***	***08/09***
Food Authenticity	0.88	0.92
Optimal Nutrition	2.26	2.39
Meat hygiene - microbiological safety	0.84	0.24
TSEs	1.35	0.16
Verocytotoxin producing e.coli o157 (VTEC)	0.07	0.33
Microbial risk assessment	0.13	0.52
Food borne disease	1.20	0.79
Eggs and Poultry	0.38	0.07
Organic Wastes	0.04	0.68
Economics	0.07	0.05
Data quality and improved methods of analysis	0.35	0.64
Chemical contaminants from food contact materials	0.37	0.47
Chemical contaminants from food production	0.21	1.50
Mycotoxins and process contaminants	0.66	0.10
Risk assessment	0.94	0.12
Phytoestrogens in the diet	0.07	1.10
Risk assessment of mixtures of pesticides and similar	0.94	0.46
Shellfish hygiene	0.08	0.03
Marine microbiology and biotoxins	0.12	0
FSA Scotland research programme	0.50	0.28
Total	**16.12**	**13.80**

Note: The FSA typically spends about £20m pa on its science portfolio which comprises R&D, analytical surveys and other related evidence gathering projects. The balance between these activities can vary year on year as dictated by the FSA's business needs.

DH

RDD/NIHR Programme	*Number of Projects/Activities*	*07/08*	*08/09*
Policy Research Programme		1.00	1.00
Research for Patient Benefit	21	1.44	1.44
Programme Grants for Applied Research	4	1.84	1.84
NIHR Central Commissioning Facility			
Diet Related Disease	28	3.29	3.29
Food Types	7	0.18	0.18
General	10	1.51	1.51
Public Health	0	0	0
Total		**9.26**	**9.26**

EPSRC

Programme	*07/08*	*08/09*
Responsive mode	3.50	3.50
Initiatives	0	8.02*
Total	**3.50**	**11.52**

Note: This data includes a £6.5M doctoral training centre in chemical engineering and advanced materials. Spend data also reflects award's in that year and not actual spend in the given financial year.

DARD

Programme	*07/08*	*08/09*
Sustainable Food and Farming	1.30	1.32
Competitiveness in the Agri-Food Industry	1.30	1.32
Agriculture and Food Economics	0.62	0.66
Total	**3.22**	**3.30**

ESRC

Programme	*07/08*	*08/09*
Diet/ Behaviour	0.88	0.88
Security	0.44	0.44
Supply/ Demand Economics	1.86	1.86
Total	**3.18**	**3.18**

NERC

Programme	***07/08***	***08/09***
CEH Water Programme	0.03	0.03
British Geological Survey -Geochemical baselines programme	0.40	0.39
Environment and Human health program	0.215	0.15
Sustainable Development and monitoring of land resources and chemicals (part of RELU spend)		
Scottish Association of Marine Scientists	0.98	0.57
Other NERC programmes e.g. RELU	1.00	1.00
Total	**2.63**	**2.15**

TSB

TSB programmes in Agriculture and Food related areas did not start in the 07/08 or 08/09 spend period; but the current estimate on future spend is ~£10M/year.

Annex 5

Acronyms

AATF	African Agricultural Technology Foundation
AFBI	Agri-Food and Biosciences Institute
AHDB	Agriculture and Horticulture Development Board
AHRF	Agriculture and Horticulture Research Forum
ASF	African Swine Fever
BBSRC	Biotechnology and Biological Sciences Research Council
BIS	Department for Business, Innovation and Skills
CAADP	Comprehensive Africa Agriculture Development Programme
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CGIAR	Consultative Group on International Agricultural Research
CIDLID	Combating Infectious Diseases of Livestock for International Development
CIMMYT	International Maize and Wheat Improvement Center
COST	European Co-operation in the field of Scientific and Technical Research
CSF	Classical Swine Fever
DA	Devolved Administrations
DARD	Department for Agriculture and Rural Development
Defra	Department for Environment, Food and Rural Affairs
DCSF	Department for Children, Schools and Families
DFID	Department for International Development
DH	Department of Health
DIIA	Detection and Identification of Infectious Agents
DRINC	Diet and Health Research Industry Club
EIARD	European Initiative for Agriculture Research for Development
ERFF	Environmental Research Funders' Forum
EMIDA	Emerging and Major Infectious Diseases of Livestock
EPSRC	Engineering and Physical Sciences Research Council
ESRC	Economic and Social Research Council
EU	European Union
ERA	European Research Area
ERC	European Research Council
ERA-NET	European Research Area Network
ESPA	Ecosystems for Poverty Alleviation
FAC	Futures Agriculture Consortium
FERA	Food and Environment Research Agency
FAO	Food and Agriculture Organisation
FAPRI	Food and Agricultural Policy Research Institute
FARA	Forum for Agricultural Research in Africa
FMD	Foot and Mouth Disease
FP	Framework Programme
FRG	Food Research Group
FRP	Food Research Partnership
FSA	Food Standards Agency
GACS	General Advisory Committee on Science
GALVmed	Global Alliance for Livestock Veterinary Medicines
GCSA	Government Chief Scientific Adviser
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GM	Genetic Modification
GPAS	Global Partnership for Agriculture and Food Security
GSIF	Global Science and Innovation Forum
HEFCE	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HEI	Higher Education Institutions
HESA	Higher Education Statistics Agency
IBERS	Institute of Biological, Environmental and Rural Sciences

ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFS	International Foundation for Science
ILRI	International Livestock Research Institute
ISPG	Institute Strategic Programme Grants
KTN	Knowledge Transfer Networks
KTP	Knowledge Transfer Partnership
LID	Livestock Infectious Diseases
LWEC	Living With Environmental Change
MDG	Millennium Development Goal
MRC	Medical Research Council
MRP	Main Research Provider
MSFFG	Microbiological Safety of Food Funders Group
NARS	National Agricultural Research System
NDPB	Non-Departmental Public Body
NEPAD	New Partnership for Africa's Development
NERC	Natural Environment Research Council
NGO	Non-Governmental Organisations
NHS	National Health Service
NI	Northern Ireland
NIHR	National Institute for Health Research
NPRI	National Prevention Research Initiative
NRCG	Nanotechnology Research Coordination Group
NVZ	Nitrate Vulnerable Zone
OCHA	Office for the Co-ordination of Humanitarian Affairs
OECD	Organisation for Economic Co-operation and Development
PSA	Public Service Agreement
RA	Rural Affairs
RC	Research Council
RDA	Regional Development Agencies
REEDNet	Rural Employer Engagement Development Network
REF	Research Excellence Framework
RELU	Rural Economy and Land Use
RIPPLE	Research Inspired Policy and Practice Learning
R&D	Research and Development
RTD	Research and Technology Development
SAC	Scientific Advisory Committee
SAF IP	Sustainable Agriculture and Food Innovation Platform
SAIN	Sustainable Agriculture Innovation Network
SARID	Sustainable Agriculture Research for International Development
SCAR	Standing Committee on Agricultural Research
SCARDA	Strengthening Capacity for Agricultural Research for Development in Africa
SEPA	Scottish Environment Protection Agency
SFC	Scottish Funding Council
SIG	Special Interest Group
SME	Small and Medium-Sized Enterprises
SNH	Scottish National Heritage
SRO	Sub-regional Research Organisation
SVD	Swine Vesicular Disease
TB	Tuberculosis
TSB	Technology Strategy Board
TSE	Transmissible Spongiform Encephalopathies
UK	United Kingdom
VLA	Veterinary Laboratories Agency
WAG	Welsh Assembly Government
WB	World Bank

WFP	World Food Programme
WHO	World Health Organisation
WRAP	Waste and Resources Action Programme