All-Party Parliamentary Group on
Science and Technology in Agriculture

Support for agricultural R&D is essential to deliver sustainable increases in UK food production



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Professor David Leaver

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Background

The All-Party Parliamentary Group on Science & Technology in Agriculture was established in March 2008 to provide a forum for Parliamentarians and other interested parties to debate and highlight the value of science and technology in agriculture.

The global challenges of climate change, food security and resource protection are focusing future thinking about and within our farming industry. Advances in science and technology will be essential to help UK agriculture respond positively to these challenges.

The All-Party Parliamentary Group on Science & Technology in Agriculture aims to promote debate among UK politicians and other stakeholders, not only to understand the role of science and technology in 21st century agriculture, but also to identify any policy, knowledge-based or regulatory barriers to its adoption.

This report provides a summary of the issues and recommendations highlighted in a series of meetings hosted by the All-Party Group in 2009-10 focused on the research targets and needs of different sectors of UK agriculture – horticulture, livestock, arable – and the mechanisms available to support future innovation in UK agriculture.

About the Author

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Support for agricultural R&D is essential to deliver sustainable increases in UK food production

Executive Summary

1. Global concerns over food security and climate change are fuelling renewed interest in productive, science-based agriculture, and the All-Party Parliamentary Group on Science and Technology in Agriculture conducted a series of meetings in 2009/10 with representatives of Government, industry and the research community to investigate the R&D targets and needs of UK agriculture and horticulture. This report discusses the issues raised and outlines recommendations.

2. The challenge for 21st century agriculture is to produce more while impacting less. By 2030, an estimated 50% increase in food and feed supplies will be needed to feed a rapidly growing world population, alongside demand for new biomass markets (such as biofuel). This increase must be achieved on less land, using fewer non-renewable resources, and with reduced environmental impact. The UK along with much of Northern Europe has appropriate soils to respond and will have a less extreme climate than many other regions.

3. It is widely accepted that the 'sustainable intensification' of agricultural production will require significant innovation and investment in the development of improved farming technologies and practices, not only to increase the physical volume of output, but also to lead to the adoption of smarter farming methods which help reduce emissions and conserve natural resources.

4. Increasing the productivity (production efficiency) of UK agriculture is essential not only to meet future food needs, but also to support economic growth within the farming, food processing and retail sectors which together account for nearly 15% of the nation's GDP. The UK's food supply chain, worth £86 billion and employing more than 3.7 million people, is dependent on Britain's farmers for much of its raw material requirements.

5. Against this background, however, the agricultural R&D pipelines in the UK - including the extension services required to transfer new knowledge and technologies onto farms – have been allowed to weaken over the past 25 years. Growth in UK agricultural productivity is now lagging behind comparable countries and this reducing level of competitiveness must be addressed.

6. While funding for basic research (with no particular application or use in view) has remained substantial, and the UK is recognised as a world leader at this level – the progressive withdrawal of public sector funding for applied agricultural research (directed primarily towards a specific practical aim or objective) has

significantly reduced the UK's capacity to innovate and to translate relevant basic research into practice.

7. This report calls for this situation to be reversed as a matter of urgency to ensure public sector R&D investment directly addresses emerging global and national policy objectives. The focus must shift from the UK being a 'world leader in basic research' to the UK becoming a 'world leader in basic research and its translation into practice'.

8. Specifically, the report urges Government to:

- Recognise that funding applied research in agriculture is a public sector as well as a private sector responsibility, and develop a clear strategy – integrating all relevant policy initiatives – to ensure the UK contributes to long-term food security challenges through sustainable increases in agricultural productivity;

- Publish an account of public sector funding for UK agricultural research, using a consistent approach to differentiate between basic and applied research, and including a statement of the priority currently placed on applied research to increase agricultural productivity and production;

- Based on this information, take action to re-connect and strengthen the UK agricultural R&D pipeline by transferring a proportion of public sector funding from basic research to applied research;

- Ensure that the value of applied research is reflected not only in research funding priorities, but also in the provision of attractive career structures, opportunities, recognition and reward for applied scientists;

- Support the development of new metrics for the 'sustainable intensification' of agricultural production to inform future policy-making, and to ensure gains in productivity are related to, and balanced against, associated resource use, greenhouse gas emissions and other environmental and social impacts;

- Based on these metrics, set long-term targets for the outputs of R&D investment in terms of sustainable productivity gains in each sector. For example, a minimum 2% annual increase in cereal yields will be required to match the increase in 2030 global food requirements.

9. Future priorities for the three main production sectors of UK agriculture – arable, horticulture and livestock – are also considered in this report and specific recommendations made on the research issues for these sectors.

Introduction

10. Producing more food in the UK sustainably is needed to contribute to an estimated 50% increase in food production required globally by 2030[1]. Taking responsibility for increasing food production is reflected in the recent comments of EFRA[2] which said that *doing nothing to contribute to the world's food supplies would be morally unacceptable: at a time when a fundamental shift in thinking is required, the UK should set an example, not bury its head in the sand.*

11. The Food 2030[3] strategy of the government in January 2010 provided a positive response to this statement and supported the view that increasing food production is a component of food security. It concluded that *with a growing population, climate change, and the pressure we are putting on land, we will have to produce more food sustainably,* and that the route to this was *through improving productivity and competitiveness, while using natural resources responsibly*.

12. The new coalition government has also confirmed the priority *to support and develop British farming and encourage sustainable food production.* This is one of the three priorities in Defra's Structural Reform Plan[4].

13. Increased agricultural productivity and competitiveness are influenced by a range of factors but science-driven innovation and the development of new technologies and systems are essential elements. The Chief Scientific Adviser, Professor Sir John Beddington[5] has emphasized that *science and technology have contributed greatly in the past to enhancing food security in the face of substantial increases in demand, and there is enormous potential for it to do so in the future.*

14. Nevertheless there is a continuing view[6,7,8] and highlighted in the APPG meetings in 2009/10[9], that the agricultural (including horticultural) R&D pipelines in the UK necessary to deliver innovation and new technology have been successively weakened over the last 25 years. The main weakness lies in the

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[1] The Royal Society (2009) Reaping the benefits. Science and the sustainable intensification of global agriculture. The Royal Society, London.
[2] EFRA (2009) Securing food supplies up to 2050: the challenges faced by the UK. Volume 1. The Stationery Office Ltd, House of Commons, London.
[3] Food 2030 (2010) Department for Environment, Food and Rural Affairs. January 2010.
[4] Defra (2010) Defra Structural Reform Plan. Our priorities. ww2.defra.gov.uk/about/our-priorities/.
[5] EFRA (2009) Securing food supplies up to 2050: the challenges faced by the UK. Volume 2.
[6] Commercial Farmers Group (2008) The need for a new vision for UK agricultural research and development. www.commercialfarmers.co.uk.
[7] NFU (2008) Why science matters for farming. Why farming matters. National Farmers Union, Stoneleigh.
[8] Leaver, D (2010) Practice with science and agriculture. The need to re-invigorate this partnership. Royal Agricultural Society of England, Stoneleigh.
[9] All-Party Parliamentary Group on Science and Technology in Agriculture. www.appg-agscience.org.uk.

lack of applied research capability still remaining that is needed to innovate at the applied research level and to translate relevant basic research into practice. The relevant deficits are in scientific expertise, infrastructure, knowledge exchange and knowledge transfer capacity.

15. This loss of capability in applied research for the agricultural industry has created a vacuum which has led to less translation of basic research into practice, less innovation at the applied level, and to a loss of communication in both directions along the R&D chain. There is also evidence that the decline in the rate of growth in agricultural productivity, which is now lower in the UK than in comparable countries is one outcome of the loss of this R&D capacity[10].

16. If this analysis is correct then the food security risks from global population growth, climate change and decreasing land availability for food production will not be addressed, and the result is likely to be an increasing reliance in the UK on imported food. However there is a major opportunity, particularly in view of the predicted impact of climate change in different global regions, to focus much of the world's productive crop growing capacity on more temperate regions such as Northern Europe including the UK[11].

17. The APPG during 2009/10 has attempted to clarify many of these issues through a series of meetings with prominent scientists, government officials and sectors of industry. It discussed the role of food production in food security and in particular the need to increase investment in agricultural science and technology.

18. This report discusses current R&D issues arising from these meetings including the need to clarify the role of government funding for basic and applied research, to re-constitute workable R&D pipelines, and to identify the R&D needs of the three main agriculture sectors; arable, horticulture and livestock. Recommendations are made on the actions required to address these issues.

[10] Thirtle, C and Holding, J (2003) Productivity of UK agriculture. Causes and constraints. Chapter 4. www.statistics.defra.gov.uk.
[11] Summers, R. (2010) APPG Science and Technology in Agriculture, February 2010. www.appg-agscience.org.uk.

Food Security Research

19. There was a change of approach by government to the issue of food security in 2008. The food price 'spike' in that year established the view that producing more food in the UK is an important component of food security, and a series of government reports have since confirmed the importance of food production in the UK[12,13,14].

20. The challenge is to not only increase food production but as indicated by the Chief Scientific Adviser to do this *on less land, using less water, using less energy, fertiliser and pesticides while not increasing greenhouse gas emissions,* and for this we need *a newer and greener revolution to address this challenge*[15].

21. The 'UK Cross-Government Food Research and Innovation Strategy'[15] produced in early 2010 aims to promote *a more coherent approach on research and innovation to support these goals,* and it stated that *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*.

22. A number of initiatives have already been taken in the public sector including:

- Global Food Security Programme – was established and is co-ordinated by BBSRC and delivered jointly with the other Research Councils and government departments, working closely with industry and the third sector. This aims to strengthen research coordination and research partnerships, build a more integrated community of researchers, funders and users, and provide multi-disciplinary research to ensure a sustainable and secure food system within a common strategy.
- Sustainable Agriculture and Food Innovation Platform – was created by the Technology Strategy Board[16]. In co-funding with BBSRC, Defra, the devolved governments and AHDB this will introduce up to £90m over 5 years to fund R&D in the areas of crop productivity, sustainable livestock production, reduction of food chain waste and reduction of greenhouse gas emissions.
- Food Research Group – was formed by the Chief Scientific Adviser, Professor Sir John Beddington. It includes representatives from the devolved administrations in Scotland, Wales and Northern Ireland and

[12] Food 2030 (2010) Department for Environment, Food and Rural Affairs. January 2010.
[13] Cabinet Office (2008) Food Matters – towards a strategy for the 21st century (2008). Cabinet Office. London.
[14] UK Cross-Government Food Research and Innovation Strategy (2010). Government Office for Science, London.
[15] Beddington, J. (2010) APPG Science and Technology in Agriculture, March 2010. www.appg-agscience.org.uk.
[16] Technology Strategy Board. www.innovateuk.org.uk.

aims to address the issues set out in the UK Cross-Government Food Research and Innovation Strategy[17].

- Food Research Partnership - was also formed by the Chief Scientific Adviser and brings together the Food Research Group members with representatives and scientists from industry, the research community and others outside government.
- Advanced Training Partnership – established by BBSRC to provide a range of specialist high level training to meet industry needs in partnership with higher and further education sectors.

23. These initiatives will bring greater awareness and co-ordination to the research agenda required to meet the longer term objectives of food security. Nevertheless, at a time of significant constraint in government funding throughout the public sector, it will take strong leadership to bring about change in support for agricultural research through applied research programmes at university and research institutes.

24. This can only be brought about by a fundamental change of thinking to the funding strategy. At present the focus remains on being a 'world leader in basic research' but this needs to be extended to being a 'world leader in basic research and its translation into practice'. The funding strategy, in particular the balance between basic and applied research to address the issues of food security need to be reviewed in order to ensure that UK research makes a significant contribution to the future food challenges.

25. **It is recommended that:**

- **Government develops a clear strategy on the role of the public sector in funding R&D aimed at increasing food production and productivity sustainably**
- **A review of funding is carried out by funding agencies within the public sector with the objective of providing support for the translation of basic research through applied research programmes to address the long-term food security challenges**

[17] UK Cross-Government Food Research and Innovation Strategy (2010). Government Office for Science, London.

Types of Research

26. The terms ‘basic’ and ‘applied’ research often appear to be confused and overlap at times, and the term ‘strategic research’ is also used rather loosely in policy discussions and funding documentation. It would be extremely helpful to have consistency in their meaning and the adoption of a single set of definitions. The Frascati guidelines are those most often quoted[18] although not always adhered to, and it would be beneficial to use these when describing funding for basic and applied research. The Frascati guidelines define three categories of research expenditure:

- *Basic Research* is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.
- *Applied Research* is also original investigation in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective.
- *Experimental Development* is systematic work, drawing on existing knowledge gained from research and practical experience that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

27. For the most part, basic research funding is the responsibility of the public sector and experimental development funding the responsibility of the private sector, whereas applied research could be considered to be the responsibility of both public and private sectors. The proportions of applied research funded by each are likely to vary for different research areas, and where appropriate applied research may be jointly funded.

28. This report adheres to these Frascati guidelines when referring to the three areas of research.

29**. It is recommended that:**

- **Government and its agencies use the Frascati guidelines when discussing basic and applied research and in reports of research funding for the public sector**

[18] EFRA (2009) Securing food supplies up to 2050: the challenges faced by the UK. Volume 2 (Ev 41). EFRA. House of Commons, The Stationery Office Ltd, London.

Funding of Agricultural Research

30. Justification is given for the current approach to public sector funding of agricultural research by the claim that extremely high levels of funding are currently being invested. A recent survey for example showed that under the heading of 'agricultural research' the total annual spend for 2010 was proposed to be £280m, including >£150m by BBSRC, £65m by Defra, £16m by TSB, £12m by Funding Councils to universities, £30m by the Scottish Government and £7m by the Northern Ireland Assembly[19]. A further £85m was proposed to be invested in agricultural research by the private sector, namely trade, farmer organisations and charities, providing total agricultural research funding for 2010 of £365m representing over 6% of UK agricultural GVA.

31. In addition there is EU funding of research through the Seventh Research Framework Programme (FP7)[20] which from 2007-13 proposes to invest 1.9 billion euros (276 m euros per year) in food, agriculture and biotechnology research across EU countries. This programme supports cooperation between universities, industry, research centres and public authorities throughout the EU and beyond, although it is unclear what proportion directly supports UK applied research in agriculture.

32. Whilst the £280m per year of UK public sector support for agricultural research represents a very significant amount of funding, it is not known how much is spent at the applied research level and 'directed primarily towards a specific aim or objective'. It is equally unclear whether basic research funding 'undertaken primarily to acquire new knowledge…without any particular application or use in view' has been included in these totals.

33. If the Frascati guidelines are used to describe the purpose of funding then that for 'agricultural research' should not include funding for basic research which by definition is not directed at specific agricultural aims or objectives. Confirmation is therefore needed that the public sector funding of agricultural research is truly for applied research in support of the industry, and it would be of particular interest to know what proportion is aimed specifically at increasing production and productivity (efficiency of production) sustainably.

34. Similarly the UK Cross-Government Food Research and Innovation Strategy[21] also indicated a high level of research funding stating that £415m was invested by the public sector in food research (including agriculture), but highlighted the issue of not having a longer-term strategy for R&D funding, and a

[19] Leaver, D. (2010) Agricultural research needs and priorities: survey findings from the food and farming industry. 64th Oxford Farming Conference. www.ofc.co.uk.
[20] Seventh European Research Framework Programme (FP7). http://cordis.europa.eu/fp7/home_en.html.
[21] UK Cross-Government Food Research and Innovation Strategy (2010). Government Office for Science, London.

concentration on short-term funding. It concluded that the absence of long-term strategies for funding of research leads inevitably to a *focus on more immediate objectives linked to individual projects* and *there is a risk that long-term research and policy goals will be compromised.*

35. A more co-ordinated approach to the long-term issues of food security, population growth and climate change therefore needs to be reflected in public sector funding policies for research. This will require a clear research strategy focus on increasing agricultural production and productivity, developing sustainable production systems and the implications of such changes for land use. This may also require some movement from shorter-term to longer term research contracts.

36. **It is recommended that:**

- **Clarification is provided by research funding agencies on what is basic and what is applied research in published information on research funding, and that when reporting research expenditure on behalf of an individual sector such as 'agricultural research' that only applied research (or experimental development funding) is included**
- **In view of the emphasis being given to increasing agricultural production and productivity sustainably that information is provided on public sector funding support for these priorities**
- **Changes in the approach to funding of research should also include a re-consideration of how research grants/ contracts are structured, and this may entail the provision of longer term awards than currently offered**

Public Sector Funding and Translation of Research

37. The agricultural R&D pipeline responsible for translating research into practice can be considered at a range of levels; agricultural industry level, agricultural sector level (arable, horticulture, livestock etc), enterprise level (wheat, apples, pigs etc), and individual technology level (eg using genetics to control blight in potatoes). When attempting to evaluate the success or otherwise of R&D pipelines it is often more meaningful to do this at the individual technology level because the pipeline differs both in length (time) and in diameter (amount of work required at each stage) for the development of different types of new technologies and practices.

38. The important question is whether for each potential piece of new technology or practice, the necessary scientific expertise and infrastructure is in place to link science with practice and practice with science. This will vary considerably across agricultural sectors and enterprises. However the change of public sector funding of agricultural research over the past 25 years has adversely affected the research translation capacity in most technology areas[22].

39. Government intention over those 25 years has been to put this country at the leading edge of world-class basic research output, and the UK is now one of the leading countries globally as measured by citation indices of its scientific publications in international journals. This policy has of necessity an associated expectation that market pull for new technologies and practices will ensure full use of the outputs from basic research.

40. Whether citation indices (the number of times an individual paper is quoted by other authors) in international journals should have such a dominant role in assessing quality of research and in government funding policy, is certainly open to question. Citation indices have strongly influenced the policy on funding of research in both universities and research institutes, and have influenced the switch of funding from applied to basic research.

41. For some industries and sectors this has not presented a major problem, in particular where there are large international companies in the R&D pipeline with high R&D capability, and where there are large charities such as the Wellcome Trust to bridge the gap between basic research and practice. Also in some areas such as medical research funded by the Medical Research Council, the public sector continues to fund both basic and applied research and much of this is linked closely to the associated industries for the next stages of research translation.

[22] Leaver, D. (2010) Practice with science and agriculture: The need to re-invigorate this partnership. Extract 3: Applied Agricultural Research. Royal Agricultural Society of England, Stoneleigh.

42. In contrast, agriculture has only limited areas where international companies are translating public sector basic research outputs into products of benefit to the industry, such as the pharmaceutical industry in its development and supply of veterinary health products for livestock. Investment in the development and transfer onto farm of improved management practices will be critical to the effective application of new products and technologies. Agriculture does not possess any substantial independent research funding organisations such as large charitable trusts in support of its R&D needs, and since 1994 it has not had its own Research Council to safeguard its research pipelines.

43. The levy bodies of the AHDB funded mainly by farmers, spend about £20m per annum on R&D[23]. This only represents about 0.3% of agricultural GVA in the UK. The low levels of profitability from agriculture (total income per year from farming per full-time person ranged from £9k to £23k over the last 10 years[24]), and the possible reduction in SFP from 2013 following the review of the CAP suggest that an increase in R&D investment by the industry itself is unlikely to occur in the short to medium term.

44. However, the AHDB has an important role in providing leadership to the industry in the coordination of agricultural research; firstly at policy level by working together with public and private sectors to develop R&D policies aimed at improving agricultural productivity and competitiveness; secondly at the implementation level in ensuring the individual levy bodies are collaborating with public and private sectors in funding relevant applied research; and thirdly at knowledge exchange level by continuous monitoring of the R&D pipelines between research and practice to identify weaknesses and develop collaborative solutions.

45. The consequence of concentrating public sector funding on basic research has led to a substantial loss of scientific expertise in agricultural applied research. This is confirmed in recent evidence relating to crop production[25] and soils and water[26] which has shown that the numbers of applied research scientists who bridge the gap between basic research and practice in the public sector are getting fewer and older

46. The recent Royal Society report has also indicated[27] that *Universities should work with funding bodies to reverse the decline in subjects relevant to a*

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[23] Leaver, D. (2010) Agricultural research needs and priorities: survey findings from the food and farming industry. 64th Oxford Farming Conference. www.ofc.co.uk.
[24] Defra (2009) Agriculture in the UK. http://www.defra.gov.uk/evidence/statistics/foodfarm/general/auk/latest/excel/documents/
[25] Tatchell, M. (2005) Scientific skills for knowledge transfer in arable agriculture in England: a survey. Rothamsted Research Association. www.rothra.org.uk.
[26] Godwin, R., Spoor, G., Finney, B., Hann, M. and Davies, B. (2008) The current status of soil and water management in England. Royal Agricultural Society of England, Stoneleigh.
[27] The Royal Society (2009) Reaping the benefits. Science and the sustainable intensification of global agriculture. The Royal Society, London.

sustainable intensification of food crop production, such as agronomy, plant physiology, pathology and general botany, soil science, environmental microbiology, weed science and entomology.

47. In addition to the loss of applied research scientists there has been an associated loss of applied research infrastructure in agriculture, and this has been substantial. Twelve research institutes with agricultural research activities have either closed or been merged into universities, and a number of agricultural colleges and agricultural departments in universities have also closed[28].

48. The Technology Strategy Board establishment of a Sustainable Agriculture and Food Innovation Platform[29] is however a positive move in the translation of research into practice. It is clearly focused on the public and private sectors working together on specific projects, although the proposed funding level is relatively small (£18m per year for 5 years of public sector funding), and much of this has been transferred from other funding programmes.

49. Whilst the agricultural industry (in particular, producers, suppliers, and product buyers) must find ways to carry out the necessary experimental development work close to practice such as field trials and demonstrations for crops and livestock and in knowledge transfer, it is also necessary for a fundamental change to take place in the way public sector research is funded.

50. The present constraints on public expenditure lead to the clear conclusion that the only way to reinvigorate applied research in agriculture is to transfer a proportion of funding by government departments and agencies from basic research (research with no application in view) to applied research in agriculture (research which is directed primarily towards a specific practical aim or objective). The size of the transfer required will depend on clarification of current spending on applied research in agriculture as outlined above.

51. **It is recommended that:**

- **Government recognises that funding applied research in agriculture is a public sector as well as a private sector responsibility and both should work together to ensure this goal is delivered. This recognition should be reflected not only in funding policies, but also in the types of scientists appointed and the career opportunities, recognition and reward for scientists in the public sector**
- **In view of the current constraints in government funding, there is a transfer of a proportion of funding by government departments and agencies from basic research (research with no application in view) to applied research in agriculture (research which is directed**

[28] Commercial Farmers Group (2008) The need for a new vision for UK agricultural research and development. www.commercialfarmers.co.uk.
[29] Mason, P. (2009) APPG Science and Technology in Agriculture, December 2009. www.appg-agscience.org.uk.

primarily towards a specific practical aim or objective). The proportion transferred will depend on clarification of the amount currently spent on applied research in agriculture

Future research aims

52. The Global Food Security Programme should provide leadership in the development of relevant research strategies, but there is a risk that the dominant influence within the Programme of those involved in basic research could lead to a continuation of the applied research deficit and the broken research pipelines for agriculture of recent times.

53. There is much discussion about the importance of food security, and what the research aims should be in support of this objective. It remains unclear however as to how current public sector research will deliver in developing sustainable agricultural production systems with higher production levels using lower inputs of energy, chemicals and water and with reduced greenhouse gas emissions. This must be the overriding aim of agricultural research.

54. Specific research aims for the future will vary between sectors and areas within agriculture. However the common themes across sectors within which research programmes will be funded might be:
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- Increasing food production through 'sustainable intensification'
- Using lower energy, chemical and water inputs in production systems
- Developing new uses for agricultural products and by-products
- Reducing the environmental impact of production systems
- Reducing waste in production systems
- Ensuring food quality and safety

55. Sustainability will be a key component of future government policies[30]. For agriculture this should mean developing production systems which satisfy the economic, environmental and social aspects of sustainability, not just environmental which has tended to dominate the agenda in recent times. A holistic and balanced approach across all three elements of sustainability is therefore essential in the development of sustainability policies.

56. There is an urgent need to develop metrics for assessing sustainability of agricultural production systems. The Keystone Center[31] in the USA is demonstrating one such approach to assessment. These metrics of sustainability will allow more objective, holistic and balanced approaches to policy making.

57. **It is recommended that:**

- **Projects funded from within the public sector for agricultural research should be within themes such as:**

[30] Caroline Spelman statement on arms-length-bodies (2010) ww2.defra.gov.uk/2010/07/22/arms-length-bodies-statement/.
[31] The Keystone Center (2009) Field to market: The Keystone Alliance for Sustainable Agriculture. http://www.keystone.org/spp/env-sustain.ag.html.

  - **Increasing food production through ‘sustainable intensification’**
  - **Using lower energy, chemical and water inputs in production systems**
  - **Developing new uses for agricultural products and by-products**
  - **Reducing the environmental impact of production systems**
  - **Reducing waste in production systems**
  - **Ensuring food quality and safety**
- **Sustainability metrics are developed for agricultural production systems incorporating economic, environmental and social assessments, in order to provide a more objective, holistic and balanced approach to policy making**

The Arable Sector

Background

58. Over the last 100 years cereal planting in the UK has ranged between 2million hectares in the 1930's and 4million hectares in the 1980's with over 3 million hectares currently grown. In recent years production has ranged from 19 to 25 million tonnes with 2 to 3 million tonnes imported and 2 to 5 million tonnes exported annually[32].

59. A number of factors will influence future cereal demand but population growth estimated in the UK to be almost 20 % over the next 20 years[33] and globally 50% over the next 40 years[34] will be a major influence. A more immediate driver for increased demand is the emergence of UK-based bio-ethanol production capacity which in the next few years will increase the annual demand for cereals by approximately 3 million tonnes[35].

60. A major factor affecting cereal production is the volatility in cereal prices which has ranged from well under £100 /tonne to over £200/ tonne in recent years. This affects the confidence of growers in trying to optimise inputs to produce a high yielding crop, and to some extent may explain why the annual yield per hectare of cereals is no longer increasing. Oilseed rape remains the main break crop for cereals totalling 0.6m hectares, followed by field beans at 0.2m hectares and imports are consistently higher than exports for both crops[36].

61. Potato production was reasonably stable until about 2000 but there has been some decline since then. About half the crop is sold fresh and other half is processed, and UK annual consumption is about 5.8 million tonnes. Farm prices are strongly influenced by the degree to which production exceeds or under-supplies this demand. However, the number of producers has declined by about 70% in the last 10 years leaving fewer, larger producers. The area of crop has also declined but this has been compensated for by an increase in yields per hectare[37].

62. The proportion of crop grown for seed in Scotland is declining. This will have an important impact as lower seed production will mean higher levels of seed

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[32] Cowans, J. (2009) Cereals. In 'Feeding Britain'. Ed J. Bridge and N. Johnson. The Smith Institute, London.
[33] National population projections, 2008-based. Statistical Bulletin. Office for National Statistics, October 2009.
[34] The Royal Society (2009) Reaping the benefits. Science and the sustainable intensification of global agriculture. The Royal Society, London.
[35] Sheppard, D. (2010) APPG Science and Technology in Agriculture, February 2010. www.appg-agscience.org.uk.
[36] Defra (2009) Agriculture in the UK. http://www.defra.gov.uk/evidence/statistics/foodfarm/general/auk/latest/documents/AUK-2009.pdf
[37] Priestley, H. (2009) Potatoes. In 'Feeding Britain'. Ed J. Bridge and N. Johnson. The Smith Institute, London.

imports. This is not only a self-sufficiency issue, it also *exposes the whole industry to a much higher risk of very serious disease outbreaks, such as brown rot and ring rot*[38].

Research issues

63. It has been suggested that over 90% of yield improvement in the main arable crop, winter wheat in the past 25 years has been due to the introduction by plant breeders of new higher yielding varieties[39]. Cereal yields were increasing by over 2% per year until the 1980's but since then there has been a significant fall off in the rate of increase in yield arising from breeders introducing new varieties of wheat, barley and oilseed rape. Varieties being developed currently by plant breeders are only increasing yields by about 0.5% per year, and unfortunately even this small increase in potential is not translating into yield increases on farms[40].

64. There is clearly a need to address the issue of the fall off in rate of progress in plant breeding for yield, and to fully understand why yields are not increasing on farms. The current rate of increase in yield potential falls well short of the +2% annual year gain required to meet 2030 global targets[41].

65. HGCA, the UK cereals levy body, has pointed out that molecular biology research in model plant species has been well funded in the last 20 years and has led to many advances in the understanding of gene function, but suggests that unfortunately *much of this has still to be applied to crop species*[42]. This again highlights the vacuum lying between basic research and practice.

66. The pre-breeding programme of research being carried out by NIAB[43] and funded by BBSRC, HGCA and British Wheat Breeders is aiming to fill some of this gap and link molecular biology research on model species to arable crop species. However the research is limited in scope at present and focused mainly on wheat but this is an important development and needs to be expanded to other arable crops.

67. For the future, biotechnology will be required increasingly across crop species to introduce new traits which increase yields and reduce environmental impacts. These traits will include nitrogen fixation ability, increased efficiency of

[38] Priestley, H. (2009) Potatoes. In 'Feeding Britain'. Ed J. Bridge and N. Johnson. The Smith Institute, London.
[39] Summers, R (2010) APPG Science and Technology in Agriculture, February 2010. www.appg-agscience.org.uk.
[40] Summers, R (2010) APPG Science and Technology in Agriculture, February 2010. www.appg-agscience.org.uk.
[41] Summers, R (2010) APPG Science and Technology in Agriculture, February 2010. www.appg-agscience.org.uk.
[42] HGCA (2007) Research strategy overview. www.hgca.com.
[43] Barsby, T. (2010) APPG Science and Technology in Agriculture, February 2010. www.appg-agscience.org.uk.

nitrogen, phosphorus and potassium use, improved water use efficiency and increased resistance to pests and diseases. GM technology will be necessary as an important means of delivering these benefits, but will first have to overcome the negative influence generated by lobby groups, and the associated political and regulatory issues.

68. There is also a need to refine and develop precision methods to increase efficiency of production (productivity) and reduce environmental impact, through reducing the external inputs of chemicals, water and energy, and by reducing soil degradation. Collaborative multi-disciplinary applied research between engineers, plant and soil scientists will be necessary to deliver these changes.

69. Biofuels will continue to develop as part of the renewable energy agenda and to be competitive will require an R&D platform. Critical areas where technology will play a key role in the successful development of sustainable and competitive biofuels are in feedstock, in conversion technologies and in end-use technologies[44], although much of this will rely on private sector R&D.

70. **It is recommended that:**

- **Research is carried out to determine what changes need to be made in the public and private plant breeding sectors to ensure that a minimum 2% annual increase in crop yields is achieved in order to meet the 2030 global targets in food production, and to explain why cereal production on farms is not increasing at the rate of increase expected from the introduction of new higher yielding varieties**
- **The pre-breeding research carried out by the public/ private sector is expanded to other crops to fill the gap between basic research on model species and arable crop species**
- **Co-ordinated, multi-disciplinary programmes of research are instituted to progress the use of precision methods in arable farming to increase productivity and reduce environmental impact**

[44] European Biofuels Technology Platform (2008) Strategic research agenda & strategic deployment document. Newbury. www.cplpress.com.

The Horticultural Sector

Background

71. Production horticulture has been going through a difficult period over the last two decades and between the mid-1990's and mid 2000's self-sufficiency of vegetables declined from 74 to 54% and fruit from 13 to 10%[45]. Changes in demand for particular fruits and vegetables account in part for the decline in self-sufficiency, but this decline in UK production occurred in spite of an increase of over 20% in UK sales in the fresh produce sector. The declines in production were mostly due to reduced areas grown, although a few products, notably strawberries and carrots increased in production due to increases in yields.

72. There is a contradiction between the policy for human health which is to increase consumption of fruit and vegetables, and the decline in UK production. This can only be resolved when UK production systems become more competitive relative to imported products, and R&D is an important driver of this competitiveness.

Research Issues

73. Clearly there are wider issues than just the lack of adequate R&D explaining the decline in horticultural production. The profitability of much of the sector is low and this leads to a lack of investment for the future. Nevertheless, *horticulture R&D facilities have been dramatically reduced and fragmented over the past 20 years, and the age profile of researchers and particularly crop agronomists is a cause for concern*[46].

74. The recent Fuit and Vegetable Task Force report[47] has also highlighted the loss of R&D capability and the need for a sustainable R&D capacity to ensure there is a competitive industry. It emphasises that applied research is crucial for the industry to keep pace with competitors and to attract customers as well as to deal with challenges from pests, diseases and climate change. Fruit and vegetable production is high risk with low returns and the report considers *there has been no overall strategic view on what is the minimum requirement to support UK horticulture in terms of expertise and facilities and so there are now three weakened R&D facilities for commercial fruit and vegetable crops.*

75. The loss of the Defra LINK Horticultural Programme which along with other LINK programmes, was closed to new applications in 2009 represents a significant loss of joint public and private sector R&D funding, and will put the future of more applied research scientists at risk. Similarly the uncertainty over

[45] Beckenham, M. (2009) Horticulture. In Feeding Britain, eds J. Bridge and N. Johnson. The Smith Institute, London.
[46] Beckenham, M. (2009) Horticulture. In Feeding Britain, eds J. Bridge and N. Johnson. The Smith Institute, London.
[47] Report of the Fruit and Vegetable Task Force (2010). http://www.defra.gov.uk/foodfarm/food/policy/partnership/fvtf/index.htm.

the future of the scientific staff and research infrastructure at HRI Wellesbourne since its transfer into Warwick University[48] provides further confirmation of the low priority being given to applied research in the public sector, although subsequent plans for a new Applied Crop Research Centre offer potential to ensure this vital resource of applied expertise and knowledge is not entirely discarded.

76. In Europe most countries have retained a network of horticultural research centres focused on the needs of growers and applied research is actively integrated by many into the university sector[49]. There is a strong view from those still involved in horticultural research in the UK that *food industry R&D had delivered impact and value for money but was now at risk* and… *a joined-up approach was needed between government, research councils and levy bodies to provide a relevant balance and flow of R&D investment from basic through to applied research*[50].

77. It is a priority for research to make progress in biotechnology and to introduce new traits into fruit and vegetable crops which lead to benefits in human health, to increased efficiency of external nutrient use, to improved efficiency of energy and water use and to increased resistance to pests and diseases. As for arable crops there is also a need to refine and develop precision techniques to increase efficiency of production and reduce environmental impacts through reducing the external inputs of chemicals, water and energy, and by reducing soil degradation for field crops[51].

78. Production horticulture relies greatly on immigrant labour in particular for harvesting crops. Reliance on this support in the longer term presents a risk, and the development of robotic precision technology is a priority for the industry. This will require a multidisciplinary approach to this applied research objective.

79. **It is recommended that:**

- **Government recognises the importance of horticultural production to the UK economy and to human health, and the severe negative impact that public sector funding changes have had on R&D capacity and the industry's competitiveness**
- **Action is taken to prioritise horticultural R&D, and to halt the continuing loss of scientific expertise and research infrastructure**
- **Pre-breeding and multidisciplinary research is carried out as for the arable sector to fill the gap between basic research on model species**

[48] Bright, S. (2009) APPG Science and Technology in Agriculture, October 2009. www.appg-agscience.org.uk.
[49] Bragg, N. (2009) APPG Science and Technology in Agriculture, October 2009. www.appg-agscience.org.uk.
[50] Atkinson, C. (2009) APPG Science and Technology in Agriculture, October 2009. www.appg-agscience.org.uk.
[51] Commercial Farmers Group (2009) Priorities for Agricultural and Horticultural R&D. www.commercialfarmers.co.uk.

and horticultural crop species, to increase productivity and reduce environmental impact

- **Co-ordinated, multi-disciplinary programmes of research are instituted to progress the use of precision methods in horticulture to increase productivity, reduce environmental impact and reduce reliance on hand labour methods**

The Livestock Sector

Background

80. The livestock sector is extremely important to the UK representing about 60% of agricultural output, and it is 3x the size of the cereal sector and 5x the horticultural sector in the value of its outputs[52]. However all sectors are in decline with dairy and beef cattle numbers down 12%, sheep down 25%, pigs down 40% and poultry down 2% in the last decade[53]. Self-sufficiencies have therefore dropped and currently range from under 50% for pig meat to almost 90% for milk and dairy products[54].

81. Animal disease, especially BSE, foot & mouth and TB have been major negative influences on the livestock sector over the last 25 years. For the ruminant sectors, there are significant additional pressures coming forward in relation to climate change in particular its methane emissions. Whilst these emissions from sheep and cattle only represent 3% of total UK emissions (adjusted for global warming potential), and although these have not particularly increased over the last century, they receive a disproportionate amount of negative publicity with calls for the public to reduce consumption of livestock products.

82. The livestock sector is therefore under pressure and this is reflected in the decline in stock numbers. The sustainability challenge is between the need to increase production and productivity through intensification in order to increase economic and climate change environmental indicators, and the need to extensify production systems to increase social sustainability for example in animal welfare, and other environmental indicators such as biodiversity. However there will have to be sustainability trade-offs for moves in either direction.

Research Issues

83. It is important that the gains in efficiency of livestock production from research which have been extremely high in the past continue in the future. For example *the production of lean meat per tonne of feed in pigs had doubled, the number of days taken to rear broiler chickens to 2kg had been cut by 60%, while layer hen egg production per year had increased by 30%*[55]*.* These improvements have brought great benefits to the economy in reducing retail food costs and to the environment through a significant reduction in GHG emissions and in nutrient losses per unit of output.

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[52] Leaver, D. (2010) APPG Science and Technology in Agriculture, January 2010. www.appg-agscience.org.uk.

[53] Defra (2008) Agriculture in the United Kingdom 2008. Defra, DARD, Welsh Assembly Government, Scottish Government.

[54] The Smith Institute (2009) Feeding Britain. Ed J. Bridge and N. Johnson. The Smith Institute, London.

[55] Warkup, C. (2010) APPG Science and Technology in Agriculture, January 2010. www.appg-agscience.org.uk.

84. The primary means of increasing efficiency in the future will be through breeding, by utilising faster methods of genetic progress including biotechnology methods such as genome-wide selection which will be used to supplement established quantitative genetics methods[56,57]. The objectives will be to increase productivity, improve the quality of the product for human health and reduce GHG emissions and nutrient (N + P) losses.

85. A continuation of the challenge of animal disease prevention and control will remain a high priority. Endemic diseases continue to challenge production systems at a high cost to the producer and to the public purse, and climate change will mean that exotic diseases become even more prevalent in the future.

86. There is also a need to refine and develop precision techniques relating to the nutritional management of livestock and to field operations in order to increase efficiency of production, reduce energy inputs and to reduce environmental impacts of GHG emissions and surplus nutrients.

87. **It is recommended that:**

- **Methods of making genetic progress using genome-wide selection methods for livestock continue to be developed with the objective of increasing productivity, improving the quality of the product for human health and reducing GHG emissions and nutrient (N + P) losses**
- **Appropriate disease control systems are sustained for livestock diseases, as endemic diseases continue to challenge production systems at a high cost to the producer and to the public purse, and climate change will mean exotic diseases become more prevalent in the future**
- **Precision techniques are developed relating to nutritional management of livestock and to grassland and forage management in order to increase efficiency of production, to reduce energy inputs and to reduce environmental impact**

[56] Warkup, C. (2010) APPG Science and Technology in Agriculture, January 2010. www.appg-agscience.org.uk.
[57] Simm, G. (2010) APPG Science and Technology in Agriculture, January 2010. www.appg-agscience.org.uk.

Summary of Recommendations

1. Government develops a clear strategy on the role of the public sector in funding R&D aimed at increasing food production and productivity sustainably

2. A review of funding is carried out by funding agencies within the public sector with the objective of providing support for the translation of basic research through applied research programmes to address the long-term food security challenges

3. Government and its agencies use the Frascati guidelines when discussing basic and applied research and in reports of research funding for the public sector

4. Clarification is provided by research funding agencies on what is basic and what is applied research in published information on research funding, and when reporting research expenditure on behalf of an individual sector such as 'agricultural research' that only applied research (or experimental development funding) is included

5. In view of the priority being given to increasing agricultural production and productivity sustainably that information is provided on public sector funding support for these priorities

6. Changes in the approach to funding of research should also include a re-consideration of how research grants/ contracts are structured, and this may entail the provision of longer term awards than currently offered

7. Government recognises that funding applied research in agriculture is a public sector as well as a private sector responsibility and both should work together to ensure this goal is delivered. This recognition should be reflected not only in funding policies, but also in the types of scientists appointed and the career opportunities, recognition and reward for scientists in the public sector

8. In view of the current constraints in government funding, there is a transfer of a proportion of funding by government departments and agencies from basic research (research with no application in view) to applied research in agriculture (research which is directed primarily towards a specific practical aim or objective). The proportion transferred will depend on clarification of the amount currently spent on applied research in agriculture

9. Projects funded from within the public sector for agricultural research should be within themes such as:

- Increasing food production through ‘sustainable intensification’
- Using lower energy, chemical and water inputs in production systems
- Developing new uses for agricultural products and by-products
- Reducing the environmental impact of production systems
- Reducing waste in production systems
- Ensuring food quality and safety

10. Sustainability metrics are developed for agricultural production systems incorporating economic, environmental and social assessments, in order to provide a more objective, holistic and balanced approach to policy making

11. Research is carried out to determine what changes need to be made in the public and private plant breeding sectors to ensure that a minimum 2% annual increase in crop yields is achieved in order to meet the 2030 global targets in food production, and to explain why cereal production on farms is not increasing at the rate of increase expected from the introduction of new higher yielding varieties

12. The pre-breeding research carried out by the public/ private sector is expanded to other crops to fill the gap between basic research on model species and arable crop species

13. Co-ordinated, multi-disciplinary programmes of research are instituted to progress the use of precision methods in arable farming to increase productivity and reduce environmental impact

14. Government recognises the importance of horticultural production to the UK economy and to human health, and the severe negative impact that public sector funding changes have had on R&D capacity and the industry’s competitiveness

15. Action is taken to prioritise horticultural R&D, and to halt the continuing loss of scientific expertise and research infrastructure

16. Pre-breeding and multidisciplinary research is carried out as for the arable sector to fill the gap between basic research on model species and horticultural crop species, to increase productivity and reduce environmental impact

17. Co-ordinated, multi-disciplinary programmes of research are instituted to progress the use of precision methods in horticulture to increase productivity, reduce environmental impact and reduce reliance on hand labour methods

18. Methods of making genetic progress using genome-wide selection methods for livestock continue to be developed with the objective of increasing productivity, improving the quality of the product for human health and reducing GHG emissions and nutrient (N + P) losses

19. Appropriate disease control systems are sustained for livestock diseases, as endemic diseases continue to challenge production systems at a high cost to the producer and to the public purse, and climate change will mean exotic diseases become more prevalent in the future

20. Precision techniques are developed relating to nutritional management of livestock and to grassland and forage management in order to increase efficiency of production, to reduce energy inputs and to reduce environmental impact