What shapes the research agenda? in agricultural biotechnology / a report by the Agriculture and Environment Biotechnology Commission (AEBC).

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in agricultural biotechnology

A report by the Agriculture and Environment Biotechnology Commission (AEBC)

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1 Summary

Since the Biotechnology Commission was established in 2000, we have often been told that one underlying factor in the genetic modification controversies that we have addressed in our past work is the way funding is allocated in agricultural research. With this report, we have examined this by asking what shapes the research agenda in agricultural biotechnology.

The approach we have taken has been both broad and deep, involving five stand-alone modules: general information gathering, detailed case studies on plant breeding and soil science, a written consultation and a public and stakeholder engagement exercise. All five of these modules have contributed to this final report. Most of our recommendations are supported by the findings of more than one of the modules, which are also available separately to anyone who wishes to see the detailed evidence that backs our conclusions. Our work has focused on publicly funded, UK-based research in agricultural biotechnology, but most of our recommendations have implications for research more widely and should also be addressed by Government in this general context. We also encourage agricultural biotechnology and other agri-food companies, as well as the agricultural levy bodies, to look closely at our recommendations.

The drivers that influence agricultural biotechnology research today can be categorised under four main headings:

1) Advancing knowledge and technology and maintaining the science base
2) Wealth creation and international competitiveness
3) Government policy, regulation and legislation
4) Public priorities and aspirations for science

These four drivers are the starting point for our work (although we identify some problems and shortcomings with them, as Recommendation 5 below demonstrates). They each apply to all agricultural biotechnology research, but to varying degrees because each funding organisation has different perspectives and priorities.

Recommendation 1: *Diverse research agendas mean a plurality of drivers behind research and therefore encourage a balanced and varied portfolio. This diversity is healthy and research funders and strategic decision-makers should ensure that no one agenda or driver is allowed to dominate.*

Scientists themselves still influence agendas, but this is constrained within a strategic focus over which they have declining influence. However, basic research, to underpin more applied research and maintain the science base, received strong support from both stakeholders and members of the public whom we consulted.

Recommendation 2: *Support for high-quality, basic research should be maintained, to generate fundamental knowledge even if it has no direct and immediately obvious practical value. Basic research priorities and areas of science cannot be divorced from overall strategic direction or accountability, but they should be protected from short-term pressures such as policy needs and the drive for wealth creation. Excellence should be the primary criterion for funding and as wide a science base as possible should be maintained.*

There is some danger of certain drivers becoming over-dominant. Technology has been a major influence on the direction of agricultural research, but must not be a disproportionate focus. Systems-based, less reductive research should not be neglected.

Recommendation 3: *Science decision-makers should ensure that technologies do not become ends in themselves, but are integrated with explicit goals of benefit to society and sustainable agriculture.*

Recommendation 4: *We endorse the recommendation of the BBSRC sustainable agriculture review group for a review of the capacity for more systems-based, longer-term sustainable agriculture studies.*

Wealth creation is rightly an important driver behind research, and scientists must always be in a position to identify potential commercial applications and to facilitate their exploitation. Wealth creation should apply to the full range of economic activities, including smaller and non-conventional farming and food enterprises. While the creation of wealth contributes to improving quality of life and the public good, it is no substitute for explicitly aiming for these goals. Neither does targeting research to support Government policy encompass all public goods, nor is it perceived in this way, as Government tends to be mistrusted and there is a belief it uses science to support its own political ends. In the context of agricultural biotechnological research, the concept of sustainability best represents and encompasses the aims of wealth creation, public good and quality of life.

Recommendation 5: *The public good should be a more explicit objective within research agendas. For agricultural biotechnology research specifically, sustainability should be an overarching and key strategic driver. The concept of sustainability encompasses the need for more explicit reference in research to the 'trade offs' between economic, social and environmental objectives.*

Gaps and overlaps exist between different research funders. We have decided against recommending the establishment of a coordination group for sustainable agriculture research primarily because of our conviction that maintaining a diversity of agendas is essential and because moves have already been made towards increased cooperation and flexibility in funding. Nevertheless, our model of plurality of drivers will only work if remaining unnecessary barriers to cooperation are removed. There is a need for cross-funder, cross-disciplinary project management (with broad stakeholder input) of sustainable agriculture research. Obstacles to multidisciplinary studies need to be addressed.

Government Departments withdrew from near-market research in the 1990s, and many people feel that this has created gaps in applied research, for which there is little incentive on the part of publicly funded scientists to pursue. Sustainable agriculture requires products and processes that benefit the environment, and funding of targeted near-market research may help. However, a market pull is also required and Government needs to influence the market to incentivise farmers to buy the products and use processes that allow more sustainable farming methods.

Recommendation 6: *Public funding for near-market research should not be ruled out where it contributes to the sustainability of farming. Where a need is identified, Government should look towards providing either research and/or market incentives to encourage product or process development. If research has commercial applications, priorities should be determined in consultation with appropriate stakeholders to ensure the market relevance of the research. The appropriate distance from market for the publicly funded research must be carefully determined.*

Openness, transparency and accountability of decision-making by research funders should be normal practice, but our information gathering has found that it is still exceptional. Research funders should be able to explain on what grounds priorities have been chosen, as well as why other areas are not favoured.

Recommendation 7: *From the highest-level scientific committees, including the Council for Science and Technology, to Research Council and Government Department decision-making bodies, meetings should be held in public wherever practicable. This applies particularly to strategic level and priority setting bodies. Documents should be made freely available, or the reasons for not making them available should be clearly explained.*

Recommendation 8: *For all publicly funded research projects, a short summary of the project, including an explanation of why it has been funded and how it will contribute to strategic objectives, should be written. This should be comprehensible and informative to a non-specialist and should be made easily available to the public.*

Moves by public research funders and wider Government towards public engagement and dialogue in science are commendable, but there is still a considerable way to go to put aspirations into practice. Certain principles should be applied to any public engagement exercise. First, it should only be undertaken if there is a willingness to accept and adapt to its outcomes in some way. Second, it should be distinct from stakeholder engagement: participants should be as broadly representative of the general public as possible and any bias avoided. Third, it should supplement, rather than substitute for, institutional decision-making. Fourth, genuine engagement requires a more active approach than standard consultation processes. Fifth, participants should be given the opportunity to frame the dialogue, rather than simply responding to preconceived questions. All this can be time consuming and expensive, and adequate funds need to be made available. Public engagement is a professional activity, and its practitioners should be innovative and self-critical.

The case for engagement is strongest at the upstream or strategic level. There is also a strong case for more downstream engagement, although research is needed on the potential for public engagement in grant-making decisions.

Recommendation 9: *All public sector research funders and advisory groups should use validated methods of public engagement or dialogue to supplement their high-level, strategic decision-making. Funders should say in advance how they plan to use the results of engagement, and should document clearly how the results have influenced them. The approaches used should preclude undue domination by any one interest. Engagement should not be passive, but should actively seek out opinion and should also allow participants to frame the issues being discussed.*

The more diverse the input into research agenda setting, the more solid the outcome will be. As well as engaging the public, a full range of stakeholders should be involved. This need for broad representation extends to the very highest level of scientific decision-making, such as the Council for Science and Technology. The responsibility for openness and public engagement should also apply to these committees because they are as far "upstream" as UK research agendas get.

Recommendation 10: *From the highest-level scientific committees, including the Council for Science and Technology, to Research Council Strategy Boards and Government Departments' advisory panels, there is a need to enlarge membership to include those outside academia and industry.*

Participants in our engagement exercise were aware of and concerned about their lack of knowledge about science, and recognised that they would benefit from being better informed if they were to be engaged in research agenda setting. Nevertheless, several people told us how much they had enjoyed the opportunity to participate in the workshops and to think about how science is governed. This enthusiasm was unexpected, as research agendas might be seen as a dry topic, far removed from most peoples' daily lives. An idea began to emerge about a new type of citizen's duty, perhaps analogous to jury service, to participate in public engagement in science.

Recommendation 11: *Given the enthusiasm and willingness to take part that we found in public participants in our engagement exercise, the Office of Science and Technology should explore the potential for promoting engagement in science and technology as an exercise in citizenship and an opportunity to better inform the public.*

While science communication is not a major focus of this workstream, the people we spoke to attached great importance to it. All participants returned again and again to the portrayal of science in the media, and expressed a keen thirst for more digestible, balanced and trustworthy scientific information. The lack of incentive for scientists to communicate with the lay public was also raised. Problems with science communication are multifaceted and caused by a number of factors including scientific culture, campaigning media behaviour and deficiencies in school science education as well as in research organisations' public relations efforts.

Recommendation 12: *Communication of science to non-scientists must not be neglected, although it is only one aspect of engagement and dialogue. The Office of Science and Technology should commission an independent review of the presentation of science and technology matters in the media, and of Government's role in this. It should develop a programme of work bringing together the media, scientists, public and other sectors of society to reflect on science communication.*

2 Introduction

2.1 Why we are interested in research agendas and scope of the work

Hundreds of millions of pounds of public money are invested each year in agricultural research in the UK, much of this using modern biological techniques - that is, biotechnology in its broad sense. Since it was established in 2000, the Biotechnology Commission has become aware of a number of concerns expressed by stakeholders about research spend in this area. Often, people have told us that the underlying problem behind the genetic modification (GM) controversies that we have addressed in our past work is that the wrong research is being done in agriculture. The GM controversy raised scientific issues that had not previously been addressed, calling into question why these areas had not been covered by earlier research agendas[1]. Issues that have been raised with us include a sense that the balance of public research has shifted and is now too focused on underpinning commercial applications; that creativity and innovation are stifled by a preoccupation with risk and regulation; that there is insufficient transfer to market of applied research; that intellectual property rules restrict openness and transparency; and that public funding into areas of possible benefit to society is neglected due to low commercial significance. But are these concerns well founded? What shapes the research agenda in agricultural biotechnology?[2]

To answer these questions, we have taken a systematic look at the drivers behind research, and the mechanisms in place for setting priorities, and have tried to identify the implications of what we have found for the research that is done.

This is an issue that goes much wider than agricultural biotechnology, and there is high-level interest in research agendas. The Government's ten-year investment framework for science and innovation considers the overall science agenda and its relationship with the economy, policy and society[3]. Starting with the House of Lords Science and Technology Committee's report on Science and Society in 2000, a number of groups have called for science to be more open and accountable to the public[4].

How, then, does the AEBC add value to the debate? With our broad membership, including natural and social scientists, people from the biotechnology industry, environmental campaigners and lawyers, our consensus report incorporates and has the backing of a wide range of perspectives. Our thorough approach, which has included information gathering, detailed case studies, written consultation and public and stakeholder engagement modules (see below) means that our conclusions and recommendations are solidly backed by a large and varied body of evidence. We have attempted to address and incorporate views from everyone we have talked to throughout the exercise, from farming organisations to Research Council Chief Executives and from members of the public to agricultural scientists.

Our focus, as befits our remit, is on agricultural biotechnology research[5], though we have often strayed towards agricultural research more generally, and even science as a whole. We make no apologies for this, because the relationship between agricultural biotechnology and agri-food research in general is interesting and a rigid adherence to biotechnology would have been both practically difficult and artificially constraining. Furthermore, while our conclusions and recommendations apply specifically to agricultural biotechnology, most of them have wider relevance. In some respects, our work has implications for research agenda setting in general. In responding to this report, Government may want to consider how its recommendations apply to the science base as a whole, incorporating input from the Office of Science and Technology as well as the agriculture and environment departments to whom our previous reports have primarily been addressed.

From the beginning, we decided to concentrate our attention on publicly funded research. This is because we feel that it is more appropriate, and in line with our remit, to pay attention to the public sector. As advisers to Government, the funder of public research, it is here that our advice is likely to have most impact. In addition, gathering information on private sector research activities in agricultural biotechnology poses practical difficulties. However, we recognise that a significant part of agricultural biotechnology research, the majority globally, is in the private sector and, more importantly, that private companies have a strong influence on and links with public funders. We have devoted much attention to the relationship between the public and private sector, and we feel that our findings are also relevant to private companies.

Agricultural biotechnology research is an international activity and international influences on research agendas cannot be ignored. Overseas research in biotechnology has an effect on and is affected by UK research. Some UK research is targeted specifically at the needs of developing countries. In addition, the major policy influences on agriculture, and therefore agricultural research, are international, including the Common Agricultural Policy and its reform, and liberalization of world trade. We have constrained our scope to UK research for similar reasons to our concentration on the public sector. But we acknowledge that as UK researchers look increasingly to European Union programmes and other opportunities for international cooperation, especially for expensive, large-scale work, this constraint is becoming more and more significant.

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[1] *See for example Levidow L. and Carr S. (2000) UK: precautionary commercialization? Journal of Risk Research 3(3), 261-270. Levidow and Carr quote the former ACNFP chairman: "eventually the scientists learned how to ask questions which would concern consumers". They also suggest that the basis for risk assessment for commercialisation of GM herbicide tolerant crops was broadened as a result of Government's conservation agencies calling for further research.*

[2] *Throughout this document, research agenda or agendas should be taken to refer to the body of research that is actually funded and carried out, overall or for a particular organisation. It does not refer to research that some may aspire to carry out, but is not actually funded.*

[3] *HMT, DFES, DTI (2004) Science and Innovation Investment Framework 2004-2014*

[4] *House of Lords Science and Technology Committee (2000) Science and Society: Third report of session 1999-2000*

[5] *In this work, the AEBC has adhered to a broad definition of agricultural biotechnology, which goes much wider than just genetic modification: novel scientific and technological interventions in biological systems used in agriculture, particularly the use of modern methods of molecular and cell biology.*

2.2 The modular approach and its findings

We have taken a modular approach, with five separate strands to this work, conducted largely simultaneously, contributing to the overall findings set out in this report (see Annex 1):

1 Information gathering and analysis
2 Written consultation exercise
3 Public and stakeholder engagement exercise
4 Plant breeding case study
5 Soil science case study

This is a distinctive structure and the modules have been important in allowing us to draw robust conclusions. The output of each module, and its main findings, are summarised below. Reading these summaries will allow the conclusions and recommendations in section 3 below to be seen in a wider context. However, in order to benefit from the comprehensive analysis that has contributed to our findings, we recommend visiting the full papers themselves, which are available on line and in hard copy[6].

Most of our conclusions and recommendations are supported by the findings of more than one of the modules. Throughout the report that follows, we have referred to relevant data from the modules, which we feel lend weight to our views.

2.2.1 Information gathering and analysis

Our first step in examining research agendas was to gather a large volume of information covering[7]:

- a historical overview of UK research policy in general and agricultural biotechnology research policy specifically;
- the key over-arching influences on research agendas; and
- detailed descriptions of organisations funding agricultural biotechnology research in the UK, breaking down their expenditure and describing how they set research agendas, the aims and specific drivers that influence them and how stakeholders and the public are engaged in their operations.

We gathered this information from three main sources: desk research by the AEBC secretariat; academic literature provided by AEBC members and experts in science policy; and the evidence of guests invited to AEBC meetings during 2004 and 2005[8]. The information was analysed in a paper that also made some broad observations and drew preliminary conclusions from the data. This analysis paper, which forms the output for this module[9], suggested that the drivers behind research agendas in agricultural biotechnology could be grouped in four main categories:

1 Advancing knowledge and technology and maintaining the science base
2 Wealth creation and international competitiveness
3 Government policy, regulation and legislation
4 Public priorities and aspirations for science

However, it was clear that formal drivers and mechanisms were not the whole picture and cultural and historical factors, which are difficult to describe or measure, were important.

The balance between the drivers varied for different funders and different scientific areas. Advancing knowledge was a more significant driver for Research Councils and Universities, while supporting policy was a higher priority for Government Departments. However, general trends could be detected. The importance of research to support policy appeared to be growing. The pursuit of knowledge and scientific excellence continued to be important, but the reasons for this were increasingly linked to wealth creation. As a result, research for wealth creation was focused on supporting underpinning knowledge or technology, such as biotechnology, for industry to draw upon. Despite the emphasis on wealth creation, there was no sign of a move towards more near-market, experimental development type research - in fact, there might be said to be a gap in the provision of near-market research.

Examination of the mechanisms for research agenda setting suggested that policy drivers influenced research agendas through policy representation on Research Council decision-making bodies and other, less formal, interactions between scientists and policy makers. The drive for wealth creation and competitiveness came mainly through high-level Government initiatives, including financial incentives for individual scientists, and through private sector collaboration and representation on high-level committees and advisory groups.

We found that all Research Councils and Government Departments used a process of consultation and a structure involving advisory groups with "end user" membership in developing research strategies. However, there were few mechanisms to allow the views of the lay public to influence research agendas directly. The majority of public 'engagement' activities seemed to focus on information dissemination and education.

Academic scientists dominated the highest-level advisory committees, influencing the research agenda in this way and also by "bottom-up" prioritisation through responsive-mode funding. While scientists retained considerable autonomy over research agendas, there was growing central scrutiny of the strategic direction of research agendas. With some exceptions, decision-making processes were not fully open, transparent or accountable.

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[6] *For electronic copies, go to www.aebc.gov.uk and click on "Reports". Hard copies are available by calling the DTI Publications Orderline on 0845 015 0010 and quoting the Unique Reference Number (URN) code for the paper wanted – these codes are given for each paper in subsequent footnotes.*

[7] *The raw information is documented in a Background Information Paper (October 2004) - see http://www.aebc.gov.uk/aebc/subgroups/research_agendas_consultation.shtml. Note that this has not been updated with the publication of this report.*

[8] *Guests at May 2004 meeting: Professor Ian Crute (Director, Rothamsted Research), Professor Howard Dalton (Chief Scientific Advisor, Defra), Dr Brian Johnson (English Nature) and Colin Tudge (science writer). Guests at July 2004 meeting: Dr Alistair Carson (Science Service, DARD NI), Mike Foulis (Head of the Environment Group, SEERAD), Professor Maggie Gill (Director, Macaulay Land Use Research Institute) and Professor John Hillman (Director, Scottish Crop Research Institute). Guests at February 2005 meeting: Professor Julia Goodfellow and Dr Monica Winstanley (Chief Executive and Head of External Relations, respectively, at BBSRC). Minutes of these meetings are available on line at http://www2.aebc.gov.uk/aebc/meetings/meetings.shtml*

[9] *AEBC (2005) What shapes the research agenda? Information and Analysis Paper URN: 05/1082*

2.2.2 Written consultation exercise

In October 2004, the AEBC launched a written consultation on research agendas, writing to over 150 organisations and individuals and making the consultation documents available to all on the Commission's website[10]. The consultation invited comments on 14 specific questions as well as general views, and the draft analysis paper (see 2.2.1 above) was enclosed to stimulate comment.

A total of 30 responses were received, with a fairly even distribution from a variety of categories including Government, non-departmental public bodies, research providers, Research Councils, the agriculture industry, other non-governmental organisations (NGOs), and a number of individuals. Unfortunately, no responses were received from agricultural biotechnology companies or large agri-businesses, or their representative organisations, although a number of these were invited to respond. We were extremely gratified by the high quality of responses, which contained a diverse range of stimulating comments and thought-provoking suggestions to help us in developing our conclusions and recommendations. The responses are available on the AEBC's website[11], and the output of this module is a summary and analysis paper of the responses[12].

Overall, respondents welcomed the AEBC's interest in research agendas in agricultural biotechnology, considering it an area worthy of examination. Several gaps were highlighted in the Commission's preliminary analysis, including research to benefit agriculture in developing countries, University research funding and the Research Assessment Exercise, and charity and levy body-funded research. A number of respondents raised concerns about the overall nature of agricultural biotechnology research, feeling that fundamental change was needed to make sustainable farming the aim. Some felt that this required a shift in focus from product development to agricultural methods and processes, or to a more systems-based, holistic approach.

Most responses agreed broadly with the drivers we identified in our analysis. Several respondents expressed concerns that the focus on advancing fundamental knowledge and scientific curiosity meant that agendas were insufficiently targeted to practical applications. Others felt that the wealth creation driver was too strong, and several, mainly NGOs and individuals, viewed the increasing links between the public and private sectors with suspicion. However, some farming industry respondents commented on the need for more market focus and said that more private sector cooperation was needed. All respondents acknowledged the increasing emphasis on research to support Government policy and regulation and while some research providers and NGOs welcomed this, other NGOs, and several individuals, felt that policy needs were too far removed from the fundamental objectives of public good and sustainability.

On mechanisms for setting agendas, Defra and BBSRC cited recent improvements. Several respondents agreed that there was a tendency for increased stakeholder involvement, but there was a general agreement that more openness and transparency were needed in priority setting. Most respondents, across all categories, wanted more public engagement in decision-making and several suggested ways in which this could be made more genuine and meaningful. Some responses, particularly from research funders and providers, commented on the practical difficulties. Avoiding disproportionate influence from self-selecting groups was also a concern for many.

2.2.3 Public and stakeholder engagement exercise

We wanted to involve in our study the public and certain stakeholders who are not normally consulted, to understand what they think about science, to seek their views on whether the public could be involved in setting research agendas and to get feedback on our own thinking on the issues. To do this, we contracted Opinion Leader Research to conduct a public and stakeholder engagement exercise. The approach was based on two parallel and interacting strands, one with the public and the other with stakeholders of three different kinds – scientists, field advisers and farmers – selected to try to involve people who did not normally become involved in policy issues. Whilst neither group could be claimed to be 'representative', they were recruited to give breadth in terms of age, social class and geographical location. The results therefore represent an in-depth snapshot of these people's views and how they are arrived at.

The public strand comprised three stages. An initial three-hour discussion group, where people's general views on science were studied, was followed by a second half-day workshop where participants were given more information on current systems of agenda setting to discuss and debate. These two stages were similar for stakeholders, except that the three different stakeholder groups met separately in the first stage and were brought together in the second. At the final, full-day workshop, public participants were brought together with stakeholder participants and several AEBC members to reflect in more depth on some of the key issues and consider the AEBC's emerging conclusions.

Several underlying themes recurred throughout the process. Participants were positive about science, and its contribution to society. The public became convinced of the importance of basic or "blue skies" research through what they learned in the engagement process. Doubts expressed about science often related to particular applications, including controversial areas like GM foods and embryo research, but participants also showed a more general concern that all stakeholders had a vested interest, whereas there was nobody acting wholly in the public interest. This mistrust resulted in sceptical reactions to some of the key drivers identified by the AEBC, particularly wealth creation and support for Government policy and legislation. It is also related

[10] *http://www2.aebc.gov.uk/aebc/subgroups/research_agendas.shtml*
[11] *http://www2.aebc.gov.uk/aebc/subgroups/research_agendas_consultationresponses.shtml*
[12] *AEBC (2005) What shapes the research agenda? Analysis of responses to written consultation URN: 05/1083*

to participants' wish to see a wide range and balance of different interests on committees and for more transparency and accountability in decision-making.

After lengthy deliberation, almost all participants believed that the public had an important contribution to make to research agenda setting, primarily at the strategic level. Public participants thought that they could bring 'common sense' to the debate and counterbalance vested interests. However, they were also concerned about their lack of scientific knowledge, and the lack of a trusted source of scientific information, seeing media coverage as either sensationalist or inaccessible.

Stakeholders shared most of the above perspectives but differed from the public participants' views in some important areas. For example, scientists often felt that funders imposed heavy constraints on them and worried about science being directed by political expediency. They were more ambivalent about public engagement than other participants, seeing the complexity of science as a real barrier. Farmers felt that they did not have much of a say in the science that was conducted and therefore felt detached from it. They were generally open to public engagement. Field advisers tended to hold views which fell between those of the scientists and the farmers, probably reflecting their roles as intermediaries between the two.

From the discussions that took place, we have gained much greater insight into the views of all participants in ways which are directly relevant to our conclusions and recommendations. Overall, participants (both public and stakeholders) were positive about the process and the experience and pleased that their views were being sought. The main problems experienced were the limited time available in relation to the complexity of the issues being discussed, and a difficulty in recruiting stakeholders, particularly farmers and field advisors, with no previous involvement in policy issues. The full reports of each stage, which describe the process in much greater depth, are available on the AEBC website. A short summary report of the whole exercise has also been produced, and this is one of the five modules that form the main output of this workstream[13].

2.2.4 Case studies

Our two case studies[14] aim to focus on a specific research area in order to identify the important influences on that field, and explore in some depth the implication of the drivers for the research agenda in that area.

2.2.4.1 Plant breeding

Plant breeding was an area of research highlighted for a case study early on in the AEBC's thinking, as it is an area where significant changes to the research structure have occurred, both in the public and private sectors. The paper was developed through consultation and discussion with a number of practising plant breeders and academics, in addition to desk-based research.

The case study looks at changes to the structure and nature of plant breeding research in the UK, and the reasons behind this. It is possible to see that all the drivers behind agricultural research in general identified by the AEBC have had an influence on the plant breeding research agenda.

Technological developments have contributed to significant advances to the rate and nature of crop improvements. However, in the UK this technological drive has been tempered by slow uptake of new technology by industrial breeders, and negative public reaction to biotechnologies.

Policy decisions to move out of near-market research in the 1980s, and the sale of the Plant Breeding Institute have catalysed a shift of plant breeding research from the public to the private sector. Plant breeding has also responded to shifts in priorities in the farming industry partly driven by changing Government agricultural and trade policies. However, with a large proportion of breeding now in the private sector, market forces have a dominant influence on the research agenda.

Although a number of positive developments have resulted from these changes, the case study concludes that there is now a risk that plant breeding research objectives will be overly focused on purely economic goals, at the expense of social and environmental objectives. A role for Government therefore emerges in providing research to fill any potential gaps, as well as incentivising industry to undertake research relevant to sustainability goals, and creating market demand for the resulting products. The importance of engaging with the public and stakeholders at an early stage of technology development is also highlighted.

2.2.4.2 Soil science

Soil science was chosen as a case study because of an often-cited perception that agricultural soil science has declined in recent years. As a more process-oriented and less industry-focused area of science, it contrasts helpfully with the plant breeding case study. The paper was developed through consultation and discussion with a number of practising soil scientists.

The soil is a highly complex and dynamic system. Understanding its physical and chemical properties is hard enough, but it also harbours a remarkable biodiversity. The relationships between these abiotic and biotic components and the soil's many functions are still poorly understood. Nevertheless, since its beginnings in the 19th century, soil science has helped to produce the vastly improved yields of modern agriculture.

The soil's role in a host of other processes, such as carbon cycling and climate change, pollution and ecosystem function mean that factors other than a desire to improve agricultural productivity can influence research agendas. In the last twenty-five years in most Western

[13] *AEBC (2005) What shapes the research agenda? A consultation with the general public and stakeholders URN: 05/1086*
[14] *AEBC (2005) What shapes the research agenda? Plant breeding case study URN: 05/1084*
AEBC (2005) What shapes the research agenda? Soil science case study URN: 05/1085

cultures, the key drivers behind soil science have changed considerably as technical advances have begun to allow fundamental soil processes to be understood (food production continues to be the driving force behind soil science research in developing countries).

Soil science is an interesting case study of how a particular area of science is adapting to changing priorities and as technical developments allow new approaches to be taken. The case study examines the implications of the redirection of priorities and resources on the soil science that is carried out today, including the key areas of work and sources of funding, and looking particularly at the consequences for agricultural soil science. It concludes that, after a period of neglect in the 1980s, soil science has entered a dynamic and exciting phase, and a time of great potential to contribute to understanding of today's most important environmental issues. It also finds that the research agenda setting process has proved to be agile in responding to new challenges and opportunities.

The reconstruction of soil science to address wider, environmental questions has inevitably meant a decline in the resources directed to agricultural research, and our case study finds that soil science has not yet been able to respond as thoroughly to the sustainable agriculture agenda as it has the potential to do. Some important agricultural questions are in danger of being neglected. It also concludes that the rapid redirection of resources has had a negative consequence on the skills base, with a dangerous loss of expertise particularly in the physical soil sciences. This poses a threat to the multidisciplinarity that is necessary for soil science to thrive, and to which current funding structures pose some barriers.

3 Conclusions and recommendations

3.1 What is the research agenda?

In spring of 2004, the AEBC set out to investigate "What shapes the research agenda?" in agricultural biotechnology. Through the approach described above, we are now in a position to answer this question, to say where we think the system works well, and to make recommendations in areas where we think it could be improved.

But, before describing our conclusions, it is important to emphasise that we have used the concept of "*the* research agenda" as a convenient short hand. We do not believe that there is one single research agenda in agricultural biotechnology in the United Kingdom, or indeed in any other area of science. Instead there are multiple agendas, set by a variety of funding bodies that have different perspectives and priorities. This was reflected in our written consultation and in other discussions with stakeholders, where views differed depending on whether comments referred to Research Councils, Government Departments or other funding bodies. Clearly, there are links and strong similarities between the overarching agendas of different funding bodies, but every funder of agricultural biotechnology research has a different emphasis. This is an advantage – it ensures a plurality of drivers behind research strategies and therefore encourages a more balanced overall portfolio of research. Our soil science case study showed that the drivers behind this area had diversified hugely in recent years, and that this had helped to make soil science dynamic, responsive and exciting. **However, as we shall describe below, we have concluded that there is some danger of certain drivers becoming over-dominant and we feel that having a diverse array of research agendas militates against this to some extent.**

Recommendation 1: *Diverse research agendas mean a plurality of drivers behind research and therefore encourage a balanced and varied portfolio. This diversity is healthy and research funders and strategic decision-makers should ensure that no one agenda or driver is allowed to dominate.*

A second proviso is that not all the drivers behind research agendas are explicit. Informal influences have a significant effect on research agendas. These include past precedent and inertia, current scientific trends, areas of UK expertise, and lobbying by groups representing a range of interests. As Dr David Heaf pointed out in his response to our written consultation, the *Zeitgeist*, or the trends in thoughts and feelings among those setting agendas, plays a key role in shaping what science is done. Informal influences on research agendas are inevitable and need to be acknowledged alongside the more overt drivers. We agree with the Institute of Food Research that they should not be considered a problem as long as our recommendations below for openness, transparency and accountability in agenda setting are adhered to[15].

Notwithstanding these two caveats, **we believe that the four drivers that we have identified in our analysis paper remain a good summary of what actually drives research agendas today:**

1. **Advancing knowledge and technology and maintaining the science base**
2. **Wealth creation and international competitiveness**
3. **Government policy, regulation and legislation**
4. **Public priorities and aspirations for science**

This brief list is necessarily a crude summary, and the four drivers are multifaceted, complex and interrelated. They are described in more detail in our analysis paper. Nevertheless, the other modules of our workstream – the written consultation, engagement exercise and case studies – largely confirmed our view that these are the key factors that currently drive research.

Government policy and regulatory concerns might dominate research on the safety of agricultural technologies, while research into new agricultural products would be focused on wealth creation and experiments looking at flowering mechanisms in plants would be based largely on advancing knowledge. However, we believe that each of the key drivers affects all agricultural biotechnology research, and indeed all of agricultural research, albeit to a varying extent.

The four drivers are therefore the starting point for our work. However, they are not our conclusion. As Recommendation 5 below proposes, an additional driver should be introduced in order more explicitly to identify values of sustainability and public good alongside the equally desirable as well as necessary driver of wealth creation and international competitiveness.

3.2 The role of scientists in setting agendas

"RRes hopes to be able to influence the agenda for scientific research of relevance to agriculture and the environment but, in the final analysis, the organisation must always demonstrate agility in its response to the research agenda as set externally by its funders (mainly Government Departments and the Research Councils)." ***Rothamsted Research (RRes) response to written consultation, December 2004***

"Our feeling is that ... the majority of the scientific community who are involved in and excited by biotechnology still lie largely in the 'curiosity driven' domain and, in the main, do not prefer to align their activities with policy issues over and above the development of fundamental science."
Scottish Agricultural College response to written consultation, December 2004

The above quotes are just two of many, sometimes conflicting views we received on the role of scientists in setting agendas, an issue which relates largely to the first driver listed above (advancing knowledge and technology and maintaining the science base). It is clear that scientists can to some extent determine the science that they do, as shown by the existence of responsive mode funding, and the research councils' emphasis on this route. At the February 2005 AEBC meeting, Professor Julia Goodfellow, BBSRC Chief Executive, stressed that BBSRC responsive mode funding had grown faster than any other mode in recent years[16]. We

[15] *See their response to our written consultation.*
[16] *See also the responses to our written consultation from the Research Councils, particularly NERC.*

believe that scientists have most impact in setting agendas by providing the innovation, in terms of theoretical and technological developments and methodology, which underlies their discipline. However, scientists are influenced in their choice of grant proposal by what subjects they think are most likely to receive funding, and therefore by the *Zeitgeist* mentioned above. In our analysis paper, we discussed the growing central scrutiny and control of research agendas. This is demonstrated, for example, by the proposed Office of Science and Technology (OST) performance management system for the Research Councils[17], and by the new SEERAD strategy, which seeks to align the research it funds more closely to its policy needs, thereby reducing the autonomy of the institutes it supports[18].

During our public and stakeholder engagement exercise, many of the scientists participating felt very strongly that their own influence was variable and heavily constrained by the narrow parameters set by strategic priorities and mechanisms such as the Research Assessment Exercise (in Universities) and the "box-ticking" of the grant application process. Other participants in the exercise believed that scientists had important knowledge and insight and should certainly be involved in setting research agendas, but not without input from a broad range of other stakeholders.

In retrospect, the terms "bottom-up" and "top-down" that are commonly used, and that we have used previously, are not really appropriate here. It is impossible to distinguish "bottom-up" from "top-down" influences completely because they feedback on one another. As well as "bottom-up" influence from scientists, there is also the question of input from end users of the research, including farmers or consumers – this is covered in the discussion on public and stakeholder engagement below (see 3.10).

Overall, we conclude that ordinary scientists (that is those not sitting on funders' decision-making bodies) **still retain a significant influence on research agendas, but that this influence is constrained within a strategic focus over which they have declining influence. The extent of this constraint varies between the different funders.**

3.3 Advancing knowledge and basic research

Our public and stakeholder engagement study showed that people were very positive about science, and well persuaded of its importance to society[19]. Much of the ambivalence that people held towards research seemed to be related to the applications to which it was put and the interests of those conducting it. People's views on basic or "blue skies" research[20] developed interestingly in the course of the three-stage exercise. At first there was some scepticism, with a view that some basic research was scientific self-indulgence, and that limited budgets should not be targeted towards areas with no obvious benefits. However, by the final stage, there was strong support for continuing basic research, on grounds of the intrinsic value of knowledge about the world provided by scientific discoveries, but mainly of the instrumental value of such knowledge for the good of society, either in the short or long term. Although some were concerned about the lack of more applied agricultural research being done, nobody we heard from in our written consultation queried the need for basic research.

> *"If you ask us which is more important – whether we can land on Mars or find a cure for cancer, I mean, there's no competition is there?"*
> ***Engagement exercise (Public, Bristol Stage 2)***

> *"I think it's our duty as members of the public, and therefore it's the Government's duty, to make sure there's some baseline funding for blue skies research. I'm certain of that"*
> ***Engagement exercise (Public, Perth Stage 2)***

As discussed above and in our analysis paper, there is an increasing trend for research agendas to support Government policy and regulatory needs, particularly in Government Department funded research but also, though to a lesser extent, Research Council science. These moves are not unwelcome and we agree with Government on the importance of balanced, evidence-based policy making. **However we feel that the importance of basic research, to underpin more applied work and maintain the science base, and the broad support for this that we have found, must be highlighted.**

The case studies that have contributed to this work support this conclusion. The plant breeding study concludes that a healthy plant breeding industry is a public good, and that the public sector has a role to play in supporting it, particularly through providing basic plant research. This support is also necessary in order to train plant breeding scientists to supply the industry. Our second case study looks in depth at soil science, an area that has responded in an agile and very positive way to new technological opportunities and changing policy requirements, away from agricultural production towards environmental goals. However, it demonstrates that this rapid shift to meet policy needs has threatened the wider science base in soil science in two main ways: first, some agricultural soil science questions are in danger of being neglected, and second and most importantly, a decline in some areas of the skills base, particularly the physical sciences, that are necessary for effective soil science. These problems could damage the future capabilities and responsiveness of soil science in the UK.

Scientific excellence must be a prerequisite for funding basic research. Research funding bodies should however be mindful of the fact that research proposals and activities may be conducted within more than one framework, each endorsing its own criteria of what constitutes excellence. In agricultural research today

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[17] *Paragraph 3.56 of HMT, DFES, DTI (2004) Science and Innovation Investment Framework 2004-2014.*
[18] *SEERAD (2005) Strategic Research for SEERAD 2005-2010: environment, biology and agriculture*
[19] *This observation is supported by the findings of a recent Office of Science and Technology commissioned report by MORI, which found that over 80% of adults think science makes a good contribution to society and that science will make our lives easier. MORI/DTI (2005) Science in Society: Findings from Qualitative and Quantitative Research*
[20] *In referring to basic research throughout our work, we use the Frascati definition of "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view" (see http://www.ost.gov.uk/setstats/background_info.htm). This definition can equally apply to the terms "blue-skies" or fundamental research.*

one may identify two emerging frameworks, namely, the life sciences approach, based primarily on the new molecular biological sciences, and that based on the ecologically-oriented sciences. The former is reductionistic while the latter is more holistic in character[21].

Recommendation 2: *Support for high-quality, basic research should be maintained, to generate fundamental knowledge even if it has no direct and immediately obvious practical value. Basic research priorities and areas of science cannot be divorced from overall strategic direction or accountability, but they should be protected from short-term pressures such as policy needs and the drive for wealth creation. Excellence should be the primary criterion for funding and as wide a science base as possible should be maintained.*

3.4 Technology as a driver

Part of the *advancing knowledge and technology and maintaining the science base* driver, as described in our information and analysis module, is the "technology push", exemplified in 1994 by the subsuming of the Agricultural and Food Research Council (AFRC) in the creation of the Biotechnology and Biological Sciences Research Council (BBSRC), in order to exploit the biosciences with an increasingly technological focus.

It is clear that technology has been a major influence on the direction of agricultural research. In our case study on soil science, we show that advances in molecular biological and genomic technology have opened up new avenues and created opportunities for soil science to pursue questions that were previously largely inaccessible. "Platform" technologies such as genomics can revitalise research areas, greatly improving scientific quality and the potential to generate results. Some technologies are also favoured for their wealth creation potential.

However, we conclude in our case study on plant breeding that the technology driver in this area must work alongside and towards the aspirations of society to restore public confidence. Moreover, some of the respondents to our written consultation expressed concerns about the emphasis on molecular and biotechnological techniques, and the associated reductionist perspectives, in agricultural research in general. They believe that this technology focus is disproportionate and does not necessarily result in research of optimum benefit to society. **They feel that there is a need for holistic, systems-based research that is directed more towards agricultural methods and processes than at present.** Some of the soil scientists we spoke to in the case study suggested that it was difficult to get funding for research proposals that took such an approach. A 2002 BBSRC review of sustainable agricultural research[22] recognised the historical focus on reductionist molecular and cellular level studies and the "relative weakness in integrative and systems studies of relevance to sustainable agriculture at the whole organism, field, farm or catchment level". It recommended a review of the resources needed for the sustainable agriculture programme, with a view to providing the kind of generic platform facilities available for structural biology and genomics[23]. We sympathise with these views (see also Recommendation 5 below).

Recommendation 3: *Science decision-makers should ensure that technologies do not become ends in themselves, but are integrated with explicit goals of benefit to society and sustainable agriculture.*

Recommendation 4: *We endorse the recommendation of the BBSRC sustainable agriculture review group for a review of the capacity for more systems-based, longer-term sustainable agriculture studies.*

3.5 Economic, social and environmental drivers

3.5.1 Wealth creation

Our analysis paper concluded that wealth creation is a key driver behind agendas, in agricultural biotechnology as in other areas of research, and suggested that its importance was increasing. Responses to our written consultation supported this conclusion. Evidence from all parts of our workstream suggests that wealth creation is in danger of becoming over-dominant. The definition of wealth creation, in theory and in practice, needs to be examined closely, and alternatives should be considered.

Economic returns from research started to receive increasing emphasis in the budget freezes of the 1980s, but rose to prominence with the 1993 White Paper *Realising Our Potential*, which focused on the concept of harnessing the UK's strength in science and engineering to the creation of wealth. This was to be achieved by "closer and more systematic contact with those responsible for industrial and commercial decisions"[24]. Wealth creation continues to be a key theme in the *Science and Innovation Investment Framework 2004-2014*, the first paragraph of which says that "harnessing innovation in Britain is key to improving the country's future wealth creation prospects" and defines the Government's ambition "for the UK to be a key knowledge hub in the global economy".

Our engagement exercise revealed confusion among both public and stakeholder participants about the context and purpose of wealth creation as a driver behind research. In theory, the concept of wealth creation could be interpreted very broadly, to include non-material and non-financial values. Indeed one of our consultation respondents suggested that a broad definition like this should be adopted[25]. However, several consultation respondents expressed concern about the growing

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[21] *Lang T. and Heasman M. (2004) Food Wars, Earthscan.*
[22] *BBSRC (2002) Review of BBSRC-funded research relevant to sustainable agriculture: a report for BBSRC council*
[23] *BBSRC's Sustainable Agriculture Strategy Panel plans to address this recommendation later this year.*
[24] *HMSO (1993) Realising Our Potential: A Strategy for Science, Engineering and Technology, Cm 2250*
[25] *See the response to our written consultation from Sir John Marsh.*

influence of industrial and commercial interests. The examination of the composition of a selection of research committees in our information and analysis paper indicates a prevalence of, though certainly not complete domination by, large commercial interests[26]. This suggests that wealth creation may tend in practice to be narrowly defined for the benefit of particular business sectors, rather than the general stimulation of economic activity.

Some interpret the wealth creation driver more generally as a focus on market considerations and cooperation with the private sector[27]. As well as stimulating economic activity, this focus should generate more practical applications from research. **The creation of wealth from the results of scientific research is beneficial, and wealth creation should be one of the drivers behind research. It is important to ensure that scientists are in a position to identify potential commercial applications and to facilitate their exploitation. However, we believe that wealth creation should apply to the full range of economic activities, including smaller and non-conventional farming and food enterprises, as well as large agri-food and technology companies.** This has implications for the involvement of stakeholders in agenda setting, as discussed below.

3.5.2 Quality of life, the public good and sustainability

The concept of "quality of life" was an important feature of *Realising Our Potential*, albeit one that was clearly secondary to wealth creation. The wider benefits of research, for which public expenditure on science could be justified, were "above all the generation of national prosperity and the improvement of the quality of life". Though not explicitly defined, quality of life was included in the new mission statements of the Research Councils and for science and technology in Government Departments in the 1993 White Paper. Tellingly however, "quality of life" receives only three passing mentions in last year's *Science and Innovation Investment Framework*. It does not appear to have been replaced by an alternative concept. Several respondents in our consultation suggested that "sustainability" or "the public good" should drive agricultural research more explicitly, but neither of these appears significantly in the science and innovation framework.

Wealth clearly contributes to quality of life and the public good, but wealth creation does not substitute adequately for these aims. A significant amount of research done today generates public good without necessarily creating monetary wealth directly. Examples include food safety research and studies of the effects of climate change or soil pollution. However, research with no immediate wealth creating value may save a great deal of money by tackling future, unanticipated problems with serious cost implications, such as outbreaks of an infectious animal disease or flooding. In addition, all research has significant wealth creation benefits by training people in scientific methods and maintaining the scientific skills base.

As noted in our information and analysis module and supported by consultation responses, public good and the old quality of life driver seem to have become subsumed in today's high-level science policy documents under the banner of supporting Government policy and improved service delivery. **Like wealth creation, policy and public service support does not encompass all public goods;** quality of life priorities will not be identical to Government policy priorities. Furthermore, our public and stakeholder engagement exercise showed clearly that wealth generation and policy support are not necessarily equated with public good goals. Participants supported wealth creation as a key driver behind research, but perceived a clear distinction between economic interests and wider public interest, which they felt should also influence agendas. Similarly, while there was a recognition by some that commissioning research to support Government policy could improve the quality of decision-making, there was also widespread doubt that Government always acts in the public interest. **Government and politicians appeared to be seen in a particularly cynical light and expected to use science to support their own political ends. This was the strongest manifestation of a belief that everyone involved in research has a vested interest** (see 3.10).

"The problem with the private sector and the Government is that they are thinking of purely financial benefits, and nothing is tested for long enough, or is tested without a view to helping the public. There's a difference between helping the public and making money out of developing something"
Engagement exercise (public, Stage 3)

"I think we have a moral obligation to fund research for reasons other than just financial returns"
Engagement exercise (field adviser, Stage 2)

"It seems to me that it's distinctly possible that the outcome of the research is set out at the beginning to reinforce the policy the Government want to put in, so that it's there to back them up."
Engagement exercise (public, Perth Stage 2)

We do not doubt that most scientists, and funders of science, already consider the generation of public good and improvement of quality of life to be key drivers for their work. But public good should be made a more explicit part of overarching research agendas. However, public good is a concept that is very open to interpretation – do we mean good for the agriculture industry, good for the environment or good for the developing world? **In the context of agricultural and more specifically agricultural biotechnological research, we feel that the concept of sustainability best represents and encompasses the aims of wealth creation, public good and quality of life.**

We acknowledge that sustainability is as open to different interpretations as public good, and is widely regarded as

[26] *I. Table 6.1 of AEBC (2005) What shapes the research agenda? Information and Analysis Paper URN: 05/1082*
[27] *See the response to our written consultation from the National Farmers' Union.*

being ill-defined in public discourse, but it is certainly better defined within policy making than wealth creation. Importantly, Government is explicitly committed to sustainable development (in line with a shared set of UK principles agreed across Government and a high-profile new Government-wide strategy[28]) and specifically to sustainable agriculture[29]. Sustainable agriculture research is already part of the agendas of most of the funders we have looked at, but as the extract below from our written consultation shows, sustainability does not appear to be perceived as a key driver. It seems wrong to us that sustainability does not share the high-level strategic importance given to the key drivers we have identified behind current research.

"Although we agree that policy relevance is increasingly perceived as a strategic driver of research and development in agricultural research, there is little evidence that agendas have yet responded to this driver in the context of agricultural sustainability and impacts of agriculture on the environment."
British Statutory Conservation Agencies response to written consultation, December 2004

Sustainability encompasses the three pillars of economic advancement, environmental protection and social progress. While the economic pillar is clearly represented in current research agenda setting by the wealth creation driver, the social and environmental pillars are not represented in the same way. Adopting sustainability as a key driver for agricultural biotechnology research would acknowledge the need to evaluate the 'trade-offs' between economic, social and environmental objectives (or wealth creation, public good and quality of life), and would influence the research agenda in a more holistic and integrative way than the current focus on the economic pillar allows. It would enable society to be increasingly clear and well-informed about the immediate practical and perhaps longer-term implications of biotechnological innovation as well as its ethical and social dimensions. In this respect, we agree with the recommendation of the Food Ethics Council in their recent report on food and farming research[30]. Note that this does not preclude our recommendation on continuing to support basic research (Recommendation 2).

Recommendation 5: *The public good should be a more explicit objective within research agendas. For agricultural biotechnology research specifically, sustainability should be an overarching and key strategic driver. The concept of sustainability encompasses the need for more explicit reference in research to the 'trade offs' between economic, social and environmental objectives.*

3.6 Coordination and multidisciplinary research

"The sectoral approach to farming by Government and the industry itself has led to a rather fragmented approach to R&D strategy."
FARM response to written consultation, December 2004

"...We welcome the cross cutting initiatives from Research Councils and Government Departments. Greater coordination in developing strategy will have a beneficial effect on delivery too."
Applied Research Forum response to written consultation, December 2004

A number of the responses to our written consultation highlighted the need for coordination between funders of agricultural research in agenda setting, including international collaboration. Our soil science case study suggests that it can sometimes be difficult to obtain funding in areas that do not fall neatly within the portfolio of any single Research Council, and where a multidisciplinary approach is required. The BBSRC's 2002 review of sustainable agriculture research recommended coordination between BBSRC, NERC, ESRC, Defra and SEERAD in sustainable agriculture research, including establishing a joint sustainable agriculture research committee and concerted funding actions[31].

Our information gathering suggests that gaps and overlaps do exist between different research funders. We have considered whether we might ourselves recommend the establishment of a coordination group for sustainable agriculture research, along similar lines to the BBSRC review's recommendation. In the end, we have decided against this, first because we are loath to recommend establishing another committee unless we feel it is absolutely necessary, but primarily because of our conviction that maintaining a plurality of drivers, and avoiding domination by any one agenda, is essential (see Recommendation 1).

Nevertheless, our model of a plurality of drivers will only work if there is good coordination between funding organisations and unnecessary barriers to cooperation are removed. We feel that there is a need for cross-funder, cross-disciplinary project management (with broad stakeholder input) of sustainable agriculture research and of specific areas such as plant breeding and soil science. In addition, obstacles to multidisciplinary studies need to be addressed. We welcome greater flexibility in funding, for example to allow joint support of grants by more than one Research Council and applications for BBSRC grants by staff in NERC institutes and vice versa. But barriers still exist - for example, mathematicians and physical scientists employed in NERC or BBSRC Research Institutes are ineligible to apply for funds from the EPSRC responsive mode, in spite of this being the main Research Council for their discipline[32].

More positively, we welcome moves towards increased cooperation and multidisciplinarity, such as the Environmental Research Funders Forum[33] and the joint Rural Economy and Land Use programme[34]. We support the aim of the Defra

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[28] *See http://www.sustainable-development.gov.uk/*
[29] *Although note that commercial breeders we spoke to as part of our plant breeding case study lacked confidence in a stable agricultural policy agenda and asked for a clearer vision from Government to aim towards.*
[30] *Food Ethics Council (2004) Just Knowledge? Governing Research on Food and Farming. One of the report's recommendations is "that the Government develops a more joined-up approach to research and innovation around the theme of sustainable development".*
[31] *This recommendation has not yet been implemented. However, BBSRC's Sustainable Agriculture Strategy Panel plans to address the issue later this year.*
[32] *Although the BBSRC Chief Executive told us at the February 2005 AEBC meeting of an arrangement whereby BBSRC institute staff could submit grant proposals to EPSRC which would actually be paid for by BBSRC if awarded.*
[33] *http://www.erff.org.uk*

Sustainable Farming and Food Research Priorities Group to create a more cohesive farming and food research area across the range of different funders. Having published its first report, which identifies research priorities to underpin Defra's sustainable farming and food strategy, in March 2005, the group intends to produce a second report in 2006 addressing how different funding organisations have acted upon its recommendations and reporting on its activities to improve coordination. We await this report with interest.

3.7 Applied research and the private sector

As described above, our examination of agricultural biotechnology research agendas has been explicitly limited to public sector research. But we have not ignored the private sector, particularly in its research links with the public sector and as an end user of publicly funded research. **We encourage agricultural biotechnology and other agri-food companies, as well as the agricultural levy bodies, to look closely at our recommendations and, bearing in mind their corporate responsibilities, consider carefully whether they could apply them to their own research.** We suggest that the area of public engagement (see 3.9 below) should be given particular consideration, and point private sector organisations to the RSA's Forum for Technology, Citizens and the Market, and in particular its web-based *Guidance for Science-Based Business on Engaging the Public*[35].

An important issue that emerged from our initial information gathering and analysis was the suggestion that **Government Departments' withdrawal from near-market research in the 1990s has led to gaps in applied research.** We asked in our consultation whether this was true, and several respondents felt that it was. Others felt that a distinction should be made between research that promises instant commercialisation, and can therefore reasonably be left to the private sector, and research that is close to practical application, but does not show significant profit-making potential. The latter category would include research into agricultural methodology and processes, as opposed to product development.

The scientist participants in our engagement exercise told us that gaps in the public sector provision of applied or near-market research were due to the fact that they had little incentive to pursue this kind of research. Scientific careers were built on publication in peer-reviewed journals, the most prestigious of which favour basic over applied research. Those scientists working in Universities cited the constraints of the Research Assessment Exercise, success in which is based on peer-reviewed publications rather than the generation of any practical applications, or even contribution to sustainability, wealth creation or policy goals.

Our plant breeding case study illustrates some of the complexities of public sector support for applied research. There was strong agreement among the public and private sector plant scientists and breeders we spoke to that the link between basic plant/crop science and practical plant breeding was weak (and had been weakened by privatisation of plant breeding). The plant breeding industry did not object to basic plant science being done, but did not consider it directly relevant to plant breeding, at least in the short to medium term. Some felt that a 'middle ground' of strategic applied research was missing between the public and private sectors. They felt that if money were to be earmarked for applied research into plant breeding, as recommended by the 2004 review of BBSRC crop science[36], it was essential that the output filtered into the private sector, as this was the only route by which new crop varieties could be generated. They were also adamant that new models of publicly funded plant breeding must not reinvent the pre-1990s situation, whereby the public sector took crop varieties all the way to market and was therefore in competition with the industry.

We sympathise with these concerns, but they highlight a problem. Sustainable agriculture needs products and processes that benefit the environment. However, there will be no market for these unless farmers buy or use them – a market pull is required. As discussed in our plant breeding case study, disease-, pest- or drought-resistant crop varieties are called for, as well as new varieties of the so-called minority crops that are not bred by the private sector today. But the market continues to be dominated by high-input/high-output varieties or a few large commodity crops, with improved yield and quality. **Market issues are beyond the scope of this work and of the AEBC. However, if this situation is to change, Government needs to influence the market to incentivise farmers to buy the products and use processes that allow more sustainable farming methods.**

Recommendation 6: *Public funding for near-market research should not be ruled out where it contributes to the sustainability of farming. Where a need is identified, Government should look towards providing either research and/or market incentives to encourage product or process development. If research has commercial applications, priorities should be determined in consultation with appropriate stakeholders to ensure the market relevance of the research. The appropriate distance from market for the publicly funded research must be carefully determined.*

3.8 Openness and transparency

"When you talk about balance you need to see how decisions were arrived at and what the alternatives were, what the priorities were and what the thinking was behind the decision, not just that we are going to do that."
Engagement exercise (Stage 3)

The AEBC's information gathering and analysis of the agenda setting processes of public research funders showed that decision-making was not fully transparent. Consultation responses on this subject agreed that public sector research needed to be more open. Several respondents pointed to conflict between the desire for openness and the emphasis on

[34] *http://www.relu.ac.uk*
[35] *See the RSA website at http://www.rsa.org.uk/projects/forum_for_technology.asp. The web-based guidance is at http://www.techforum.org.uk/guidance/.*
[36] *BBSRC (2004) Review of BBSRC-funded research relevant crop science: A report for BBSRC council*

public-private collaboration and intellectual property protection, which tended to reduce the accessibility of information. Some of us agree and feel strongly that the increasingly blurred boundary between public and private sector research is undermining the virtue of science as an objective, repeatable activity conducted in the public domain. Others feel equally that the misuse of science by lobbying organisations can also damage the integrity of science.

In line with the legal requirements for public sector openness, we found that Government Departments and Research Councils had commitments to make information publicly accessible, but this applied mostly to individual research projects rather than strategic decisions. However, there are examples of good practice. Defra's Science Advisory Council held an open meeting in January 2005, attracting around 60 people, and aims to hold at least one of its four annual meetings in public[37]. It also makes meeting minutes and the majority of its papers publicly available. NERC also holds one open council meeting a year. **But such examples are still exceptional: we believe they should be normal practice, and that public funders of agricultural biotechnology research need to be more open, transparent and accountable.**

While openness is required across the whole spectrum of research funders' activities, we feel that it is in the thematic or strategic level decisions that openness is most important. Participants in our engagement exercise agreed that transparency was important, both about the funding decisions that are made and about the mechanisms by which they are reached. They also felt that decisions should be accountable, so that the reasons for taking them were justified.

We feel that funders should be able to explain on what grounds priorities have been chosen, as well as why other areas are not favoured. This would be helped by holding meetings of decision-making committees in public, and making their documentation freely available.

The AEBC has met in public and published all of its papers since its inception in 2000. When this was first proposed, some of us were sceptical, but we have not found that meeting in public has adversely affected our business. While we do not have large numbers of the public attending meetings, we feel that our adherence to openness has been of great benefit in our relations with the public and stakeholders: it has helped us to fulfil our remit to consider the wider issues behind agricultural biotechnology. There is a cost associated with transparency, and this should be recognised and additional funds made available where necessary. We also recognise that there will always be cases where papers will not be suitable for publication and discussions cannot be held openly. Meeting in public is most important and practical for strategic decision-making bodies, rather than those dealing with issues that are commercially sensitive or involve individuals. For example, grant-making committees, where there are data protection concerns and intellectual property issues, and committees that deal with employment and institutional management, are probably not suited to meeting in public. In such cases, the reason for this should be made clear.

We believe that, to achieve genuine transparency, the need for openness must extend beyond agricultural research to the very highest level of scientific decision-making, including the Council for Science and Technology[38], and the industry-led Science Forum announced by the Chancellor in his pre-budget report of December 2004[39].

Recommendation 7: *From the highest-level scientific committees, including the Council for Science and Technology, to Research Council and Government Department decision-making bodies, meetings should be held in public wherever practicable. This applies particularly to strategic level and priority setting bodies. Documents should be made freely available, or the reasons for not making them available should be clearly explained.*

At the more downstream level of individual grants, we note the requirement made by some funders for a short summary in lay language to be attached to each grant. We recommend that this requirement be made universal to all publicly funded agricultural biotechnology research projects, and that these summaries should be required to include an assessment on how the work will contribute to the public good and the sustainability of agriculture (in the case of basic research this contribution can of course be indirect). Once grants have been awarded, we recommend that the relevant grant-making committee publish an explanation of why each was funded, in a similarly short, comprehensible format. Funders should ensure that these summaries are made publicly available in a prominent and easily accessible way. We recognise that there may be some circumstances in which details of researchers and locations should not be made public for security reasons (for example in the case of some animal research); these are necessary exceptions to a presumption of transparency.

Recommendation 8: *For all publicly funded research projects, a short summary of the project should be written, including an explanation of why it has been funded and how it will contribute to strategic objectives. This should be comprehensible and informative to a non-specialist and should be made easily available to the public.*

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[37] *See http://www.defra.gov.uk/science/how/advisory.htm*

[38] *The Government's top-level advisory body on science and technology policy issues. See http://www.cst.gov.uk.*

[39] *The Chancellor's pre-budget report statement to the House of Commons on 2 December 2004 announced that Government would, "to benchmark progress in raising business R&D, establish an industry-led Science Forum chaired by the Chief Executive of Astra Zeneca Sir Tom Mckillop". See http://www.hm-treasury.gov.uk/pre_budget_report/prebud_pbr04/prebud_pbr04_speech.cfm*

3.9 Public engagement

3.9.1 Rationale

"What is primarily required to reach the public, in my view, is that academics be willing to recognise and verbally formulate the ethical drivers of their research, open these drivers up to debate, and in doing so exercise a more holistic perspective on research agendas than they are accustomed to.... This should lead to an understanding of the societal relevance and meaning of research agendas that speaks much more directly to the public's interest than is presently the case, and should be perceived as intrinsically more transparent and honest."
Scottish Agricultural College response to written consultation, December 2004

The Government supports "action to achieve greater public confidence and improved engagement in science and technology"[40]. Its Science and Innovation Investment Framework commits to a doubling of OST's Science and Society expenditure, and an initiative to build capacity and identify and propagate good practice in public engagement. The aim is to enable "public fora where the ethical, health, safety and environmental impact of new science and technologies can be debated"[41].

Our analysis paper shows that funders of agricultural biotechnology research generally aspire to involving the public in decision-making about science and technology. The Research Councils are working together under Research Councils UK to produce a public engagement strategy, and individual research councils are making progress[42]. But we found that genuine public engagement in the setting of research agendas remains rare. Many activities billed as public engagement are actually closer to information dissemination and education – activities that are important and to be welcomed, but which are not the two-way dialogue implied by engagement. Most of our consultation respondents agreed that improvements were needed to current methods of public engagement.

We commend moves by public research funders and wider Government towards public engagement and dialogue in science, but we believe that there is still a considerable way to go to put aspirations into practice.

Why do we believe that public engagement is important? Three principal motivations are often cited: normative, instrumental and substantive. These motivations, which can apply individually or together, have been discussed in detail elsewhere[43] but it is helpful to summarise them here. The *normative* justification holds that public engagement should be done because it is the right thing to do in a democratic society. It allows the public to feel some ownership and partnership with the science and with its results. An *instrumental* justification says that public engagement is a means to an end, such as improving trust in science and technology or in Government's decision-making. Finally, engagement can be justified on *substantive* grounds, the belief that it improves the quality of decision-making. In our view, all three motivations are sound, but we agree with Demos, in their pamphlet *See Through Science*[44], that although there is a role for normative and instrumental approaches, engagement must always be substantive in order to genuinely involve the public in decision-making.

Participants in our public and stakeholder engagement exercise were not immediately strongly enthusiastic about public involvement in decision-making. However, after much deliberation, and consideration of the level at which the public could be involved and the methods that could be used, almost all participants were convinced that the public had a legitimate role in influencing research agenda setting (though not taking final decisions). This was largely based on the belief that the public provided detached "common sense", or experience about how things would behave in the real world, and an important counterbalance to the views of interested parties. This is a substantive justification, but the quotes below show that normative (the public should be involved because they are affected by the decisions) and instrumental (public involvement is political useful) justifications were also raised.

"It affects us all, and it affects our children and that's something the public are concerned about"

"We thought the public could question why and what was coming through this and how things are going to be done. They may not understand exactly each project, so their questions will maybe generate things that weren't thought about or kind of clarify problems or anything or bring out the problems that may exist because they'll bring more common sense"
both Engagement exercise (Stage 3)

"I think the involvement of the public is political, and it's politicians being able to say they have involved them, rather than it being really useful"
Engagement exercise (Field advisor, Stage 2)

Scientist participants in the exercise were more ambivalent than others, feeling that the complexity of research was a major barrier to public engagement. They were concerned about hostile public opinion generated by media misinformation. This was also a concern for field advisers, but these participants were generally more positive about public engagement. Farmers seemed to feel more detached from science and more closely aligned with the public and were therefore generally open to public involvement in agenda setting.

"I mean the difficulty is that science is so technical now and the concepts are so convoluted that in some ways you have to make compromises addressing the general public and the consequences of compromise is over-simplification and that means that important details get lost"
Engagement exercise (Scientist, Stage 1)

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[40] *Chapter 7of HMT, DFES, DTI (2004) Science and Innovation Investment Framework 2004-2014.*
[41] *Ibid.*
[42] *BBSRC told us at the February 2005 AEBC meeting that the RCUK strategy would cover engagement on specific areas of science as well as broader issues. BBSRC has recently established a Bioscience for Society Panel, independently chaired, which will give high-level strategic advice about public engagement and accountability. Its membership includes social scientists, representatives of consumer groups, ethicists and members of NGOs in areas such as environmental matters and animal welfare, as well as science communication professionals.*
[43] *Stirling A. Opening up or closing down? Analysis, participation and power in the social appraisal of technology, as referenced in Wilsdon J. and Willis R. (2004) See-through Science: Why Public Engagement needs to Move Upstream, Demos.*
[44] *Wilsdon J. and Willis, R. (2004) See-through Science: Why Public Engagement needs to Move Upstream, Demos.*

3.9.2 Methodology

"There is compelling evidence that involving people who are not professional stakeholders can make for better decisions... There are plenty of tried and tested methods of public dialogue on science and technology. The biggest challenge is to ensure decision-makers are able to take that input seriously."
Food Ethics Council response to written consultation, December 2004

"At the more fundamental scientific level, the views of lay people are more difficult to incorporate. Perhaps more (social) research is needed on how such views can be included in a meaningful way."
SEERAD response to written consultation, December 2004

Research funders and others involved in science often point to the practical challenges of engaging the public in a genuine and meaningful way, and several of the responses to our consultation suggested that more social research was needed to develop techniques. We agree that effective public engagement is challenging. Some of us are sceptical about existing methods, while others feel that there are a number of legitimate methods to choose from. We do not intend to make recommendations on which particular methods research funders should employ, as this is a decision best made on a case-by-case basis. However, we feel that it is crucial to recognise that public engagement is an activity that requires specific training and expertise. The validity of its methods can be assessed and subjected to peer review, and its practitioners should be innovative and self-critical. In short, **public engagement is a professional activity.**

"The means by which more direct input should be accomplished would require some form of deliberative process between citizens – and for logistical reasons this must mean a smaller number than the population at large. Mechanisms such as deliberative mapping, consensus conferences, citizen's juries exist to allow some kind of feedback and evaluation. However there need to be some clear conditions and limitations on this approach:

a) There's no point doing it unless the existing decision-makers are prepared to change their actions to accommodate markedly different perspectives. A failure to do this would amount to going around stirring up cynicism.
b) Public involvement is a supplement to decision making not a substitute for it. The decision remains that of the decision-maker, but public input should (see above) require a much higher level of justification for decisions taken.
c) These mechanisms would go much further than a standard 'consultation' and would require organisations to actively seek out opinion rather than sit back and expect to receive it.
d) To be meaningful the starting point of a public involvement mechanism needs to be that they are able to shape the questions being asked, not to be given questions that e.g. presupposes that GM food has an important role to play in future food supply."

Greenpeace response to written consultation, December 2004

While we do not advocate any particular methods, we do feel that certain principles can be applied to any public engagement exercise. **We support the Principles for Public Dialogue on Science and Technology recently published by Government[45]. We also agree with the four conditions suggested above by Greenpeace in their response to our consultation.** In particular, we agree that public engagement should only be undertaken if there is a willingness to accept and adapt to its outcomes in some way. Research funders should say in advance how they plan to use the results of engagement, and should document clearly how the results have influenced them. Our own experience is that results need to be critically evaluated by their sponsor, and used as a starting point for further internal reflection.

We agree that public engagement should supplement, rather than substitute for institutional decision-making. It is also clear that standard consultation documents and similar processes cannot be labelled as public engagement simply by making them open to anyone. Genuine engagement requires a more active approach, and also benefits from an opportunity for participants to frame the issues being discussed, rather than simply responding to preconceived questions. As discussed below, public participants in our engagement exercise felt that they would need the time to become properly informed to enable them to participate effectively (see 3.11). All this can be expensive, and adequate funds need to be made available.

One point that emerged strongly from our consultation was a feeling that public engagement should be organised to avoid domination by specific groups or stakeholders. We agree. Participants in public engagement exercises should be as broadly representative as possible, and selected so as to avoid bias or domination by campaigning groups from any sector, from environmental organisations to farming unions and industry associations. **In short, public engagement should be distinct from stakeholder engagement.**

3.9.3 Upstream or downstream?

"In order to engage upstream, we believe that early identification of issues is important and we are evolving our consultation processes to help the scientific community to be more reflective about potential applications, social impact and misuse of research. ...However, long-term some of the most important implications may come from the growing awareness amongst the research community of the need to account credibly for public money spent on research and of the benefits that can arise from constructive engaging with the public on issues associated with the research, and the increased mutual understanding between research funders."
BBSRC response to written consultation, December 2004

The question of at what level of decision-making public engagement is most appropriate is an important one. The Government has recently thrown its backing behind "upstream" engagement, that is early on in the

[45] *Annex B of HM Government (2005) Response to the Royal Society and Royal Academy of Engineering report: "Nanoscience and nanotechnologies: opportunities and uncertainties".*

scientific and technological development process[46]. Participants in the AEBC's engagement exercise were most in favour of upstream engagement, including on very high-level strategic issues to do with where we want science and technology to take us in the future. Downstream levels, including individual grant applications, were felt to be more for specialists, although some sort of public engagement was not ruled out. See Annex 2 for the AEBC's interpretation of the spectrum of upstream to downstream engagement in the context of research agenda setting.

"The public should determine the strategic aims of research... it's extremely difficult to put modern technologies and theories into words that laymen can understand at a sufficient level to approve whether or not to grant money to that research. What is more necessary is to determine in what direction you want that research to go"

"The public should be involved in this and are already involved because if you're looking in that distance those are not just scientific issues, they are political issues as well, by definition"
both Engagement exercise (Stage 3)

We believe that the case for engagement is strongest at the upstream or strategic level. This is because the strategic decisions taken early on impact at all later levels, down to awarding individual grants and the exploitation of new technologies.We also feel, as supported by the above quotes, that public input is most obviously valid on the issues of what society wants from science and what directions it should go in, and this is the level where lack of scientific expertise is least problematic.

However, upstream engagement should not preclude involving citizens at later stages, and we see a strong case for more downstream engagement. Public involvement is most contentious at the level of grant-awarding committees, because of concerns about possible detrimental effects on science quality and the over-riding importance of scientific excellence. The opinions of AEBC members differ here and, on balance, we believe that research is needed on the potential for public engagement in grant-making decisions before a considered view can be taken.

Recommendation 9: *All public sector research funders and advisory groups should use validated methods of public engagement or dialogue to supplement their high-level, strategic decision-making. Funders should say in advance how they plan to use the results of engagement, and should document clearly how the results have influenced them. The approaches used should preclude undue domination by any one interest. Engagement should not be passive, but should actively seek out opinion and should also allow participants to frame the issues being discussed.*

3.10 Stakeholder engagement

"I think it's a good idea to have a representative from lots of different backgrounds to try to give more of an unbiased kind of viewpoint"
Engagement exercise (public, Bristol Stage 2)

"Most of the things they'll be deciding on have to do with farmers...yet they don't know how it affects farmers unless they ask"
Engagement exercise (farmer, Stage 2)

A striking feature shaping the views of participants in our public and stakeholder engagement was a strong belief that everyone involved in research agendas, including charities, industry, scientists and Government, had vested interests, and nobody acted wholly in the public interest. As a result, people felt that having a balance of different interests on decision-making bodies would make them more likely to act for the common good and independently of individual agendas. Broad representation was seen as a more realistic alternative to truly independent representation. **We believe that the more diverse the input into research agenda setting, the more solid the outcome will be. As well as engaging the public, a full range of stakeholders should be involved.**

However, as discussed above, our examination of the composition of research decision-making committees in Research Councils and Government Departments indicates a prevalence of large commercial interests[47]. End user representation includes the private sector (mainly food industry, pharmaceutical and high-tech sectors, with a significant presence from the farming sector and agricultural industries) and, to a lesser extent charities and NGOs. Some responses to our consultation expressed concern about the poor range of stakeholder representation, particularly on Research Councils' committees, though there was a feeling that Government Departments were improving in this area. Examples of good practice include Defra's Sustainable Farming and Food Research Priorities Group and its Science Advisory Council, as well as the planned establishment of a similar Strategic Advisory Panel and an Independent Expert Advisory Board respectively for SEERAD's and DARDNI's research programmes.

We agree that stakeholder and end user involvement in decision-making is not as broad as it should be. For example, the needs of non-conventional, lower-input farming systems are under-represented on decision-making bodies. As with Recommendation 7 above, we feel that this issue extends to high-level bodies such as the Council for Science and Technology. **Because these committees are as far "upstream" as UK research agendas get, we also believe the responsibility for openness and public engagement must extend to these bodies.**

Recommendation 10: *From the highest-level scientific committees, including the Council for Science and Technology, to Research Council Strategy Boards and Government Departments' advisory panels, there is a need to enlarge membership to include those outside academia and industry.*

3.11 Science communication and informing the public

"Well the public can be informed. I think the scientists probably think that we can't learn about things and then have an opinion on it, whereas I think that's their opinion. I think we can and I think the public should be involved as long as they are informed"
Engagement exercise (public, Stage 3)

The public engagement model has found favour with science policy makers today and, at least in declarations of policy if not in practice, appears to be replacing the

[46] *Chapter 7 of HMT, DFES, DTI (2004) Science and Innovation Investment Framework 2004-2014.*
[47] *Table 6.1 of AEBC (2005) What shapes the research agenda? Information and Analysis Paper URN: 05/1082*

previous 'deficit' model, which held that increasing the public understanding of science would reduce public mistrust[48]. It is now recognised by many that simply informing people of scientific facts does not work.

However, this does not mean that efforts to improve the communication of science to non-scientists, and its understanding, should be neglected. Public participants in our engagement exercise were aware of and concerned about their lack of knowledge about science, and often pointed to deficiencies in school science education. **They recognised that if they were to be engaged in research agenda setting, they would benefit from being better informed**, perhaps requiring a long and iterative engagement process and careful facilitation. In addition, several participants told us how much they had enjoyed the opportunity to participate in our engagement exercise and think about how science is governed. This was encouraging, as in our initial planning of the exercise we were uncertain whether we would be able to engage participants on a topic like research agendas, which is so far removed from most people's day-to-day lives. **Although there was no time to explore it in depth, an idea began to emerge about a new type of citizen's duty, perhaps analogous to jury service, to participate in public engagement in science. We believe that this is a creative suggestion, which indicates people's underlying interest in science and scientific decision-making.**

Recommendation 11: *Given the enthusiasm and willingness to take part that we found in public participants in our engagement exercise, the Office of Science and Technology should explore the potential for promoting engagement in science and technology as an exercise in citizenship and an opportunity to better inform the public.*

"Papers and TV and everything like that will do anything to get a good story"
Engagement exercise (public, Perth Stage 1)

"Scientists are pretty inept sometimes at talking, and they do their best but they're not very good at it and so they get easily swamped by the media and knocked off course"
Engagement exercise (public, Stage 3)

"It can be quite stressful actually, when you get a call in the morning and it's someone saying I'm from the Sunday this... The other issue is it's not just the media's fault because often the media are going on press releases which are generated by the university press office."
Engagement exercise (scientist, Stage 3)

Public participants also returned again and again in discussion to the portrayal of science in the media, particularly on television, their primary source of scientific information. The trustworthiness of information is a key issue here. There was recognition that media coverage can sensationalise science stories and should not always be taken at face value, and a feeling that its presentation of conflicting views was often confusing or misleading. There was also a mistrust of the interpretation put on scientific information by Government.

Participants expressed a keen thirst for more digestible, balanced and trustworthy scientific information. They suggested a number of possible routes, such as monthly science news programmes and the use of trusted scientific TV personalities. Independent, public service broadcasting was considered important for making science more accessible to a wide audience. However, there was also a pragmatic recognition that public interest in science was, and would continue to be, limited.

Scientist participants acknowledged that communication was not seen as a key skill among scientists, except within their own peer group. In explanation, they pointed again to the scientific career structure, particularly the Research Assessment Exercise, and the lack of incentive to communicate with non-scientists. **We feel that problems with science communication are multifaceted and caused by a number of factors including scientific culture, campaigning media behaviour and deficiencies in school science education as well as in research organisations' public relations efforts[49].** While this area has not been a major focus of this workstream, the importance attached to it by participants in our engagement exercise leads us to make the following recommendation.

Recommendation 12: *Communication of science to non-scientists must not be neglected, although it is only one aspect of engagement and dialogue. The Office of Science and Technology should commission an independent review of the presentation of science and technology matters in the media, and of Government's role in this. It should develop a programme of work bringing together the media, scientists, public and other sectors of society to reflect on science communication.*

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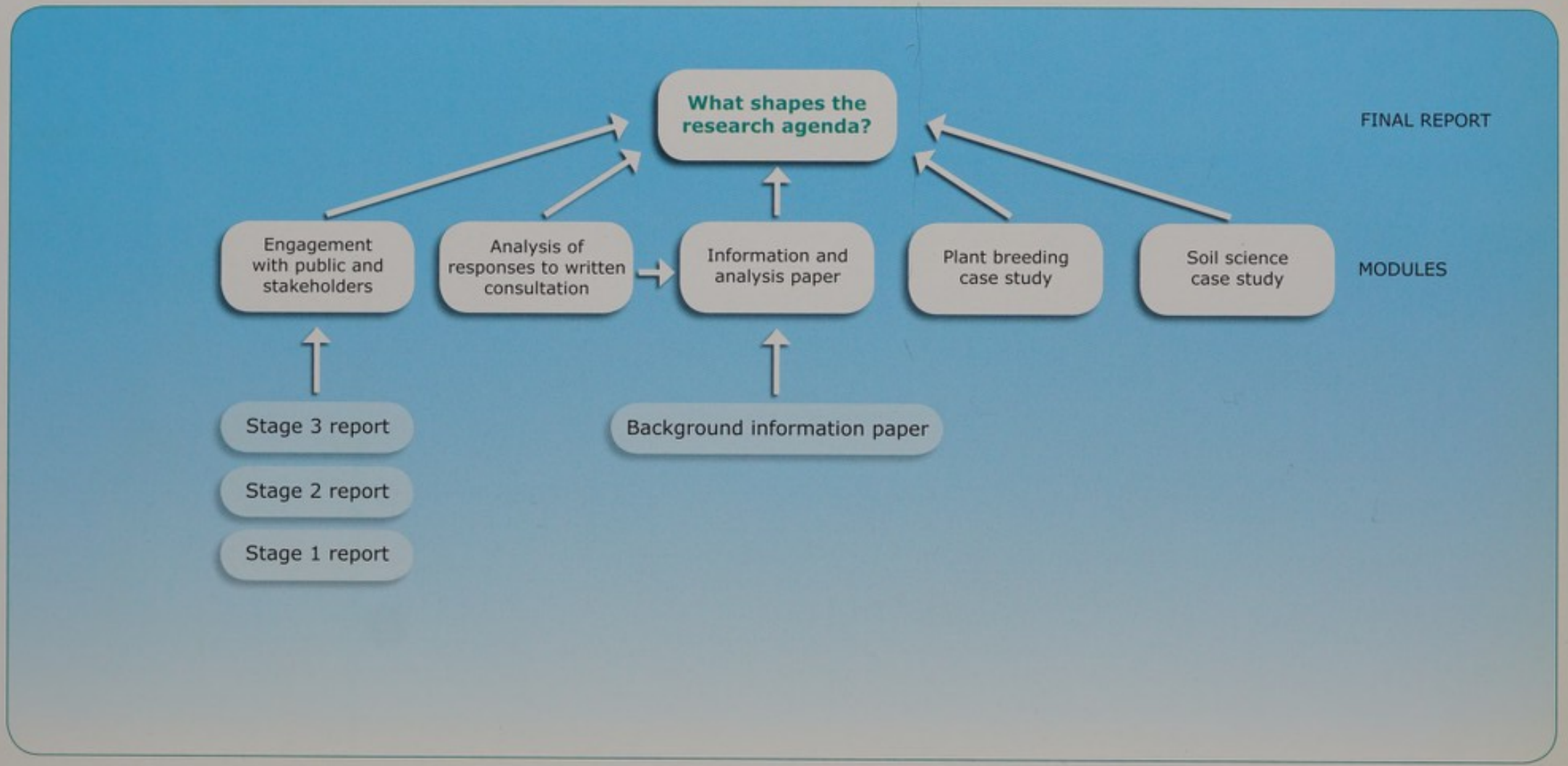
[48] *Professor Brian Wynne, of Lancaster University, has asserted that the failure of scientific and policy institutions to allow their own culture and assumptions to be questioned means that the supposed embracing of public engagement and dialogue is actually characterised more accurately by the continued reinvention of different deficit models. Wynne B (2005, forthcoming) Public Dialogue/Engagement as a means for Restoring Public Trust in Science - Hitting the Notes, but Missing the Music? Community Genetics (special issue), Karger AG, Basle.*

[49] *A study by Hargreaves and Ferguson of the University of Cardiff suggests that there is a mutual misunderstanding between all parties involved – the media, scientists and the public – and that this weakens society's ability to make progress through wise judgements about science. It points out that the internet and other communication technologies mean that the media can no longer be seen as a separate, identifiable group, and recommends further research in a number of areas including risk communication and "plain speech" translation of scientific language. Hargreaves I. & Ferguson G. (2000) Who's Misunderstanding Whom? Bridging the gulf of understanding between the public, the media and science', Report for the Economic and Social Research Council, Swindon.*

Annexes

Annex 1: Structure of modular output for AEBC work on agricultural biotechnology research agendas

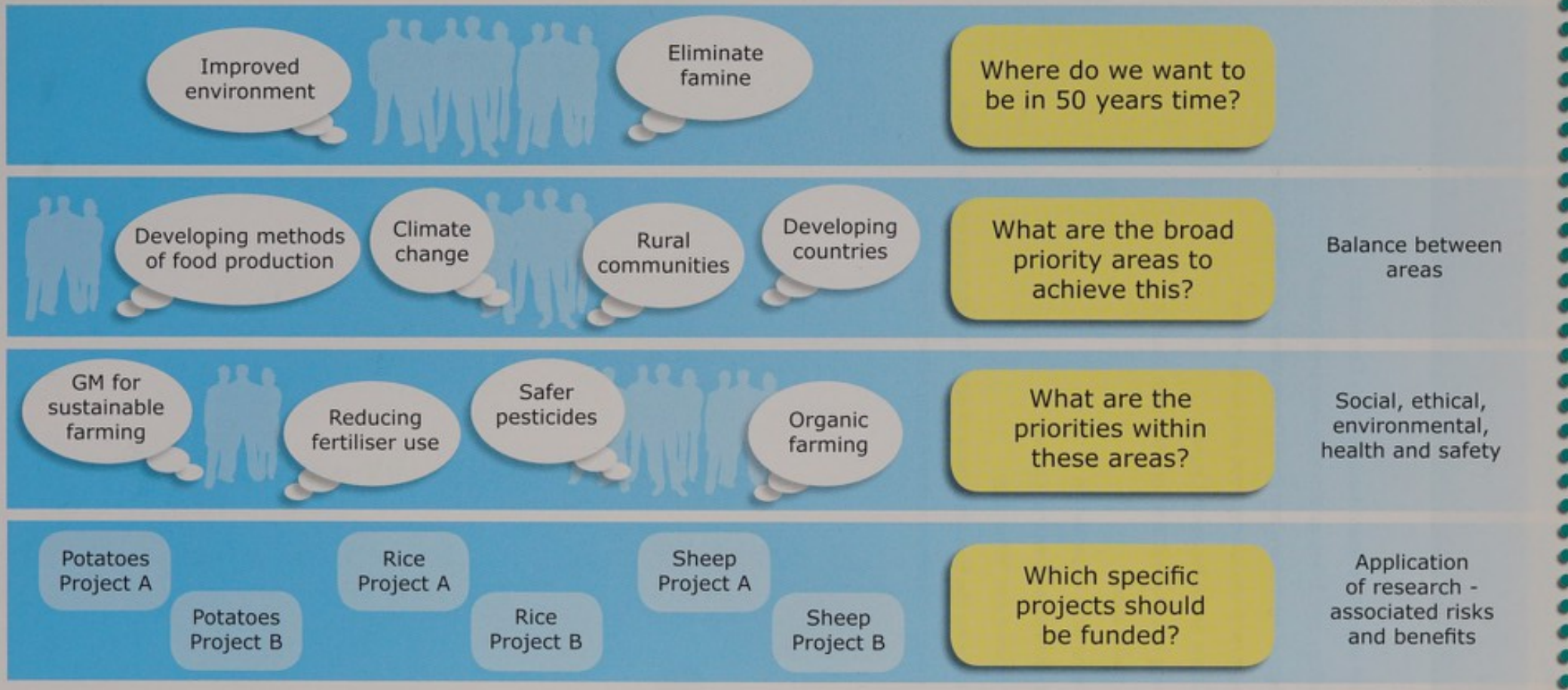


biotechnology commission
Agriculture and Environment Biotechnology Commission (AEBC)

Annex 2. Stimulus material used in public and stakeholder engagement exercise on upstream vs. downstream engagement

Get participants to think about...

Upstream



Downstream

Annex 3: List of acronyms

AEBC	Agriculture and Environment Biotechnology Commission
BBSRC	Biotechnology and Biological Sciences Research Council
DARDNI	Department of Agriculture and Rural Development Northern Ireland
Defra	Department for Environment, Food and Rural Affairs
ESRC	Economic and Social Research Council
EPSRC	Engineering and Physical Sciences Research Council
GM	Genetic modification
NGO	Non-Governmental Organisation
NERC	Natural Environment Research Council
OST	Office of Science and Technology
RSA	Royal Society for the Encouragement of Arts, Manufactures and Commerce
SEERAD	Scottish Executive Environment and Rural Affairs Department

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