

Royal Society response to the Defra consultation on *Evidence and Innovation Strategy 2005-08*

January 2006

This submission has been prepared in consultation with Royal Society Fellows and other scientists with expertise in areas relevant to the content of the consultation document. The Royal Society is the UK's independent national academy of science, promoting excellence in science, engineering and technology, both in the UK and internationally. The Society encourages public debate on key issues involving science, engineering and technology and the use of high quality scientific advice in policy-making. We therefore welcome the Department for Environment, Food and Rural Affairs' (Defra) invitation to comment on the Evidence and Innovation Strategy 2005-2008 consultation document. This strategy will provide an important framework for the delivery of research integral for the achievement of Defra's policy goals.

The Royal Society has chosen to respond to Part I of the document (the aims and introduction) and to selected strategic priorities from Part II. We have provided specific comments regarding the approach and content of the analysis for four of the six Strategic Priorities. These include: Strategic Priority: *Climate change and energy*; sections 5, 6 and 7, Strategic Priority: *Sustainable consumption and production*; sections 11 and 13, Strategic Priority: *Protecting the countryside and natural resource protection*; sections 17 and 18, and Strategic Priority: *Sustainable farming and food, including animal health and welfare*: section 20. All question numbering refers to the original numbering assigned in the Defra consultation document.

Summary

The consultation document's analytical approach involved the development of graphical summaries for each section resulting in a very long and complicated document. The quality of the analysis varies between sections with some providing a high level of detail and others providing much less. For some, the extent of Defra's responsibility is unclear and relevant work underway in other areas of government is at times poorly acknowledged. The Royal Society has concerns that priorities may have been inappropriately assigned, and research gaps may not have been identified. Research aimed at improving the evidence base and at providing innovative science has been separated. This may hinder the ability of Defra to meet its policy objectives and systems are required to ensure these are brought together in the crucial stages of research planning and development.

The Royal Society agrees that the delivery of Defra's strategic outcomes will be dependent on the involvement of social and opinion research, multidisciplinary analysis and assessment, and expert specialist support. More collaborative work with delivery bodies and agencies, other government departments, research delivery providers, the learned societies such as the Royal Society and the Royal Academy of Engineers, and other stakeholders will be essential.

Part I: General issues for consultation - developing Defra's approach to evidence and innovation

a) Defra's approach to evidence and innovation

Q. i) Please comment on our approach to identifying Defra's evidence and innovation needs in relation to our Strategic Outcomes, as set out in paragraphs 9-17 and the associated figures.

The majority of experts that contributed to our response found Defra's approach to identifying research evidence and innovation needs complicated and unclear. While Figure 1 (the evidence-based graphical summary, p 9) was conceptually useful, Figure 2 (modified evidence-based graphical summary, p10) was less intuitive and perhaps too simplistic to be of use in helping to provoke the required input.

While we recognise that the aim of this exercise was to inform the Defra Evidence and Innovation Strategy many of the sections were addressing cross-cutting issues for which other government departments and agencies also have responsibility. In some of the sections the scope of Defra responsibility was unclear (particularly in relation to the sections included within the Climate Change and Energy Strategic Priority). Consequently we may have identified gaps and suggested priorities for areas that are being addressed or fall within the responsibilities of other government departments (eg the Department for Trade and Industry (DTI)). Ideally it may have been more useful to develop a cross-government evidence and innovation strategy which identified research needs and other responsible government departments, and assigned responsibility and accountability as appropriate. This would have the benefit of reducing the risk of duplication of effort by departments and the development of conflicting research and policy priorities.

The use of graphical summaries for each section individually is useful for enabling a higher degree of specificity in identifying evidence and innovation gaps and priorities. However, the quality varied considerably between sections and where there was less detail provided it was difficult to establish exactly what work is being proposed and consequently gap identification and priority setting was problematic. This may mean that some of our responses have identified priorities that Defra were already planning but which were not apparent from the text or graphical summaries.

Furthermore, while there are clearly benefits of developing graphical summaries for each section in terms of the consultation document as a whole, this created a hugely onerous and complicated task for organisations and individuals who wished to respond, particularly if they wished to respond to more than one section. Given the overlaps between sections this was often necessary. Consequently the Royal Society has chosen to respond to only 9 of the sections, although we clearly have interests in all 24.

Some of our respondents voiced concerns about the way in which the analytical approach has separated the innovation and evidence research strands. We note the document justifies this on the basis of the need to consider needs and opportunities for major advances separately. However, our respondents were concerned that this separation could preclude and potentially hinder the evidence based approach from facilitating the identification of innovative solutions and that ultimately this could compromise Defra's ability to meet its research and policy objectives. Innovation will flow from research aimed at strengthening the evidence base (and vice versa) and it is important that systems are in place to capture and facilitate this process. We encourage Defra to consider putting in place systems for ensuring this.

Defra could, and should, exert some influence over research-led innovation through selective investment either on its own or in collaboration with others (eg Research Councils). Furthermore, one of the aims of the Defra Evidence and Innovation Strategy should be to provide guidance to ensure that investment in innovation is directed towards priority areas as identified as part of the strategic planning process.

Q. ii) Please comment on the implications of the generic changes in our needs and approach suggested in paragraph 17.

We agree with the analysis that Defra will increasingly require social and opinion research, multidisciplinary analysis and assessment, improved levels of evaluation, and broader expert support to deliver its Strategic Outcomes. We support Defra's commitment to involve social and economic scientists more in helping to meet its evidence and innovation needs.

A consequence of these changes is likely to be an increase in broader stakeholder expectation in relation to improved opportunities for involvement, dialogue and influence and also in terms of policy delivery. It is important that Defra is able to manage these expectations while retaining a sufficient level of engagement. Understanding the financial and political implications of these changes for Defra will be important.

b) Facilitating better joint working

Q. i) Is the material provided under each of Defra's Strategic Outcomes (in particular, the graphical summaries) sufficient and appropriate to enable other funders to engage effectively in joint planning and strategy work on evidence and innovation?

As stated in our response to Q1 in Part I it would have been helpful for the information on strategic outcomes to indicate where appropriate responsibilities fall across government. For example, the strategic priority relating to climate change and energy made no reference to the UK Government Energy White Paper presumably because this was led by DTI. However, some of our respondents were concerned that the evidence and innovation priorities identified within the DTI process were not reflected in the Defra document (eg hydrogen and carbon abatement technologies). Taking into account the differences in remit between the two departments, we would still expect work undertaken by Defra to support and complement priorities identified by DTI.

The utility of the graphical summaries varies depending on the section. For example the graphical summaries relating to *Strategic Priority: Protecting the countryside and natural resource protection, Section 14: Protect and enhance the natural environment*, is very detailed. In contrast the graphical summaries relating to *Section 13: Chemicals/Nanotechnology* is very general. On the basis of what is identified in section 13 it would be difficult for other funders or research providers to identify what work Defra was undertaking in this area and consequently to plan to engage either at a strategic or operational level. The same is true of *Section 11: Sustainable Production and Consumption (decoupling)* which is also very general.

c) Links with Defra's delivery bodies and statutory agencies

Q. i) What do you see as the key issues, barriers and opportunities for improved joint working between core Defra and delivery bodies on research and other evidence and innovation activities?

Defra has at its disposal a wide variety of non-departmental government bodies, and other independent advisory organisations that have been established specifically to provide advice to Defra. We agree that it is important these are utilised in formulating and implementing research evidence and innovation needs. We were therefore surprised to see that the work undertaken by the UK Sustainable Development Commission, particularly in terms of sustainable consumption and production is not reflected in this document, most notably in Section 11 *Sustainable consumption and production*.

Q. ii) Do you agree that we should aim to produce in the future a combined evidence and innovation strategy for the Defra family? How do you see this being developed? What might be the advantages and disadvantages?

We agree with the proposal to develop a combined approach for the Defra family (the core department, delivery bodies and non-departmental government bodies), but encourage Defra to think more widely than this and include other government departments and agencies with related or overlapping responsibilities. The current structure of the consultation document provides a good model for the future development of a combined approach, however, it could be improved by identifying those sections which are cross-cutting, and those which are sectorally based. It is important to be able to identify overlaps between sections to enable cross-fertilisation of ideas and reduce duplication of effort and resourcing. Similarly, innovation can result from bringing different sectors and/or specialists together and any new strategy should aim to facilitate this kind of interaction.

e) Engaging with other Government Departments and the Devolved Administrations

Q. i) What is the scope for better cross-departmental evidence and innovation activities? How does our analysis help engage other departments and the devolved administrations?

The analysis is at times poor at identifying other departments and devolved administrations with direct (or indirect) responsibilities in policy areas. For example; the sections dealing with climate change and energy include very little reference to the work underway at DTI or Department for Transport, and include almost no information relating to work in the government agencies (particularly the Joint Nature Conservation Committee and English Nature). As mentioned in our response to question b.i. (in Part I) these gaps, and the variable level of detail included in each section, made it difficult for respondents to know whether apparent gaps were real or rather a reflection of the less detailed nature of that section.

f) International co-ordination and influencing

Q. i) In the different Strategic Outcome areas, where should Defra put the overall balance of effort in its Evidence and Innovation Strategy between engaging at the international level and the domestic level?

The UK Government prides itself on leading by example in terms of environmental and sustainable development policy, particularly in relation to climate change. However, the UK also has a lot to learn from other international partners, for example in terms of research in some sectors (eg radioactive substances) and policy development (eg in biodiversity protection). For this reason the UK should place equal weight on engaging at the international and domestic level.

Q. ii) What issues, opportunities and barriers do you see as especially relevant to Defra in developing evidence and innovation internationally in support of its sustainable development and environmental leadership goals?

Defra should make more use of non-government experts at international meetings, particularly where input is required in scientific or technical matters. The Royal Society would be happy to nominate suitable individuals.

Part II Evidence and Innovation needs by strategic outcome and related policy areas:

Strategic Priority: Climate change and Energy

Strategic approach to Evidence and Innovation

Many of our respondents commented on the approach taken in the strategy to identify Defra's evidence and innovation needs. These are reflected in our response to Part I of the consultation document.

Particular concerns were raised in relation to Section 5: *Reduction in UK's greenhouse gas emissions*. The consultation document treats the processes of evidence gathering and innovation identification separately when in reality the two are closely linked. Concerns were raised that this separation will preclude, and possibly even hinder, research aimed at improving the evidence base from facilitating the identification of possibly innovative and revolutionary solutions to tackling problems, in this case, in relation to carbon dioxide emission reduction and air quality improvement. The approach taken by the DTI to providing the context for the UK hydrogen energy debate (E4tech *et al* 2004) and in defining a strategic framework for hydrogen energy development (Eoin Lees Energy *et al* 2004) was identified as a good example for facilitating the identification of research, development and policy priorities, and one that Defra might like to consider as part of this process.

Interdepartmental cooperation

As previously stated we are disappointed that the Climate Change and Energy Strategic Priority does not refer to the UK Energy White Paper or reflect its priorities. While we acknowledge that the role of the consultation document is to identify Defra's priorities, the Energy White Paper is a key document that should form a more explicit part of the basis for the identification of evidence and innovation priorities.

Ocean Acidification

We acknowledge and support the high profile given by Defra to climate change in the consultation document. However, we are concerned and disappointed to note that the related issue of ocean acidification is not mentioned. Climate change is one of the major consequences of excessive CO₂ production, ocean acidification is the other. The two are closely interlinked with physical feedback systems and for this reason any action aimed at climate change must also consider ocean acidification.

We recommend that the evidence and innovation priorities identified in the consultation document be updated to reflect the content of our report on ocean acidification (Royal Society 2005a), particularly Sections 3, 5-7, 14 and 17 of the strategy. A copy of our report is attached for your information.

Freshwater conservation and supply

This strategic priority has a clear overlap with Strategic Priority: *Protecting the countryside and natural resource protection* which includes protection and access to the natural environment, and water quality. Although, the water quality section considers the issue of water supply and sustainable resource provision there is no mention of the changing demands for water likely to occur as a result of climate change. Similarly, within the six sections considered as part of the climate change and energy strategic priority there is no mention of the need to look at the research required to understand and manage issues relating to water supply. It is important that the Defra divisions working on sustainable development, climate change, sustainable production and consumption, natural resource protection, sustainable rural communities, and sustainable farming and food, work in an integrated fashion to ensure the broad range of research needed into freshwater conservation and supply are met.

Section 5: "Reduction in UK's greenhouse gas emissions"**Q.5.1 In the summary charts of evidence and innovation need, are there major missing items (eg key areas of uncertainty, opportunities for innovation) or any erroneous ones?**

This section is very vague in terms of the innovation priorities specified and our respondents were concerned that the correct priorities had not been identified. We would expect the priorities to include the identification of measures and policies that enable emerging low carbon technologies (such as renewables, material alternatives to fossil fuels, new energy efficiency technologies, hydrogen related technologies and carbon abatement technologies) to demonstrate their potential.

Major missing items not included within the areas of work identified include:

Marine environment

The sectoral activities proposed in this section are primarily land based and do not mention the marine environment. Oceans play a fundamental role in CO₂ exchange (Royal Society 2005a) and this must be recognised and reflected in Defra's (and the rest of UK Government's) work on climate change including policy development, mitigation and adaptation activity. For example, understanding of the effects of mitigation and adaptation activities on marine and coastal systems and human activities will be required. Similarly, investment in ocean acidification research (observational, experimental and modelling) is needed and should be linked to existing UK global change modelling activity (Royal Society 2005a).

Fiscal instruments

The Royal Society has identified well designed economic instruments as the most cost-efficient way to reduce CO₂ emissions (Royal Society 2000a, 2002a) and as the single most important factor controlling the sustainable growth of renewable technologies (Royal Society 2005b). However, we note that the development of innovative market based instruments for this purpose is identified only in the transport part of this section. We suggest that work in this area could benefit all of those sectors identified and encourage Defra to invest in identifying novel approaches to the use of fiscal instruments for the purposes of meeting the climate change challenge. Similarly, we note the intention to undertake research into understanding the impacts of market-based instruments in relation to households. This research should be extended to all of the sectors identified in this section.

We note that Defra is intending to "*undertake work to develop energy-efficiency technology cost curves that identify technical costs as well as economic and hidden costs*" in each of the sectors. Cost identification is important, however it is also important to identify and quantify the benefits of energy efficiency technology (and other activity) and we encourage Defra to expand this area of work.

Regulatory evaluation

The assessment of the impact of new regulations and policy measures is important both in terms of understanding the effectiveness of the measures, but also for justifying the development of future measures. While the energy supply, households, transport and public sector parts of this section suggest this work will be done in some form or another, it is important for the evaluation to extend beyond the immediate sector to other related areas to evaluate the positive and negative effects of the measure. This post-implementation evaluation should be a core component of all of the policy areas.

Energy Supply (Figure 5)

In relation to the evidence needs of the energy supply issue, the statement "*Information on how renewable energy sources are used in the energy supply*" is very vague and it is unclear what work is planned. Specific evidence needs that we would like to see addressed include: the collection of data from existing sources on the total annual electricity generation from the different renewable energy sources, the collection of annual operational data to determine the overall contribution and efficiency of combined heat and power installations, and an assessment of the public perception and effectiveness of the domestic home insulation programme.

In relation to the innovation needs of this issue, aside from a vague statement relating to transport there is no mention of research into the use of renewables such as wind, wave, tidal, solar power, and, similarly, no mention of hydrogen and fuel cells. This is a serious oversight.

The energy supply priorities do not mention carbon abatement technologies which have the potential to deliver significant global reductions in carbon dioxide (see also point regarding forestry sinks below). One of the major focus points of Defra's activities in this area should be the development of policy measures and technologies that would encourage and facilitate the use of carbon capture and storage and other carbon abatement technologies in the UK.

Agriculture, forestry and land (Figure 5)

The innovation priorities identified here include the analysis of information on the development of biofuels and energy crops. There is no mention of the forestry sector in terms of the potential for the use of forestry timber as a sustainable resource (in place of materials that require fossil fuels in the manufacturing process or which produce CO₂), as a biofuel, or the potential for the use of carbon sinks through forestry (or other forms of agriculture). There is still uncertainty in the scientific understanding of the causes, magnitude and permanence of the land carbon sink, and the potential to enhance the land carbon sink through changes in land management practice (Royal Society 2001a, 2005b). Defra should be seeking to advance this knowledge and to modify the methods of forest and agricultural crop production to reflect their potential role. This recommendation is relevant also to section 21 *CAP Reform*. In particular, research is required into the interactions between vegetation, soils and climate to improve the accuracy of projections of future climate change, and the permanence of the land carbon sink (Royal Society 2001a).

Q.5.iii How should major gaps in evidence and innovation be filled?

Although Defra is the responsible government department for climate change it is not necessary or appropriate for Defra to be responsible for undertaking all of the required work. However, Defra should provide a long-term, forward thinking strategic framework to guide research and policy development in the UK, and this should encompass all government departments and agencies whose activities are likely to have a direct or indirect impact on climate change. We hope that the UK Climate Change Programme Review will deliver this framework and encourage Defra to take a firm, proactive and innovative approach to tackling the challenge.

The gaps we have identified, for example in terms of ocean acidification, could be partly filled through closer collaboration between Defra and the Natural Environment Research Council (NERC) (and its centres, surveys and collaborative laboratories), through improved inter-departmental coordination and collaboration (eg DTI, and Defra) in terms of setting policy targets, and identifying research evidence and innovation needs. Similarly, greater collaboration between the UK and international partners in facilitating research is required.

Q.5.v What are the most important requirements in evidence and innovation needed to achieve the overall objectives of a reduction in UK global greenhouse gas emissions? Please list up to a maximum of 10.

An improved understanding of biological systems and their role in the carbon-climate cycle is a top priority. In particular the importance of oceanic and terrestrial carbon sinks and consequent biological impacts of changing greenhouse gas concentrations require further investigation.

Q.5.vi How could Defra work more effectively with your organisation and other key climate change partners to strengthen evidence-gathering and innovation?

The UK government has in the past made limited use of the expertise within relevant non-government institutions working in this area. We encourage Defra to engage more proactively with the learned societies such as the Royal Society and the Royal Academy of Engineers and also with the Universities.

Q.5.viii What further work can be done to raise public awareness of climate change in the UK and what contributions can your organisation make towards this?

Our response to this question is relevant to all of the climate change related sections we have chosen to respond to (sections 6 and 7).

The emphasis of the Royal Society has been on demonstrating that there is scientific consensus on the climate change phenomenon in terms of the causes and impacts. We have been active in promoting climate change as an issue of sufficient concern to warrant coordinated international action and have facilitated joint international action by bringing the best scientists together to evaluate and direct research into climate change and facilitating and encouraging capacity building in developing countries. We have tried to ensure that the best scientific information is available to decision makers on the international and national stage, while at the same time have gone to significant effort to ensure that this information is accessible to the public.

The widely-held perception that climate change is a future problem and not one that is going to affect business, or general members of the public in the short term is a major issue and a significant barrier to achieving progress on the climate change issue. Defra must develop an innovative approach to communication and must translate the expected impacts into terms that individuals will understand and relate to. We hope that the Defra climate change communication initiative launched in late 2005 will go some way to achieving this.

Section 6: International Action to tackle climate change

Q.6.i. In the summary charts of evidence and innovation need, are there are major missing items (eg key areas of uncertainty, opportunities for innovation) or any erroneous ones?

International Cooperation to improve the scientific assessment of climate change (Figure 6)

As stated previously it is disappointing that the evidence and innovation priorities in this section do not include research priorities related to ocean acidification. This is an area where international collaboration in the collection and analysis of relevant data is particularly important. International collaboration is essential for getting a better understanding of the role of the oceans in CO₂ exchange, the potential impacts of increases in greenhouse gas emissions on marine systems, informing the development of adaptation strategies and in terms of potentially providing alternative mitigation solutions to those currently under consideration. Ocean acidification is likely to result in significant socio-economic impacts, which may fall disproportionately to developing countries. These impacts need to be understood and factored into planning and management programmes.

Q.6.ii Where should the emphasis of evidence and innovation investment by Defra be put (including sun-setting)?

Our respondents did not agree that Defra is adequately funding the work on *“improvement of our understanding of the patterns of climate change and climate-driven changes in developing countries”*. The Royal Society recommends that emphasis be placed on mobilisation and coordination of UK expertise to focus on developing countries (particularly Africa) in conjunction with developing country scientists and the development community (Royal Society 2005c). For example, the development of innovative solutions and adaptive strategies that deliver long-term, sustainable livelihoods for rural Africa are essential and should be delivered within a framework that promotes capacity building within Africa (Slingo *et al* 2005). As the department responsible for climate change policy, Defra should be working with the Department for International Development (DFID) to establish climate change centres of excellence in the developing world.

Q.6.iii How should we approach gaps where Defra has no current mechanism or intelligent customer capability (eg policy piloting; social science capability)?

Defra must utilise existing national and international networks. For example this section makes no mention of the International Geosphere and Biosphere Programme (IGBP¹) for which the Royal Society hosts the national committee. This programme studies the interactions between biological, chemical and physical processes and human systems and collaborates with other programmes to develop the understanding necessary to respond to global change.

The UK should continue to play a major role in the Intergovernmental Panel on Climate Change (IPCC) and should support the participation of UK scientists as appropriate.

Q.6.v How could Defra work more effectively with your organisation to strengthen evidence gathering and innovation?

The Royal Society is happy to work with Defra to help strengthen the evidence and innovation strategy and its implementation. It is important to ensure terms of reference are well defined at the outset of the research contracting process and that the right questions are being asked. Similarly, independent scientific peer review is essential. We are willing to provide relevant experts for these purposes.

Q.6.vi How can the UK improve its influence with key climate change partners?

The UK must lead by example in terms of reducing greenhouse gas emissions and investing in research and technology. This must extend beyond mitigation to adaptation and must include those sectors that to date have received inadequate attention (for example the transport sector, the finance sector and households).

In addition the UK should act proactively to facilitate information exchange, capacity building and technology transfer in developing countries.

¹ <http://www.igpb.kva.se/cgi-bin/php/frameset.php>

Section 7: UK adaptation to unavoidable climate change

There is no mention in this document of the need for innovation in the development and implementation of adaptation techniques, this is despite the statement in the Defra document that there is considerable scope for innovation in the adaptation area. For example; new regulatory approaches are required to cope with the specific challenges of climate change, ie frameworks that are long-term but flexible to enable modification with changing circumstances and new evidence. Similarly, new technologies may be required for enabling adaptation (for example, innovative technologies may be useful for facilitating species movements within ecological networks).

There are clearly overlaps between this section and those included within the Sustainable Farming and Food Strategic Priority (in particular Section 20 *Sustainable farming and food*). Consequently we refer you to the comments we have made in our response to Section 20 (see Questions 20.i.-20.vi).

We note that Defra is currently consulting on the first phase of a National Adaptation Policy Framework. We expect that the results of this work will be used to identify the evidence and innovation priorities for UK climate change adaptation activity.

Q. 7.i In the summary charts of summary of evidence and innovation need, are there any major missing items (eg key areas of uncertainty opportunities for innovation) or any erroneous ones?

Improved understanding and awareness of the expected impacts of climate change in the UK (Figure 7)

The work identified in the summary chart does not reflect the need for basic research to enhance our knowledge and understanding of the physical and ecological systems that underpin a healthy environment. This is particularly important in relation to climate change and adaptation because in order to adapt we must know what is likely to be affected and what the likely impacts are going to be.

In addition to the evidence based priorities for this area of work, research is required into the non-linear feedbacks between climate change and its impacts. It is important to gain a better understanding of these feedbacks in order to inform research aimed at characterising the uncertainties and variability associated with current climate change science.

Coordination of existing adaptation activities and strengthening and promotion of new activities and options (Figure 7)

The evidence and innovation needs identified here are very general. It is assumed that it is intended that the work outlined will be undertaken for all sectors. However, we encourage Defra to develop an integrated approach to adaptation to ensure that sectoral approaches are mutually supportive. For example it is important that transport and energy adaptation strategies are developed in a way that does not compromise biodiversity objectives.

Q.7.v. How could Defra work more effectively with your organisation to strengthen evidence gathering and innovation?

Please refer to our response to question 6.v.

Q.7.vii What further work can be done to raise the public awareness of adapting to climate change and what contributions can your organisation make towards this?

Please refer to our response to question 5. viii.

Strategic priority – Sustainable Consumption and Production

Section 11: Sustainable Consumption and Production (decoupling)

We are pleased that Defra has identified sustainable consumption and production (SCP) as a priority cross-cutting issue and support the approach proposed in this section. SCP is important for all of the sectors addressed in the consultation document and we therefore encourage Defra to include SCP evidence and innovation priorities in each.

We were surprised to see that neither the text nor the graphical summaries mentioned the UK Sustainable Development Commission (SDC) or the associated UK Sustainable Consumption Roundtable. The SDC is the Government's independent advisory body for sustainable development and although it is independent of Government it is meant to inform Government policy. Consequently we would have expected the work they have completed to be reflected here.

Overall, this section was very weak in terms of attention to the economic dimension of sustainable production and consumption. We acknowledge that the "*sustainable production*" category identifies the need for the evaluation of costs and benefits of market intervention mechanisms and the use of regulation and economic instruments to stimulate and enable more competitive business. However, this work is required across the board in sustainable production and consumption and should not be confined to the business sector. Furthermore, research and analysis into the economic costs and benefits of sustainable consumption and/or production is required to help build the evidence base for encouraging decision makers to build SCP into policy. For example; this approach could be particularly useful in terms of the fisheries sector and encouraging behavioural change of both producers and consumers.

Finally, the international dimension of SCP is very poorly dealt with in the document. Improved understanding is required of the economic, environmental and social impacts of UK consumption and production internationally. This information is required, for example if foot-printing analysis (the calculation of the physical resources and environmental services required to support current standards of living) is to reach its full potential.

Q.11.i How can the SCP Programme most quickly and efficiently draw relevant information from the existing research base and establish genuine gaps in knowledge?

We support Defra's proposal to place an emphasis on literature review and the collation of existing information before initiating more primary research.

In terms of drawing relevant information from the existing research base we suggest Defra considers undertaking the following:

- Development of a list of relevant topics or sub-topics under the SCP label, and the construction of a framework for information collection and categorisation;
- Search, categorisation and review of existing SCP-related existing research publications;
- Development of a network of experts who are actively involved in research in this and other related fields.

In terms of establishing knowledge gaps we recommend that Defra uses the framework developed above as the basis for a gap analysis. The aim should be to develop a strategic framework to guide research effort and ensure identification of the key players and key research priorities over the short to medium term. This work should complement that of the UK Sustainable Consumption Roundtable (due to report in March 2006) and should evaluate the concept of sustainable production and how it relates to other concepts such as full life-cycle analysis and integrated product policy. It should investigate what the interlinkages are (if any) between sustainable consumption and sustainable production and identify opportunities for the development of mutually supportive policies. In addition, Defra should consider the sponsorship of existing research programmes in the sustainable production and consumption area. This should have a focus on bringing together academic and other research sector programmes across the UK.

Our respondents identified a need for UK government to provide more support for SPC related work within the research sector. For example it was suggested that Defra should consider the establishment of research institutes or centres focused on SPC research, and that they should work closely with universities to develop courses on SPC topics. Similarly, it was suggested that Defra could forge closer links with the academic sector to help foster a dialogue regarding research needs.

Q.11.ii What areas of identified evidence and innovation need for SCP seem likely to be genuine gaps? Are key evidence needs for SCP workstreams or for the Programme as a whole currently missing?

We welcome the establishment of the SCP Evidence Advisory Group and encourage Defra to consider expanding the remit of the group to enable it to consider innovation needs.

Sustainable Consumption (Figure 11)

The evidence and innovation categories identified in the diagram are logical although the sustainable consumption dimension of the diagram is lacking detail. This may be a reflection of the fact that sustainable consumption is being managed as part of the sustainable consumption round-table process. However if this is so, this work should be reflected in the diagram to inform respondents.

Sustainable Procurement (Figure 11)

Sustainable procurement is an important tool however it is important that efforts are made to ensure sustainable procurement initiatives are credible and transparent. Further effort could be placed on the development of certification and other labelling systems. The development and instigation of monitoring and reporting processes is also important but is not mentioned in the document. Furthermore, the emphasis of this category appears to be on the public sector. We recommend that this be extended to include the activity of consumers and the private sector.

Q.11.iv How can the capacity of the research community be built up to meet the needs of SCP evidence development? Is there potential to broaden or reshape existing programmes to support SCP?

As indicated previously, improved co-ordination and communication between UK Government and the research community would help to improve capacity in UK SCP evidence and innovation development. The development of a strategic research framework for SCP would help to ensure the research needs in this area are met. Such a framework should provide for the involvement of academic associations and other research bodies.

Section 13: Chemicals and nanotechnology

Significant concerns were raised by our respondents in relation to this section and it was recommended that it be revised to reflect both the conclusions of the joint Royal Society and Royal Academy of Engineering report on nanotechnologies that outlines research priorities (Royal Society 2004a), and the more recent Defra nanoparticles research report (Defra 2005a). Furthermore, it was recommended that this section would benefit from a review of the issues, ie legislative controls and possibly unregulated risks that chemicals and products from nanotechnologies pose to the environment. This would enable scientists and socio-economic specialists to identify in more detail the evidence and innovation needs.

Q.13.i. Where are there missing areas of evidence and innovation need (eg key areas of uncertainty; opportunities for innovation) or erroneous ones (lines of argument which are untested or untenable)?

Chemicals (Figure 13)

The evidence and innovation priorities identified here are so general that it is difficult to know what Defra is intending to do. For example, research into developing policies to address sustainable production and consumption of chemicals is very broad and could (indeed should) cover research into consumer behaviour, full life cycle analysis of chemicals, products and manufacturing processes, the regulatory frameworks, corporate social responsibility (eg manufacturer and retailer), development of market based instruments and other positive incentive systems. Concerns were raised that the emphasis of this work appears to be on industrial chemicals with some question regarding how household chemicals are captured within this process in terms of identification of scientific but also regulatory gaps. Analysis is required in evaluating the drivers of chemical impacts on the environment and whether these arise as a result of regulated or unregulated use and whether this varies between industrial and home use chemicals.

In its report on Endocrine Disrupting Chemicals the Royal Society (Royal Society 2000b) recommended that further research was required into identifying chemicals with endocrine disrupting properties, the interactions between these chemicals, the longevity and action of these chemicals in the environment, the levels of exposure of humans and wildlife to these chemicals, and the levels at which chemicals are likely to cause adverse effects.

Nanotechnology (Figure 13)

We were surprised and somewhat disappointed to find no mention of the joint Royal Society and Royal Academy of Engineering report (Royal Society 2004a) in this section. In this report (commissioned by the UK Government) we identified a number of recommendations about research needs and regulation of relevance to the evidence and innovation strategy. A copy is included for your information. We recognise that Defra has also recently published a report outlining nanoparticle research priorities (Defra 2005) and trust that the evidence and innovation strategy will be updated to reflect these.

We (along with the Royal Academy of Engineering) welcomed the publication of the Defra nanoparticle research programme and were pleased to see that it addressed many of our recommendations. However, we have concerns regarding the proposed funding arrangements and would like to see more funding earmarked for addressing the uncertainties associated with the human health and environmental impacts of nanotechnologies. Similarly, we would like to see the programme contain specific mechanisms for facilitating collaboration between UK Industry and Government. We therefore encourage Defra as part of the evidence and innovation strategy process to develop a strategic approach to the development of a programme aimed at investigating the potential health and environmental risks associated with nanoparticles. This should include a dedicated funding programme, and a targeted programme aimed at facilitating collaboration between Government and industry to develop safety testing of public dialogue activities and encouraging international collaboration.

Q.13.ii Where should the emphasis of evidence and innovation investment by Defra be put (including sun-setting)?

In terms of the sustainable production and consumption of chemicals the emphasis of Defra's investment should be placed on:

- A comprehensive review of the issues around chemical use and impacts to human health and the environment, including an analysis of the regulatory framework and the influence this has on relative risk.
- Improving understanding of the individual and additive effects of chemicals in the environment on human health and wildlife.
- Investigating methods for improving the sustainable production and consumption of chemicals (and related products).
- Development of innovative solutions for mitigating or avoiding these effects.
- Development of innovative approaches to communicating risks to consumers and engaging stakeholders.
- Development of innovative methods for reducing the need to use animals for testing effects of chemicals.

Defra's emphasis in terms of investment in nanotechnologies should be placed on achieving the research objectives outlined in the Defra report (Defra 2005a) by:

- Provision of a strategically focused funding framework sufficient to implement the recommendations of the report with funding earmarked to build capacity.
- Implementation of mechanisms to facilitate collaboration between UK Government Departments and Industry nationally and internationally.

Q.13.iii How should we approach gaps where Defra has no current mechanism or intelligent customer capability (eg policy piloting; social science capability)?

Improved collaboration between Defra, other government departments, industry and other research stakeholders at a national and international level would help Defra to fill the gaps identified. Where functions are best situated in other organisations the development of a strategic national framework and associated funding pool would facilitate appropriate capacity building.

Q.13.iv Where are there opportunities for greater co-ordination/collaboration/partnership with others to share and develop evidence? Where does this work best at the moment, and where are the best examples that we should look to?

We welcome the way in which Defra has worked across Government in the nanotechnology area and specifically in their preparation of the nanoparticle research report. It is unfortunate that this effort has not been reflected in the Defra Evidence and Innovation Strategy.

As already stated, improved collaboration between Defra and industry and internationally with other governments and multilateral organisations is essential if resources are to be used efficiently and to ensure the development of research priorities in appropriate directions without unnecessary duplication. We have previously recommended the creation of a UK Research Councils interdisciplinary centre, and note that this was one of the recommendations of our report (Royal Society 2004a) not accepted by Government. However, we believe that the creation of such a centre, aimed at undertaking research into toxicity, epidemiology, persistence and bioaccumulation of manufactured nanoparticles and nanotubes, work on exposure pathways and the development of measurement methods, is key to building capacity in this research area in the UK. It would also have the added benefit of improving coordination, collaboration and the facilitation of partnerships, both at the national and international level.

Strategic Priority: Protecting the countryside and nature resource protection

Section 17 - Sustainable Marine Environment

It was unfortunate that the web-links provided for the Sustainable Marine Environment and Marine Biodiversity Statements of Need were not accessible.

The way in which the categories have been divided in this section is curious and should be revised to facilitate a more ecosystem based approach to management in the marine environment. For example, whales should be considered within the broader marine biodiversity context. Arguably fisheries should be considered in the same way. The research activities indicated within the marine biodiversity conservation and sustainable marine fisheries categories are very similar and it is important that this work is integrated to achieve the same outcomes (ie clean, healthy, safe, productive and biologically diverse oceans (Defra 2002)). Furthermore, the UK marine policy framework must facilitate this integration through the development of mutually supportive outcome measures, monitoring and reporting requirements.

Q.17.i Where are there missing areas of evidence and innovation need (eg key areas of uncertainty; opportunities for innovation) or erroneous ones (lines of argument which are untested or untenable)?

Ocean Acidification

As noted in our response to the Climate Change and Energy Strategic Priority, we were disappointed and concerned to see that the issue of ocean acidification (Royal Society 2005a) was not mentioned in the strategy (please refer to our response provided to the climate change and energy strategic priority).

Marine and Freshwater management

We suggest that a new section be added to address the evidence and innovation needs of the freshwater sector. Currently freshwater priorities are addressed in terms of its fishery value (this section) and water quality (section 16). This ignores the other important biological and physical values (eg biodiversity) associated with the freshwater environment. We are extremely concerned by this oversight. The new section should be closely linked to sections 16 and 20 of the Defra strategy, and the sections relating to climate change, to ensure that the issues of water supply are integrated.

Sustainable Production and Consumption

The issue of sustainable production and consumption is of fundamental importance to the sustainable management of the marine environment, yet it is not mentioned anywhere within this section. The decoupling of economic growth from environmental degradation is particularly important in the marine environment, especially when considering the problems encountered in transforming the fishing industry within the UK and Europe, and when considering the environmental footprint of UK fisheries in developing countries and international waters. Significant work is required in terms of both evidence and innovation research for developing the sustainable production and consumption approach to marine policy.

Managing human activities (Figure 17)

The Royal Society has in the past concluded that precautionary management of UK marine resources is required due to poor understanding of marine ecosystems and the relatively unknown long term ecological impacts of fisheries and declining fish stocks (Royal Society 2003a). As part of the work to develop research priorities for improving the evidence base Defra should develop criteria and guidelines for application of a precautionary approach in the marine environment. This would complement the research proposed in relation to marine biodiversity conservation (see section below) by enabling regulatory decisions to be taken in the absence of robust scientific data while still providing for appropriate management of biodiversity.

One of the most obvious evidence gaps in this section is the absence of activity directed towards improving stakeholder engagement and communication. One of the most significant barriers to progress in achieving sustainable marine policy outcomes is the conflict between stakeholder groups. Social research is required to identify what these barriers are, why they exist and how they can be addressed. The research aimed at improving the evidence base must be part of a broader package of work aimed at informing and educating the various stakeholder groups and could be complemented by a programme of innovative measures aimed at making stakeholders responsible and accountable for the sustainable management of the marine environment.

Recreational marine activity is an important consideration in terms of managing the marine environment. Understanding the importance of recreational activity in terms of valuing a clean and healthy marine environment, and for understanding what pressures the range of activities might place on the marine environment is fundamental to the development of a coherent policy framework. There are significant research needs, for example, improving knowledge of recreational fish landings and bycatch and discard mortalities, contribution to marine pollution levels, understanding how marine recreational activity is valued by fishers, bathers, boat users.

In addition to the need for an enhanced understanding of ecosystems from a biological perspective there is a related need for an improved understanding of the ecosystem based approach in terms of delivering sustainable development objectives (as recommended by the Convention on Biological Diversity). Innovative research is required to develop approaches and tools for resolving conflicts between biological and economic considerations in fisheries management (Royal Society 1995). Similarly innovation is required for finding ways to integrate social, economic and environmental factors in ecosystem modelling. This will help to deliver models that are more applicable to the broader societal context.

Marine Biodiversity Conservation (Figure 17)

We note that Defra has identified work in *understanding ecosystem structure and function and the identification of key components*, and in *valuing marine biodiversity*. However, we would like to encourage Defra to bring these strands of work together to ensure that the valuation work reflects as far as possible both biodiversity and ecological values (social, environmental and economic). It is also important that the outcomes of this research are translated into policy relevant terms and fed directly into the policy process. This should include policy aimed at improving economic growth and social cohesion as well as improving environmental quality.

The Royal Society is supportive of work aimed at managing the marine environment within the ecosystem context. However, the underlying science of marine ecosystems is poorly developed, and we need a better understanding of fisheries recruitment, juvenile and adult interactions, competition within and between species and predator-prey interactions to be able to incorporate ecosystem information with management advice (Royal Society 2003a & b). While, in some systems we now have a reasonable knowledge of structure, functioning and resilience as separate features, our understanding of how these interact remains poor (Steele 2005). Research to enhance our understanding in this area must complement the biological research outlined above. This is clearly a long-term challenge and one that requires ongoing funding.

Biological indicators, if selected and researched robustly, can provide a valuable and cost effective means of monitoring the health of an ecosystem, however these should be complemented by social and economic criteria to provide an integrated understanding of the causes of marine habitat degradation.

Sustainable marine fisheries (Figure 17)

In terms of the evidence needs for sustainable marine fisheries further research is required to investigate multi-species changes in marine ecosystems (deep bottom and midwater systems in particular) during or following exploitation (Royal Society 1995). Ongoing monitoring in this area is essential to provide information regarding the resilience of these systems.

Ongoing research is required in the area of sustainable marine fisheries (and marine biodiversity) to reduce the level of uncertainty within fisheries models (Royal Society 2003a & b). In particular this work should look

at multi-species systems and should include work to characterise and quantify bycatch and discard fisheries, information which is essential for input to multi-species assessments.

Research is also required to monitor the effects of the implementation of the Common Fisheries Programme reforms in terms of contributing to the sustainable management of fish stocks within both a single-stock and ecosystem based context. This work should investigate the effects of effort controls in terms of fishing levels (Royal Society 2003b).

We acknowledge that the strategy includes work relating to *investigation of the effects of fishing on vulnerable species, and the development of indicators of impacts of fishing on fish stocks and the environment*. This work should be extended to include the investigation of the ecosystem effects of fishing activity (such as trawling, longlining and aquaculture) (Royal Society 2003 a & b).

Innovative research is required to devise methods for reducing the dependence of fishers on government subsidies (Royal Society 2003b). Alternative incentives, including market based instruments are required to encourage sustainable fishing practices (Royal Society 2003b). This must be accompanied by the development of innovative approaches to policy development in this area, in particular a move beyond the short-term political cycle to medium to long-term planning is essential if sustainable management of the marine environment is to be achieved. A re-evaluation of the way in which science is used in this process would be useful, in particular, the way in which policy makers use uncertainty should be evaluated and the results used to inform research aimed at addressing uncertainty in decision making. It may be possible to target research towards particular areas of uncertainty where these areas have held particular weight in the political decision making process.

We acknowledge that section 14 identifies the need for an audit and comparison of populations of marine non-native species across the UK. We support this work. However, the issue of marine non-natives and their impacts, vectors, pathways and characteristics are significantly different from those observed in the terrestrial and freshwater environments. Innovative research is required to characterise the risks posed by marine non-native species and to identify methods for managing these risks.

Sustainable aquaculture production (Figure 17)

The evidence priorities identified within this section include the effect of *“fish nutrition demand by aquaculture on wild fish stocks”*. This should be expanded to include research into the effects of aquaculture stocking (or fish ranching) on wild fish stocks (for example: Atlantic and Pacific bluefin tuna).

Section 18 - Radioactive substances

The comments provided in response to this section are primarily taken from the recommendations of our recent report on the management of radioactive waste (Royal Society 2006). Consequently, the bulk of our comments are related to issues of radioactive waste management rather than the broader issues of radioactive substances.

The Radioactive Substances division at Defra should consider the development of a long-term strategy for management of radioactive substances (including waste). Such a strategy should integrate the Committee on Radioactive Waste Management's (CoRWM) recommendations as appropriate, and should be sufficiently

flexible to enable changes in policy or research as necessary. Related to this, it will be necessary to convene an independent advisory body to continue the work undertaken and recommended for the future by CoRWM. This body should be independent, continue engagement with the public and have a stronger scientific and technical input than the CoRWM.

Q.18.i Where are there missing areas of evidence and innovation need (eg key areas of uncertainty; opportunities for innovation) or erroneous ones (lines of argument which are untested or untenable)?

We note with surprise the limited nature of the innovation priorities identified in relation to the radioactive substances section. Radio-active substances are a field for which there is a significant need for innovative science and technology, and innovative communication and engagement methods.

Innovative research can arise as a result of new knowledge adding value to existing or old technologies or information, some of which may have been discounted in the past as being of no use. We believe that waste disposal options excluded because they are not currently viable may hold value in the future. Given the long-term nature of the radioactive waste issue it is important that old knowledge is retained and is available within the research and development framework alongside new and emerging knowledge and technologies.

A decline of related research and teaching in UK universities has been matched by a collapse in nuclear industry funding for research in the 1990s, such that the research base and the availability of trained staff are currently inadequate (Royal Society 2006). The science base for fundamental research on issues such as encapsulation, novel vitrification techniques, geological containment and radio chemistry has been eroded in the UK (Royal Society 2002b). A focused and well funded national initiative is needed to restore an adequate knowledge base in the UK. Collaboration with international research partners can also help in this case.

Satisfactory long-term management of the UK's radioactive waste (Figure 18)

We welcome the emphasis placed on research needs in the evidence and innovation strategy and encourage Defra to commit to continued engagement with the scientific community and to obtain stronger scientific input into management of the UK's radioactive waste (both CoRWM and any future body).

Risks are inevitably associated with any suite of options designed to manage radioactive waste. However, the priorities identified here do not include research aimed at risk identification or characterisation. Scientific input is vital to ensure that risk is assessed in a balanced way. Furthermore this will be essential for assessing the potential risks of long term unforeseen impacts. Work is therefore required to look at both the likelihood and consequence dimensions of risks (both short and long term), and their potential cumulative impacts. This work is essential for improving understanding of what the risks are and how they can be managed and similarly, for understanding how these risks are perceived and therefore how they should be communicated.

Additional research focused on improving the evidence base is required to aid the development of criteria for quantification of radiation risks to human health and the environment. This will be an important contribution to cost-benefit (or equivalent) analysis. Similarly, it is an important input to the review of regulatory standards and the setting of appropriate risk thresholds. One desired outcome should be a risk register to rank different policy options and to identify the most important areas of uncertainty/knowledge gaps in a given option.

We note that the priorities identified in this part of the section include the *'need for social research in public attitudes and understanding of issues'*. However, this statement is rather vague, and we encourage Defra to be more specific and to include work aimed at improving understanding of perceptions of risk and how these vary between sectors and community groups.

The emphasis on the evaluation of risks posed by radiation has so far focused on potential impacts to human health. There are no exposure limits set for flora and fauna. Research is therefore required into the impacts of radiation on the environment. In particular it is important to understand the effect of low radiation doses in the natural environment (flora and fauna), and the potential effects this may have on human health over the longer term. This information is also necessary from a policy perspective to facilitate costs/benefit (or equivalent) analysis in decision making.

The evidence and innovation priorities identified in this section do not include work to develop a process and criteria for future waste disposal site selection. The *"research to implement the chosen option for long term management"* evidence need could presumably include this work but is unclear due to the general nature of this statement. The disposal of radioactive waste presents specific unique challenges which need to be accounted for. One site will not be suitable for all the different waste streams. Consequently, research will need to be long-term and include monitoring and the ongoing assessment of suitable sites. Criteria for site selection will therefore need to be flexible, and the processes for selection of criteria transparent. The policy on the timescale for protection will need to be justified and defined.

The long term nature of radioactive substances and concomitant management requires an ongoing monitoring process by an appropriate independent body. It is important that monitoring results and any consequent new information is fed back into the research and development process, and also into public dialogue relating to risk communication and management.

Strategic Priority: Sustainable farming and food, including animal health and welfare

Section 20 – Sustainable farming and food

There are clearly overlaps between this section and those included within the Climate Change and Energy Strategic Priority, in particular, Section 7 (*UK Adaptation to tackle climate change*). Consequently we refer you to the comments we have made in our response to Section 7.

Q.20.i .Where are there missing areas of evidence and innovation need (eg key areas of uncertainty; opportunities for innovation) or erroneous ones (lines of argument which are untested or untenable)?

The UK Government's First Report of the Sustainable Farming and Food Research Priorities Group (Defra 2005b) provided a comprehensive list of research priorities. However, some gaps remain and we have tried to indicate these below.

One of the most obvious gaps in the strategy is the need for increased effort in rigorous scientific research to inform decision making in sustainable farming. There is a requirement for basic and applied research (Royal Society 2001b). For example the collection of baseline information relating to biological diversity including taxonomic information relating to micro-organisms, and environmental quality standards.

The collection of long-term data is also important for enabling the analysis of the effects of changes in land-management (eg the effects of the Common Agricultural Policy reforms). This is important for providing an evidence base to underpin decision making and future priority setting. In our response to the Policy Commission on the Future of Farming and Food (Royal Society 2001b) we emphasised the importance of gathering knowledge regarding how agricultural practice affects biodiversity (both in terms of benefits and costs), and therefore the importance of monitoring agricultural practice for environmental impact and the examination of the assumptions that underpin agricultural schemes. We voiced concern regarding the decreasing supply of taxonomists and ecologists available to provide this important data and analysis.

The emphasis of this section of the Strategy has been placed on farming and food in the UK. However, there is a need to also consider the international context, in particular, the global footprint of UK activity in the agricultural sector. Better information is required regarding identification and characterisation of impacts both on a product or activity basis, but also in terms of the cumulative impacts of the various agricultural activities. Innovative solutions are needed to facilitate sustainable development both in the UK and internationally. The work suggested below aimed at investigating climatic extremes and the interactions between atmospheric composition and crops will be relevant to both the UK and developing countries and will be an important element of international capacity building in the area of agriculture and climate change more generally.

Adaptation to farming practices (Figure 20)

The Royal Society recently convened a meeting to discuss “food crops in a changing climate” (Royal Society 2005c). The results of this discussion were extremely useful and are relevant to most of this section. However, the following recommendations were of particular relevance to the Adaptation to Farming Practice category:

1. Research is required to understand the importance of temperature and rainfall extremes at key stages of crop development for crop yield. This should be complemented by improvements in predictions of seasonal variability on a regional and national basis. This will improve our understanding of how climate change will affect local weather patterns and the associated impacts on different stages of the growing cycle of crops, and will enable the development of strategies to facilitate appropriate societal and agricultural responses.
2. Better understanding of the impacts of climate change and crop growth on water availability is required to inform both crop choice and crop water management.
3. The interactions between atmospheric composition and crops require further investigation. For example, research is required into the thresholds above which crops become highly vulnerable to climate and weather and responses to changes of atmospheric composition. In particular the benefits of CO₂ fertilisation and implications for water availability and the effects of increasing surface ozone need to be better understood.
4. Improved modelling techniques are required that integrate the feedbacks between climate, crops, land and water use changes, and which enable the identification and measurement of the uncertainties associated with such models.
5. Mitigation and adaptation strategies must be subjected to impact assessments prior to implementation to ensure that they do not make conditions worse. Changes in the crops should be subjected to full life-cycle analysis (“from farm to plate”).

6. Adaptation strategies are likely to require changes in infrastructure (ie for food distribution) rather than just attention to agricultural practice.

We note that the Strategy refers to the need to identify crops and livestock that will flourish under, or tolerate, climate change. The Royal Society supports this. However, it is important that this work is conducted within an ecological framework to identify those crops and livestock that may pose an environmental risk, for example as a result of competitive advantage arising from increased temperature tolerance.

The development of adaptation strategies for the agricultural sector should be based on further investigation of the potential impacts of climate change on land use at a range of scales, and on a range of values over the short and long-term. Adaptation strategies should be integrated to address the range of drivers across sectors that may influence farming and agricultural land use.

Impact of food and farming on climate change (Figure 20)

In terms of the impact of food and farming on climate change, agricultural impacts on climate change are likely to be broader than the “pollution” identified in the text of the Strategy. For example, improved understanding of agricultural ecosystems will be necessary to ensure that changes to crops do not exacerbate the impacts of climate change, or contribute to climate change processes (eg more efficient water use by crops may result in less water being lost to the atmosphere under increased levels of atmospheric CO₂ causing reduced regional rainfall (Royal Society 2005c).

Similarly, it is necessary to get a better understanding of the role of agricultural land and practice in mitigation (ie reducing emissions) and adaptation. This will provide a better evidence base on which to develop strategies for encouraging the carbon mitigation potential of agricultural land and which increase the adaptation potential both of the agricultural sector and other sectors (such as fisheries, biodiversity, transport (Royal Society 2001a & b).

Energy, waste and water- Efficiency of resource use and reduction of waste (Figure 20)

We recognise that the UK Government First Report of the Sustainable Farming and Food Research Priorities Group (Defra 2005) focuses on the development of new technologies in relation to the Energy, Waste and Water section of the Strategy. The priorities identified by the group are comprehensive and our respondents had nothing to add.

Food supply - Food security and sustainability (Figure 20)

The food security and sustainability part of the section focuses on evaluating the impacts of CAP reform on animal welfare and milk supply, and the red meat sector. However, it is also important to understand the impacts of CAP reform on plant genomics (European Academies Science Advisory Council 2004), land-use practice and environmental quality.

The Royal Society has recently completed a follow up to the Royal Society Infectious Disease in Livestock Inquiry (Royal Society 2004b). There were a number of recommendations made in the follow up that should be addressed by Defra in this section (and also in section 22). For example, surveillance arrangements, the capture and handling of data during an outbreak, support for animal health research and training of staff.

Genetically Modified Organisms (Figure 20)

The Genetic Modified Organisms (GMO) priority areas identified in the Strategy were noticeably general and brief and referred only to genetically modified crops. We are surprised that research relating to genetically modified animals (for example for agricultural purposes) was not included.

Plant Health (Figure 20)

It is curious that the plant health area is treated separately from the animal health section and that the two do not have closer links with section 14 *Protect and Enhance the Environment*. It is important that links are drawn between the three, particularly in terms of identifying risk pathways vectors and hosts, and in terms of understanding the epidemiology of pathogens. It is noticeable that section 22 *Animal health and welfare* deals primarily with livestock. This is an oversight as wildlife populations may act as reservoirs for pathogens of importance to the livestock/horticultural industries (and *vice versa*). The problems associated with Bovine tuberculosis (*Mycobacterium bovis*) and cross infection between infected cattle herds and badger populations is a good example of this. There are potential benefits of treating plant, animal and wildlife health issues together. These include developing surveillance and monitoring processes, understanding the impacts that climate change may have on pest and disease incidence and impact, and in risk communication.

Q.20.vi Do you have any other comments on how Defra could improve its evidence and innovation strategy?

The Strategy could be significantly improved if integration between sectors was identified as a priority. Various mechanisms are available for integration and these should be utilised to ensure that maximum benefit is obtained by ensuring cross-fostering of ideas, methods, data capture and technologies. For example there are obvious opportunities for synergy in the climate change and sustainable farming and food sections, similarly between the climate change and sustainable marine environment, protecting the countryside and natural resource protection.

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