NERC Science: Future Impacts Summary Report

BGS Futures Group

Open Report OR/13/037

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Foreword

This report is the published output of the 'NERC Science: Future Impacts' event held in March 2013 at Regent's Park College, London. It represents the combined contribution of all NERC centre participants who took part in the event and its activities. The participants are listed below.

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Zoe Fleming	NCAS	Composition
Jo Chamberlain	CEH	replacing Colin Mackechnie
Richard Sanders	NOC	in place of Alex Poulton

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In addition to the NERC centre participants, the following individuals are gratefully acknowledged for their excellent contributions to the event and its organisation.

Peter Woodward (facilitator); Andrew Staines (keynote speaker); Denis Peach (summariser); Linda Hetherington (event manager); Jonathan Chambers, Kathryn Goodenough, Caroline Graham, Anita Weatherby, Richard Sanders, Felicity Perry, Lynne Porter (conveners); John Bloomfield, Colm Jordan, John Laxton, Wayne Shelley, Simon Price, Jon Naden, Michael Watts, Dan Condon, Andrew Barkwith (BGS Futures Group).

Contents

Summary

This report outlines the main outcomes from the NERC Science: Future impacts event held in March 2013 at Regent's Park College, London. The meeting was convened by a cross-centre group to examine future social, technological, economic, environmental and political trends over the next 20 years that will drive the need for science research. By undertaking a series of horizon scanning activities, two questions were explored;

- What key shifts in natural environment research focus are needed to ensure socio-economic impact in 20 years time?
- What do we need to do as a family of institutions to ensure we are fit for purpose in delivering natural environment research outcomes with socio-economic impact?

The activities during the day were based around six themes for which environmental science research is required to deliver solutions to future challenges. The six themes were:

- Energy and mineral resources
- Food and water resources
- Urbanisation and land use
- Biodiversity
- Natural hazards
- New technologies

The likely drivers and challenges for research within each theme were identified through a series of facilitated horizon scanning activities. Common emerging trends and challenges were then recognised. The overarching themes that were identified included enhanced public engagement, sustainable delivery of ecosystem services and natural capital (including sustainable resource exploitation), urbanisation and population growth, vulnerability of people to hazards and characterisation of offshore and extraterrestrial environments.

In addressing the question of how to ensure that NERC is 'fit-for-purpose' in delivering long-term impact, four critical issues emerged during the discussions.

First, clear mechanisms and incentives are required to support and promote multi-disciplinary research. Resolution of the future environmental challenges will require work across scientific, social and economic research areas.

The second and third issues are closely linked, and relate to direct engagement with the public, and communication with multiple (and potentially competing) stakeholders. To resolve difficult decisions about the use and management of the environment requires direct, informed debate with those who benefit from natural environment research including the public, industry and government. This could be supported by providing information about the consequences of different decisions, and communication could be enhanced through use of new technologies. Most importantly, this should be driven by responding to issues of practical societal and economic value. Recognition of the influence of human activity within the wider environment is essential to demonstrate NERC's role and relevance in understanding the role of human-environment interactions.

Fourth, the style of communication, the mechanisms used to deliver scientific solutions, and the measurement of impact are essential considerations for demonstrating societal and economic relevance. In particular, research outputs need to show that NERC science contributes to long-term as well as short-term aims, and need to be tailored to the requirements of the principal stakeholders in order to deliver the maximum impact.

1 The workshop aims and structure

The workshop provided a forum for 36 active scientists, engineers and technologists from the Natural Environment Research Council (NERC) research centres (BGS, BAS, NOC, CEH, NCEO and NCAS) to **consider** ***how to maximise the economic and social impacts of NERC research in the medium to long term***. The idea for the workshop came from a core cross-centre group, drawn together by the BGS Futures Team.

The day incorporated a substantial element of horizon scanning, and was designed to elicit creative and 'out of the box' thinking from NERC Centre scientists and technologists actively involved in research. ***Wider aims were to strengthen grassroots engagement between the NERC research centres, provide researchers with exposure to horizon scanning, and produce some stimulating and insightful conclusions regarding the future economic relevance of our science for the NERC Executive Board to consider***. Two key questions were explored:

1. What key shifts in natural environment research focus are needed to ensure socio-economic impact in 20 years' time?
2. What do we need to do as a family of institutions to ensure we are 'fit for purpose' in delivering natural environment research outcomes with socio- economic impact?

The workshop began with an introductory talk from Jon Chambers, Chair of the BGS Futures Team, and was followed by a 'scene-setting' talk from Andrew Staines, a member of the Foresight Programme at the Government Office for Science. He highlighted some of the mega-trends identified by Foresight, including: demographic change, migration and urbanisation; globalisation verses localisation; climate change and extreme weather; and rapid changes in technology and the way it is used.

For the main part of the workshop, participants engaged in a series of small group discussions focussed around the following theme areas chosen by the cross-centre organising group:

- Energy and mineral resources
- Food and water resources
- Urbanisation and land use
- Biodiversity
- Natural hazards
- New technologies

The groups were asked to identify emerging trends in their theme area, and to highlight priority areas where NERC science could make an impact in the medium to long term future (next 20 years). Individuals had the opportunity to work in different groups to consider more than one theme area, and were not required to be specialists in the theme areas to participate. These themes were not intended to provide comprehensive coverage of the major challenges in environmental science; instead, and in recognition of the limited time available, the topics were designed to provide an initial framework in which to begin developing ideas. The workshop concluded with reflections on the day from the BGS Chief Scientist, Denis Peach, and a plenary discussion focussed on the question of how NERC can become more fit-for-purpose in delivering high quality science with impact.

This report describes some of the key points that arose from the workshop. In addition, a record of the group discussion methodology provided by the facilitator can be found in Appendix A.

2 Key future science topics for NERC

2.1 ENERGY AND MINERALS

Within this group there was extensive discussion of where NERC science should focus – either identifying energy and mineral resources and potentially supporting their exploitation, or minimising the environmental impact of any exploitation. In general it was agreed that, in a world of growing population, we will continue to exploit the Earth's resources and NERC science should address all aspects of sustainable resource use. This might include predictive science to enable exploitation, but also environmental monitoring during extraction to minimise damage to the environment. NERC science will thus have to balance many competing demands. As part of this, the need for understanding the resource lifecycle – from identification, extraction, processing, and restoration of sites, use and recycling - was recognised. Use of all natural resources should come with a cost-benefit analysis.

The group identified the need to consider resources in inaccessible or unusual areas. Offshore resources are an important and developing area, with potential for renewable energy, CO_2 sequestration, and seafloor mining for minerals. A more futuristic possibility, but one that we should not ignore, is the potential for extraterrestrial resources. Alternative future sources of energy, such as nuclear fusion and thorium, were also discussed.

A further key issue is engagement with the public and policy-makers. The need for resources to support the modern lifestyle typically has to be balanced with the views of those people who do not want to see mining, quarrying or power stations in their back yard. It is vital that scientists learn to engage effectively with the public.

2.2 FOOD AND WATER RESOURCES

Food and water are global resources vital to societal health and well-being; food is already transported across the world, and this is starting to happen with water. The prospect of water becoming a marketable commodity was raised. Supply chains for food and water are likely to become ever more complex, with a range of effects on the environment.

Climate change and growing populations influence demand on food and water resources. As ever more land is needed for food production - what effect will this have on biodiversity? It was agreed that a failure to carefully plan for sustainable food and water in the face of climate change will drastically impair our ability to meet future demands. Genetic modification of crops for food is still the subject of debate about ethical concerns, but is clearly a major future issue. As population pressures increase, natural landscapes will increasingly become a thing of the past – both land- and seascapes will need to be managed to serve a number of different uses.

2.3 URBANISATION

Cities are the engines of economic growth, and more and more of the world's population is moving into them. Are they in the right places? What density of population is acceptable? Should there be national 'city planning', and at what point do cities become too large to manage as individual entities? One potential future approach to coping might involve 'village' clusters within cities, with local, sustainable food and energy production, and sustainable systems for drainage and waste disposal. This 'localism' agenda provides a contrast with the globalisation discussion for food and water and highlights one of the major issues raised at the workshop.

Many of the discussions noted the importance of green space for health & well being. Another key issue is the need for sustainable, long-term subsurface planning in cities, along with long-term monitoring (urban observatories). Ecosystem services, and their links to health and wellbeing, are vital parts of city management and planning.

Cities can increase the vulnerability of populations to natural disasters such as floods, earthquakes or pandemics, with the potential for these to affect large numbers of people concentrated in cities. Urban planning needs to consider the potential for natural hazards.

As more and more people move into the cities, the perception of the countryside is changing. Many people now view the countryside as somewhere for leisure activities, rather than as a landscape that is managed to produce food and other resources. The discussion of this group focused largely on towns and cities, with only limited discussion of land use in the countryside.

2.4 BIODIVERSITY

The group felt that it was important to note that biodiversity refers to the degree of variation of all organisms on Earth – including humans and their interactions. It is a key part of a range of ecosystem services – including food provision, the water cycle, the carbon cycle, and the climate system. However, the current state of the world's biodiversity is still not fully known – how many species are there and where do they live? Many of the interactions within the biological realm, and with the rest of the Earth system, are still not fully understood, and tipping points may not be recognised until it is too late. The impacts of the global market in food products and other plants and animals may be increasingly leading to homogenisation of global biodiversity.

Biodiversity is disconnected from the real world of many people living today, and the group discussed how we should go about 'selling' its importance. Again, public engagement is vital to explain the importance of biodiversity. As more people live in cities, urban biodiversity is as important as preserving 'untouched' landscapes – somewhere like Singapore has the potential to be as important for biodiversity as the Amazon. Methods need to be found to measure and quantify the importance of biodiversity to people.

2.5 NATURAL HAZARDS

As global population grows we become ever more vulnerable to natural hazards; people are concentrated in cities, are moving into areas of higher risk such as floodplains, and are more reliant on technologies such as satellite navigation. Thus, although the risk of any particular natural hazard occurring has not necessarily increased, our vulnerability to it has increased. Many people believe that we can, or will be able to, control natural hazards, but for some types of hazard such as earthquakes this will never be true. Other types of hazard, such as flooding and extreme weather, may be driven by climate change. Again, there was a debate here as to how much NERC science should focus on recognition and mitigation of climate change-induced hazards, as opposed to research into ways to restrict climate change. It was noted that governments need to be prepared for natural hazards, and responses increasingly need to be trans-national.

We need to improve monitoring of a range of natural hazards in order to improve forecasting. Another theme that is important in this area is public engagement; scientists need to get better at communicating messages about hazard and risk. We can't prevent many natural hazards, but we can greatly mitigate their effects on human populations. Emerging technologies offer opportunities for better monitoring, forecasting, and communication of risk. Yet at the same time we must be aware that our reliance on technology increases our vulnerability to some hazards.

2.6 NEW TECHNOLOGIES

The issue of urbanisation and greater reliance on technology was raised here, along with the importance of grids and networks for power and communication. Our ability to communicate instantly with people on the other side of the world, and to share large volumes of data, has revolutionised the way we work and live; but equally it has increased our vulnerability. Over-reliance on technology is in many ways risky. It is necessary now to spread knowledge and capability on local and global scales, and to communicate risk and uncertainty. The changing use

of technology amongst different communities is also likely to result in a push for NERC science to simultaneously meet both current communication/information needs and provide new approaches relevant to/required by 'Generation Z' (i.e. those born after the advent of the internet). Such new 'soft technologies' are also likely to have a significant influence on the way NERC scientists collect data, with growing opportunities for direct interaction with members of the public who will have the ability to constantly monitor their own 'micro-environments' at home. The effective use of these new technologies will rely heavily on NERC's ability to recruit and train young scientists with Generation Z - specific understanding.

Whilst participants in this group focussed primarily on soft technologies, it was also acknowledged that a wide variety of emerging hard technologies are likely to impact NERC science in the future. These included the development of novel materials (nanomaterials, biomimetics, etc.) and micro/nanosensors, providing new opportunities for large-scale data collection in a wide range of conditions and environments. Also discussed were the likely increasing reliance on high performance computing and the resulting increase in the use of complex, coupled simulations for system monitoring and forecasting.

3 Overarching themes from the workshop

Public engagement should be considered as a vital part of our scientific research. We must use all the methods at our disposal to communicate our science and why it is important, and to broaden knowledge. Only by communicating effectively will we really be able to see wider impact for our science. Conflicting interests among the public will have to be managed sensitively. Future trends clearly suggest that this will become an increasingly important area for NERC to develop in order to effectively interact with the public.

Urbanisation is a key trend associated with a growing population and the way people live. 'Natural' environment research must increasingly also focus on manmade environments – and indeed, there is an increasing loss of distinction between natural and managed environments. Ecosystem services and subsurface planning in urban environments are likely to be important parts of NERC's research in the next twenty years.

Ecosystem services and natural capital are themes which recognise the value of the environment in providing essential life-support systems and resources for society. The way we establish and quantify the benefits we derive from the environment and the degree to which we value them is essential to secure societal well-being, economic growth and environmental health.

Globalism versus localism is undoubtedly a debate that will affect all aspects of environmental science – but will the trend be towards globalism or localism or a mixture of both depending on the availability of the resource? For a wide range of global resources, it is increasingly important to understand the resilience of the supply chain.

Exploitation versus environmental protection was widely discussed – the growing population needs a range of resources; NERC should be involved in all the science that underpins sustainable resource use. Managing this is extremely complex; for instance, wind farms may have a positive impact on global climate in terms of CO_2 reduction, but they can have negative effects on the local environment where they are built and also where the raw materials for turbine components are extracted.

Vulnerability to a wide range of natural hazards is driven by increasing populations and migration towards cities. Likewise, demographic and societal changes are also increasing our vulnerability to resource scarcity and technological challenges (e.g. space weather/cyber attacks). Monitoring, forecasting, mitigating and communicating these threats to an increasingly vulnerable population is a major future challenge.

Offshore and extraterrestrial environments may, in part, seem like the stuff of science fiction now, but are likely to become increasingly important for a wide range of resources. Increasing demands/changing requirements are likely to see new exploration technologies (e.g., the 'shale-gas rush') appearing in previously unstudied/unconsidered materials and environments. NERC science will need to be flexible enough to adapt to these shifts in a timely fashion.

It is clear from all the above that **whole systems** approaches are becoming increasingly necessary, as more and more environments are managed for a range of different uses and purposes. We need to understand the interplay of all our activities across the Earth system.

4 How does NERC become more fit for purpose?

The final plenary session and discussion sought to address the very practical question of how we, as NERC researchers, can become more fit-for-purpose in delivering applied science with high social and economic impact that meets future needs. The group identified a number of issues which are summarised here in terms of challenges and potential solutions:

4.1 CROSS-SYSTEM APPROACH:

Challenge: Likely future environmental problems impacting society and the economy are highly complex and require an inter/multi-disciplinary response.

Potential Solution: Clear mechanisms and incentives for linking research with other research councils (e.g. ESRC) and public sector/governmental organisations (e.g. Met Office); Study whole-life cycles of key resources.

4.2 PUBLIC ENGAGEMENT:

Challenge: Many future challenges will require informed debate, or involvement, in a public forum. We need to engage and inform the public, in topics which are highly politicised and where conflicting interests are becoming increasingly common (e.g. shale gas/fracking).

Potential Solutions: Provide information regarding the consequences of different actions; Increased public involvement (and steerage) in NERC science, including direct communication through new technologies; Emphasise the positive messages from our research; Where appropriate, directly involve the public in NERC science (e.g. crowd sourcing)

4.3 COMMUNICATION WITH ALL STAKEHOLDERS:

Challenge: There are likely to be increasing demands for an intermediary between research and society/economy – are NERC solutions focused or applied enough to fulfil this role and are we targeting our priorities effectively?

Potential solutions: There is a need to harness knowledge of stakeholders to achieve impact – consequently, more emphasis needs to be given to knowledge exchange and communication, and 'selling' science proactively – communicating directly with public/business/industry and keeping closer ties with end-users; Programmes should be designed based on the 'pull' of issues not the 'push' of 'sexy' or 'bandwagon' science; Clearly define our role and understand our unique selling points (USPs) – we could consider whether the use of 'Natural' in NERC's name limits our perceived relevance when working in the urban environment or improving our understanding of human-natural environment interactions.

4.4 DELIVERY AND MEASUREMENT OF IMPACT:

Challenge: With increasing social and economic pressures, how do we measure and improve our impact in key sectors?

Potential Solutions: Examine our current approaches to assessing and monitoring impact – to establish what the key impacts are for our stakeholders and to determine whether we are improving. This may require a re-evaluation of the current priority given to achieving 'outcomes' compared to 'outputs'; Maintain a focus on the long-term, as well as shorter-term interests; Maintain our current world-leading environmental science (keep the best bits), whilst also developing new research areas; Increased industry co-funded research (TSB model).

5 Summary of participant feedback

Feedback was captured in the form of a questionnaire, which was completed by nearly 90% of the participants. The various elements of the event were rated using a scale of 1 (very poor) to 5 (very good). The format of the workshop (i.e. invitation process, speaker, facilitator) was regarded as good to very good (average score 4.4). Likewise, the opportunity for individual engagement and networking was regarded as good to very good (average score 4.6). Emerging outcomes were rated as ok to good (average 3.7). This feedback indicates that participants felt they benefited from the day in terms of interest, relevance and networking, but were less clear about ways in which to build on the outcomes of the workshop.

Participants were given the opportunity to comment on the ratings given in the table, and to provide suggestions on maintaining momentum beyond the workshop.

6 Conclusions and recommendations

6.1 WAS THE WORKSHOP USEFUL?

There is a significant appetite for this type of event as indicated by a good response to the original call for expressions of interest and the feedback received from participants after the workshop. In particular, the strongly interactive nature of the workshop and the opportunity for 'grass roots' researchers from across NERC to develop new links were highlighted as particular benefits. ***The objectives of strengthening grass roots engagement and providing researchers with the opportunity to engage in horizon scanning activities have therefore been met.***

The benefits of the workshop (i.e. cross-centre engagement, exposure to horizon scanning, opportunity for senior management to receive grass roots feedback) were clearly recognised in the feedback, but it is less clear how the outcomes of the workshop can be further developed. This may in part be related to the long term perspective that was considered at the workshop (i.e. beyond that of normal business planning cycles) and the necessarily 'fuzzy' nature of attempting to anticipate developments decades ahead. However, it is our contention that ***it is a useful exercise for active researchers to devote at least some time to considering the big picture in order to generate new ideas and promote multidisciplinary science.***

This event was initiated by the BGS Futures Team, who engaged other centres in the design and organisation of the workshop. To continue the cross-centre approach, ***for future events of this sort, it is our recommendation that another centre next takes the lead in developing a concept, perhaps focussing on a specific theme, and securing buy-in and engagement from the other centres.*** We also hope that this has stimulated NERC centres to consider initiating, or further developing, in-house horizon scanning activities.

6.2 WHAT WERE THE KEY MESSAGES OF THE WORKSHOP?

Of the socio-economic and scientific drivers considered during the workshop, the following emerged as being particularly significant: ***human-environment interactions; urbanisation, globalism versus localism, vulnerability to hazards, whole systems science, and UK***

environmental asset management (surface & subsurface, including ocean and atmospheric assets). In addition a number of cross-cutting messages also emerged, which related more directly to the question of how we can make NERC more fit-for-purpose. These concerned public engagement, the identity or branding of NERC, and our focus. These are summarised in the following paragraphs.

The strongest cross-cutting message was that ***to improve our socio-economic impact and make us more fit-for-purpose, NERC researchers must be more willing and able to engage directly with the public, industry and government***. NERC has information and answers relevant to many pressing societal issues, but these issues are often politically sensitive and require careful and high-quality communication. For example, NERC researchers will increasingly have to manage the tension between conservation and responsible exploitation of natural resources; 'NIMBYism' associated with new developments such as wind farms and nuclear power stations; the emphasis we give to limiting climate change compared to adapting to climate change.

A ***tension between natural environment research and our growing involvement in manmade (e.g. urban) environments*** was identified during the workshop – an increasing requirement for clarity is likely, needed for the benefit of NERC stakeholders, so that we are not perceived to be less socially and economically relevant than we really are.

We should involve stakeholders more in the assessment of impact, to guide our methods for its measurement. This may mean more collaborative research (e.g. drawing more upon the TSB model of industry/stakeholder co-funding) – and certainly requires us to ***look to stakeholder requirements, in order to develop strong solutions to their needs***. Enhanced NERC impact can be achieved by considering the type of scientific outputs and their target audience. It is essential to recognise the appropriate types of outputs related to the nature of applied research undertaken by NERC research centres. Equal weight and value should be applied to outputs recognised by stakeholders beyond peer-reviewed outputs. This may include, but not be limited to, web and application delivery of digital data and information, stakeholder dissemination events and industry focused publications and presentations.

Finally, it is clear that all the NERC centres need to work together, with other partners from science and industry, to understand environmental systems as a whole. Only in this way will our science have significant socio-economic impact.

Appendix 1 Photographs of emerging trends within key environmental themes

Group Discussions

Participants in small groups, considered each one of the following theme areas:

1. Energy and mineral resources
2. Food and water resources
3. Urbanisation and land use
4. Biodiversity
5. Natural hazards
6. New technologies

The groups were provided with a 'prompt sheet' of key economic, social and scientific issues. They were asked to consider the theme in the following ways:

1) Draw up a shared understanding of the theme area (blue rectangles)
2) Identify emerging trends/ issues relevant to this area (orange rectangles)
3) Identify potential 'focus areas' for future UK-funded natural environment research that offer best value related to socio-economic trends over the next 20 years. (green rectangles)
4) Prioritise two focus areas for further work (long green rectangles)
5) Give a key messages emerging from your discussion (long yellow rectangle)

Participants had the opportunity to view other group work. Additional comments were noted down (blue circles)

The outcomes work board for each theme is included in this report and then transcribed for clarity.

Theme 1: Energy and mineral resources

Theme 2: Food and water resources

Theme 3: Urbanisation and land use

Theme 4: Biodiveristy

Theme 5: Natural hazards

Theme 6: New technologies