# BBSRC Knowledge Integration Tool

## Version 1.0　|　December 2015

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## Preface

This report is the product of a rewarding collaboration between the authors and BBSRC staff in 2015. It builds on the authors' past research around responsible innovation and stakeholder engagement [1-3] with the support of a University of Nottingham ESRC Impact Accelerator Award and the BBSRC. We developed the case study in November and December 2015, including a week-long research trip to the BBSRC offices in Swindon.

The report presents the first iteration and preliminary testing of a tailored stakeholder mapping and solicitation tool, the Knowledge Identification Tool. This tool is a response to on-going discussions within the academy and BBSRC regarding the concept of Responsible Research and Innovation and its implementation. As such, this tool is intended to contribute to BBSRC's commitment to deliver its 'openness agenda', specifically with regards to broadening the range of expertise that feeds into strategic and funding decisions[4,5]. It should be understood as the first of a two-stage process involving identification and integration of expert knowledge.

The report aims to:

1. Re-frame stakeholder engagement as 'knowledge integration' rather than stakeholder mapping.
2. Create an adaptable, simple and appropriate tool for identification of external actors with knowledge relevant for BBSRC decision-making based on robust social science.

# 1. The thinking behind the Knowledge Identification Tool

## From technologies in focus to technologies in context

The goal of *responsible research and innovation* (RRI) is to shape the direction and nature of science, technology and innovation for the benefit of society, demanding public value from science and innovation that is broader than economic growth. A core dimension of RRI is the inclusion of a broad range of societal actors in decisions about the future of science, technology and innovation [6-8]. Societal actors need to be included upstream as well as downstream in the research and innovation process, and mechanisms for engaging these actors need to move from facilitating 'conversation' to 'deliberation'[9]. This new approach to innovation governance creates opportunities for research funding councils to re-examine their stakeholder engagement activities.

The desire to generate public acceptance of innovations, particularly if the innovation is controversial reflects an instrumental motivation for engagement. Just as different scientific disciplines address different knowledge gaps[10-12], s*ocietal actors* have valuable knowledge about the possible uses of innovation. This knowledge can substantively improve the quality of decision making in the area[13-15]. The motivations for engaging societal actors must be substantive rather than instrumental[16]. This means that societal actors (rather than stakeholders) are selected for engagement because of their knowledge. Approaching stakeholder engagement in this way will help to produce better decisions that are also more likely to be socially legitimate.

Researchers often promote the benefits of innovations from science and technology in terms of particular societal challenges or emphasize their use within a specific sector. Contextualising innovations in this way will also help to identify a broader range of societal actors with knowledge about the sector in which the science / technology is intended. It may also lead to the identification of novel, unexpected, and societally useful applications[17].

## 2. Procedure

Module 1 – Organisational siting [cf. 18-20]

**Logic**: Stakeholder engagement processes must visibly shape future decisions and have tangible impacts on BBSRC practices.

**Goals**: i) identify why BBSRC is pursuing engagement; ii) understand organisational context, including related past activities and possible future decisions; iii) identify where stakeholder knowledge could usefully be applied and which internal individuals / groups would need to be enrolled.

**Output**: 1.1 - Answers to the three questions set below.

## Module 2 – Internally identifying purposes and actors [cf. 21,22]

### Logic

*BBSRC has significant internal expertise that should be mined and mobilised to identify the purpose of BBSRC-funded research and existing stakeholders.*
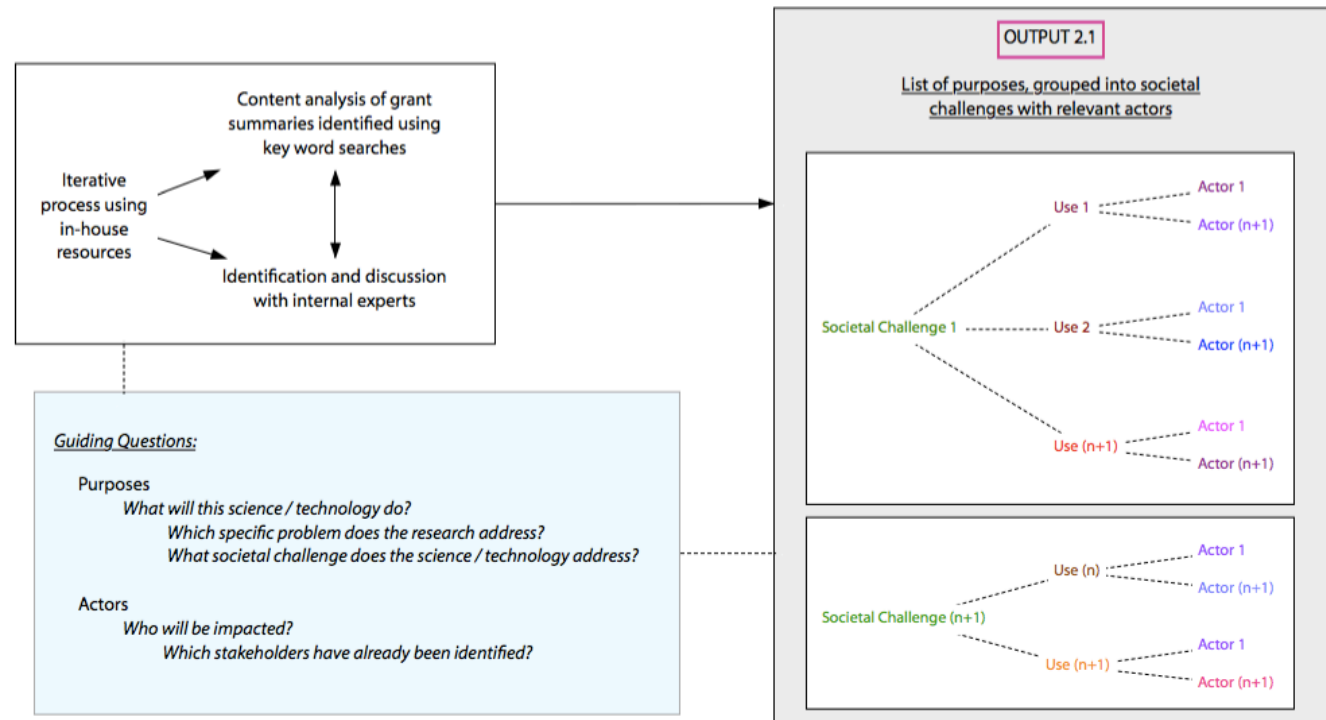
### Goals

Identify the potential uses of this science / technology;

Begin to identify which actors will be necessary to engage with.

### Output

*2.1 - Document summarising the purposes, grouped into societal challenges, with relevant individuals / organisations to feed into Module 3*



Iterative process using in-house resources

Content analysis of grant summaries identified using key word searches

Identification and discussion with internal experts

**Guiding Questions:**

Purposes
- What will this science / technology do?
- Which specific problem does the research address?
- What societal challenge does the science / technology address?

Actors
- Who will be impacted?
- Which stakeholders have already been identified?

OUTPUT 2.1

List of purposes, grouped into societal challenges with relevant actors

Societal Challenge 1
- Use 1 — Actor 1, Actor (n+1)
- Use 2 — Actor 1, Actor (n+1)
- Use (n+1) — Actor 1, Actor (n+1)

Societal Challenge (n+1)
- Use (n) — Actor 1, Actor (n+1)
- Use (n+1) — Actor 1, Actor (n+1)

## Module 3 – Putting the knowledge in context

### Logic

*The products of science / technology address social, environmental, or technical problem areas. Stakeholder engagement requires knowledge of these areas.*
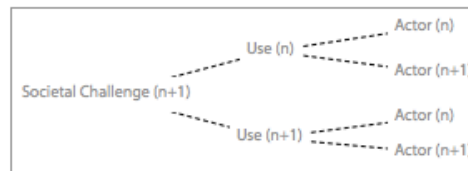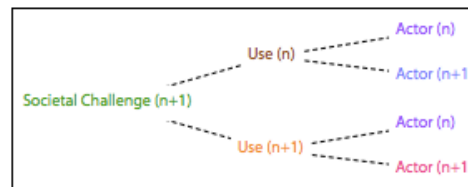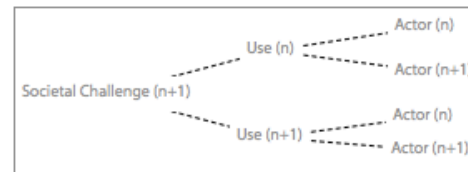
### Goals

1. *Decide which societal challenge to use for further analysis*
2. *Contextualise the science / technology in relation to the societal challenge using information gathered in Module 2.*

### Outputs

*3.1 - Document listing pre-identified purposes and stakeholders.*

*3.2 - Brief responses to adjacent questions.*



OUTPUT 3.1

Preliminary list of purposes with associated individuals / organisations

OUTPUT 3.2

Brief responses to following questions

According to the information gathered in Module 2,

**Vision**

1. What societal challenge do the researchers claim the science / technology will address?
2. How do researchers claim the science / technology addresses this challenge?

**Assumptions**

3. What shared assumptions underpin the above proposals' responses to the societal challenge?

**Knowledge Gaps**

4. What knowledge might be needed to substantiate the above claims?

# Module 4 – Mapping knowledge and actors [23,24]

**Logic** Broad stakeholder knowledge is required to substantively improve decision-making

**Goals** i) Build on the preliminary map of actors and purposes to develop a more detailed understanding of who has knowledge / expertise of how the science / technology might meet the societal challenge; ii) map actors and the knowledge they hold onto the matrix

**Output** Completed matrix

1. Map output 3.1 onto adjacent matrix

2. Identify prominent public reports and procedures relating to both the science / technology and the societal challenge (e.g. Royal Society, House of Lords Select Committee, Nuffield Council on Bioethics)

3. Extract actors from consultation responses, working groups, acknowledgements and references

4. Fit actors in adjacent matrix

5. Use bibliographic snowballing to expand range of knowledge until matrix is saturated.

OUTPUT 4.1

Completed knowledge matrix

| Knowledge | Sector | Academia | Private | Public | Civil Society |
|---|---|---|---|---|---|
| Legal | | | | | |
| Social | | | | | |
| Environmental | | | | | |
| Economic | | | | | |
| Political | | | | | |
| Technical | | | | | |

# 3. Test case – Genome editing as a new (crop) breeding technology

## Module 1 – Introduction

1. **What is the history of and BBSRC's current stance on the topic in question?**

   → BBSRC produced an externally-facing position statement on novel crop breeding technologies centring on genome editing and epigenetic modifications (overseen by a working group of external experts);
   → BBSRC convened an internal cross-office working group on Novel Crop Breeding Technologies ('NCBT working group');
   → BBSRC funded research through responsive mode but no formal commitment has been made. As it stands - and will likely remain - genome editing and associated techniques do not fall under the remit of one single priority area.

2. **What decisions are to be made and where can external knowledge be integrated into BBSRC?**

   → BBSRC wants broad external input on its position statement and future actions;
   → There is a lot of interest in integrating external knowledge but no clear decision pathway;
   → There are, however, two potential points of integration:
     – In the development of BBSRC's research portfolio;
     – In the existing Strategy Advisory Panels.

3. **Which internal groups does BBSRC need to enrol to facilitate integration?**

   → All representatives on the NCBT working group and their respective teams;
   → Strategy Advisory Panels, including: Bioscience for Society; Bioscience for Health; Agriculture and Food Security; Bioscience for Industry; Industrial Biotechnology and Bioenergy; and Exploiting New Ways of Working.

## Module 2 – Purposes and actors

| Project | Societal challenges | Uses (technical, environmental, social etc.) | Relevant actors |
|---|---|---|---|
| [**A**] Alphey – A synthetic approach to gene introgression in mosquitoes | Sustainable Agriculture<br><br>Food Security<br><br>Human Health | The use is to spread under-dominant traits through a population which will control pests and disease.<br><br>Work is being developed in mosquitoes but intention is to develop proof of principle method, which may then be broadly applicable including for "livestock, plants and wild animals". | – Pest management research communities<br>– Synthetic biology community – adopting the engineering language but translating to insect rather than microbe.<br>– Policy makers and regulation; specifically, to allow "some space for considered thought without immediate pressure to take decisions regarding potential field use"<br>– Private Sector (Oxitec) |
| [**B**] Swan – DNA synthesis at the Norwich Research Park | Food Security<br><br>Energy<br><br>Human Health | The project proposes to develop a synthetic DNA facility which will enable the production of long chain DNA fragments which can be used to screen for beneficial phenotypes (e.g. of crops). This is an underpinning infrastructure rather than application but is probably a fundamental part of the enabling the visions associated with genome editing. | – Academic communities (UK) |
| [**C**] Halford - BBSRC Embrapa: Temperature resilience of flowering in UK and Brazilian wheat (TempRe) | Food security | Genome editing is one of the methodologies that they may employ to investigate and develop wheat varieties that are more resilient to temperature stress. | – Partner institutions in UK and Brazil<br>– UK-Brazil Partnership for Yield Stability and Protection in a Changing Climate |
| [**D, E**] Hall & Rattray – Development and benchmarking of improved computational methods for transcript-level expression analysis using RNA-seq data | Food Security (eventually) | This project proposes to develop a computational tool which will make it easier to understand transcript expression (and thus how different traits are modulated). | – Academics in the UK<br>– Users (other relevant projects) will be brought into ensure that the model is developed to meet their needs. |

## Module 3 – Knowledge in context

### Vision

1. What societal challenge do the researchers claim the science / technology will address?

   → *Food security*;
   → Crop genome editing intersects with several other challenges, notably *energy* (i.e. bioenergy) and *sustainable agriculture* (i.e. by providing novel pest management and disease control options).
   → Two proposals [A] [B] are explicit in suggesting that the work will address numerous challenges, including human health - relevant because it implies cross-fertilisation between challenges.

2. How do researchers claim the science / technology addresses this challenge?

   → By developing technical expertise and underpinning methodologies [D, E];
   → By expediting the development of crops with increased yields and/or resilience to environmental stresses [B, C];
   → Through direct manipulation of plant genomes (which will depend on whether genome-edited crops will be classed as genetically modified in existing regulatory frameworks) [A].

### Assumptions

3. What shared assumptions underpin the above proposals' responses to the societal challenge?

   → Food security will be addressed by creating crops that are either more closely tailored to their growing environment or that are more adaptable to environmental stresses than current crops.

### Knowledge Gaps

4. What knowledge might be needed to substantiate the above claims?

   → Knowledge of user needs [A, C, D, E];
   → Knowledge of the regulatory landscape [A, C];
   → Knowledge of the direct environmental interactions (population dynamics, soil, water, etc.);
   → Knowledge of the local social interactions and community needs;
   → Knowledge of the commercial process and IP [A];
   → Knowledge of the broader factors affecting food security, not just technical solutions. Technical solutions are important, but as should be shaped to the social and environmental context without excluding alternative options.

## Module 4 – Mapping

This module presents a preliminary mapping, using the output from Module 3. Nevertheless, the initial mapping highlights a number of initial knowledge gaps. It is clear that to date knowledge has been dominated by technical plant science from the academia. There is a reasonable level of political and legal knowledge from the public sector, but there appears to be little input regarding, for example, IP regimes. Whilst a range of other knowledge bases are represented (e.g. economic / environmental, social), they appear comparatively underrepresented in relation to the aforementioned technical breadth.

Further mapping from external reports and documents needs to be conducted with the documents below. This external knowledge mapping should focus on the sparsely populated and empty boxes using specifically formulated questions to identify gaps:

1. Joint Research Centre (2011) New plant breeding techniques State-of-the-art and prospects for commercial development
2. UK Agri-Tech Strategy submissions in response to the call for evidence
3. Nuffield Council on Bioethics (Forthcoming) Working group and report into genome editing – this is forthcoming and will provide an important repository of information in the future - http://nuffieldbioethics.org/project/genome-editing/open-call-for-evidence/
4. National Academic of Sciences Inquiry into Gene Drive Research in Non-human Organisms - http://nas-sites.org/gene-drives/

Key
⊙ Identified by funded researchers
⊙ Identified by BBSRC staff (e.g. NCBT workshop)

<u>Knowledge matrix:</u> *crop-based genome editing in the context of food security*

| Sector / Knowledge | Academia | Private | Public | Civil Society (3rd Sector) |
|---|---|---|---|---|
| Uncategorised | ⊙ Laura Bellingham, Society of Biology<br>⊙ Pere Puigdomènech, European plant sciences organization, working group on agri-tech<br>⊙ Mimi Tanimoto, UK plant sciences federation | ⊙ Penny Maplestone, British Society of Plant Breeders | ⊙ Paul Burrows, BBSRC<br>⊙ Elizabeth Duxbury, POST<br>⊙ Jackie Hunter, BBSRC | |
| Economic<br>Relevant Questions: | | ⊙ Unspecified<br>⊙ Oxitec<br>⊙ Penny Maplestone, British Society of Plant Breeders<br>⊙ Andy Fray, NIAB | | |
| Environmental<br>Relevant Questions: | ⊙ Les Firbank, population biology, sustainable agriculture, UoLeeds<br>⊙ Frank Hartung, biosafety, Julius Kuhn Institute<br>⊙ Matt Heard, Centre for Ecology and Hydrology | | ⊙ Ian Boyd, DEFRA CSA | ⊙ Friends of the Earth |
| Legal<br>Relevant Questions: | ⊙ Chris Pollock, Aberys.U, plant science | | ⊙ Louise Ball, DEFRA<br>⊙ Huw Jones, member of EFSA GMO panel<br>⊙ Frank van der Wilk, COGEM (Dutch advisory panel)<br>⊙ Verity Hawkes, GO-Sci<br>⊙ Noelita Ilardia, DEFRA<br>⊙ Philip Macdonald, Canadian Food inspector agency | |
| Political<br>Relevant Questions: | ⊙ Elizabeth Bohm, Senior policy advisor, Royal Society<br>⊙ Ian Crute, European Academies Science Advisory Council | | ⊙ Louise Ball, DEFRA<br>⊙ Ian Boyd, DEFRA CSA<br>⊙ Verity Hawkes, GO-Sci<br>⊙ John Kerr, Scottish Gov.<br>⊙ James Reeve, GO-Sci<br>⊙ Mark Walport, CSA | |
| Social<br>Relevant Questions: | ⊙ Claire Marris, Centre for Food Policy, City University<br>⊙ Judith Petts, UoSouth<br>⊙ Jack Stilgoe, UCL | | | ⊙ Roland Jackson |
| Technical<br>Relevant Questions: | ⊙ Wide range of academics and unspecified bioscience community<br>⊙ Ian Crute, European Academies Science Advisory Council<br>⊙ Ottoline Leyser, plant science, UoCam<br>⊙ David Baulcombe, plant science, UoCam<br>⊙ Chris Pollock, Aberys.U, plant science<br>⊙ Dale Sanders, JIC, plant science<br>⊙ Nick Talbot, UoEx, plant science<br>⊙ Sophien Kamoun, UoEA<br>⊙ Jim Beynon, plant science (pathogen interactions), UoWar<br>⊙ Vicky Buchanon-Woollaston, UoWar.<br>⊙ Jim Dunwell, plant science, University of Reading<br>⊙ Rupert Fray, plant molecular biology, UoNot<br>⊙ Nick Harberd, plant science, UoOx<br>⊙ Keith Lindsay, plant science, DurU<br>⊙ Alistair McCormick, Plant Science, UoEd<br>⊙ Steven Penfield, plant science, JIC<br>⊙ Jie Song, plant science, Imperial-C-L<br>⊙ Nick Talbot, plant science, UoEx<br>⊙ Catherine Tetard-Jones, plant stress & evol. ecology, NewU | ⊙ Unspecified<br>⊙ Oxitec<br>⊙ Lesley Boyd, NIAB<br>⊙ Andy Fray, NIAB | ⊙ Ian Boyd, DEFRA CSA<br>⊙ Caroline Dow, BBSRC<br>⊙ Mark Walport, CSA | |

# 4. Reflections and further tool development

The pilot case demonstrated proof of principle and suitability for rapid deployment. A number of further questions remain regarding future development.

## Procedural questions

1. The testing process identified the importance of framing in each module. Calibration with other users is therefore needed to identify where guiding questions are required, e.g. to help elicit specific knowledge gaps in module 4.

2. The case demonstrates a desire for external input and existing knowledge of external actors but obvious gaps and no clear decision making pathway. Work is needed to develop a procedure to integrate knowledge in this situation, e.g. by mobilising formalised horizon scanning[25] or socio-technical integration methodologies[26].

## Adaptability

There are two primary ways that this tool needs to be adaptable:

1. _To different timescales_. If the importance of question framing is understood, it may be possible to develop 'diet' versions, which focus on particular modules. E.g., using an advanced module 2 (see below) to understand how a science / technology is being positioned by researchers. Alternatively, module 4 with augmented guiding questions and expertise types (see below) could be used solely to map existing actor interactions and gaps. Time requirement can also be modulated by altering the breadth of the case (e.g. genome editing vs. plant genome editing / selecting multiple societal challenges in Module 3).

2. _Across cases_. The pilot case has a number of specificities that would not exist for others (e.g. bioenergy). Suitability for alternative cases can only be known with further testing.

## Mobilising and building capacity within BBSRC

1. There is significant internal knowledge of the field and BBSRC's position, especially within BIU and CPSG. ERU should work with these groups to identify and mobilise it. Doing so will also identify possible decision pathways for external knowledge and help to build organisational buy-in.

2. There are existing in-house tools that are currently being developed and may be adapted to expedite the process of knowledge mapping and integration. In particular efforts should be focused on developing a set of key words that can be used to mine BBSRC's grant portfolio to automate Module 2. A set of specific expertise terms could also be developed to be used in N-Gage and Knowledge Graph. This will be of significant value in Module 4.

3. There are also pre-existing stakeholder databases that have been developed within ERU which may be suitable to capture past uses of KIT. At a minimum, each output should be stored in a standardised shared folder.

4. In the longer term it may be possible to develop tailored software, for instance by adapting a Multi-Criteria-Mapping package.

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