NEXUS Network Networking Grant "Nexus Brexit" – Final Report*

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Background

In January 2013, David Cameron, the then prime minister pledged to the British public that if the Conservative Party were to win the General Election in 2015 the government would call a Referendum with one simple question: whether to remain in the European Union (EU) or whether to leave. Following the election of a Conservative government, David Cameron began negotiation with the EU for a better deal for the UK within the Union. European leaders, however, publicly denounced the UK's intentions to change major provisions of the EU Treaty, such as the freedom of

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movement, saying that only after the UK vote to stay part of the EU, would Brussels should negotiate minor changes that would apply to all countries.

Against a backdrop of few concessions from the EU during pre-referendum negotiations, the conservative government set a referendum date of 23rd June 2016. The Nexus Brexit project (survey and workshops) ran during November and December 2015, during which time the polls suggested that the UK leaving the EU following the referendum was unlikely (https://ig.ft.com/sites/brexit-polling/).

Following the completion of the Nexus Brexit project workshops, on 23rd June 2016 the UK electorate voted to leave the EU (51.9% to 48.1%) with an extraordinary turnout of 72.2%. The decision made by the British public came as a surprise to many politicians and policy makers, the majority of major political parties had openly supported the Remain campaign. This makes the findings of the Nexus-Brexit project, which was devised and conducted pre-Brexit extremely important.

The Nexus Brexit Project

Following the announcement of an upcoming referendum on EU membership in January 2013, an active discussion on the impacts of Britain exiting the EU flourished, mainly in public media but also in academic literature. Most of the arguments focused on the issues causing this UK-EU "crisis", namely immigration (i.e. freedom of movement) and the delegation of power to Brussels. However, the Brexit holds risks and opportunities in many areas of public policy, and can profoundly impact the UK economy and society. The Nexus-Brexit project was developed to focus on the possible consequences of the EU Referendum on the UK water-food-energy systems and the natural environment.

The Nexus dimensions of Brexit are vast and complex, with many interconnected issues, drivers and modulators of impact. The Nexus Brexit project was developed from the need for stakeholders (government, agencies/regulators, business, NGOs, civil society, local authorities etc.) to work collaboratively in order to consider plausible consequences and futures for Brexit. The project initiated this process by combining a widely-distributed survey and two stakeholder workshops.

Aims

- Co-design and co-produce with a wide range of stakeholders a report exploring Nexus risks and opportunities from UK exit from the EU (Brexit)
- Identify research gaps and possible partners, methods and data to fill these in Phase 2 and/or by exploring other research funding opportunities

Structure of networking activities

In order to address the aims of the project, a combination of participatory workshops and a widely distributed survey were devised.

Email Survey

Following an initial project launch in Leeds, a snowballed online survey was sent via email to identified stakeholders. The survey ran for two months between May and July 2015. The aim of the

survey was to identify the drivers of change (on the water-energy-food nexus) that were most influential and most uncertain. As well as exploring perceptions, the survey was designed to elicit interest in the workshops.

Workshops

Two one-day workshops entitled "Uncertainties of future UK water, energy and food consumption" were held, one in Leeds (23rd Nov 2015) and one in Cambridge (8th Dec 2015). The purpose of these workshops was to bring together academic and non-academic experts to discuss:

1. What are the drivers that will affect mid-century UK water, energy and food consumption?
2. How are they inter-connected with each other?
3. Which are more important (more influential and/or more uncertain) to better project future UK demand?
4. What information will decision-makers want on these drivers and scenarios?

Workshops were advertised via on open invitation and targeted emails to relevant stakeholders.

Networking activities

The methodology chosen for the workshops was an analytical modelling framework known as "Fuzzy Cognitive Mapping" (FCM). Fuzzy cognitive mapping is widely used for problem solving in situations in which numerous interdependencies are thought to exist between the important components or variables of a system, but quantitative, empirically-tested information about the forms of these interdependencies is currently unavailable or hard to gather in short time. FCM aims to encapsulate the qualitative knowledge of expert participants or system stakeholders in order to rapidly construct a simple systems dynamics model of a specified issue. FCM can be used for projection or scenario testing purposes and to facilitate further discussion and interaction within or with a stakeholder group.

The process was split into two workshops, each workshop opened with an introduction, discussion on overall project objectives and a specific introduction to the theory behind fuzzy cognitive mapping. During the first workshop the group of experts split into sub-groups and each sub-group focussed on developing one FCM for the UK household demand for either: water, food or energy. Initially, groups were asked to identify the major components or variables important in modelling UK household demand for either: water, food or energy. These key components form the nodes of the FCM. Examples of some of the key components identified for the Energy FCM include: UK domestic energy demand and the proportion of energy from non-traditional sources.

Following the identification of the major components, groups worked to collectively identify the relationships between these key components. According to FCM methodology relationships are presented as arrows from one component to another and were classified by the stakeholders as either positive (increase in component A = increase in component B) or negative (increase in component A = decrease in component B). Finally, each relationship was assigned a weighting of between -1 and 1 depending upon the perceived strength of the interaction where -1 indicates a strong negative relationship and +1 indicates a strong positive relationship. In the second part of the workshop the individual FCM maps for energy, water and food were combined into one large FCM using connecting principles/concepts identified by the stakeholders.

Following workshop 1 the paper FCMs constructed by participants were digitised using the Mental Modeller FCM software package (http://www.mentalmodeler.org/) in order to ease interpretation by the next group of workshop participants (See Figure 1). The outputs of the first workshop (November 23rd, University of Leeds) were used in the follow up workshop (December 8th 2015, Cambridge University). In the second workshop the FCM was updated and validated by a different group of experts and then several contrasting future climate and Brexit scenarios were discussed, and their impact on the FCM explored.

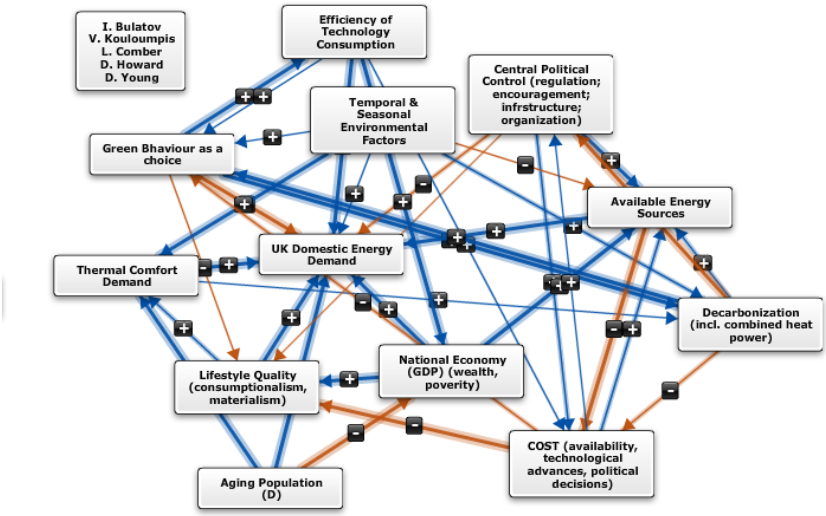


Figure 1 - An example of the Energy FCM developed during workshop 1

The workshops were facilitated by a professional facilitator from the Centre for Facilitation (Christine Bell), supported by two University of Leeds PhD students with specific expertise in FCM.

Outcomes

Survey

The online survey received only 7 responses, and was not referred to in the workshops.

Workshops

Stakeholder participants

Appendix A contains a list of all academic and non-academic expert participants from both workshops. A total of 23 experts participated in the workshop series, 14 in workshop 1 and 11 in workshop 2 representing 12 different organisations. The majority of participants (78 %) were from academic institutions. The remainder of the participants represented business (13 %) and non-governmental organisations (9 %). Encouraging participation from non-academic stakeholders was challenging. However, many of the academic attendees had significant experience of working with stakeholders outside of academia and were able to feed this into the process. Although the Cambridge workshop had a lower amount of attendees overall, it had the largest number of non-academic experts, perhaps highlighting the importance of conducting one-day workshops within commutable distance of industry centres (e.g. London).

Figure 2 - Workshop 1 a group of academic and non-academic experts outline the main concepts for the water FCM

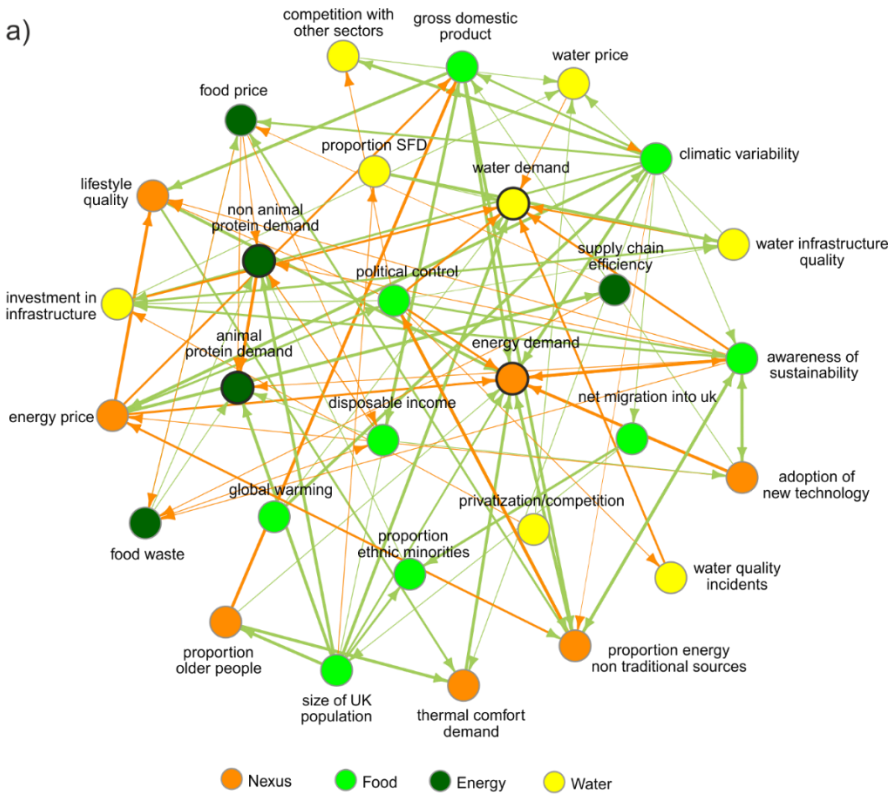
Networking activities

The individual maps produced for water, energy and food in workshop 1 had an average of 18 concepts connected by an average of 36 directional relationships. Interestingly, during validation in workshop 2 in all instances there was a net increase in the number of concepts and connections indicating that more concepts and connections were added, than removed. The combined map produced by stakeholders after workshop 2 contained 50 nodes/concepts and 132 connections.

Figure 3 - Workshop 2, validation of FCMs developed in workshop 1

The final fuzzy cognitive map

Figure 4 shows the final fuzzy cognitive map which was developed and validated during workshops 1 and 2.



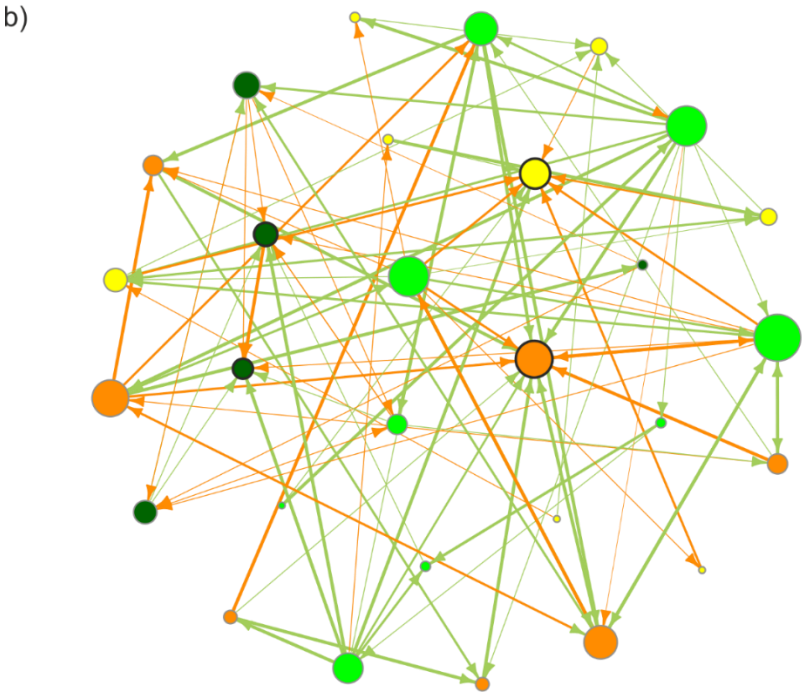


Figure 4. Visual representation of the aggregated and validated fuzzy cognitive map developed during the participant workshops. 29 concepts are connected by 95 interactions. a) The direction of the arrow indicates the direction of the causal interaction between two concepts, the stroke of the arrow indicates the weighting assigned to this relationship, with thicker arrows having a stronger weighting (green = positive, orange = negative). The colour of each concept indicates its source map, where a concept was on more than one of the energy, water of food maps or was highlighted as a connecting concept by participants it is identified as a 'nexus' concept. Demand concepts are highlighted with a black border. Some concept labels have been abbreviated to aid clarity, SFD = single family dwelling. b) Concept labels have been omitted for clarity, interactions as above, the size of the concept nodes is proportional to their centrality to the system. Larger nodes are more central.

Lessons learned, obstacles encountered and insights generated

In this section, we have taken some of the questions outlined in the deliverables guidelines and provided insights from the delivery of the Nexus Brexit Project:

How helpful or unhelpful was the framing of 'the nexus' for engaging with stakeholders and formulating a project proposal?

During the first workshop, groups were based on self-declared expertise to food, water or energy. The framing of 'the nexus' was however very engaging when we brought the groups together to create a connections map.

Comment from one participant: "*Definition of the Nexus, always woolly, but this helped today – the "meta-concepts"* (phrases that captured important factors that spanned all 3 vectors) *could be useful"*

How easy/ difficult was it to achieve 'buy-in' to the project from stakeholders outside academia? What were the issues or obstacles encountered, and what might have helped to alleviate these?

Attracting participation in the project from business and non-governmental organisations was challenging. We conducted one workshop in Leeds and one in Cambridge. Travel expenses to both workshops were covered. Although the workshop in Leeds had more participants overall, the Cambridge workshop attracted more stakeholders from outside of academia, perhaps indicating that workshops located within commutable distance of industry centres (e.g. London) appear to be more attractive to non-academic stakeholders.

How appropriate were the choice of networking activities carried out as part of this grant (e.g. workshops, use of surveys etc.), and what might have been done differently in retrospect?

The return rate for the online survey could have been better; in this instance the workshop format was more successful in generating interest. The survey was too complex and time consuming, having some focus groups beforehand might have been a better approach – given more time.

The size of the workshops was good, the fuzzy cognitive mapping methodology would have been difficult to apply with larger groups. In retrospect, it may have been advantageous for individuals to make their own FCM before the workshop, this might have prevented some of the issues highlighted by participants with the dominance of a small number of individual voices.

How easy or difficult was it to engage people from different disciplinary backgrounds in the project? What kinds of communication problems or other issues were encountered between disciplines (e.g. conflicting problem definitions and priorities; disciplinary hierarchies), and what helped, or what might have helped to overcome these?

Following the first workshop, participants were asked for their comments on the process of developing the FCM and how it facilitated the networking process. We include a table highlighting key points below:

Liked	**Could have been better**
• *Discussing issues around the table (Initial 3 tables), learning from anecdotes.* • *Quantitative aspects (unusual but valuable)* • *Method made us **articulate influences** in a clearer way – **"less wishy/washy"*** • *Definition of the Nexus, always woolly, but this helped today – the "meta-concepts"* (phrases that captured important factors that spanned all 3 vectors) *could be useful* • *Kept on time and task so completed the work in the time available*	• *3 groups of people still processed 3 separate maps – would have been useful to add to the other maps* • *More local scale - Localism didn't get through (e.g. see photos of food post-its on flip charts, didn't incorporate the local content on left-hand chart)* • *Terminology meaning (always a challenge definition to create clear concepts)* • *Different groups → different maps* • *Scale?* • *Ended up at a national scale, because we were on "expert" tables. Maybe if we had rotated tables during development of 3 maps may have helped*
Other observations: • *Topology of maps (3 variations) – did that matter?* • *Validation of the work of this workshop?* • *Could we have used social media to visualise map?* • *Group dynamics did mean that some voices dominated, particularly when we did the finally bringing together of the three maps. Consider how do we get more individual voices captured in this type of process?*	

Table 1 - Feedback on the FCM process from participants of workshop 1.

The FCM approach adopted in the two workshops proved to be useful in facilitating discussion and debate between stakeholders from different disciplinary backgrounds. The FCM approach was relatively straight forward to explain to stakeholders and the process of outlining key concepts and assigning weights to relationships helped to develop debate and conversation about the importance of various concepts and relationships of the nexus. Participants liked the structured nature of developing the FCM and enjoyed the semi-quantitative nature of the task.

However, there were some issues with the FCM process as highlighted by participants, firstly, some participants felt that some voices dominated, and that perhaps it would be good to get individual voices captured in this type of process. There are examples of studies where workshops have taken a different format, and where each participant develops an individual fuzzy cognitive map representing his/her individual understanding of the system. These individual maps can then be combined by the researcher. However, there are drawbacks to this approach, which is less likely to facilitate debate and discussion between stakeholders (something the stakeholders thought was positive), and perhaps less likely to challenge perceptions or misconceptions and incite debate. In this instance, the approach taken (working in groups on individual maps) was probably still the best course of action to meet the aims and objectives of this project.

During workshop 1 participants were split into groups and worked on only one of the maps (water, energy or food). Stakeholders commented that they would have liked to opportunity to work on all three maps. Studying the maps following the workshop, it is evident that people with different disciplinary backgrounds have worked on different maps. It may have been good to rotate stakeholders between maps. However, this would lengthen workshops.

Another comment from participants was the challenge in defining the concepts. Although this was seen as something the participants might like to improve, in terms of one of the aims of the project which was to facilitate discussion and debate between the stakeholders this might actually be considered positive. In defining concepts stakeholders had to think deeply about the meaning of each concept. An alternative approach which could be adopted in the future might be rather than each concept being given just a title, that it be given a description or a definition which could aid clarity. However, this would add complexity to the workshop process and lengthen workshops. Finally, participants commented that the scale (local, national, global) was not clear; in future it would be good to outline the scale at the beginning of the exercise.

What kinds of support do you think would be appropriate to facilitate meaningful transdisciplinary collaboration of the kind attempted in this grant call?

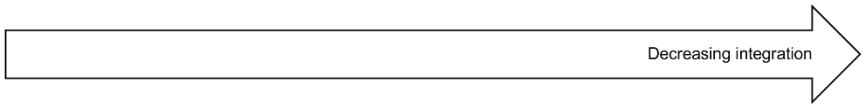
Perhaps something like a Knowledge Exchange fellow that can help running projects improve communications (e.g. online surveys) knowing what works with diverse groups of stakeholders, specifically those connected to Nexus dimensions of water energy and food.

Phase 2: preliminary results

Phase 1 of the Nexus-Brexit project (reported above) involved two workshops conducted at a time when the polls suggested that the UK leaving the EU following the referendum was unlikely (https://ig.ft.com/sites/brexit-polling/). Therefore, the decision by the UK electorate to leave the EU threw the project in a new light.

Following the vote by the UK population to leave the EU, there is a degree of uncertainty around the nature of any future relationship between the UK and EU. We use the FCM generated in the workshops to test three scenarios based around possible future relationships between the UK and the EU in order to assess the potential impacts of different levels of UK-EU integration on energy, food and water demand in the UK. Three scenarios were developed (Table 2), each scenario represents a different level of integration between the UK and the EU, ranging from the most integrated case (Scenario 1) to the least integrated (Scenario 3). It is unlikely that any of the scenarios captures the exact nature of the future UK-EU relationship, rather the idea is to capture the range of integration. The aim of this additional phase of the project is to gather an expert consensus on the implications of the three different scenarios on energy, food and water. Workshop participants were invited to complete an additional online survey in which they were asked what might happen to the value of four key concepts (Gross domestic product, size of UK population, net migration to the UK and political control and regulation) under the different scenarios.

Table 2. Scenarios outlining the possible future relationships between the UK and EU on a scale from the most integrated to the least integrated scenario.



	Scenario 1	Scenario 2	Scenario 3
Votes on EU Law	No	No	No
Bound by EU Law	Yes	No direct obligation, but domestic legislation must reflect EU rules	No direct obligation, businesses wanting to trade in the single market must meet EU legislation
Access to the single market	Free trade on goods **and** services	Free trade on goods but **not** services	No
Free movement of people	Yes	Partial/special agreement	No
Schengen border-free area (area with no border controls)	Yes	Partial/special agreement	No
Contribution to EU budget	Partial, lower contributions still ~80% of those of EU members	Partial, lower contributions still ~40% of those of EU members	No
World trade	Can agree trade agreements with countries outside the EU	Can agree trade agreements with countries outside the EU	Can agree trade agreements with countries outside the EU

Semi-quantitative scenario analysis was conducted using FCMapper (Wildenberg et al., 2010) which uses a logistic squashing function to normalise the values of concepts to between [0,1] (Gray et al., 2014; Özesmi and Özesmi, 2004). In order to estimate the baseline scenario representing the steady state of the system where there has been no intervention or change, the value of each concept is initially set to 1 and iterated until the system reached a stable state. Scenario analysis was conducted following the clamping method of Kosko (1986). The value of one or more of the key concepts is artificially clamped to a high or low value (usually 1 or 0) for each iteration (Vasslides and Jensen, 2016). Examining the difference between the baseline steady state value for each concept and the value for each concept at the steady state resulting from the clamping procedure allows for an assessment of the impact of a change in the value of the clamped concept on the functioning of the system. Relative changes in concept values can then be compared (Özesmi and Özesmi, 2003).

Figure 5 shows the responses from seven participants of the scenario exercise. Scenario 1 represents the scenario with the most integration between the UK and the EU, and is therefore the closest to the current situation. Scenario 3 represents the scenario with least integration between the UK and the EU and is therefore most different from the current situation. In general there is lots of uncertainty and little consensus between the participants about what might happen to the values of the four key concepts under the different scenarios. However, there is agreement that we are unlikely to see large changes (increases or decreases) in the values of these four concepts under scenarios 1 and 2. Under scenario 3, the least integrated case, some participants indicate that large changes might occur in the values of concepts such as GDP, political control, and net migration to the UK. No large changes are indicated in the size of the UK population, the concept which has the largest impact on food and water demand, under any scenario.

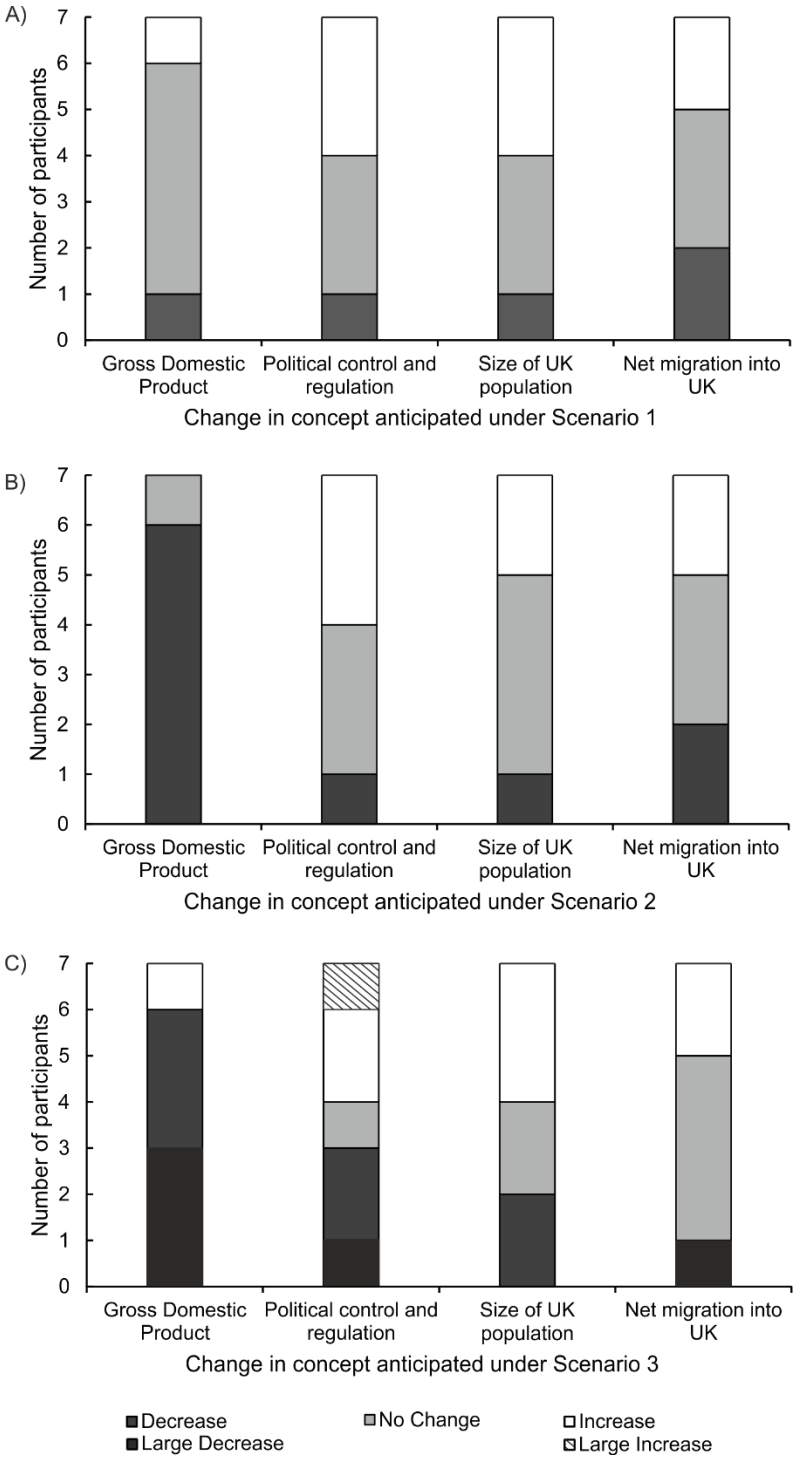


Figure 5. The changes to four key concepts anticipated by the seven survey participants under different scenarios.

The range of responses from the participants' increases from scenario 1 to scenario 3, perhaps reflecting the increased uncertainty as we move further away from the current relationship with the EU. Although there is a lack of consensus on the degree and direction of changes in the value of concepts, particularly in scenario 3, there are some apparent trends. For example, GDP is largely assumed to change little under scenario 1. However, according to the majority (6/7) of the workshop participants its value decreases in both scenario 2 and scenario 3 as the UK becomes less integrated

with the EU. These results are perhaps unsurprising, the link between EU membership and economic performance was stressed by the Bank of England prior to the referendum and the UK joining the EU is estimated to have resulted in an annual gain equivalent to around 10% of GDP, as a result of free trade in the single market (Crafts, 2016).

Political control and regulation is one of the concepts which showed the most variation in perceived change by participants under the three different scenarios. There was no consensus on the direction of change (increase/ decrease) under any of the scenarios. Under all scenarios, one of more of the participants thought that political control and regulation could increase, remain the same, or decrease. The range of responses for the future value of this concept reflects the degree of uncertainty around political control and regulation which in the UK at present, is majorly influenced by the EU.

Reducing uncontrolled migration into the UK was one of the prominent arguments of the Leave campaign during the run up to the referendum. It is therefore interesting that the expert participants in this study did not come to a consensus on the impact of the three different scenarios on net migration to the UK. For scenarios 1 and 2, participants were fairly evenly split between increase (2), decrease (2) and no change (3). Under scenario 3, although one participant suggested a large decrease in net migration to the UK, the majority (4) indicated that no change would occur and 2 participants suggested an increase in net migration even under a scenario where there was no free movement of people between the UK and EU. Similarly, the participants were split on the impact of the three scenarios on the size of the UK population.

For scenarios 1 and 2, the general consensus from participants is for little change. Participants indicate that it is unlikely there would be a large change in the value of any of the four scenario concepts. 3 of the seven participants indicate that there might be an increase in political control, and a further 3 indicate a possible increase in the size of the UK population. Therefore we model scenario 1 by fixing the value of GDP and net migration and artificially increasing the values of the size of the UK population and political control by clamping these concepts to 1.

Under scenario 2, there is a consensus (6/7 participants) that GDP would decrease, the size of the UK population and net migration would not change and that political control would either increase or remain the same. Scenario 2 was modelled by artificially reducing GDP to zero, increasing political control to 1 and holding the values of the concepts size of UK population and net migration to the UK.

As with scenario 2, under scenario 3 the majority (6/7) of the participants thought that the value of GDP would decrease either moderately or greatly. However, there was no consensus on the degree of change or even the direction of change (increase/decrease) in political control. Three participants suggested an increase in the size of the UK population under scenario 3 although the majority of participants indicated that there would again be no change in net migration to the UK. Given the split between participants on the direction of change in political control, we model two scenarios (3- and 3+). The scenarios both see a decrease in GDP and an increase in the size of the UK population, while net migration does not change. However, in scenario 3- political control is decreased, whilst in scenario 3+ political control is increased. Figure 6 shows the difference between the demand concept values for scenario 1, 2, 3- and 3+.

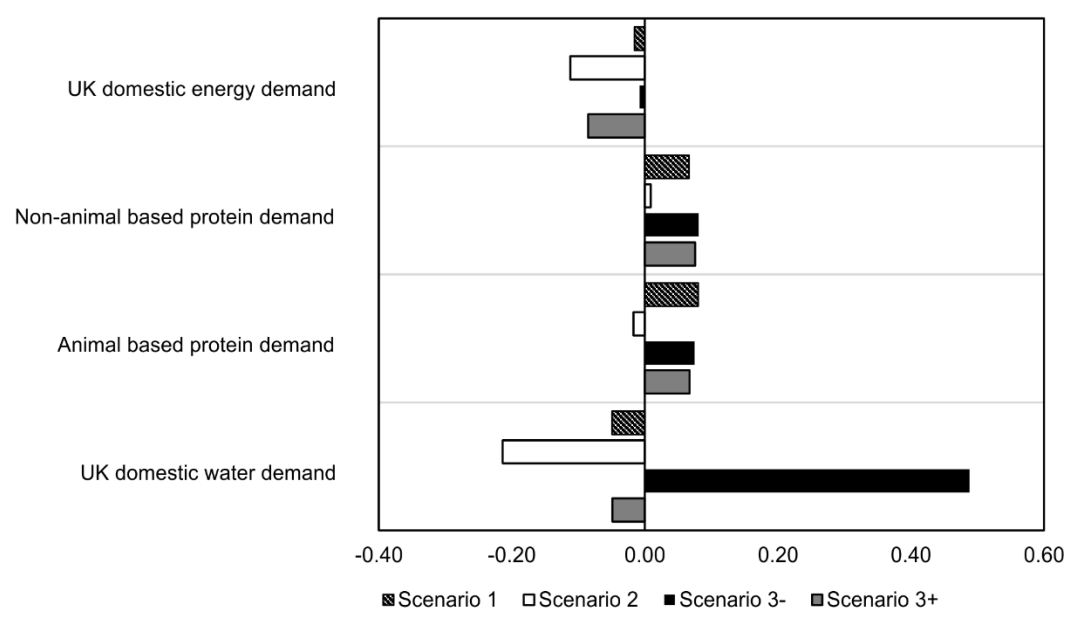


Figure 6. The relative change from the steady state of energy, water and food demand under scenarios 1, 2, 3- and 3+

All scenarios show similar trends in some concepts with a decrease in lifestyle quality and disposable income, linked in scenarios 2 and 3 to the reduction in GDP. However, the scenarios show contrasting trends on concepts heavily influenced by political control, these include: energy price, water demand and awareness of sustainability. UK domestic energy demand will decrease under all scenarios, particularly those in which there is an increase in political control or a decrease in GDP. Under scenarios 1, 3+ and 3- demand for food increases, linked to an increase in the size of the UK population. The major difference between scenarios 3+ and 3- is the degree of water demand which is closely linked to political control and regulation. Decreased political control and regulation leads to a large increase in water demand.

The Nexus Brexit team

The Nexus-Brexit team:

- Dr. Guy Ziv, School of Geography, University of Leeds (Principle Investigator)
- Ariella Helfgott, Environmental Change Institute, University of Oxford
- David Howard, Director LEC Centre for Sustainable Energy, Centre for Ecology and Hydrology
- Shaun Larcom, Centre for Development, Environment and Policy, University of London
- Jean-Francois Mercure, Deputy Director, Cambridge Centre for Climate Change Mitigation Research,
- University of Cambridge
- Andrew Tanentzap, Department of Plant Sciences, University of Cambridge
- Kristian Steele, Senior Consultant, Advanced Technology and Research, Arup

Appendix A – list of workshop participants

Name	Organisation	Job Title	Sector	Workshop 1	Workshop 2
1. Joe Williams	University of Manchester	PhD Student	Academia	Y	
2. David Howard	NERC Centre for Ecology & Hydrology (CEH)	Director LEC Centre for Sustainable Energy	Non-governmental organisation	Y	
3. Victor Kouloumpis	University of Manchester	Post doctorial research assistant	Academia	Y	
4. Philip Rees	University of Leeds	Professor Emeritus	Academia	Y	
5. Alison Heppenstall	University of Leeds	Associate Professor	Academia	Y	
6. Chad Staddon	University of West England	Professor	Academia	Y	
7. Guy Ziv	University of Leeds	Lecturer	Academia	Y	Y
8. Robert Sparles	University of Manchester		Academia	Y	Y
9. Igor Bulatov	University of Manchester		Academia	Y	
10. Suad Al Manji	University of Leeds	PhD Student	Academia	Y	
11. Dylan Young	University of Leeds	PhD Student	Academia	Y	
12. Michael Green	Anglia Ruskin University	Lecturer	Academia	Y	
13. Andy Challinor	University of Leeds	Professor	Academia	Y	
14. Lex Comber	University of Leeds	Professor	Academia	Y	
15. Al Meghji	MWH Global	Design Engineer	Business		Y
16. Liz Varga	Cranfield University	Director Complex Systems Research Centre	Academia		Y
17. Angus Berry	Mott MacDonald		Business		Y
18. Andrew Tanentzap	Cambridge University		Academia		Y
19. Bob Evans	Anglia Ruskin University	Visiting Fellow	Academia		Y
20. Richard Widows	The Flow Partnership		Non-governmental organisation		Y
21. Xiaoyu Yan	University of Exeter	Lecturer	Academia		Y
22. Sally Watson	Mott MacDonald	Principal Hydrogeologist	Buisness		Y
23. Raquel Ajates	City University London	Teaching Fellow	Academia		Y