BEST FOOT FORWARD

Bringing sustainability down to earth

How to Feed a City

A review of UK food chain resilience and environment impact

"Farms, changes in land use and waste contribute 11% of UK greenhouse gas emissions. ***We need to find ways of emitting less while safeguarding our environment and producing food sustainably".***

DECC, the UK Low Carbon Transition Plan

Contents

Project background

This project had multiple objectives which developed through the course of the research in light of early findings. In summary, the work themes were as follows:

1. Review the latest research into food resilience/security – and resilience theory
2. Undertake high level assessment of UK food consumption footprint under business as usual and alternative diet scenarios (using metrics which address greenhouse gases, ecological footprint and agricultural land use).
3. Propose structure for framing future work in this area by *How to Feed a City* (HFC) partners and develop a specification for a web tool which allows users to explore issues relating to food consumption and resilience

This report is presented by these three work areas.

Part 1 – Resilience

Food resilience and security

The food price spike of 2007/8 prompted a number of governmental and non-governmental organisations to launch significant research projects into food system resilience (and related topics including 'food security' and 'food sustainability'[1]). The results of this work are only just coming through now (e.g. the new Defra food strategy[2]).

A complete list of references can be found at the back of the document; however Table 1 below sets out the contemporary publications and projects of particular note – quite a crop!

What role for *How to Feed a City* partners?

Commissioning research in this arena will be an ongoing challenge. The time lag between commissioning and reporting is such that new work risks being out of date or not novel by the time it is completed. It is also likely that other institutions will have access to larger research budgets which will allow more comprehensive studies. One alternative is that HFC partners should adopt a novel approach to research e.g.: a compilation resource of other work (e.g. specialised Wikipedia); distillation and innovative communication of key principles; targeted conferences and network developments to facilitate progress within the sector.

What is the current UK approach?

Government responses tend to focus on business continuity (e.g. of existing retail supply chains) at national/regional levels – whereas those at the cutting edge of thinking in this area stress a more holistic, systems approach which considers 'cross-scale' issues, all three strands of sustainability – and crucially prepare for the unexpected.

Several authors suggest that UK is over-reliant on the free trade solution (we can buy our way out of trouble), and that policy makers are falling for the 'illusion' of European self-sufficiency … i.e. many of the inputs upon which EU production currently depends (e.g. fertilizers and phosphate) are imported from non-EU states, but this isn't picked up in self-sufficiency stats.

The latest offering on food security from Defra – its new 'food sustainability indicators' – have not been well received by some. The City University paper says of them that they "marginalize the real challenges facing food supply in the near future. The impression is of a set of indicators and a policy mind-set rooted in the recent past rather than looking to the future"[3].

[1] See box on Pg. 5 for exploration of the plethora of terms used in this area of food policy
[2] http://www.defra.gov.uk/foodfarm/food/strategy/
[3] *Rethinking Britain's Food Security* (2008). Centre for Food Policy, City University London

What role for *How to Feed a City* partners?

BFF frames sustainability considerations as 'business as usual, evolution and revolution'. These three self-explanatory terms are useful to dissect the congested policy and research arena on food systems, and HFC partners need to decide where on this continuum it wishes the organisation to sit. Because there are so many actors and researchers, HFC should set out its political/philosophical position which will in turn identify likely collaborators and possible adversaries.

The bigger picture…

Because food production is so significant and has many unique qualities, it is easier to forget that it cannot be addressed in isolation. This was expressed in only one reviewed paper: "The food system is and must be understood as a component of the larger economy. It follows that sustainable food can only be achieved if and when the economy overall is re-oriented towards well-being, social justice, stewardship and system resilience."[4]

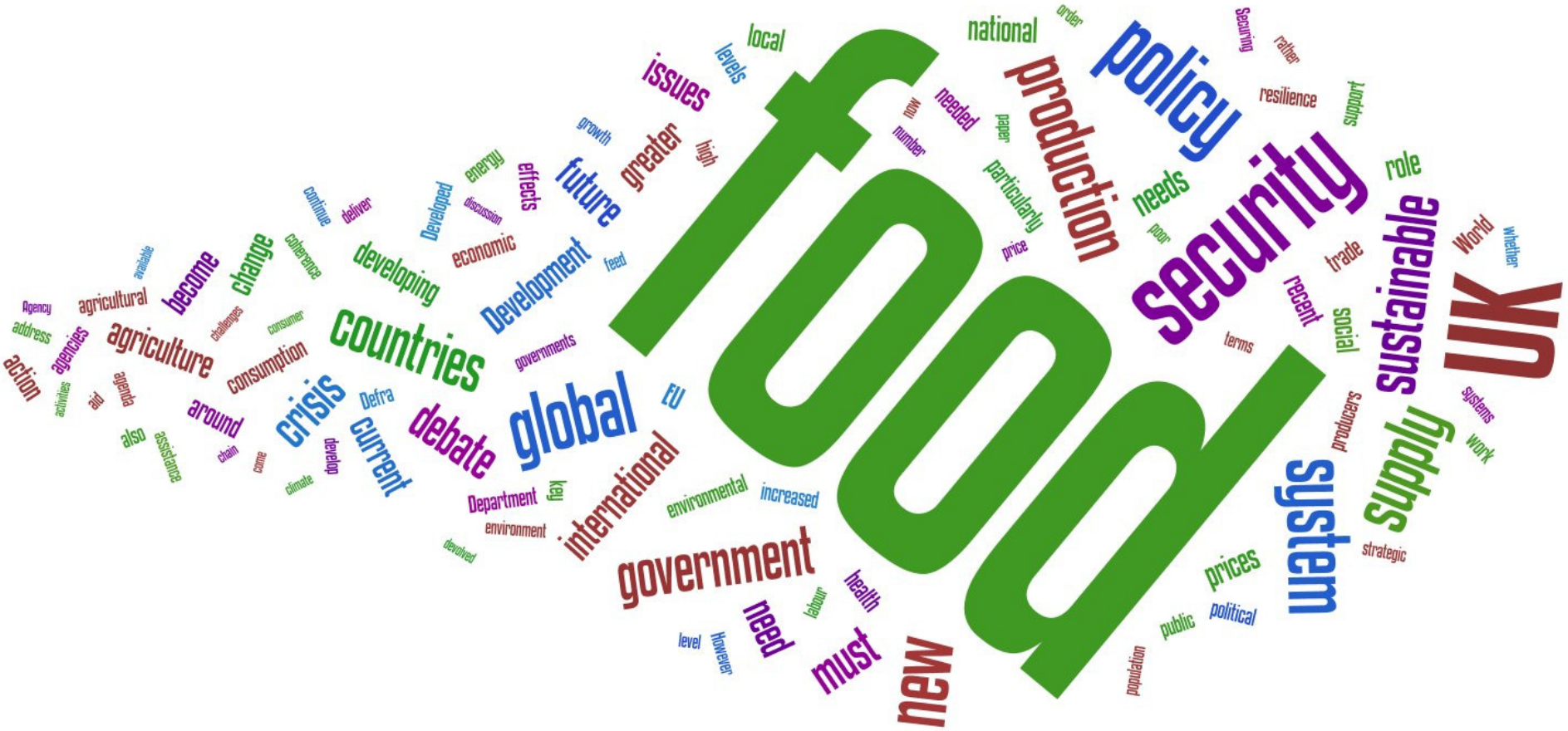
In addition, the NEF points out: "The proposition underlying this agenda for action is that the transition towards more sustainable food must go hand-in-hand with fundamental changes in where and how we live, our residential and commuting patterns, working hours, family and neighbourhood interactions and consumption patterns".

[4] *Re-framing the great food debate: The case for sustainable food* (2009). New Economics Foundation

Table 1: Summary of key food security projects and publications

Project/publication	Institution	Year	Comments
Rethinking Britain's Food Security	Centre for Food Policy, City University London	2008	Proposes 'New Fundamentals' of food systems and criticises current UK approach for being backward looking and too trade-dependent. Need to rethink policy around national food security, but only if this is built into and on a sustainability framework.
Food Futures: Rethinking UK Strategy.	Royal Institute of International Affairs	2009	Final report of two year research project: 'UK Food Supply in the 21st Century: The New Dynamic'. The report highlights the likely limitations of current policy frameworks and governance models in the light of the potential changes it identifies.
UK Food Security Assessment	Defra	2009	A framework of indicators and evidence for assessing UK food security. It is structured around six themes and assesses the current position for each indicator, compares this with past and future predictions.
Development of indicators for a sustainable food system	Defra	2009	Aiming to produce a suite of indicators which will measure progress towards a sustainable food system. When complete, these will form a companion to the UK food security assessment (see above).
Just Desserts? Securing global food futures	Institute for Public Policy Research	2009	Review of current policy that suggests distribution and consumption, plus availability and affordability are vital to achieving food security, yet these are to an extent ignored by current proposals at the expense of increasing production
Re-framing the great food debate: The case for sustainable food	New Economics Foundation	2009	NEF define sustainable food as food associated with high levels of well-being, social justice, stewardship and system resilience. A focus on sustainable food is particularly attractive because it provides a basis for a holistic approach to the challenge of re-making the food system
Food security and sustainability - The perfect fit	Sustainable Development Commission	2009	The message that there is an ideal 'fit' between sustainable development and food security is in danger of being submerged in appeals to single-issue solutions. Food security is a complex issue which in future will require the entire food system and consumers to change
Securing food supplies up to 2050: challenges faced by the UK	Environment, Food and Rural Affairs Committee	2009	Focuses on the challenges involved in securing food supplies up to 2050 and how Defra should respond to them. Concentrates on the political aspects of food security.
Foresight Project on Global Food and Farming Futures	Department for Business, Innovation & Skills	2009	The project will look out to 2050 and take a global view of the food system; considering issues of demand, production and supply as well as broader environmental issues. Findings are due in October 2010.
Foresight Project on Land Use Futures	Department for Business, Innovation & Skills	2009	The project will produce an evidence base which will help government and other policy makers understand whether existing land use patterns and practice are fit for the future. Findings are due in January 2010.

Figure 1 - A ‘word cloud’ developed from the executive summaries of all the reports highlighted above



What role for *How to Feed a City* partners?

How can HFC partners keep abreast of such large volumes of research? This will be a major challenge for the organisation in such a dynamic field, but is essential if it wishes to become an informed voice which moves the agenda forward.

Factors effecting the resilience of the UK food system

While undertaking the literature review a note was made of which food system risk factors feature most commonly. The following list shows these in descending order of popularity, separated into three tiers. Many of these issues are linked by feedback loops – this is what makes assessing of the UK food system's *overall* resilience particularly challenging.

Tier 1

1. **Peak oil** – the almost complete fossil dependence of food systems is number one risk
2. **Climate change** – changes affect production: floods, droughts, temperature, etc.
3. **Population growth** – particularly developing countries
4. **Land resource competition** – particularly biofuels, urban areas, textiles
5. **Water scarcity** – Water counting is likely to be as important for 21st century food and farming as carbon and greenhouse gases are[5]
6. **Quotas, tariffs, protectionism** – bilateral agreements and neo-colonial land grabs featured more frequently than had been expected
7. **Diet** – the likely 'nutrition transition' of developing countries
8. **Labour, social capacity, skills** – will we have the capacity to deliver new food systems?

Tier 2

9. **Soil quality** – degraded land, desertification, poor soil carbon/nutrient levels
10. **Peak phosphate** – essential nutrient predicted to run out this century
11. **Urbanisation/migration** – reductions in rural skills, changes in diet, supply chain needs
12. **Ecosystem collapse** – food production relies on a properly functioning ecosystem
13. **Demographic changes** – an aging population, smaller households
14. **Supply chain bottlenecks** – a few actors control large parts of chain
15. **Animal health** – do food systems promote transmission?
16. **Food safety** – do food systems promote transmission here too?
17. **Conflict/terrorism**
18. **Human illness** – reduces the capacity for food production e.g. AIDS, influenza

Tier 3

19. **Economic shocks** – can be precipitated by any number of causes, many unpredictable
20. **Feeding other nations** – EU has moral obligation to feed other nations?
21. **Political barriers/instability**
22. **Acceptability of new tech to society** – for instance GM
23. **National 'buying power'** – current UK food security relies on economic power. What are risks of currency devaluation; inflation; unemployment; etc.?

[5] *Rethinking Britain's Food Security* (2008). David Barling, Rosalind Sharpe, Tim Lang. Centre for Food Policy, City University London

24. **Soya-based animal feed** – key food chain input which comes from outside EU
25. **Genetic diversity of crops/livestock** – poor diversity increases disease risk
26. **IT corruption** – affecting supply chain
27. **Contamination**
28. **Transport disruption** – port, rail or motorway blockages

What role for *How to Feed a City* partners?
This list of themes and their frequency of occurrence can be used by HFC partners to identify those areas of core interest to the organisation. On one hand, the organisation may wish to focus on the key issues recurring across all areas of research (Tier 1) or on the other hand, HFC partners may wish to select a set of issues which have varying levels of coverage in other research.

A big problem with many names …

Many authors note that the unhelpful plethora of terms used in this field. As noted in City University's research paper *Rethinking Britain's Food Security*:

"The term food security deserves to be reworked. It means different things to different people: food nationalism, food defense, community food security, food democracy, food sovereignty, food risks, food resilience, food capacity. All these carry connotations and have their own as well as overlapping literatures, yet are in the policy discourse. We have ourselves championed the notion of capacity. It is useful in policy to indicate links between productive capacity (can we grow it?), environmental capacity (what is the impact?) and social capacity (are the skills and cultural bases supportive; are the appropriate foods being produced and consumed for a healthy society?)."

What role for *How to Feed a City* partners?
HFC partners need to consider what terminology to use. Once key issues are identified the supporting language must be carefully constructed and remain consistent in communications and engagement. Indeed, HFC partners may wish to champion some terms within the sector to encourage more holistic thinking or focus attention on areas deemed particularly important.

Common themes

The following ideas were common to many of the reviewed papers:

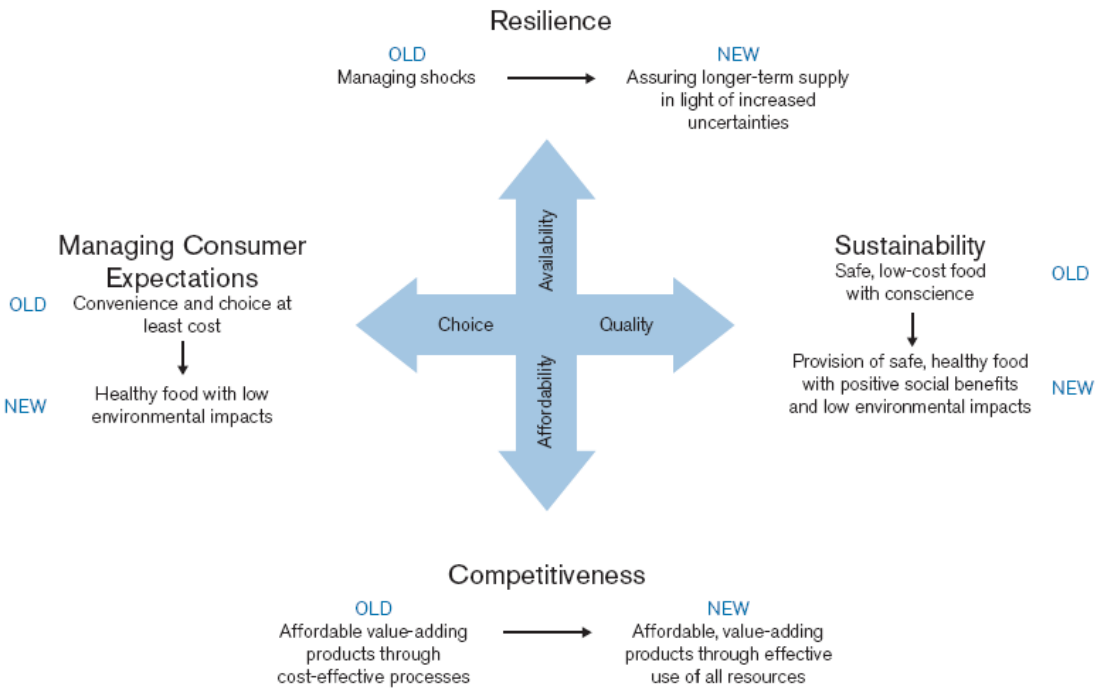
- There is huge variation in what is understood by **the term 'food security'**
- Modern food supply chains are extremely **complex** and there are bottlenecks (e.g. UK retail environment). Ensuring that 'staple' supply chains (e.g. grains for bread) are resilient is a priority. Increased regional stocks may be needed.
- Biophysical and socio-economic **conditions are markedly different** than the past
- **Radical changes are required**: new policy frameworks, institutions, farming practices
- There is urgent need to **understand dependencies** of UK food system at all scales
- We need to prepare the food system for the **'unexpected inevitable'** and attempt to anticipate unintended consequences
- Risk factors (outlined above) are **currently addressed separately** – this won't work
- **Low 'carbon' is not enough** – all 'three pillars' of sustainability (environmental, social & economic) need to be addressed
- The topic of **self-sufficiency** is tackled often – key points seem to be: it is currently value-based (£) but needs to be expressed in actual volumes or nutritional value, however accounting in this way is far more complex; few reviewed authors support radical UK self-sufficiency ('autarky'); self-sufficiency can also be an illusion if it masks the dependence on agricultural inputs e.g. fertilisers. So, what is optimum level of sustainable self-sufficiency?
- There is still debate on the importance of '**local food**' and what exactly this term means. Are we falling for the 'local trap'? Although there is general agreement that we could make much better use of local land e.g. urban & peri-urban areas.
- **Health** issues e.g. obesity, are important and need addressing
- We need to establish a clearer description of a **'sustainable diet'** and to develop communication and education strategies to engage the public on key food issues. Common recommendations include reduced meat & dairy consumption, and promotion of seasonal and unprocessed foods.
- There needs to be increased **investment in public agriculture** and food research
- We need to **work closely with the EU** on food policy
- Can **'comparative advantage' paradigm** – the idea that countries should only produce what they're good at **-** accommodate new challenges?
- Relatively little progress has been made in understanding surprises in agri-food systems, and in defining management practices, social and institutional mechanisms behind these practices to make these systems more resilient
- Improved **nutrient recycling** (e.g. animal, human, food wastes) is needed to mitigate against inevitable scarcity of phosphate and nitrogen inputs
- **Community support** and for agriculture and food processors needs to be fostered – as well as strong supply chain collaboration
- Food **waste** must be reduced – and the residue diverted from landfill
- **Technological** innovations, good transfer of **Best Practice**, and improved **investment** in UK agricultural R&D should be supported

Transition to a desirable food system

The Chatham House study[6] provides a useful summary of the four characteristics of a food supply system – and what transitions need to be made (see Figure 2):

- *Resilience* – long-term availability in the light of increasing global uncertainties;
- *Sustainability* – safe, healthy food with positive social benefits and low environ. impacts;
- *Competitiveness* – affordable food around a potentially higher baseline of costs
- *Consumer expectations* – shape & respond to consumer in line with societal needs

Figure 2: Transition from the old to new food systems[7]



[6] *Food Futures: Rethinking UK Strategy*. Royal Institute of International Affairs, 2009

An applied example: Growing Communities' Food Zone

Ultimately a desirable food system should address as many of the issues identified above as possible, both in terms of discrete risk factors and the wider system. One approach gaining popularity is the 'Food Zone' model which proposes a solution for providing a greater proportion of a community's food from within its boundaries and wider hinterland. Rather than embarking on an extended assessment of the model, it is useful to examine how this model maps onto proposed solutions such as 'NEW' requirements from Food Futures (as shown in Figure 2 above):

***Resilience**: Assuring longer-term supply in light of increased uncertainties*
FZ: Distributed production system and proximal supply provides buffering against global uncertainties

***Sustainability**: Provision of safe, healthy food with positive social benefits and low environmental impacts*
FZ: Local production delivers social benefits (physical and mental health); integrity and understanding of origins; and potential for significantly reduced environmental impacts

***Managing consumer expectations**: Healthy food with low environmental impacts*
FZ: Connecting consumers with food affects leads to less processed choices

***Competitiveness**: Affordable, value-adding products through effective use of all resources*
FZ: Local labour, land use optimization and reduced distribution can provide longer term, sustainable affordability when common externalities are included on the balance sheet.

Question: Does the Food Zone model not address some risks or make them more likely?
Are the four issues described sufficiently granular to highlight where the Food Zones model may result in increased risks/disbenefits?

Resilience theory

Lessons from the world of traditional 'resilience theory'

Resilience is "the ability of a system to absorb shocks, to avoid crossing a threshold into an alternate and possibly irreversible new state, and to regenerate after disturbance"[7]. Resilience theory is well-established branch of social sciences with methods for developing mental models which describe the degree to which a system can recover from disturbance. As far back as 2002, resilience was seen as a key property of sustainability[8]. Resilience theory is commonly applied to socio-ecological systems (SES), which are "a multi-scale pattern of resource use around which humans have organized themselves in a particular social structure".

Rather than attempting to control natural resources for stable or maximum production and short-term economic gain, resilience *management* assumes an uncertain and complex context for natural resources and seeks to achieve sustainable long-term delivery of benefits. This is the opposite of 'growth & efficiency' perspective that has dominated 20th century resource use.

Folk et al. also explain the fundamental resilience challenge as "building knowledge and incentives into institutions … for managing the capacity of local, regional and global ecosystems to sustain societal development in the context of uncertainty, surprise and vulnerability". Resilient systems can therefore be fostered by:

- Learning to live with change and uncertainty
- Nurturing diversity for resilience
- Creating opportunity for self-organisation towards socio-ecological system sustainability
- Combining different types of knowledge for learning

A resilience-aware approach can be also be characterised as acknowledging:

- Interactions occur at multiple temporal and spatial scales
- 'Functional redundancy' provides the potential to increase a system's 'adaptive capacity'
- Assessments are never complete – they need to be revisited continually (iteration)
- 'General' resilience to the unanticipated is needed (as well as 'specific' resilience)

In summary, solutions that address individual problems as they arise may be successful in the short term, but they may also set into motion feedbacks that come into play later. Piecemeal interventions do not prepare a system for dealing with ongoing change and future shocks.

It was decided to briefly review these methods as part of this project (presented in the following section) to see if any lessons could be learnt when considering the resilience of the UK food system – a good example of a socio-ecological system (SES). We do not believe this systematic approach has formally been used in food policy circles – although the term 'resilience' is often used.

[7] *Assessing and managing resilience in social-ecological systems: A workbook* (2007). Resilience Alliance
[8] Building resilience for adaptive capacity in social-ecological systems (2002). Folke C et al.

A systematic approach to resilience assessment

The following text[9] summarises some of the key steps in a resilience assessment of a socio-ecological system. This review focuses on the early steps of defining the system and exploring interactions between key factors and system participants. It is a comprehensive approach so this is only a very brief summary … however it is intended to demonstrate to the reader the structured approach of one type of resilience assessment.

1. Define the boundaries (spatial & temporal) of your focal system

Consider only critical components. This is an iterative process and will be challenging – needing input from the widest diversity of perspectives. If we are addressing the food resilience of the UK, this would be our geographic scale. The temporal boundary would have to be long term – perhaps 100 years? Components to consider include the follow:

- Natural resources
    - What are the main resources?
    - What are economic, subsistence, recreational, cultural, and conservation uses?
    - What are the non-marketed ecosystem services?

- People
    - Who are these people – what about future generations?
    - Are there areas of conflict and agreements?
    - What is economic status of participants – financial constraints?
    - Who has leadership role?
    - Is learning and innovation strong? What institutions and sources support this?

- Governance
    - What organisations control/manage critical resources?
    - What other informal institutions exert influence?
    - Where does real power lie?
    - What are key policies, laws, regulations?

- Commercial and non-commercial values

2. Expand the system – identify cross-scale interactions

Describe the key social, economic and ecological features/processes above and below your focal scale that are of significant influence:

- What are the critical scales? Global, national, regional, local?
- What are policy structures or groups (both governmental and non-governmental)?
- What organizations deal with issues and what are the interactions they have system?
- What critical data/information is missing – how would you fill these gaps?

3. The historical perspective

Having a broad overview of system change through time can reveal system drivers, the effects of interventions, past disturbances and responses. Create an historical profile of the focal system:

[9] Draws on a comprehensive workbook produced by the Resilience Alliance

- On a timeline identify key social, ecological, and economic events that effected your system
- Draw connections between related events & identify reasons
- Did event cause dramatic change in focal system?
- How would you characterise the focal system before and after transition?
- Give these 'eras' names
- What was 'trigger event' for end of era
- List the attributes you believe made the system vulnerable to change
- Are there any patterns in where changes come from (e.g. global economic, local social,)

4. Understand critical disturbances – past and potential
A disturbance can be thought of as anything that causes a disruption to a system. They can be characterised in a number of ways, including: frequency; duration; predictability. For example:

- **Ecological**: drought, fire, disease, hurricanes … humans!
- **Economic**: recessions, innovations, or currency fluctuations
- **Social**: revolutions, new fashions, new values, or technological changes

As part of a resilience assessment you need to characterize the disturbances in your focal system and some of the impacts of those disturbances:

- Identify disturbances that fundamentally alter your system – what are their attributes?
- What component of focal system is most effected?
- Is the disturbance 'pulse' (reoccurring) and 'press' (unremitting)?
- How frequent is the disturbance (if pulse)? And does system have time to recover in-between?
- What is the magnitude of the disturbance? E.g. minor to severe.
- What change has occurred in the past few years or decades? E.g. none, little, intense …
- Which appear most threatening to valued attributes of your focal system ('us best guess')?
- Are any disturbances being actively managed/suppressed? Perhaps too much?
- How about potential future disturbances?

5. Assess potential alternate states
Consider different visions or scenarios for the future of the system

- Briefly summarize the ecological, economic, and social characteristics
- Attempt to define the desirability of each of the states listed above based on the norms and values of different stakeholders
- For each transition, attempt to describe the ecological, social, or economic process that influences the transition(s)

6. Identify thresholds
Identify potentially critical thresholds in your system and explore which disturbances might be pushing your system closer to these thresholds. Is the focal system approaching any thresholds of potential concern?

7. Develop plausible scenarios
Scenarios are carefully constructed stories about the future, which include descriptions, events, actors (people), and mechanisms. They are descriptive models or representations about possible alternative paths that a social-ecological system might take

8. At what stage of the 'adaptive cycle' is the focal system at?
The adaptive cycle describes four phases of change (growth, conservation, release, and reorganization) that are characteristic of many systems. Having an understanding of where a system is in the adaptive cycle as well as knowing a bit about past cycles of change in the system allows for more strategic management. Global food systems are perhaps in the conservation phase?

9. Better understand cross-scale interactions
Knowing which phase(s) of the adaptive cycle these connected systems are presently in can help guide management to reduce vulnerabilities in the focal system caused by system dynamics at other scales. The resilience of a focal system is in large part determined by the interaction of systems across this 'panarchy'.

10. Adaptive & transformative change
Managing resilience requires adaptability – the ability to monitor, assess, respond, recover and renew following known and unknown disturbances and other change. An adaptable system is able to maintain or manage ecological resilience. Sometimes transformation or fundamental change of the system is required. Such transformation relies on the development and nurturing of different forms of capital in order to create and implement options for managing a system.

11. Interventions
Managing resilience involves knowing when, where, and how to intervene. It involves managing interventions holistically, by considering how multiple interventions might interact with each other and carefully planning the sequencing of actions. Single interventions or 'quick fixes' usually offer only partial solutions and are rarely successful over the long-term.

12. Adaptive assessment and management
Managing resilience involves a knowledge-based approach to interventions. Knowing when, where, and how to intervene can be informed by an adaptive management approach that involves probing the system in an experimental way to gain understanding of system dynamics. Equally important to considering which interventions to make, is knowing what not to do, and knowing when to stop current activities that are harmful to the long-term sustainability of a system.

Part 2 – The footprint of UK food consumption

An initial desk-based review of relevant research highlighted a large study was being undertaken at the same time by Cranfield University into the greenhouse gas emissions from the UK food system[10]. The study, which was commissioned by WWF and Food Climate Research Network (FRCN), was also examining the potential for emissions reductions and for the first time included an estimation of global land use change emissions attributable to UK food consumption.

In light of this new research it was decided to redirect project resources and spend less time reproducing a similar analysis – and instead further develop the conceptual framework and propose next steps for *How to Feed a City* project (Task 3). However, it was felt beneficial to undertake a *high level* assessment of UK food consumption using a streamlined approach which also addresses the ecological footprint and land use[11]. The results of this analysis are presented in subsequent tables and figures. The analysis was designed to assess the feasibility of developing a web-based engagement tool for use by a variety of interest parties (Task 3).

Method

The method used can be summarized as follows:

1. Food consumption data was extracted from United Nations FAO statistics[12]. The 'business as usual' scenario used United Kingdom food consumption data while the 'low impact' category used consumption data for Turkey. A similar approach was used in the FRCN study.
2. Ecological footprint and greenhouse gas emissions factors were derived from Resources and Energy Analysis Programme (REAP) which reports these metrics for the United Kingdom[13]. It was decided that using one source for GHGs and EF ensures assumptions and boundaries are consistent. This would not be the case if a selection of individual life cycle studies were used. REAP is a consumption-based resource accounting system which takes into account non-UK resource use and emissions.
3. Finally agricultural land use was estimated using factors published in a peer-reviewed journal. The study, which models land requirements in Netherlands, was used as a proxy for UK production[14].

[10] *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050*. WWF & FCRN: http://assets.wwf.org.uk/downloads/how_low_report_1.pdf

[11] The ecological footprint has emerged as the world's premier measure of humanity's demand on nature. It measures how much land and water area a human population requires to produce the resource it consumes and to absorb its wastes. The ecological footprint is now in wide use by scientists, businesses, governments, agencies, individuals, and institutions working to monitor ecological resource use and advance sustainable development.

[12] FAOSTAT: http://faostat.fao.org/default.aspx

[13] REAP: http://www.resource-accounting.org.uk/

[14] P.W. Gerbens-Leenes et al, *A method to determine land requirements relating to food consumption patterns.* Agriculture, Ecosystems and Environment 90 (2002) 47–58

Results

Table 2: Data sources used in footprint analysis

Data	Source	Year	Comments
Ecological footprint, carbon and greenhouse gas data for UK food consumption	Resources and Energy Analysis Programme (REAP)	2004 (latest version)	Using one source for all three footprints ensures assumptions and boundaries are consistent. Excludes catering.
Food consumption data	Food and Agriculture Organization of the United Nations (FAO STAT)	2003-5	Turkey was used as model dietary profile for alternative scenario. This was also done in recent FCRN research
Agricultural land use requirements	P.W. Gerbens-Leenes et al, *A method to determine land requirements relating to food consumption patterns.* Agriculture, Ecosystems and Environment 90 (2002) 47–58	2002	The method is applied for the Dutch situation and resulted in an overview of land requirements for over a hundred individual food items.

Table 3: Food consumption, ecological footprint, carbon footprint, greenhouse gas footprint and agricultural land use estimates for UK food consumption under two scenarios: business as usual (BAU) and low meat (based on dietary profile of modern-day Turkey).

	Food quantity (tonnes)		Ecological footprint (gha)		Carbon dioxide (tonnes)		Greenhouse gases (tonnes)		Land use (hectares)	
Food group	**BAU**	**Low impact**	**BAU**	**Low impact**	**BAU**	**Low impact**	**BAU**	**Low impact**	**BAU**	**Low impact**
Alcoholic beverages	7,405,035	5,553,776	3,416,981	2,562,736	4,270,037	3,202,528	7,462,230	5,596,672	740,504	555,378
Dairy products	14,569,789	7,383,191	5,800,951	2,939,612	4,200,126	2,128,399	15,673,691	7,942,590	1,529,828	775,235
Fish	1,310,626	415,031	2,681,395	849,108	1,506,261	476,983	4,650,141	1,472,545	0	0
Fruit & vegetables	12,778,600	20,030,729	14,424,397	22,610,551	5,811,807	9,110,131	17,892,621	28,047,065	527,090	728,053
Cereals & starches	14,111,070	16,623,103	7,057,341	8,313,678	5,507,410	6,487,831	12,773,153	15,047,012	1,260,822	2,219,326
Meat	5,220,659	1,310,626	17,999,313	4,518,656	11,924,691	2,993,646	51,202,463	12,854,175	7,556,904	1,897,131
Other products	3,647,908	2,686,783	8,081,126	5,951,967	8,287,386	6,103,883	16,528,770	12,173,884	1,260,504	930,471
Oils & fats	1,616,438	1,681,970	1,081,895	1,125,756	565,718	588,653	1,567,073	1,630,603	2,681,831	2,366,262
Total	**60,660,126**	**55,685,209**	**60,543,399**	**48,872,064**	**42,073,435**	**31,092,054**	**127,750,142**	**84,764,546**	**15,557,483**	**9,471,855**
Total per capita	**1.01**	**0.93**	**1.01**	**0.82**	**0.70**	**0.52**	**2.13**	**1.42**	**0.26**	**0.16**

Figure 1: Greenhouse gas emissions, ecological footprint and food consumption in 'business as usual' scenario

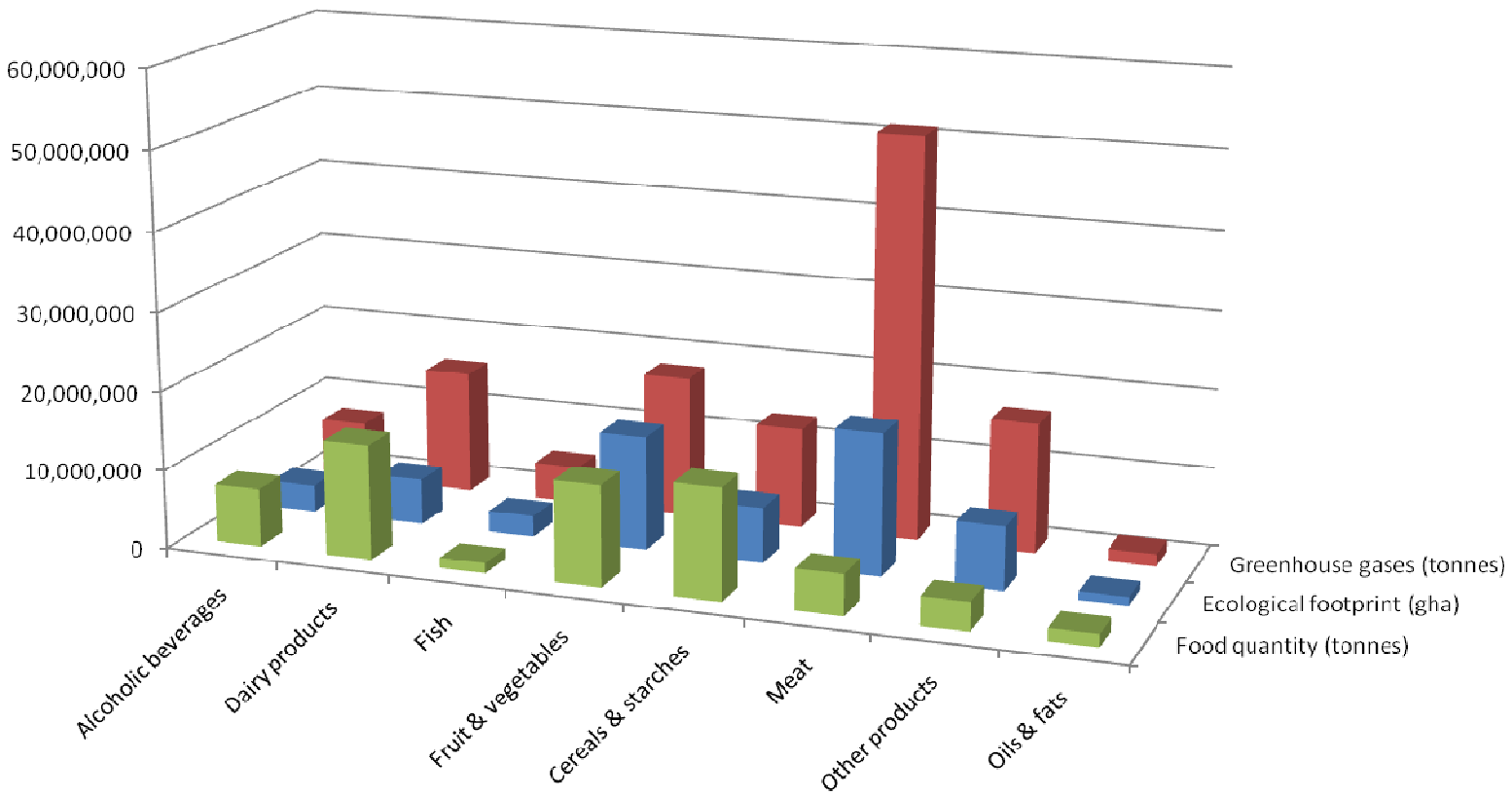


Figure 2: Greenhouse gas emissions, ecological footprint and food consumption in 'low impact' scenario

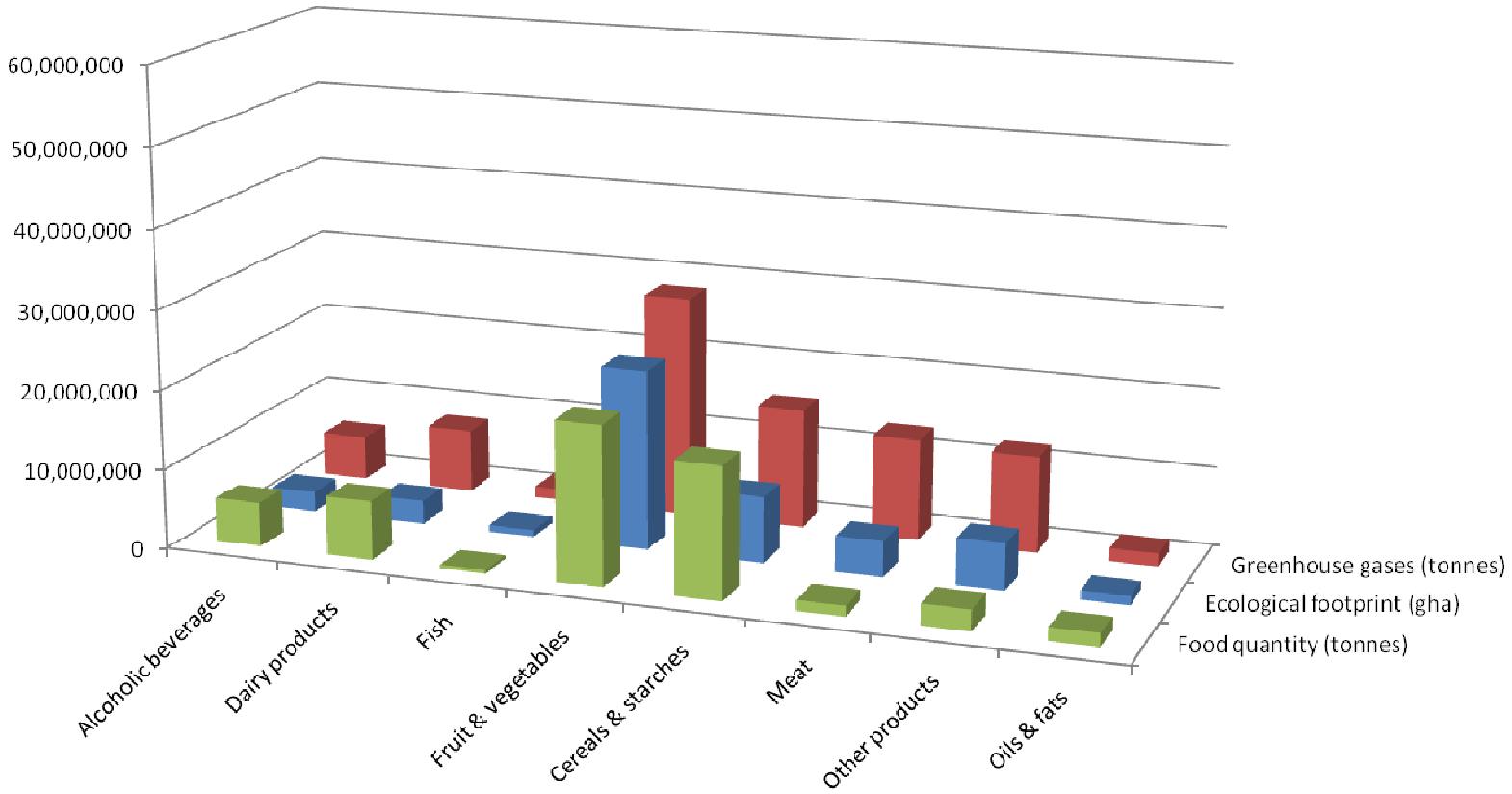
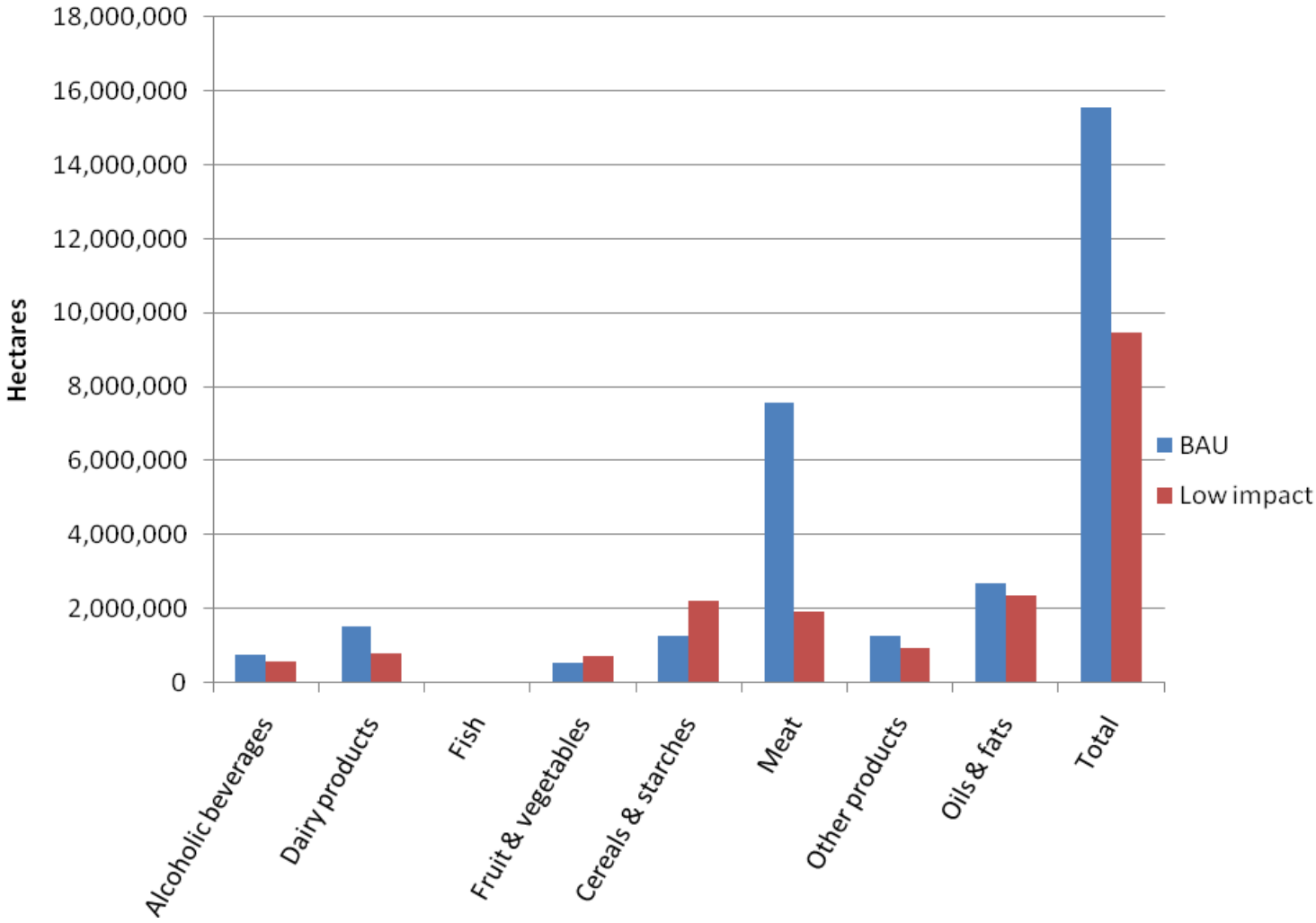


Figure 3: Agricultural land use for business as usual and 'low impact' scenarios



Actual vs. budget

To put these results in context they were compared with an estimate of a resource 'budget' by 2050 (see Table 4). Both ecological and carbon footprint measures are far in excess of budget estimates for the year 2050 – even in low impact scenarios. Based on this basic analysis physical land resource is not such an issue at a global level, but is limiting from a UK perspective[1].

Table 4: Actual footprints vs. budget in 2050 for UK and world situations

Metric	Unit	BAU	Low impact	Budget UK	Budget world
Ecological footprint	Gha	1.01	0.82	0.34	0.37[2]
Greenhouse gases	CO_2e	2.13	1.42	n/a	0.50[3]
Agricultural land use	Hectares	0.26	0.16	0.13[4]	0.38[5]

Comparison with FCRN/WWF study

A comparison with the FCRN results was made. The absolute results of this study were significantly larger than the FCRN study (127,570 ktCO2e and 85,883 ktCO2e respectively) – although spread of emissions was broadly similar (see

[1] It should be made clear that this analysis was based on European production outputs per hectare and does not take into account the appropriateness of different land types to produce different foods.

[2] Projected TOTAL per capita biocapacity (world) in 2050 based on current per capita biocapacity (Living Planet Report 2008 = 2.1 gha/person) and UN projections on population in 2050 (9.1bn). Assumes food is 25% of total capita ecological footprint (UK situation in REAP 2004).

[3] 2050 emissions target per capita assumed to be 2tCO2e (based on Dimitri Zenghelis and Nicholas Stern "Principles for a Global Deal for Limiting the Risks from Climate Change". Environmental and Resource Economics (2009) 43:307–311). Additionally assumes food allocated 25% of all emissions (FCRN estimates 19% currently).

[4] Projection based on Defra Environmental Accounts: Land cover Great Britain 2007. Arable, horticulture and improved grassland areas (9,102,000 hectares) and 2050 population (68,900,000 people).

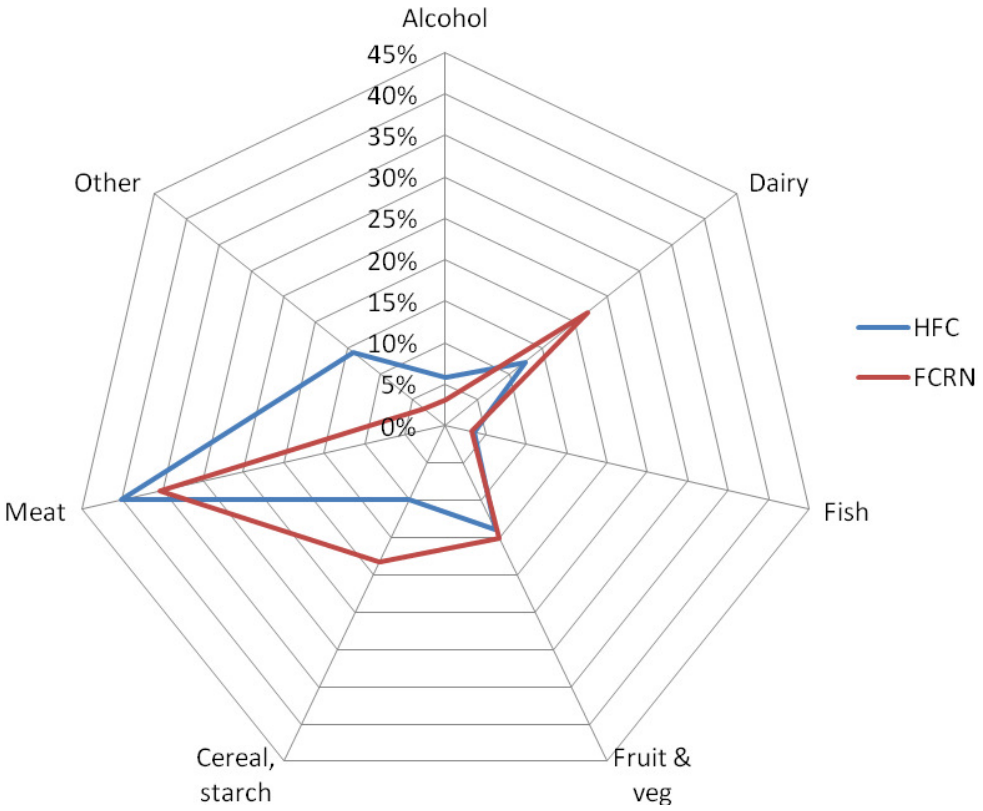
[5] Globally 3,459,780,000 hectares agricultural land, 2050 world population 9.1bn

Figure 4). Notable differences include 'alcoholic beverages' and 'other foods' – however it is difficult to assess the reasons for this e.g. different study boundaries.

Table 5: Comparison of *How to Feed a City* (HFC) and FCRN results

	Kt CO_2e		
Food group	**HFC**	**FCRN**	**% diff**
Alcoholic beverages	7,462	2,610	186%
Dairy	15,674	18,850	-17%
Fish	4,650	2,780	67%
Fruit & vegetables	17,893	12,960	38%
Cereals & starches	12,773	15,670	-18%
Meat	51,202	30,300	69%
Other foods e.g. sugar	18,096	2,713	567%
Total	127,750	85,883	49%

Figure 4: Comparison of How to Feed a City result with FCRN study



Part 3 – Future work

Despite the growing body of information on food system resilience and environmental impacts there is a lack of accessible decision support tools which can make sense of the many competing issues – and enable action.

The proposed tool will allow users to explore how different food production systems and consumption profiles impact upon the environment in a finite world. It will be pitched at informed decision makers (e.g. policy-makers, procurement professionals) and enable a high level and comprehensive assessment of key environmental drivers and risks – and so facilitate further discussion of issues.

Tool description

The key variables and outputs the tool should have are outlined below.

Variables

The user should be required to enter values for a range of relevant variables. Useful predefined defaults should be presented – but values could be edited by the user, if required. The variables should be:

Settlement size

- Number of people: men, women, children

Food consumption

- Dietary share of main food groups (to be defined – but will be at least 5 groups)
- Food intake (kg) – to capture the impacts of excessive consumption
- Waste – to the impacts of waste treatment and 'overhead' of wasted resources

Food production and distribution

- Agricultural method – due to data availability this will be 'conventional' or 'organic'
- Land use change – percentage of food from previously forested/natural grassland
- Production location – based on Food Zones. Where does the food come from?

Outputs

Results should be presented graphically and in tables 'per person' and for total modelled settlement by the following variables:

- Nutritional value – compared to UK recommended
- Land use – compared to available in each zone
- Energy
- Greenhouse gas emissions – in context of UK per capita emissions & global 'budget'
- Water (optional – see project costings below)

Additionally a risk matrix could be presented with a traffic light system (green, amber, red) highlighting the key issues affecting the modelled scenario. The risks addressed will flow those highlighted in Table 6.

Table 6: A matrix of participants, influencers, fundamental issues and other considerations – all split by supply chain location

	Production	Processing/Distribution	Retail	Consumer
Characteristic (current)	Small/medium-sized producers; global production and inputs	Medium/large-sized organisations; global	Small number of private organisations dominate; global	Individuals, families ; public sector; private sector
Key influencers	Government (all levels) Importers/exporters Agri-business (chemicals, GM) NGOs Retailers Consumer	Government Retailers	Government NGOs Media Shareholders Customers	Government (national, EU) Institutions (schools, NHS, etc.) NGOs Retail (supermarkets) Media (brand)
Tier 1 issues	Peak oil Climate change Land resource Water scarcity Trade barriers Social capacity Diet Population growth	Peak oil Water scarcity Trade barriers Social capacity	Peak oil	Peak oil Population growth Water scarcity Diet (season, vol., composition)
Tier 2 & 3 issues	UK competitiveness Soil quality Peak phosphate Urbanisation Ecosystem collapse Animal health Food safety Conflict/terrorism Human illness Economic shocks Crop genetic diversity Contamination Transport disruption	Urbanisation Food safety Conflict/terrorism Human illness Economic shocks IT corruption Contamination Transport disruption	Urbanisation Food safety Conflict/terrorism Human illness Economic shocks IT corruption Contamination Transport disruption	Conflict/terrorism Human illness Economic shocks Currency weakness/inflation Transport disruption
Other considerations	Profits Export market Brand/marketing Non-CO2 emissions	Profits	Profits Waste Brand/marketing	Quality (nutrition; perception) Provenance Value-for-money Waste Equity Cooking & refrigeration

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