Strategic Evidence of Future Change (3): trends and issues for the natural environment and food systems

Energy source developments
Controversy over CCS, and continued new sustainable energy source developments

Energy storage and distribution
Major battery innovations, and effects on the grid

Physical resource sustainability
Innovative approaches to construction and re-use of waste.

Cultural attitudes to sustainability
Shifting cultural attitudes to sustainability: no longer a fringe value, sustainability is becoming a mainstream concern

Health risks from chemicals
Both the cocktail effects in water and the risks from fracking are causing concern

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- Connected infrastructure and cybersecurity
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- Biomimicry to reduce environmental damage
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STRATEGIC EVIDENCE OF FUTURE CHANGE (3)

Executive Briefing September 2015

This foresight briefing is the third in a series produced for Defra and its Partners intended to help to identify potential strategic threats, risks and opportunities to strategy, policy and operational goals that may need new responses.

The evidence is a collection of horizon scanning data from published sources gathered by SAMI Fellows and Principals, a team of scanners at Manchester University and trained scanners across the Defra Partnership[1] over April and May 2015. It therefore contains some material which is already known within the Defra Partnership.

The report covers five major clusters of change emerging from the data and a number of emerging signals. References to developments in known trends are covered in the main report.

The full report, on which this briefing is based, can be found at http://samiconsulting.co.uk/5reports.php#Defra.

Department for Environment Food & Rural Affairs

NATURAL ENGLAND

Environment Agency

Food Standards Agency food.gov.uk

Llywodraeth Cymru Welsh Government

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Robust decisions in uncertain times

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[1] Defra, Natural England, Environment Agency, Food Standards Agency, Welsh Government

If CCS really is ineffective, and renewable energy does not succeed in reducing GHG emissions, then the environmental impacts could be enormous. Does Defra's contingency planning need to be reviewed?

Are there concerns that hydropower systems may have negative ecological effects, eg on bird populations?

ENERGY SOURCES

Continuing development of both fossil fuel and sustainable energy sources offers new opportunities and challenges

In previous reports, we identified the prospect of global energy price deflation, discussed a number of alternative fuel technologies, especially microgeneration, and explored the increasing citizen activism around climate change.

In this period we have seen:

- Continued discussion of fossil fuel policies – debates over CCS, gas lock-in – and the impacts of other new technology (supercritical carbon dioxide - sCO_2) on fossil fuel energy systems.
- Further development of wind, tide, biofuels and "Blue" energy technologies, notably:
  - high altitude wind power
  - a new type of hydropower turbine
  - pressure caused by osmosis of salt and fresh water in estuaries
  - "small hydropower" – micro-turbines in pipelines
  - several biofuel developments which don't cause conflict with food production.

What are the safety, recycling and contamination implications of large batteries used domestically? What new facilities may be needed?

Does the extensive use of "second-life" batteries pose different challenges?

ENERGY STORAGE AND DISTRIBUTION

New developments of battery technology and smart grids offer ways of responding to renewable energy generation.

Many of the renewable energy developments will only become economically viable if there are changes to the storage and distribution of energy. We have seen recently:

- Major battery technology developments such as:
  - the Tesla Powerwall battery
  - a simplified and cheaper version developed in Britain
  - "second life" batteries – ex electric vehicle (EV) batteries, used to store domestic electrical energy, such as those Nissan refurbish from their Leaf model
  - promising new technologies like Lithium-Sulphur batteries, quinone flow batteries, and nano-scale coatings on Li-ion electrodes.

- Implications for the grid
  - a “smart grid” sensing system overloads and rerouting power to prevent or to minimise any potential outage; accepting energy from virtually any fuel source
  - multi-directional grids that allow automation of the energy generated from a mix of sources, so that it can monitor and self-heal as well as collect information to improve efficiency.

PHYSICAL RESOURCE SUSTAINABILITY

Economic growth creates challenges for resource sustainability and is driving innovative new approaches to construction and re-use of waste.

With increasing construction worldwide the consumption of sand is becoming unsustainable. Inshore sand mines are running out, and desert sands are not suitable for building. Consequently, illegal enterprises are springing up and extracting sand from the coastlines, potentially causing major environmental damage to biodiversity, water resources, coastal erosion, and many other processes.

What needs to be done to protect eco-systems threatened by illegal sand removal?

Are there opportunities to use self-healing concrete to reduce maintenance costs of Defra Partnership infrastructure?

Are there regulatory implications if we wish to facilitate paper and pulp waste re-use?

What changes to waste management regulations may be required to respond to re-use of animal waste?

Is there need for greater co-ordination of energy, water and food planners and policy-makers?

“Biological buildings” with biodegradable pellets containing alkaline tolerant bacillus bacteria and a calcium lactate food source mixed in with the regular concrete mix can create “self-healing” materials.

As raw materials become more expensive, re-use of waste becomes more economic. Several new ideas are emerging involving re-using paper and pulp waste to produce fossil fuel substitutes, fragrances, bioplastics, pharmaceuticals and chemicals, or using lignin, another paper and pulp by-product.

Similarly, animal waste-based “fabrics” are being developed for biomedical applications. Pork gelatin can be turned into a wool like yarn and made into a glove, which could have applications where disposable or biodegradable materials are needed, particularly in the biomedical field where is shares similarities with tissue constituents.

The Water-Energy-Food nexus deserves attention. Improving energy, water and food supplies may be best addressed in an integrated manner. Energy, water and food planners and policymakers working together could devise integrated policy and infrastructure solutions.

To what extent does increased public concern translate into increased public activism – and how can relevant agencies ensure that interest converts into opportunities for civic partnership, rather than risks of civic protest – or litigation?

Do the relevant agencies have contingency plans in place to manage a possible massive upswing in environment-related litigation?

What response is required to a groundswell of coverage around a broader range of issues if movements similar to #DroughtShaming should gain traction in the UK?

CULTURAL ATTITUDES TO SUSTAINABILITY

Shifting cultural attitudes to sustainability: no longer a fringe value, sustainability is becoming a mainstream concern

Feeling it more: A global survey by the Pew Research Centre placed climate change as the highest public concern worldwide; the 2015 ICM Unlimited poll of over 2000 UK residents indicated that the majority of Britons remain worried about climate change.

Doing more: Crowdsourcing science by engaging citizens is a growing trend and relies on growing and informed popular interest in those impacts. Recent examples include:

- iSPEX-EU, a Europe-wide campaign involving citizens in measuring air pollution using an optical-sensor add-on to a smartphone.
- The Royal Horticulture Society's urban greening project, "Greening Grey Britain".
- Citizens in California using social media to "name and shame" people believed to be wasting water by posting photos or video evidence on social media with the tag #DroughtShaming.

Selling it more (business is getting serious about sustainability):

- Firms increasingly believe that sustainability is good for business – and one reason is that they feel consumers care more.
- Asset owners and managers are increasingly worried about climate change impacts and risks, and are making those concerns known.

Litigation could increasingly be a key public mechanism to spur sustainability

- The Dutch government was successfully challenged for taking inadequate action on climate change.
- A group of Belgian activists is planning to take legal action against their government.
- A small Peruvian community is planning to take action against a German energy company, because glacial melting is threatening to burst the banks of nearby lakes and flood their farmland.

How might these "cocktail effects" impact on water quality objectives?

If a "cocktail effect" is identified in a pair of pollutants, then should limits be reduced for one or both pollutants? How will regulators choose which?

If a health scare arises, what response should the respective agencies make to address it?

How might the regulation of fracking activities account for the potentially detrimental health effects?

Can the extraction methodology be influenced in the UK so that harmful levels of PAH pollution from future fracking activities are avoided?

Is farming land a safe disposal route for fracking waste, considering the impacts on food safety alongside other concerns such as water quality?

HEALTH RISKS FROM CHEMICALS

Cocktail effects in water and other pollutants

The toxicity of chemicals in combination is something that is increasingly rising up the research agenda, and a growing number of research papers are highlighting the impact of combinations of chemicals on the environment and health.

- Nitrogen dioxide and ground level ozone increase the allergic reaction of certain airborne allergens to humans.
- The combined toxicity of the endocrine disruptor 17a-ethinylestradiol and ammonia exceeds their effects individually.
- Methadone in wastewater can react with disinfectants used in water treatment plants, to produce N-nitrosodimethylamine (NDMA), a known carcinogen.
- New research suggests that 50 chemicals, not originally thought carcinogenic, can cause cancer when combined, suggesting current safe levels are incorrect.
- During wastewater treatment, the levels of two antibiotics increased by up to 120 per cent due to interaction with microbes.

There is a need to better understand how the combination of chemicals found in our waterways may interact. If cocktail effects mean that current limits for chemicals are not strong enough, this will have consequences for regulation.

Health effects of fracking

A number of stories appeared in this period that explore the unexpected impacts of fracking on human health:

- An editorial for a leading public health journal argues there are a range of roles for public health professionals when considering the relatively unknown health impacts of fracking. The article suggests public health professionals could take a more public role in discussions on the health implications of fracking, at a global level.
- Early evidence from studies in the USA suggests there are increased hospitalisations rates in communities around fracking sites, though the causes of these hospitalisations and any link to the fracking industry require further research.
- People living or working close to hydraulic fracturing activities could be exposed to unsafe lifetime levels of airborne PAHs (polycyclic aromatic hydrocarbons) pollutants.
- In the USA, dumping of fracking waste on agricultural land is currently economical, but this practice does not account for the risk that the toxic compounds with the waste may pose to crops, grazing animals, and, since people eat these, human health.

EMERGING SIGNALS

Connected infrastructure and cybersecurity

While a connected infrastructure may improve how the natural environment, water, and food are managed, it also creates a wealth of emerging cybersecurity vulnerabilities.

Sensors, microchips, and Wi-Fi connectivity are being built into, or attached onto, more and more infrastructure. Digital tags and sensors are being applied further along the food chain, all the way back to the farm and its livestock, including market-ready "smart" farming systems. While a wealth of data and instantaneous updating may improve how the natural environment, water and food are managed, it also creates a wealth of emerging cybersecurity vulnerabilities.

How do EU specifications for open source code create new vulnerabilities for public infrastructure? How could hackers turn "anthropomorphised" civic infrastructure against citizens, business people, or civil servants? What new forms of crime could occur via hacking environmental or food chain sensors? What havoc could hackers create on smart environmental management systems? How might this affect various agencies' incident management protocols? How do we systematically assess the vulnerability of connected infrastructure already in place, and future planned systems, to cyber threats? How do we calculate the breakeven between the benefits of deploying smart systems for built environment or natural environment management, and the considerable costs of securing them?

Innovative sources of protein for livestock and fish extracted from insects and algae

Protein from insects, algae and other sources represents a novel way of responding to increased demand.

We are seeing a number of stories on new forms of animal feed derived from various novel sources including aquatic plants, methane, and insects. Such innovations will prove very important, and potentially disruptive to existing animal/fish feed supply chains. They could create new markets that would also need new infrastructure and may need new regulatory systems.

Current EU legislation prohibits the use of insect protein in animal feed. Insect sources therefore probably present different regulatory challenges than other novel protein sources.

What new regulatory system would be appropriate for novel animal feeds? Are current EU regulations on the use of insect protein in animal feed still appropriate?

… replacing "heat, beat, treat" in industrial processes.

Decreasing environmental damage via biomimicry

Increasingly scientists, engineers and designers are creating new materials, new tools, and new processes based on the study of natural organisms and processes. This research paradigm tries to mimic nature's efficiencies. Organisms create structures and materials within their own bodies, at ambient pressures and temperatures, without the need for fossil fuel energy sources, the heat of a forge, high pressure extruders, or toxic chemical baths. If a majority of industrial processes were based on biomimicry innovations, the overall impact of human industry on the environment might be considerably lessened.

Have any studies assessed before and after effects on the environment from the adoption of nature-inspired industrial innovations? How could the UK accelerate this evolution in industrial processes?

The techniques of additive manufacturing (3D printing) are being used to construct building and bridges from metal and from concrete.

3D printing of infrastructure in situ

3D printing of concrete offers the promise to create new structures quickly and without the cost associated with shuttering necessary for traditional poured concrete construction. It may also be possible to create structures and shapes that are not possible with traditional poured concrete. Proponents have constructed houses, and even propose a complete office block using these methods.

Developments in construction are of interest from a flood defence and waste perspective. The cost savings and reduced waste of automated construction could make this technology increasingly attractive in reducing the future costs of flood protection construction and maintenance.

Would the ability to build custom structures out of concrete faster and more cheaply be relevant to flood defence? As houses can be built very quickly with this technique, what impact might it have on the pressure to build more homes? Do we need an accelerated programme of environmental life-cycle assessments on new 3D printing technologies?

Scientists calculate that temperatures will reach 2°C above pre-industrial levels by 2036.

2°C threshold to be exceeded by 2036?

Globally the current indicators show that the trajectories for greenhouse gas emissions are such that a 2-degree rise in global temperatures is very likely to be exceeded. Continuing to burn fossil fuels at the current global levels will, according to some scientists, mean that

temperatures will reach 2ºC above pre-industrial levels by 2036. This in turn will lead to an increase in the frequency and intensity of weather extremes alongside changes to habitats and biodiversity. For example, rising sea levels and the increasing probability of floods threaten the UK coastline.

Some analysis suggests the temperature rise could easily reach 4ºC, because of lack of government action and a glut of cheap coal, leading to a coal renaissance.

If we can expect this change in 20 years what modification to conservation and environmental policies may be required? Does this also presage a shift in climate change policy? If faster action is needed how best can this be encouraged?

El Niño – third strongest on record

US forecasters have upgraded the 2015 El Niño to "unusually strong"

Whilst climate impacts from these events are chiefly felt in the Pacific region, they do have implications for global weather as they are thought to be responsible for a range of weather related events, including periods of major flooding and colder winters in Europe. In turn, these effects could impinge on the global food chain, the global economy, and the global reinsurance market. All of these impacts could shift public opinion on climate change.

A new model has been developed for predicting El Niño variations up to a year in advance. The results of this model could help in planning responses globally which might minimise the impacts of El Niño effects such as increased flooding or extreme temperatures.

Cyclical events such as El Niño can be used to both support and deny climate change, What messages should be considered by the Defra Partnership in the light of the recalibration of the 2015 El Niño? If the 2015 El Niño causes extreme weather events for the UK what preparations can be put in place in advance? Could the new predictive model help flood forecasting?

Evolution of known trends

We have also seen developments in trends noted in previous reports in this series, most notably on:

- NO_2 air pollution deaths assessment, where the VW story will also have an impact.
- Biofuels, where several developments appear promising.
- Gene editing is becoming mainstream - CRISPR continues to offer new opportunities.

These changes are discussed in the main report.