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Integrating horizon scanning and strategic risk prioritisation using a weight of evidence framework to inform policy decisions.

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Abstract

Poor connection between data on emerging issues and credible policy decisions continues to challenge governments, and is only likely to grow as demands on time and resources increase. Here we summarise recent efforts to integrate horizon scanning and risk prioritisation approaches to better connect emerging issues to the political discourse on environmental and food-related issues. Our categorisation of insights including potential future risks and opportunities to inform policy discussions has emerged from a structured three-year programme of horizon scanning for a UK pan-governmental futures partnership led by the Department for Environment, Food and Rural Affairs (Defra). Our efforts to integrate horizon scanning and risk prioritisation, utilising a qualitative weight of evidence framework, has created a systematic process for identifying all signals of potential future change with significant impact for the strategic mission and underlying values of policy actors. Our approach encourages an exploration of factors out of the control of organisations, recognising that resilience depends on the flexibility of management strategies and the preparedness to deal with a variety of unexpected outcomes. We discuss how this approach addresses key cultural and evaluative challenges that policy actors have had in embedding horizon scanning in evidence-based policy processes, and suggest further developments to build confidence in the use of horizon scanning for strategic planning.

Keywords: horizon scanning, policy, strategic decision-making, risk, prioritisation, futures.

1.0 Introduction

Strategic decision-making in government necessitates systematic use of the best emerging information on potential opportunities, obstacles and change. Among the range of tools to facilitate this process, horizon scanning is applied to carry out a thorough examination of risk, uncertainty and emergent trends to identify, and work through, assumptions (implicit or explicit) about the future (Munn, 1991; Konnola *et al.*, 2012; Miles and Saritas, 2012). The method allows for an analysis of the complexity around specific strategic, policy and implementation challenges or, as a generic function, to inform and help review and evaluate overall strategies and direction (van Rij, 2010; Cook *et al.,* 2014). Horizon scanning processes provide a

means to anticipate issues, and accumulate knowledge and data about them, in order to discern where emerging threats and possible opportunities arise, and identify potential strategies to mitigate or adapt to these (Sutherland *et al.,* 2010; Palomino *et al.,* 2012). In written evidence to the Science and Technology Select Committee on government horizon scanning (28 April 2014, HC 703), we (FL) asserted that horizon scanning ensures policies are "*more sustainable and adaptable to changing circumstances, allowing for more efficient and effective use of diminishing resources*".

Most of the issues highlighted through horizon scanning are as a result of emerging research or knowledge, a shift in geographical or temporal scales of impact, or due to a heightened awareness or, new response to issues. Our knowledge about emerging issues and their impact is highly uncertain (Sutherland *et al.,* 2008), and the information gathered about them, frequently from fringe sources in the first instance, tends to lack conventional measures of credibility and authority to sufficiently influence policy making. Consequently, there is a lower level of confidence placed on horizon scanning outputs as a source of evidence for policy development (Schultz, 2006). To build confidence in the process, horizon scanning needs to be more rigorous and comprehensive and the 'subjective element', often noted by participants within horizon scanning workshops, be managed to ensure reliable and credible information is gathered for quick uptake, prioritisation and dissemination in evidence-based policy processes (Schultz, 2006; Sutherland and Woodroof, 2009). This necessitates defining the rules for source identification and scan data validation to enhance the credibility of horizon scanning outputs (Schultz, 2006). Researchers must now respond to questions that relate to the acceptance and usefulness of horizon scanning, and the evidence on which it relies, in a policy context, including:

(1) how do we judge the plausibility of evidence in the wide range of information sources used to identify and evaluate emerging issues (including weak signals[1])?; and

[1] Weak signals are defined as past or current developments (i.e. emerging issues) with ambiguous interpretations of their origin, meaning and/or implications. Often these are unclear observable trends or patterns that warn us about the possibility of future events (iKnow 2016).

(2) what is the relative importance of emerging issues given the uncertainty in evaluating their potential future impact, and how do we prioritise these to inform decision-making?

Our experience in delivering horizon scanning research suggests a need to link the process directly to strategic risk and uncertainty management in organisations (Pollard *et al.,* 2004; Prpich *et al.,* 2011; 2013; Luís *et al.,* 2016) to feed directly into longer term decision-making. As researchers supporting a pan-governmental futures partnership led by Defra (2011 – 2014), we have mapped our horizon scanning approach to the strategic risk prioritisation literature and practice (Environment Agency, 2005). This was achieved by complementing horizon scanning with strategic risk analysis (SRA) methods and techniques to assess and prioritise the importance/likelihood and impact of emerging issues on policy, strategy and delivery mechanisms (Pollard *et al.,* 2004; Prpich *et al.*, 2011; 2013). Our approach uses a qualitative weight of evidence (WOE) framework (similar to those reported by Linkov *et al.,* 2009) to establish a more systematic process for filtering information (typically from a wide range of sources) and evaluating the evidence used to identify weak signals of change. This frame allows researchers to better connect emerging issues to the political discourse on potential risks and opportunities in order to achieve greater traction between outputs and policy decisions, an issue explored in this journal since 2000 (e.g. Eduljee, 2000; Gouldson *et al.*, 2009).

Recent reviews of public-sector horizon scanning activities in UK government agencies (Day, 2013) and the Australasian Joint Agency Scanning Network (Delaney and Osborne, 2013; Delaney, 2014) suggest attempts to embed horizon scanning into the policy process has encountered several challenges including: (i) poor alignment with decision-making processes and priorities; (ii) lack of capacity of public officials to adequately engage with uncertainty, suspend disbelief and maintain an open mind; and (iii) lack of meaningful evaluation of horizon scanning outputs and failure to demonstrate how the information could be used to inform decision-making. These challenges suggest horizon scanning will continue to face resistance in an evidence-based policy environment unless the purpose, methodology and limitations are well communicated and understood, but also grounded in a theoretical context, so that the final application has credibility. A

central need is to bridge the cultural and conceptual gap that exists between horizon scanning and evidence-based policy making (Schultz, 2006).

2.0 Integration of horizon scanning and risk prioritisation for strategic long-term planning

2.1 Summary of the process

Concerns about the origin, plausibility and importance of horizon scanning outputs impact on decision makers' confidence in the process and use of the outputs. We address these concerns by integrating elements of risk assessment and risk prioritisation to provide decision makers with a 'risk-based' framework to interpret horizon scanning outputs in a relevant and meaningful way, which supports strategy or policy review for long-term planning; i.e. typically beyond a 10-years time horizon (Figure 1). In our approach, information is continuously retrieved from the web and scanned to capture 'real-time' data on the changing environment and policy landscape. Knowledge and information about emerging issues, gathered from the web is cross-referenced with the academic and non-academic literature and through expert review, using a qualitative weight of evidence framework, for a comprehensive analysis of the external macro environment (big picture) to detect and understand early (weak) signals of change. This is further distilled through informal and formal networks (e.g. food or environmental), utilising risk prioritisation methods, participatory workshops and consensus Delphi (Linstone and Turoff, 1975) to identify emerging trends and understand the broad, long-term implications for policy. Clustering methods such as network analysis (Konnola *et al.*, 2012; Saritas and Miles, 2012) are used to capture cross-cutting issues and priorities to inform decision-making.

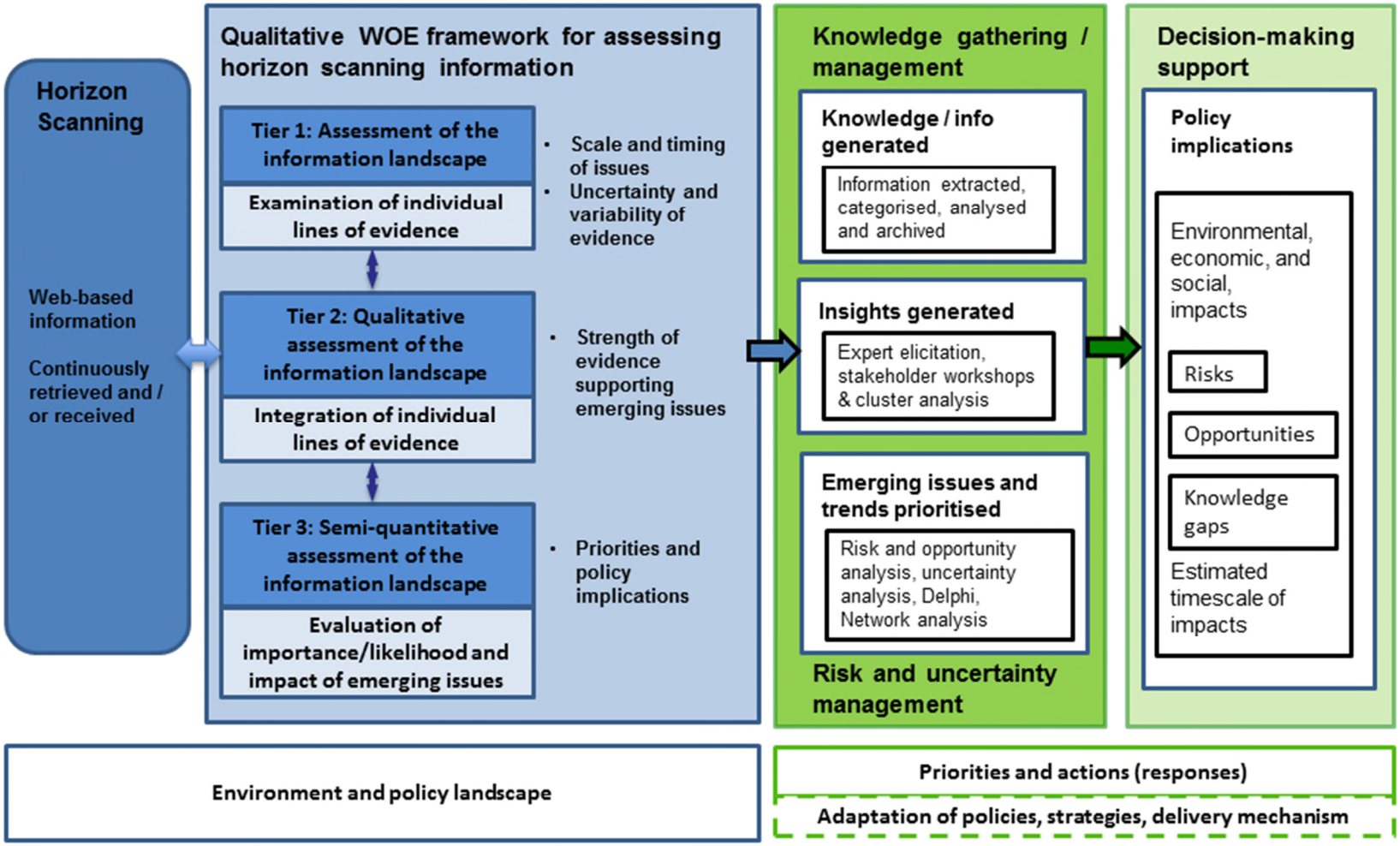


Figure 1: Integrated horizon scanning and risk prioritisation approach

2.2 Qualitative WOE framework for assessing horizon scanning information

2.2.1 Applicability of WOE frameworks

Evidence in government has been associated with a 'degree of certainty' that has improved our understanding of problems, influenced political thinking and assisted in the communication and defence of policy decisions (Campbell *et al.,* 2007). A critical element of decision-making processes is the amalgamation of different types of evidence and the evaluation of the degree to which in concert, they support or refute a claim, termed the weight of evidence (WOE; Linkov *et al.,* 2009). WOE frameworks use different types of data or information (lines of evidence), of varying provenance (quality), which differ in the degree to which individual lines of evidence support, or refute, a particular claim or hypothesis (strength of evidence). WOE frameworks are in wide use within the clinical sciences, appraisals of medical technology and nuclear waste performance assessments, to name a few applications.

WOE frameworks allow the synthesis of information from diverse and different sources rather than referring to a particular type of assessment (Suter and Cormier, 2011). Implicit within any WOE framework is a measure of causality, ensuring relevance of the data. This has previously been described for an epidemiological audience by the Bradford Hill criteria (1965), recently revised to suggest that the assessor consider the direct evidence from studies, the mechanistic evidence showing that there is a logical process from the event to the output and the parallel evidence collected from related studies (Howick *et al.,* 2009). The Bradford Hill criteria has since been adopted by other audiences including toxicology (Suter *et al.,* 2002). Within each assessment is the challenge of relevance, providing an inference of causality or association (Susser, 1991).

In the context of horizon scanning, information and data produced, though complemented with academic and non-academic literature (when available), does not constitute 'evidence' in the conventional scientific sense that governments have come to expect. Horizon scanning information is often based on expert judgement, and can be taken from a wide range of sources including trade associations, social networks, company web sites and blogs. Quality control for these sources using

WOE frameworks may not be possible, but these limitations may be overcome if they allow for (Schultz, 2006):

- formal consideration of the wide range of information sources in horizon scanning, beyond traditional sources of evidence (e.g. academic journals);
- an evaluation of statistical or methodological rigour that applies across all sources of horizon scanning information;
- assessment scoring, which evaluates the strength of evidence for a claim, but does not implicitly discount valuable information or weak signals.

These conditions suggest there is a need for horizon scanning processes to combine two core functions: an intelligence-gathering function that collects a wide range of information to consistently disrupt conventional thinking, and a sense-making function that transforms data into knowledge to better inform decision-making (Forum for the Future n.d.). We propose the use of a qualitative WOE framework meets both requirements, allowing for consistency in assessing various sources of information and synthesising different lines of evidence, as well a rigour in evaluating the importance of emerging trends and drawing out the broad, long-term implications for policy.

2.2.2 Assessment of the information landscape

Given the complexity of policy, horizon scanning practitioners (e.g. Forum for the Future, n.d.) recommend a full exploration of the information landscape (i.e. people, content, processes that constitute the whole system) to develop an understanding of the changing environment, upon which new research or knowledge about emerging issues can be compared. As an initial step in the scanning process, we seek to understand the dynamic factors (e.g. social and political drivers) operating within the complex policy space as a basis for detecting signals of change. This is achieved by scoping a broad list of themes or key factors, grouped according to the main issues and priorities of relevant stakeholders.

A high degree of stakeholder involvement is critical to arriving at a shared view of potential drivers of change within the policy environment. Early stakeholder workshops with key policy actors are carried out to examine the external macro environment (big picture) to detect and understand the broad, long-term issues that

may influence policy or strategy. Key factors relevant to the policy context are defined during the workshop, and these provide some metrics to evaluate the vast quantity of information produced during horizon scanning, thus focusing scan activities. A combination of network and web-based approaches (Palomino *et al.,* 2012; Amanatidou *et al.,* 2012) are used to scan information from the web to capture 'real-time' data on the changing environment and policy landscape. An online collaborative tool, PearlTrees (Padoa *et al.,* 2015 Licurse and Cook, 2014), has been successfully used to conduct an assessment of the information landscape to extract and categorise pertinent information according to key factors, though without attempting to integrate different lines of evidence at this stage (Figure 2). The database includes fields for inputting the article title, source, publication, key words and a brief explanation/critique of the scanning outputs.

Figure 2: Categorisation of information by key factor (PearlTrees)

The scale and timing of insights as well as the uncertainty and variability of the evidence supporting insights are important factors in reviewing the quality of the information and its source as an initial filtering mechanism. To account for the nature of information used to support insights we assign a unique reference to distinguish where the information was sourced and the timeliness of its release. All types of

information sources routinely used in horizon scanning are recorded to ensure traceability of the data and greater transparency of the process (Table 1).

Table 1: Recording and tracking insights from horizon scanning

Insight	Information sources	Date published	Type of evidence	Reference	URL
H1N1 discovered in marine mammals	EurekaAlert	15 May 2013	Online article	O	www.http
	PLOS ONE	25 October 2012	Peer-reviewed journal article	P	www.http

While no attempt is made to qualify sources at this stage, subsequent evaluation of the 'plausibility' of insights considers the accuracy, authority and objectivity of sources, particularly where lines of evidence used to support weak signals diverge.

2.2.3 Qualitative assessment of the information landscape

A synthesis of the insights is carried out through systematic consideration of the evidence gathered during horizon scanning. Building on Amanatidou *et al.* (2012), we use broad criteria to interrogate the evidence, looking for logical connections between factual findings or plausible assumptions to assess the credibility of information used to substantiate insights generated. These criteria have emerged from our horizon scanning research with policy makers, and have been used to evaluate the origin, plausibility and importance of horizon scanning outputs for a pan-governmental futures partnership, led by Defra. Application of these criteria consist of an analysis of (Rathe *et al.,* 2013a; Rathe *et al.,* 2014 unpublished):

- ***plausibility*** - relevant scientific or factual basis underpinning an issue or plausible assumptions based on expert assessment of potential future developments
- ***impact or importance*** - importance scoring that reflect different value systems; i.e. social, economic and environmental interests
- ***policy implications*** - positive and negative impacts, threats and opportunities, and the related implications for policy.

Applying these criteria allow for a systematic examination of the evidence, and greater consistency and transparency of the evaluation of insights by large scanning teams (Figure 3).

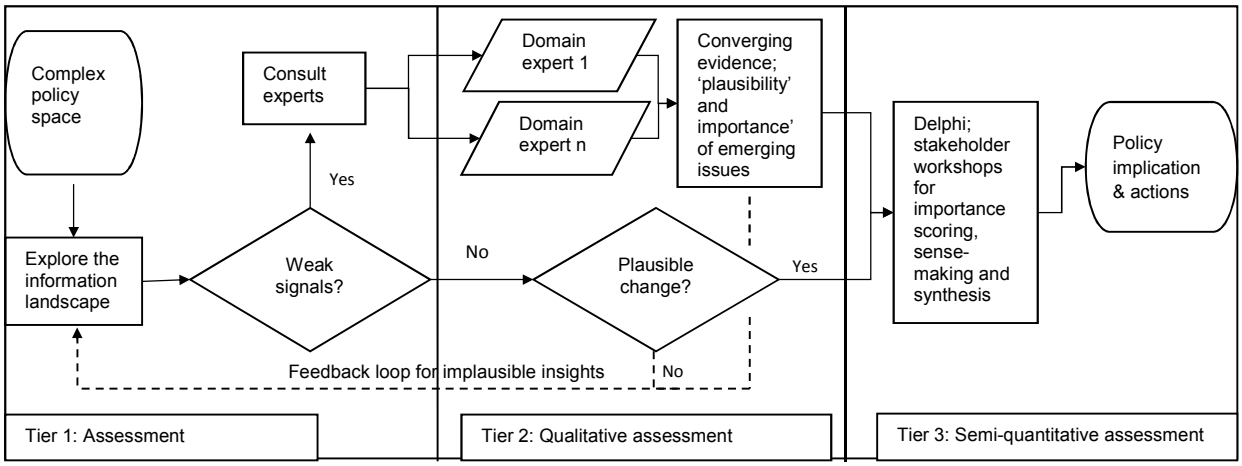


Figure 3: Monitoring and evaluating insights (weak signals) from horizon scanning

Emerging issues deemed 'plausible' may be supported by scientific or factual evidence including predictive trends. Typically these are issues extrapolated from past or current trends such as increasing flood events due to rapid change in climatic conditions, for example hotter climates that potentially increase the frequency of storm events. However, these trends may develop in a 'new direction', for example colder or severe winters due to a rapid decline of Artic sea ice, which has been linked to global warming over the years (Tang *et al.,* 2013). Often there is adequate information published on these issues to make a sound (credible) judgement of 'plausible change'. Nevertheless assembling the evidence to anticipate the outcome of a future event (e.g. food safety event, climate event, financial event) is limited as humans lack the capacity to predict future events with certainty. To do so would suggest that we could avoid any and all environmental problems before they occur. Using hindsight, we can look back and connect the high levels of atmospheric pollutants (e.g. nitrogen oxides and volatile organic compounds) with photochemical pollution, but at the time the evidence was not assembled in a manner that could enable a policy maker to anticipate the impact of exposure. Thus the utility of the scan is its exploration of the existing and emerging evidence to examine potential future developments and the possible consequences, which is useful for reviewing policy decisions and assessing organisational preparedness.

It becomes harder to assess change in other issues that are subject to higher degrees of uncertainty, including wildcards (low probability, high impact events). A reliance on scientific or factual evidence (including predictive trends) in this instance may limit the consideration of a disruptive dimension that allows us to question our assumptions about the present. For example, climate change adaptation plans for Toronto's urban forest included increases in tree planting to expand the tree canopy to deal with tree loss due to hotter climates. However, they failed to consider the need for contingency plans needed to deal with increasing storm-related tree damage, which was an unanticipated consequence of hotter climates (Wieditz and Penney, 2007).

Weak signals of potential future change, resulting from discontinuities or radical departures from observed behavioural patterns (e.g. effects of invasive species), are often not substantiated with evidence or 'hard' data (Schultz, 2006). There is often very little information about these issues so we tend to rely on best professional judgement of a broad range of experts (Chapman *et al*., 2002) to interpret 'plausible change', usually on a case-by-case basis. This involves clustering lines of evidence in a non-quantitative manner (Burton *et al*., 2002), where distinctions between parameters are made with sparse supporting evidence (Efroymsen and Suter, 2001). Schultz (2006) suggests weak signals may mature into a trend over a long period of time (5 to 10 years) or more rapidly as is often the case with disruptive technologies. Therefore, expert knowledge of the sector or policy environment is needed to fully explore the implications of weak signals. In such cases, the scan focuses on exploring the uncertainties by creating scenarios of alternative plausible events. Emphasis is not on predicting the occurrence of an event explicitly, but rather to prepare for change and build solutions that take multiple scenarios into account. This provides a basis to review policy decisions and assess organisational preparedness.

In some instances there may be too much uncertainty for experts to draw informed and acceptable conclusions about plausible events; so those issues deemed 'implausible' may not progress to the next stage, but importantly are fed back, stored in the database and incorporated in future scanning. Therefore, future scans are able to build on previous scanning efforts by identifying gaps and highlighting

new dimensions to previous outputs, which may lead to more complex questions for further research.

2.2.4 Semi-quantitative assessment of the information landscape

Building upon risk-based techniques, we have previously shown how we evaluate and prioritise emerging issues in terms of their potential future impact, utilizing expert input through Delphi approaches (Figure 4; Prpich *et al.*, 2013). This semi-quantitative approach incorporates a risk prioritisation technique that filters issues in terms of 'importance'. To bridge the gap between insights generated and policy, we incorporate a risk based prioritization scale to enable us to compare and contrast emerging issues based on their perceived importance to the organisation. This structured way of connecting issues to the 'political discourse', for example on environmental and food-related issues, ensures that policy implications drawn reflect important value systems related to social, economic and environmental interests.

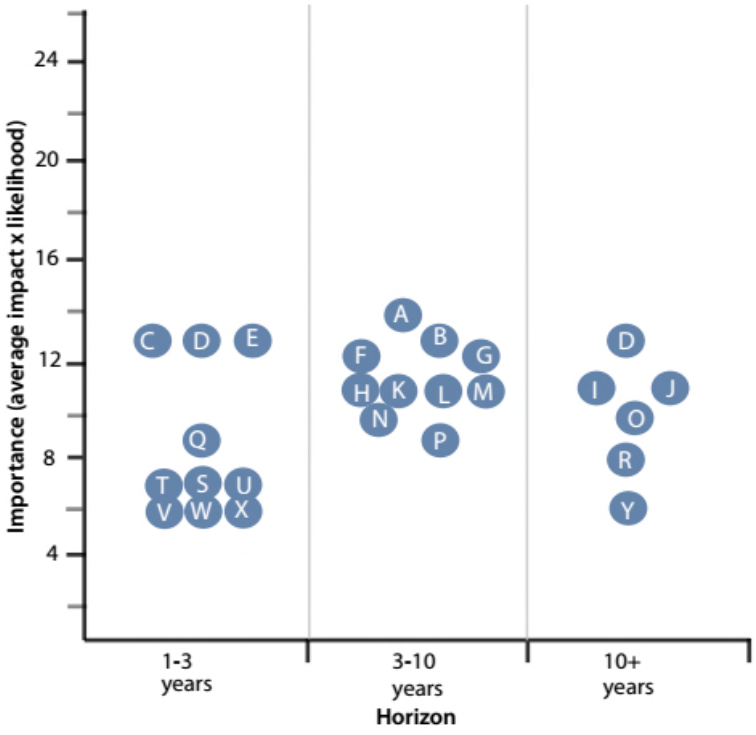


Figure 4: Prioritisation of emerging issues: threat and opportunity ratings (Rathe *et al.,* 2013b; p.3). (A) Is blue the economic answer?; (B) Anticipating ecological tipping points; (C) Immigrating global change; (D) Ash dieback: plant passport & disease modelling; (E) Globalisation of corruption; (F) Acidification and competition prove a dangerous duo; (G) Nanoparticles – a new study suggests they could stunt crop growth; (H) Green belt

development; (I) China's evolving economic model; (J) 'Fat' tax failure; (K) The brand revolution – from CSR to PSR (Public Social Responsibility); (L) An international approach for data centres; (M) UK's food consumption & waste challenge; (N) All-carbon solar cell built by Stanford scientists; (O) The future of our cities; (P) Peatlands mitigate climate change; (Q) Future proofing UK farming; (R) Who will be tomorrow's workers; (S) The doctor will 'see' you now; (T) The 2012 Social Media Report; (U) Intensive agriculture's relationship with migratory bird routes; (V) A smart surfboard; (W) Cust-owners; (X) Data mining to motivate social initiatives; (Y) Landfill mining.

Using a consensus Delphi approach, an expert panel covering a wide range of expertise assign a nominal (value) score to assess the probability (i.e. likelihood of occurrence) and impact of an emerging issue. The range of anonymous scores are then discussed and debated and the process iterated until there is some consensus on the relative 'importance' of the issue for the organisation (or a number of organisations). Uncertainty is inherent in assumptions made about the direction of change or development of past or current trends, and this forms a central part of discussion at workshops. The nature of uncertainty, whether related to the limitation in scientific knowledge or natural variability of the issue, is important (Skinner *et al.* 2014). Understanding the manifestation of uncertainty help us (during workshops) to navigate discussions, focusing efforts on bringing in a broader range of expertise to have the epistemic debate when there is little scientific evidence of causal links, or relying on domain expertise to explore natural variability of an issue. Issues deemed highly uncertainty (e.g. plausible link between infectious human disease and biodiversity preservation) tend to have a larger number of iterations to arrive at some consensus. However, if unresolved these are not progressed further, but fed back through the process and considered as new evidence and information emerges.

A time horizon is provided to indicate when an emerging issue is likely to have an impact (i.e. short: 1-3 years, medium: 3-10 years, long: 10+ years). The resulting nominal score and time horizon are only indicative due to the inherent uncertainty and complex interactions of factors operating within the policy space. However, these ratings are only indicative of importance, and help policy makers assess intervention strategies or future research needs for the highest priority issues. While the Delphi approach allows for combining disparate lines of evidence, additional 'sense checks' with policy representatives and key stakeholders are required to

ensure prioritisation does not dismiss the less evidenced information that are of 'importance' to other groups.

2.2.5 Applications

Scanning needs vary from the provision of a generic scanning function focused on key issues or factors, or scanning around specific strategic, policy, regulatory and implementation challenges. Therefore, our approach has had to be adaptive and responsive to the different policy contexts, participants, end users, issues in question and intended output types. An indicative list of applications is provided in Table 2, though most of these are client reports that are unpublished.

Table 2: Applications of our integrated horizon scanning and risk prioritisation approach.

Project	Methods	Stakeholders engaged	Outputs
Regular horizon scanning function: developments within the environment and food systems (e.g. Rathe *et al.* 2013a – public document)	• Web-based and network scanning around 13 key factors (over 600 sources) • Insights gathered via scanning team and sense-checked with experts • Prioritisation of insights (Delphi, workshops and interviews)	• 9 UK government departments and agencies; policy actors, scientific and technical teams. • Wider stakeholders (e.g. academia, businesses, industry)	• Quarterly newsletters on trends • Annual report on trends, cross-cutting issues
NERC horizon scan: Transport and flows of new materials in the biosphere (Cranfield University, 2012 – internal document)	• Strategic scanning (over 600 sources). • Insights gathered via scanning team and sense-checked by experts	• NERC strategic science team • Selected experts (e.g. academia, industry)	• Bespoke strategic scan: trends and cross-cutting issues
Natural England horizon scan: Using social media and	• Strategic scanning (over 600 sources).	• Natural England Futures Team	• Bespoke strategic scan: trends, barriers and

gaming to value cultural ecosystem services (Cranfield University, 2013 – internal document)	• Insights gathered via scanning team and sense-checked by experts	• Selected experts (e.g. government, academia, NGOs)	enablers to action, future research topics
Regulatory horizon scan - Environmental Agency (Cranfield University 2011- internal document)	• Regulatory scanning (over 600 sources). • Insights gathered via scanning team and sense-checked by experts	• Government agencies with regulatory remit • Key stakeholders (e.g. academia, industry)	• Bespoke regulatory horizon scan report: emerging trends
Defra's five year research strategy for the Rural Communities Policy Unit (Cranfield University, 2013 – internal document)	• Insights gathered via internal workshop and sense-checked by internal experts	• Defra's rural policy team (e.g. policy actors, planners, scientists)	• Bespoke strategic scan: drivers of change, emerging research themes / questions
Impacts of global trends and emerging issues on opportunities for knowledge and technology exchange between the UK and China on sustainable agriculture. (Cranfield University, 2014 – internal document)	• Strategic scanning (over 600 sources) • Insights gathered via scanning team and sense-checked with experts • Prioritisation of insights (Delphi, workshops and interviews)	• Defra policy actors (e.g. future farming review team) • Key stakeholders (e.g. academia, businesses, industry with expertise/knowledge of Chinese markets)	• Bespoke strategic scan: barriers and enablers to future collaboration, emerging research themes / questions

An example of previous horizon scanning outputs is provided in Box 1 (Rathe *et al.* 2013b; p.13). These outputs emerged from a regular horizon scanning function that explored potential future developments within the UK environment and food systems, delivered as part of a pan-governmental futures partnership, led by Defra (Table 2).

Scanning was carried out by a multidisciplinary team, focused around 13 key factors (e.g. consumer attitudes and behaviour; science, technology and innovation; energy supply and demand; (geo)politics and national security; health and well-

being). These factors reflect the strategic objectives and programme areas of work of organisations within the pan-governmental partnership.

Systematic scanning utilised an RSS feed accumulator software to search over 600 online sources including popular media, websites, peer-reviewed journal articles, technical reports and media releases. Data synthesis and prioritisation of issues included input from UK government agencies, academia, industry, businesses and non-governmental organisations, comprising 20 organisations and over 250 participants over the duration of the project (3 years).

Quarterly and annual scan reports provided an evidence base of current knowledge to highlight future issues and their potential impact, which has helped to identify, assess and understand gaps in knowledge, inform research, and highlight possible risks and opportunities for the short (1-3 years), medium (3-10 years) and long-term (+10 years). For instance, the data was used in scenario building studies that investigated a range of plausible futures and their implications for high priority issues, including: (1) exploring triggers for change in UK's food production and supply to 2035 (Garnett *et al.* 2014), and (2) investigating water management challenges for England and Wales to 2050 (Henriques *et al.* 2015).

Box 1: Defra futures partnership horizon scanning programme (quarterly scan, January 2013)

Top issues

Social
Immigrating global change; Green belt development; 'Fat' tax failure; The brand revolution – from CSR to PSR; The future of our cities; Who will be tomorrow's workers?; The doctor will 'see' you now.

Environment
Is blue the economic answer?; Anticipating ecological tipping points; Immigrating global change; Ash dieback: plant passports & disease modelling; Acidification & competition a dangerous duo; Green belt development; An international approach for data centres; Landfill mining; Buoyant trash.

Economic
Is blue the economic answer?; Ash dieback: plant passports & disease modelling; Globalisation of corruption; Nanoparticles – a new study suggests they could stunt crop growth; China's evolving economic model; Will big business take on government?

Example insight: An international approach for data centres

- Approximately 30 million kW of electricity is used by data centres across the world, which is about the same as 30 nuclear power plants. The power demand in data centres (per rack) is growing very quickly for the UK and other developed countries. Data centres use an average of about 5.3kW per rack today, compared with 3.78kW per rack last year. However, more than 10kW per rack is used in 20% of UK data centres. In addition, global investment in data centres has risen by 22%, a trend that is similar in the UK.
- An investigation by the New York Times disclosed that most data centres, specifically those associated with IT facilities, consume energy in a wasteful manner by running facilities at maximum capacity around the clock, independent of demand, which results in the waste of 90% or more of energy consumed.
- In addition, vast numbers of generators are relied upon to prevent power

Horizon: 3

Importance: 11

Links:

2.3 Practical and influential links to decision-making

Horizon scanning processes are designed to deliberately challenge the mental maps of policy actors as they present decision-makers with potential high-impact issues that embody a rise in uncertainty and assume a consequence of actions that become increasingly unpredictable. Encouraging decision-makers to engage with possible future events outside the current trends and patterns of change is a difficult task. Research on the use of foresight (including horizon scanning) to develop innovation policy suggests there has been a shift in the role of government from being "a central steering entity to that of moderator of collective decision making processes" (Havas *et al.* 2010; p.93). This aligns with a shift to *distributed policy-making and intelligence* (Kuhlmann, 2001) that relies on the knowledge, experience and competence of different stakeholders to inform policy processes.

We use collective intelligence from a wide range of domain experts to question and challenge current mind-sets. Stakeholder workshops are employed to engage widely and at all levels, reflecting a critical part of intelligence gathering. Active engagement of policy officials at workshops encourage buy-in and create opportunities for workshop outputs to inform / impact on policy development and other institutional change in the long-term (Luis *et al.*, 2016; Parker *et al.*, 2014). Thus horizon scanning may serve as a first step in gathering intelligence for policy making, which can then be used to establish or initiate other mechanism or strategic intelligence instruments needed to support policy development (Havas *et al.* 2010). Finding the right mix of 'experts' to participate is crucial and should include a wide range of stakeholder and interest groups, often comprising academia, industry, government and non-governmental organisations, and wider public entities.

Increasing the use of expertise to validate horizon scanning information has not had the desired effect of increasing degrees of certainty; rather claims of bias or poor representation of expertise in workshops has, in instances, de-legitimised outputs, resulting in dissatisfaction with scanning processes or outputs. Selection of experts is critical to address concerns about bias. Chapman *et al.* (2002) suggest the use of 'best professional judgement'. We interpret this to mean individuals that have a broad knowledge of the topic; for instance, those with a good grasp of current issues,

knowledge of the trajectory and evolution of the issues, and awareness of stakeholder and public perception. We select experts that are analytical, but also open-minded to engage with the insights generated from the horizon scanning process. Our selection of experts often consider the following factors (Rathe *et al.* 2013a; Rathe *et al.* 2014 unpublished):

- ***Heterogeneous grouping*** – wide range of expertise defined by different value systems (e.g. coverage of broad range of interests, mix of sectors, type of organisation and demographics).
- ***Expertise*** - internationally or nationally recognised expert (e.g. recognition in field; extensive/recent publications; recognised by professional or trade associations).
- ***Interest, familiarity and commitment to process*** – individuals with a demonstrable interest in the topic, familiarity and commitment to the process (i.e. analytical, open-minded thinking among participants is encouraged, and effort is taken to eliminate candour or rejection of ideas based on participants' status or association with an organisation).

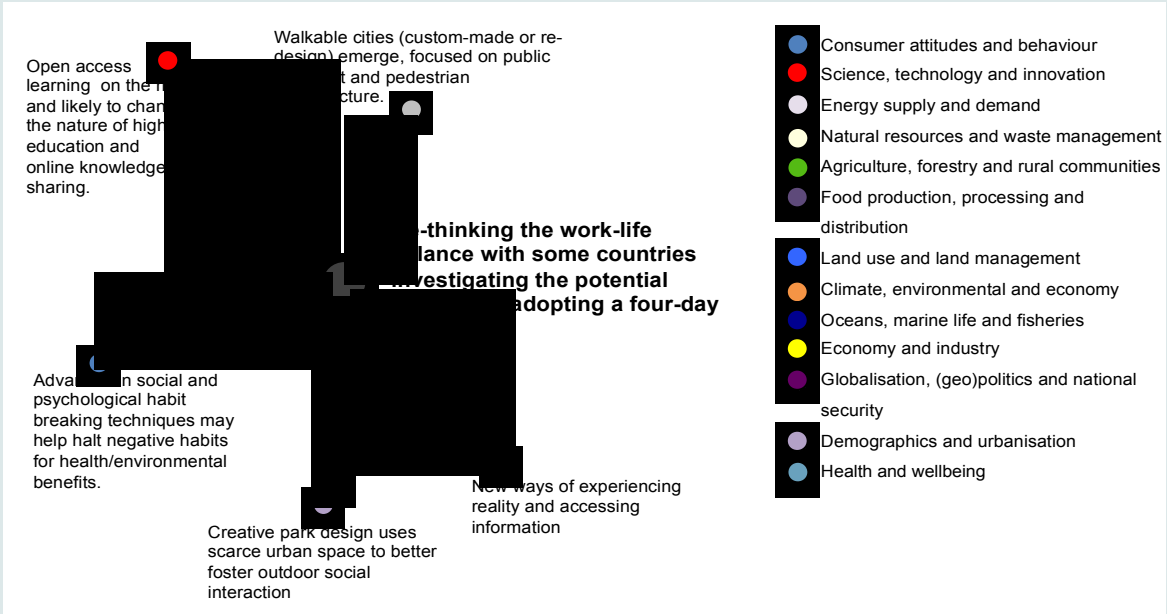
Selecting a wide range of experts ensures different knowledge bases are informing the process, although with a different group of experts there may be other issues raised and implications drawn. Therefore it becomes important to identify stakeholder representatives that are key to the development and implementation of policy, recognising that this includes representatives of public entities.

Horizon scanning outputs also require effective knowledge management/translation, and sense-making to impact on decision-making. Georghiou and Cassingena Harper (2011) suggest if issues are to be taken forward into policy formation it is often necessary to synthesise them into meaningful clusters that are linked to decision-making structures. This requires identifying issues that may have an impact at the individual policy level, but also cross-cutting issues that may have an impact at the meta-policy level (Havas *et al.* 2010). We employ network models to identify cross-cutting issues emerging across individual key factors used to focus horizon scanning activities. Cross-cutting issues are identified using a pair-wise comparison. Employing an online survey tool, participants (policy makers and key stakeholders) compare individual issues and link those that they feel are strongly connected. Pair wise connections are used to form cross-cutting issues, where

multiple connections across key factors (used to focus scan activities) are made to define an underlying trend and narrative for the cross-cutting issue. In interpreting network diagrams illustrating clusters (Box 1), it should be noted that the cross-cutting issue is developed on the basis of the combined number of direct and indirect connections made: a) direct links between key factors (sub-nodes) and the cross cutting issue (main node), and b) indirect links between different key factors (sub-notes) that are related to the cross-cutting issue (node). A narrative is developed around the central points to convey the coherent cross-cutting challenge that fit to broad policy agendas. An example of a cross-cutting issue and supporting narrative around the 'changing nature of work' is provided below (Box 2; Rathe *et al.* 2014 unpublished).

Box 2: Example of a cross-cutting issues; analysis of interrelationships between emerging issues

Trends, challenges and opportunities are emerging relevant to work and the workforce in the short-, medium- and long-term in relation to pressures resulting from, for example, increased automation and advancement in communication infrastructure associated with globalisation and the shift to a digitally advanced era.



Globalisation, technological innovation and advances in communication infrastructure and networks are driving changes in work and the workplace. For instance, the nature of jobs available and the type of skills needed for the current / next generation of employees is evolving in line with an increase in automation. One example is the increase in remote, real time data collection expected over the next 20 years, which is likely to decrease the level of human effort inherent in gathering field data, but will require a skill set competent in analysing and interpreting this data. These changes will undoubtedly have implications for education policy and delivery, future employment and contractual arrangements, pension policy and provision for carers, entrepreneurship, research and development, and health, social and gender equity.

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Integrating horizon scanning and strategic risk prioritisation using a weight of evidence framework to inform policy decisions

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