A framework for influencing food systems policymakers using data visualisation tools

Gavin Wren, Anjli Vyas, Jason Dykes, Aidan Slingsby & Radu Jianu

CITY UNIVERSITY OF LONDON EST 1894

giCentre

About Wren&Co

Wren&Co delivers specialised knowledge of food policy, food systems research, creative media, brand strategy and communications for projects that impact how people think about food. They are a unique collaboration of professionals who understand the future of food and want to help organisations from all sectors move successfully into the next generation.

About giCentre

The giCentre is based in the Department of Computer Science at City University London. They specialise in developing and applying new techniques for visualizing data. This ranges from visualization of ‘big data’ to personalised data presentation; from visual analytics to visual story telling; from cartography and GIS to statistical graphics.

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Introduction

Transforming the food system towards global food security and net-zero requires the development and implementation of new technology initiatives, to capitalise on insights available through big data. High level calls from the United Nations Food Systems summit to the UK's National Food Strategy require food systems to measure, record and present data in informative and accessible ways.

Around the globe, food systems organisations and data scientists are working on the collection of data, alignment of food systems metrics and integration of existing datasets, especially in relation to environmental data. These projects commonly focus on the collection of statistical data or setting metrics to help come within planetary boundaries. They are focused on quantitative data; the numbers that represent the food system such as agricultural yield or CO_2 production.

However, statistical data does not represent the true complexity of the food system, which is an interconnected system, or network, with complex relationships between elements. These relationships - involving chains, loops and dependencies - are too often unseen and left unmapped. This qualitative mapping of the food system, involving the relationship between producers and governance, or research and business, needs to be exposed to support better decision making. These relationships are continually evolving and developing, requiring effective, accessible mapping and visualization to elucidate the activities.

We are developing a data vizualization tool to address this need. It will allow users, such as policymakers in government, researchers and businesses, to visualise the food system as a network of interconnected relationships, activities and flows. This will enable exploration of policymaking effects from different perspectives and their connection to different stakeholders, modelling quantifiable impact and facilitating better policymaking.

This data network can be underpinned by statistical data which is being developed elsewhere in the food system, providing scope for a commercial and economically sustainable data product. We will achieve this by combining three areas of research; recent research and technology in visualization, developments in food systems data, and a critical understanding of the policymaking process.

This document will set out a framework that demonstrates three key points:

- **Why** such a sophisticated network visualisation tool is needed to advance food policymaking
- **How** it can be built using data visualisation techniques
- **What** is the commercial value for businesses, NGOs and governments.

The Thirst for Data

Many exciting new data initiatives are serving policymakers across the food system, examples include:

- Google's Food For Good department[1] proposed a Food Systems Cornucopia at the United Nations Food Systems Summit
- Henry Dimbleby, the author of the National Food Strategy The Plan[2], stated that greater data accountability was a vital step towards better food systems, a recommendation that he personally cited as the most important in the entire strategy
- Oxford University's HESTIA project[3] which is building a standardised format to represent and store agri-environmental data
- OmniAction[4] is creating a North Star to align data metrics across the food system to help measure the impact and progress of food production

These initiatives, and many others, are focussed on storing data, or aligning the metrics that can measure the food system. Their focus is on dashboards of figures and bar charts, through to large datasets that require advanced regression analysis to derive outputs.

None of these initiatives appear to explore the dynamic, interconnected nature of the food system. They commonly focus on statistical representation, rather than relationships and qualities which make up the web of interactions found in the food system. Our aim is to map the actors, activities, pathways and connections in the food system so that we can model and identify vulnerabilities to support better strategies.

An example of this statistical approach is the Food Systems Transformation Group at Oxford University, who 'mapped' the food system in 2020[5], creating graphical outputs that are statistical representations of data (Figure 1). An 'interactive tool'[6] accompanied this publication, which displayed the information in a similar way. These statistical 'maps' fail to provide any depth about the systemic nature of different stakeholders and their relationships in the food system.

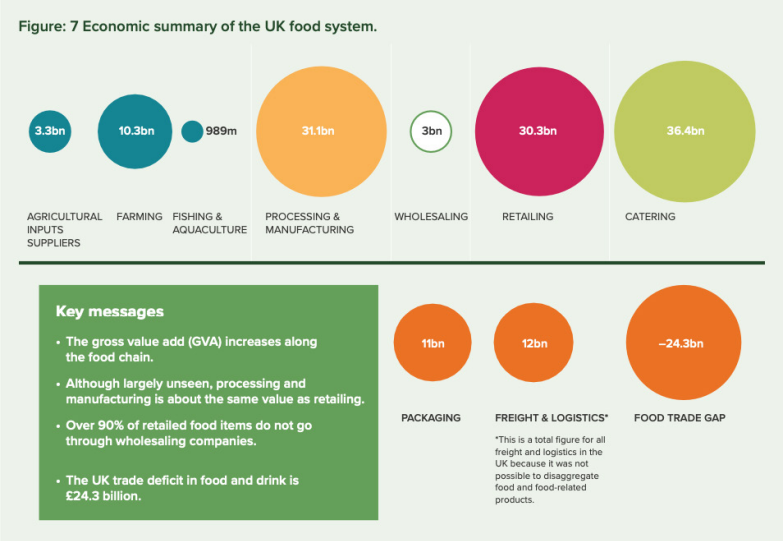

Figure 1: Oxford University economic 'map' of the UK food system

Another example, which goes some way towards addressing the stakeholders in the food system, is a widely cited 'map' of the food system produced by The Centre for Food Policy at City, University of London[7] (Figure 2). This map shows the interconnected nature of activities in the food system through a static, macro view. Whilst this works as an overview, it doesn't allow deeper exploration into the details of stakeholders and relationships within each category listed.

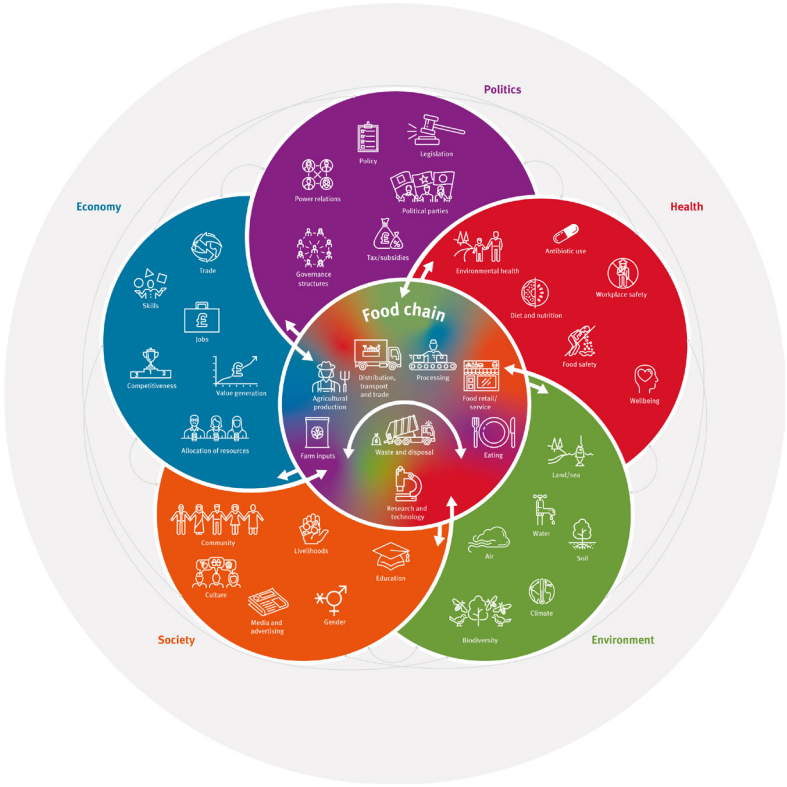

Figure 2: Map of the food system (Parsons, Hawkes & Wells, 2019)

Our framework proposes a more dynamic approach that would provide many layers levels of food systems data that could be explored underneath a macro view. Users would be able to explore specific information about activities occurring within a chosen area through the visualization.

For example, using Figure 2 as a top-level taxonomy, we propose allowing the user to select a topic, e.g. 'legislation', which would take them into a more detailed layer of data. This new layer would display the stakeholders who have been active in legislation, their locations, the details of their work and the connections which those stakeholders have with other actors in the food system. This could allow the user to identify a stakeholder in legislation who works on a specific area, such as 'food waste', and is linked with a stakeholder in another area, e.g. 'food service'. This would quickly allow users explore specific areas of the food system and identify key actors.

What Next?

We need to build an understanding of how policymakers would use data visualisation tools to make better decisions and advance the food system. How would a policymaker identify strengths and weaknesses in stakeholders working within given areas of the food system? Given that policymakers are some of the most powerful actors in the food system, we need to create data products that serve these users and support their long term decision-making, thus enabling the development of better policy.

Creating such a tool requires three stages of development, which we address in this framework:

- **Stage one:** Understanding from evidence and experience, what policymakers need to create impact in their work and how they can make better decisions by engaging with data and visualization.
- **Stage two:** Sourcing the data. The internet is also full of unstructured qualitative data about stakeholders and relationships that can be harvested and structured to build network visualisations. This can be underpinned by statistical data being collected by organisations around the world.
- **Stage three:** Building a tool which integrates the first two stages and provides real-world impact for actors and organisations throughout the food system.

We need to ensure the right people have the tools they need at the critical time, to enable them to assess and analyse data accurately. We also need to understand what data products will help to influence business decisions and drive progress to net zero. This framework will tie together the needs of policymaking, data visualisation and commercial viability to serve all stakeholders in the food system.

Food System Data Framework

This project aims to help people understand the food system as an interconnected web of entities, activities and relationships, which is constantly evolving. One of the widely cited definitions of the food system is:

> *'The food system is the interconnected system of everything and everybody that influences, and is influenced by, the activities involved in bringing food from farm to fork and beyond.'*[8].

This definition demonstrates that the food system is a network, an interconnected system, which could be mapped in a way that could also apply to other industries, such as politics, energy, transport and tourism. Stakeholders and relationships in all of these industries need to be mapped in a way that allows users to truly explore them.

We need to answer three questions to facilitate the development of a suitable tool (Figure 3):

1. **Need**: Are organisations and policymakers influenced by the delivery of data? Is there a need for more data products and how do they help policymakers?
2. **Development**: How can we build and use data visualisation as a tool to help people? What are the technologies required and what is needed to implement them?
3. **Value**: What is the impact and value of such tools? What would end users gain from using this product in terms of policy actions and commercial activity.

Finding answers to these questions will help build a successful, valuable tool for users who need to make informed decisions about the future of the food system, wheter they are in government, business or research.

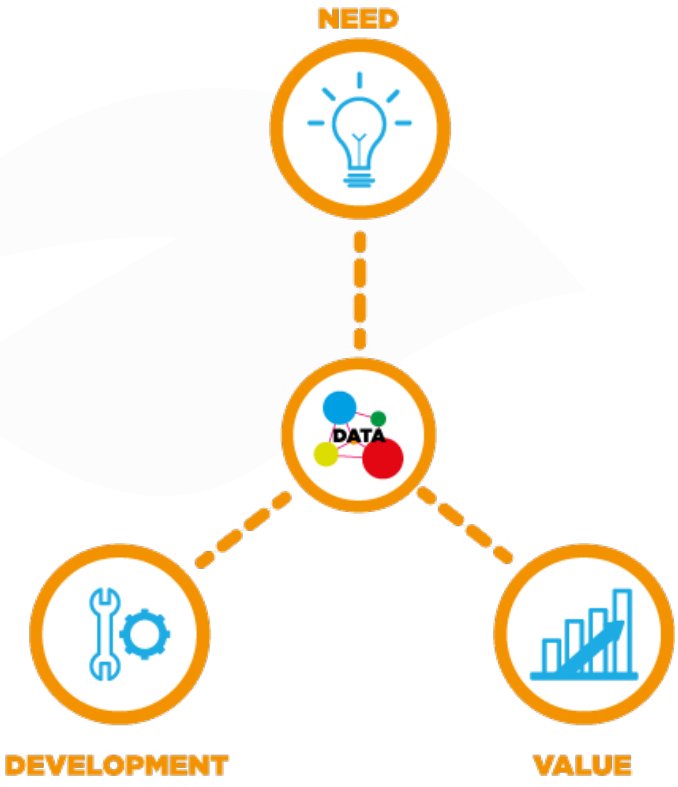

Figure 3: Three elements of the framework development, reliant on the core data

WHY? Policymaking Tools

In this section, we will explore why policymakers need sophisticated data modelling tools and how such products can lead to better decisions.

How can we help?

Policymaking is often messy and circumstantial, based on loose decisions.

A team from the Universities of York and Hertfordshire, along with the Food Standards Agency set out principles for effective generation and translation of evidence to support sustainable diets. Their advice proposes how to influence policymakers, to help them 'adopt and implement evidence'[9], and it follows three stages:

- '**Generation**: the creation of evidence (which might be primary research studies or secondary generation through review and synthesis)
- **Translation**: the interpretation, communication and dissemination of evidence to evidence users
- **Adoption and implementation**: the integration of evidence into policy or practice, and its conversion into deliverable actions.'[10]

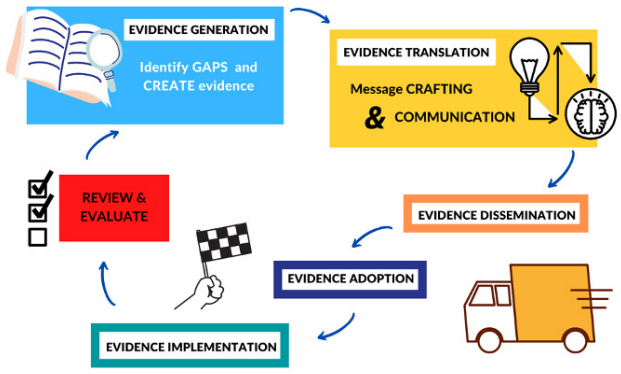

Figure 4: A representation of the evidence use process developed by Parsons et al to illustrate the theoretical stages of the process

This framework helps us to understand what is required to effectively influence policymakers via the medium of a data visualisation tool. At first, there is a need to collect data to feed this tool, supported by pre-existing food systems datasets. The key output of this document is to understand how that data can be presented to increase adoption by policymakers towards better decision making. This firmly centres the framework and resultant tool at the stage of evidence translation, to aid the communication of data, whilst being fed by data generation and aiming to support adoption and influencing implementation (Figure 4).

The same report also states:

'Good translation involves making sure evidence gets to the users that can actually take action on it, which might be directly or indirectly via a 'broker'. Effective translation also involves communicating your evidence well, by understanding the role of trust and credibility in how evidence is perceived by users. It involves communicating the evidence clearly and at the right time. It involves ensuring different evidence user needs are catered for.'

This reinforces the need for a policymaking tool that enables users to assess food systems networks in the context of their own policy situation.

What do policymakers need for this to be effective?

Policymaking models usually consist of a few common stages[11]:

- Set the agenda
- Formulate solutions
- Implement agreed action
- Evaluate

However, Smith and Kattikireddi (2013)[12] state in their *Glossary of Theories for Understanding Policymaking* that a theoretical approach to policymaking hides the 'messy' reality, that policy is a non-linear process, created across different levels of geography and power, amongst competing interests, addressing conflicting values and confronting unexpected issues. Policymakers are therefore inclined to 'muddle through' a narrower path with the greatest stakeholder support, due to the complexity of navigating the domain.

Many policy theories exist, including policy network theory, which involves "clusters of actors with interests in a given policy sector, and the capacity to help determine policy success or failure" (Marsh 1998, cited in Walt et al, 2008). Kingdon (1995) holds one of the most cited policy theories, stating that policymaking is a 'complex adaptive system' (1995, p. 224), and almost evolutionary in modelling. All of these theories suggest that tools which show food policy in a more interconnected, networked way might be able to support better outcomes.

There is widespread support across the food system for increased data, however what do policymakers require, if they are to work effectively with that data? We understand that the food system is a network and there is evidence of attempts to map the food system, alongside calls for it to be mapped as a network. Once the data is collected, what does the literature say about the needs of policymaking tools?

The National Food Strategy recommendation 12 specifically addresses the policymaking tools required, stating:

> *'The Government should create a National Food System Data Programme to collect and share data, so that the businesses and other organisations involved in the food system can track progress and plan ahead.*
>
> ***The key data should be published using visualisation dashboards that make it easier for users to compare information, model future scenarios and assess the effectiveness of different policies or logistical models.*** *These should include the National Rural Land Map (See Recommendation 9).' (bold added)*

One of the largest challenges faced by policymakers is understanding how they can move beyond rhetoric about a 'systems approach' and truly adopt a non-linear method of policymaking. Organisations and policymakers often exist in 'silos' within the food system and make decisions in isolation, for example nutrition was long focussed only on human health, with little consideration for the environment. This is exacerbated by the lack of tools to help policymakers develop cross-cutting policy.

The Organisation for Economic Cooperation and Development (OECD) are calling for methods and technologies that enable policymakers to explore and model the synergies and trade-offs when making policies that impact multiple areas, such as environment, nutrition and livelihoods[13]. Parsons et al (2022) also supports this, urging policymakers to consider evidence in a systematic way that connects across those silos. There is further literature noting that food systems need to be viewed as an interconnected network, or system, to overcome these silos [14] [15] [16] [17] [18].

The Global Panel on Agriculture and Food Systems for Nutrition (GloPAN) produced a report in 2015, further supporting this point and setting out the data and metrics which they saw as vital for food system transformation[19]:

> *'New metrics are therefore needed to measure diet quality and sufficiency, as well as food system efficiency and sustainability, and the* ***processes that link various points across food system domains****.' (bold added)*

And in recommendation 4:

> *'Designing metrics to measure the 'food environment', including* ***how different food system domains are linked to, and interact with, the food environment in which dietary choices are made****.' (bold added)*

These points support the connection of silos within the food system, alongside the ability to understand how they interact with each other. GloPAN contribute further by saying in their 2020 report Future Food Systems: For people, our planet, and prosperity[20] about the 'joined up' and 'interconnected' needs of research and science required to make change happen. This evidence suggests that mapping the interconnectedness and linkages required to support scientific communication could bridge silos and contribute towards better policymaking.

> *''Joined up' science is essential to inform multi-sectoral policies; and identify data and knowledge priorities, and ensure commissioning of necessary modelling -* ***more research needs to be driven by the specific needs of policy makers****' (GloPAN, 2020) (Bold added)*

Creating data visualisation tools to serve this interconnected nature of the food system can contribute towards better policymaking outcomes. For example 'Policy packaging'[21] is an effective policymaking concept supported in the literature where multiple policies with both push and pull characteristics are bundled together. It requires connecting policies across multiple areas to create effective change.

Furthermore, users have expressed a desire to understand the economic impact of research findings, such as the social cost-benefit implications or commercial economic impacts (Parsons et al, 2022). Therefore, it might be prescient to link other datasets, such as financial data to food systems data, to inform policymakers about the relationships between vital aspects of the food system.

Existing Policymaking Tools

There have been some examples of building data tools that compare two different areas of food systems data, such as The Food Security Media Analysis Knowledgebase[22]. This tool scrapes media coverage and allows users to compare

search terms. However, the outputs are hard to reconcile in terms of delivering value to a user, as the Knowledgebase appears to be a demonstration of how text can be analysed both linguistically and semantically to create relationships and draw comparisons. This focus is specifically targeted at the qualitative data collection process, to see how text can be analysed, rather than being a tool designed with end-user experience at the fore. Further development could help to reconcile the outputs for users and therefore derive greater value.

The Food Systems Dashboard[23] is another tool to support policymakers. It allows users to compare statistical data between geographical regions, whilst providing 42 static policy suggestions. A lot more consideration has been given to serving the end-user, and it provides valuable statistical information, whilst still being a linear, two-dimensional approach that doesn't address the full breadth of the food system's interconnectedness.

Discussion

The concept of food systems mapping is often presented in the literature, with the aim of allowing people to understand the complex web of activity that makes up the food system. At present, there are no comprehensive maps that truly allow a user to explore the food system as the dynamic network which it is presented as in the literature. A comprehensive, interactive map would be a valuable asset, however, it would not per se provide the analytical tools required by policymakers. Therefore, any network maps of the food system need to be supported by analytical or visualisation tools which help users to enter into, engage with and model-specific policymaking scenarios and their outcomes.

WHY? Framework points:

- User interface and policymaking needs are the most important factor in delivering efficacy
- Food system needs to be viewed as a network, or an 'interconnected system'
- Mapping the food system is a highly desirable activity
- Different domains need to be linked by the processes that define them
- Different user/policy needs should be facilitated
- 'Joined-up' data modelling facilitates multi-sectoral policymaking
- Identifying policy actions in different areas and connecting them creates more effective policy interventions.
- Existing tools focus on statistical representations, while policymaking is about networks and relationships within an area of focus - connecting both is highly desirable to frame thinking and support interpretation and solution finding.
- Scenario modelling is vital
- Data needs to connect across silos
- Provision of economic data is also highly desirable
- Acknowledge the messy reality of policymaking

HOW? Data Visualisation Tools

The previous section demonstrates there is a need for tools that can build network maps of the food system to help influence policymakers. These maps need to be:

- **Dynamic:** Maps update as the policy environment develops (via data updates) and when 'what if' scenarios are modelled (via user updates).
- **Holistic**: Show connections at a large scale (overview)
- **Specific**: Can be filtered and reduced to show what is happening in a given area, in a close up view
- **Relational:** Showing relationships between actors

Three components are required to build a valuable, effective tool:

1. **Data extraction:** How to collect the information required to build an interconnected model of entities and relationships in the food system.
2. **Data modelling**: How to store and connect the data that has been collected.
3. **Data visualisation**: How to enable users to engage with the data in a way that frames their policymaking needs.

Data extraction

We are working on techniques to automatically identify actors, policies, issues and the relationships between them to comprehensively map food systems. This will involve using natural language processing (NLP) to analyse the semantic content of these documents in order to identify the relevant entities and to determine the relationships between them.

Creating knowledge graphs

We are designing a domain-specific ontology that captures relevant entity types and the relationships between them for data such as those extracted from Project 1. An interactive visualisation tool to enable food system experts to understand, validate and correct the resulting knowledge graph to ensure that it reflects the specific food system issue usefully and accurately.

Helping design actions

Helping design actions: We will investigate how interactive network visualisation can be used to help those involved in the commercial side of food policy - e.g. food banks, NGOs, food charities, supermarkets, restaurants - make sense and act upon food waste problems while spreading awareness.

Figure 5: Three elements of tool development (Wren&Co & giCentre, 2021)

These three components align with three streams of work supervised by the authors of this paper in a previous project (Figure 5, previous page).

How can data viz developers make this work?

The key question this framework needs to answer is 'how can we build data visualisation products as effective, commercial policymaking tools?' This helps to focus the framework from a user-centred perspective, to ensure a user base and commercial efficacy. The data extraction and modelling stages will only create value if they can be accessed in a way that genuinely solves problems for the end-user.

There is a suggestion in the literature that technology already exists that can enable policymakers in their work:

'The visual analytics methods allow decision-makers to combine their human flexibility, creativity, and background knowledge with the enormous storage and processing capacities of today's computers to gain insight into complex problems.' (Koyamada & Kukimoto, 2014)

Ruppert (2014) explored the technology further by creating a model of how visual support can build into the policymaking analysis process (Figure 6).

In a continuation of their research, Ruppert (2016) also mapped policy documents in an EU policymaking context and found great enthusiasm amongst policymakers for such tools. The prototype delivered a useful output (Figure 7 overleaf), however, the authors did not share the feedback and Likert scale responses from users, mentioning that shortcomings were highlighted. This lack of a meaningful conclusion leaves questions, and suggests that creating an effective tool requires collaboration and iteration to ensure efficacy at all stages.

> *'...we learned that trust and the awareness of uncertainty in the data needs to be carefully considered during the design of visualization systems for policy domain users.' (Ruppert, 2016)*

> *'...the policy domain varies from other application domains. First, computer expertise strongly varies in this field. Both highly skilled technicians and seniors with little to no computer expertise collaborate in this domain, which makes it difficult to derive clear requirements from the users. Second, due to time pressure, political stakeholders are difficult to reach. Hence, it was of key importance to collaborate with partners that had close connections to EU stakeholders.' (Ruppert, 2016)*

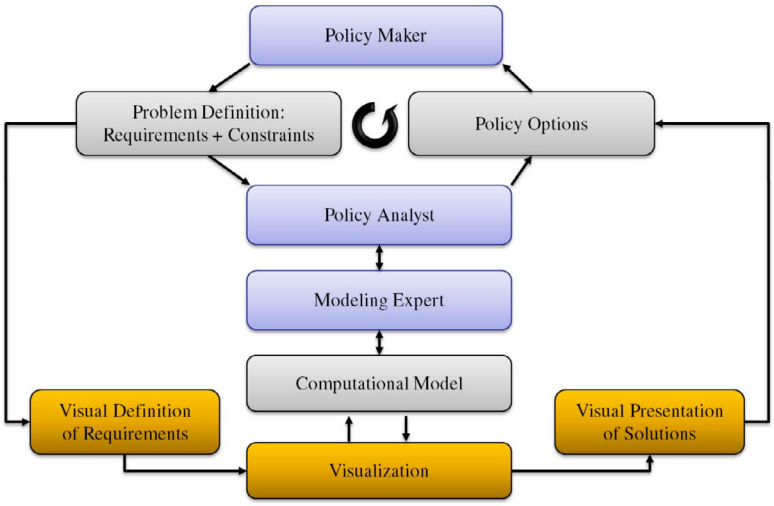

Figure 6: Visual support model for policy analysis (Ruppert, 2014)

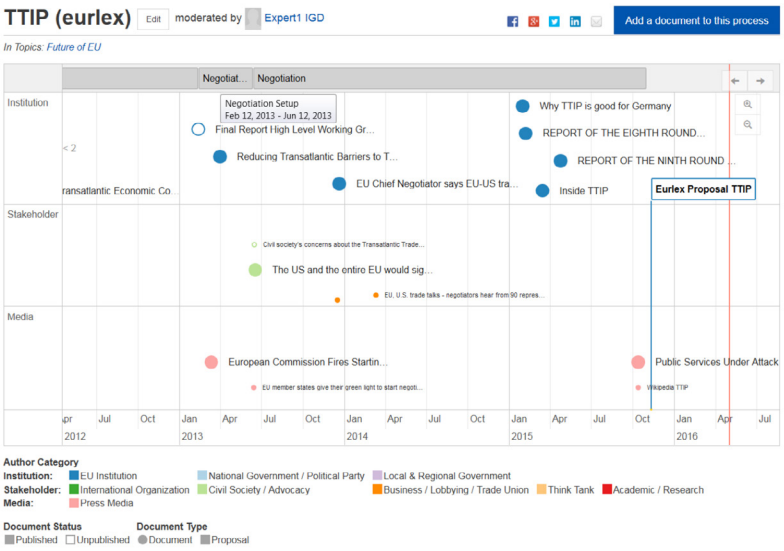

Figure 7: Policy process visualisation (Ruppert, 2016)

These developments in visual analytics and policymaking provide valuable insights, showing the policymaking domain as a complex area to serve, and that delivering impact for end-users (such as high-level policymakers) requires intensive engagement and feedback throughout development, which can be provided by existing giCentre literature.

Data extraction

Extracting data about the food system requires us to understand that imperfections will need to be reflected, rather than hoping that one day, a perfect dataset will arrive. This will allow us to accureately represent the 'messy' nature of policymaking.

Natural Language Processing (NLP) and Machine Learning (ML) are ways of analysing and collecting large amounts of data from unstructured documents[24]. There are examples of using NLP to identify food-related information and relationships from a gastronomic point of view[25].

Machine learning is also being used in the process industry to create predictions and model efficiency[26]. These technologies appear to be highly suited to the extraction of data from unstructured documents.

Data modelling

An ontology is needed to build a dictionary of terms that are used to describe the domain. There are pre-existing public access ontologies[27] [28] [29], as well as custom built ontologies used within organisations for their own needs. A comprehensive, dynamic food systems ontology would need to be obtained or built to serve this project.

The question is how do we build the data into a solution? One way to address this is the use of Knowledge Graphs (KGs). A knowledge graph can be defined as:

> *'a graph of data intended to accumulate and convey knowledge of the real world, whose nodes represent entities of interest and whose edges represent relations between these entities.' (Hogan et al, 2021)*[30]

A knowledge graph can create a relational network of data, which is necessary to map the actors, activities and their relationships in the food system. However, simply mapping these elements in a knowledge graph can lead to an uninterpretable level of data being displayed, which does not provide any value to the user (Figure 8). Therefore, it is vital to work with design interaction experts to

ensure that a policymaking tools provide front-end experiences for users that allow them to navigate the data and drill down.

A knowledge graph can be accessed and refined via queries that often require specialist skills, and this approach befits the food system due to being able to evolve flexibly in domains of incomplete knowledge (Hogan et al, 2021)[31]. Their abstract nature befits the messiness of the food system:

> *'due to its (KGs) underlying abstract structure which effectively facilitates domain conceptualization and data management'*[32]

Furthermore, there are commercial examples of KGs being used by multinational firms which address the food system issue of bridging silos. Siemens developed a KG to help move towards 'intelligent engineering and manufacturing' [33].

In their most sophisticated form, KGs allow users to explore a domain with rich context, hence why they are used by Google, Netflix and many other large businesses to create intelligent search experiences.[34]

Data visualisation

Data visualisation offers a visual front-end for querying these maps which allows anybody to to access, reason and query the data that are in the knowledge graph concurrently. The ultimate aim is to reduce the total amount of queries that a user needs to raise to get to the answer required to make progress in their policy scenario.

Evidence of communicating food systems problems with data visualisation shows that graphical displays are a powerful tool to convey complex situations with a visual narrative:

> *'Researchers and policy makers must still actively engage in ways that bring science by design into the right decision-making pathways at the right time to ensure their use.' (Otten et al, 2015)*[35]

Conveying public policy information with the aim of communicating to the public can be effectively fulfilled with visualisation. In describing *The Science of Visual Data Communication*, leading cognitive psychologists Franconeri et al. (2021) argue that:

> *'Evidence-based public policy prescriptions about climate change,*

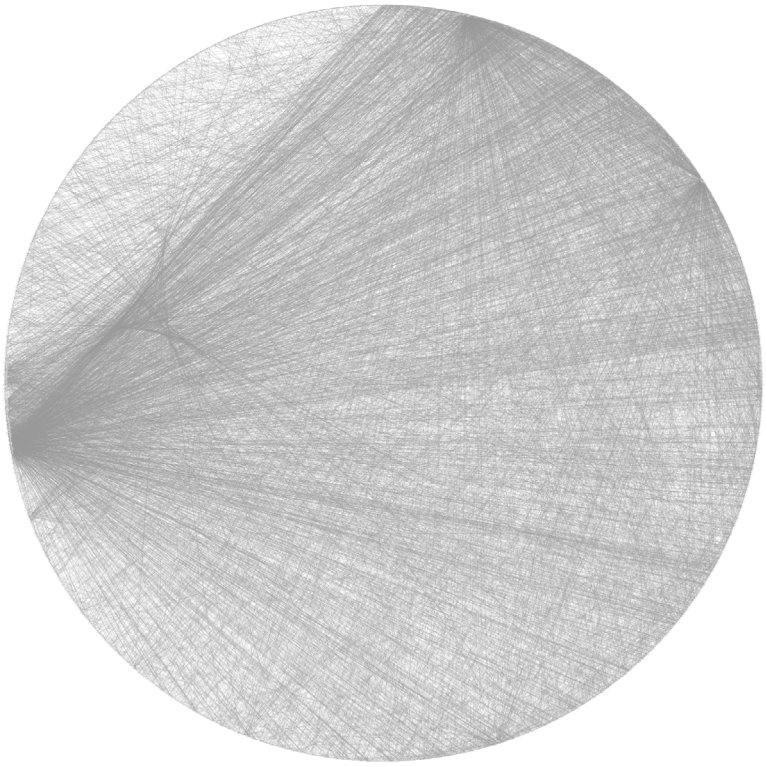

Figure 8: What happens when a small area of food system entities are mapped concurrently: you get an uninterpretable mess. Food waste knowledge graph (Keers, 2021 - https://fp-edit.herokuapp.com)

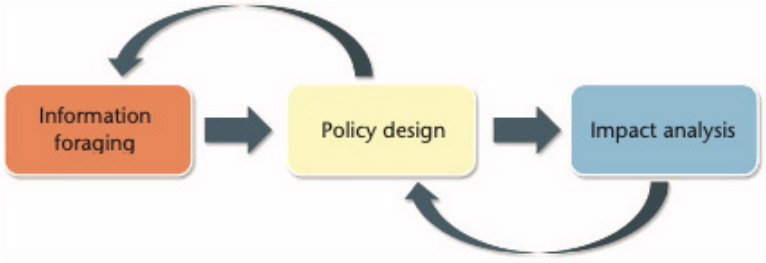

Figure 10: Policy modelling process (Kohlhammer, 2012)

vaccines, and policing are argued to be most effectively built and communicated to the public with visualizations.'[36]

A 'human is the loop'[37] approach to visual analytics will be required to understand the processes of users when interacting with the data to ensure efficacy. One of the most comprehensive pieces of evidence about how data visualisation can help in the policy process is provided by Kohlhammer et al. (2012)[38] who worked closely with policymakers and as a result developed a three stage cyclical process for data visualisation use in policy modelling (Figure 10), which is closely aligned to the 'generation, translation, adoption' cited earlier in (Parsons et al, 2022):

1. Information foraging supports policy definition. So, this stage requires visualization techniques that obtain relations between aspects and circumstances, statistical information, and policy-related issues. Such visualized information enables optimal analysis of the need for a policy.
2. Policy design must visualize the correlating topics and policy requirements to ensure a new or revised policy's functional interoperability.
3. Impact analysis evaluates the designed policy's potential or actual impact and performance, which must be adequately visualized to support the policy's further improvement.' (Kohlhammer, 2012)

This project also resulted in an example of visualisation methods being used in the policymaking process (Figure 11).

Previous policymaking prototypes also suggested trust is a key element. Visualisation can help towards building trust in AI systems[39], while opening up decision-making to greater levels of transparency to allow scrutiny and improve trust further.

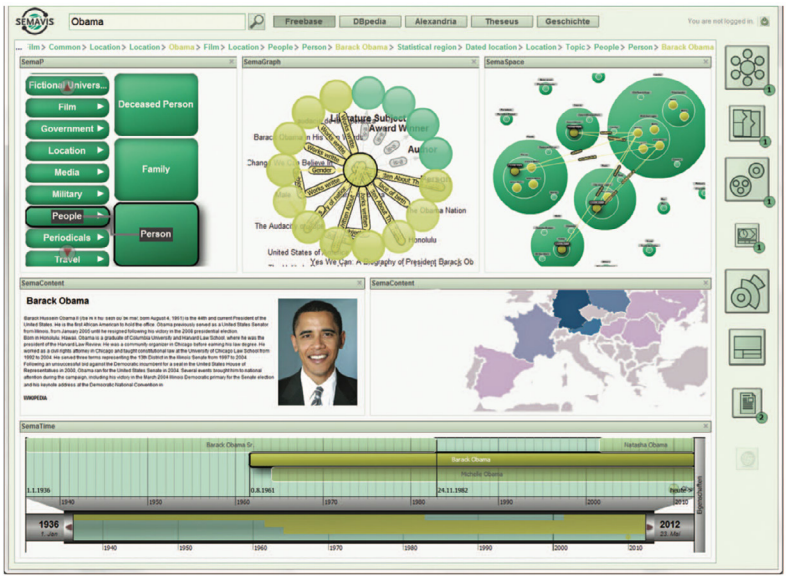

Figure 11: Visualisation methods in the policy process (Kohlhammer, 2012)

Discussion

Some examples of knowledge graph visualisations create very complex networks or require the user to understand knowledge graphs. The end-user of products from this project would be policymakers, researchers and businesses who require an accessible product with minimal training due to their time limitations. Their ability to enter the food policy domain via this data visualisation product and then extract valuable insights will determine the ultimate success.

There are several examples of researchers who have ventured into developing policy mapping projects that can help influence policymakers. The efficacy of these products is unknown, while the literature on the subject appears to halt around 2012-2016.

These data products need to convey information in ways that are interpretable, concurrent and that support learning. This will enable them to see relationships, suggest interventions and develop policy. It has become clear that to do this in an effective way, we will need to draw upon science, design and data alongside close collaboration with policymakers. In this context, the data visualisation front-end becomes one of the most important aspects of the product when aiming to ensure impact and build commercial value.

HOW? Framework points:

- Visual analysis and support can provide policymakers with valuable tools, and have expressed great enthusiasm for visual analytics tools
- User feedback and efficacy is vital - partnership, collaboration and co-creation
- Trust is of vital importance
- User skills vary enormously
- There is no evidence of successful application for policymaking
- Close collaboration with policymakers at all levels is fundamental during development to ensure efficacy
- Partnership with key actors from project inception would be vital.
- NLP / ML are methods that can be used to identify data in unstructured documents
- Knowledge graphs befit the messiness and abstract nature of the food system
- How do we create queries that result in the necessary answers for a policymaker to make progress
- Building transparency and allowing scrutiny of decision making can build trust in AI data solutions

NEED? Commercialisation and Market Value

Wealthier countries have greater impacts on the planet than poorer ones. They also have more data and information available publicly alongside companies and businesses who will embrace tools to optimise their operations.

At present there is a lack of credible evidence regarding the commercial and practical impact of policy mapping tools. For example, the data presented by Fanzo et al[40] lacks any evidence of real impact. It clearly provides a data resource, however, efficacy of engagement is lacking, with a focus on providing statistical data alongside policy recommendations, rather than exploring the food system as a network. It feels like a reference point, rather than a changemaking tool.

Commercialisation needs:

- Healthy amounts of data available for that market
- Strong economy with organisastions willing to pay for new tools
- Interpretable data

At an industry level, there is evidence that AI and Machine Learning is supporting efficiencies in food systems, specifically in the context of manufacturing and supply chains[41] with other applications including reduction of food waste[42]

Evidence of market support for data mapping/Ai products

At present, there are several revenue-generating data aggregation and analytics programmes used across regulated industries to enhance decision making. The majority of which are used for evaluating fiscal risk and returns. All are paid-for platforms that can be support growth within an organisation's corporate goals and bottom line. Some examples are:

Bloomberg Terminal[43] provides access to highly comprehensive financial market, security and asset information, with an estimated 325,000 users providing Bloomberg with up to USD $10 billion in revenue per year.

Annual cost: USD $24,000 per year (1 user)

International Civil Aviation Organization (ICAO)[44] provides access to all of the data and maps for "a new tool that presents in a dynamic and graphical environment the air transport statistic data collected from its 193 Member States. ICAO DATA+ enables users to quickly visualize trends, differences and similarities between air transport data selections and make competitive analyses (benchmarking) more accessible."

Annual cost: USD $8,000 per year

Propre[45] is an AI powered property database aiming to cover the world's property market, expanding country-by-country and costs

Flourish provides a user-friendly data visualisation platform which allows user to build network diagrams and accessible data presentations that we are creating. This is only a shell service, it does not provide data.

Annual cost: GBP £5,000 per year (3 users)

TSC AI[46] provides stakeholder mapping and food systems analysis, however details of the tool and pricing are not publicly available.

Private consultancy firms are also known to use knowledge graph data mapping to provide commercial insights for their clients.

What do organisations need to make this effective and powerful?

Building a sophisticated tool that can integrate evidence-based data and clearly display the relationships between policy areas and stakeholders would provide a valuable solution to businesses, NGO's, researchers and governments who seek to understand this landscape better. The third component is focused on how the intended audience would derive value from such a tool.

For this process its essential to understand what the definition of value is for the intended user and understanding their needs. Data is used to inform decision making across the framework of any organisational structure. The capability to make such decisions is based on 3 areas:

- Organisation's understanding of its macro and micro environments
- Ability to invest in tools
- Staff capactiy to evaluate and process data according to business goals

Time is the most critical resource when decision making in business, irrespective of size, profit margins and bottomline. All organisations require both the resource and/or tools to interpret data to empower better decision making. For this we have identified three core data competency areas[47];

- Relevance: How relevant is the presented information to the end goals of the user
- Trustworthiness: How valid is this information in order to make strategic decisions that cost time and money
- Accessibility and the interpretable nature of data: How long does it take to make these decisions with the data at hand?

Commercialisation of a data tool would need to enable a time reduction in decision making, therefore organisations would need to understand the value of the tool in relation to their goals and validate the adoption of data visualson as a strategic investment that warrants time spent and cost to company.

'We are all time poor, data really only has value if it has been critically integrated, evaluated, designed and delivered in accordance to your organisational goals and objectives.' Paul Newnhan[48]

The value of data is low for organisations who do not see the need for it, or don't have the capacity to invest the time spent on developing industry-specific learnings that enable them to effectively target better.

As a way to gauge a deeper understanding of the commercial viability of such a development, Wren&Co spoke with a wide array of food system stakeholders collecting both quantitative and qualitative data. The network involved global food policy experts, designers, data scientists, retail consultants and academics. Data shows that organisations would use data technology to empower 3 core critical areas; research, business decision making and policy mapping.

Future technology adoption

While 100% of participants agree that visual learning tools would significantly aid their ability to make decisions within their fields, less than a third of the audience had the willingness to pay for such a tool. Technology has no value if "the intended user does not know how this will impact and better their daily living" (Anonymous interviewee).

Adoption of new technology in traditional businesses can be slow. Bloomberg Terminal has been used for over forty years and is a 'trusted' platform for traders globally. However Bloomberg CPO[49] has also cited the 'need for speed', "The crazy speed requirements are going up. We used to put data in front of humans, and only needed to do it so fast. Now many of our systems are connected to customers' computers, which like to see things faster than humans".

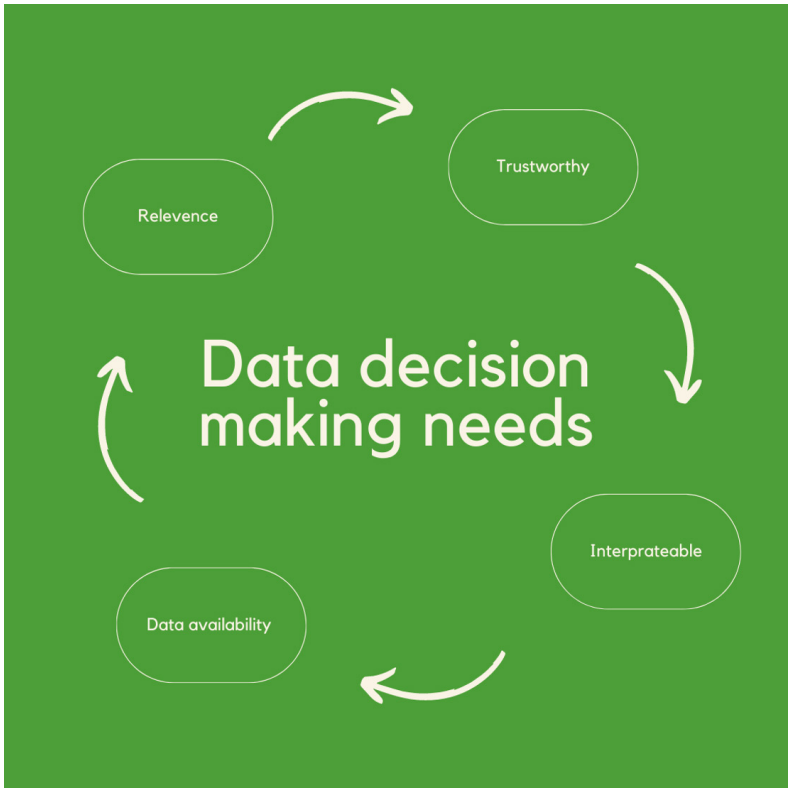

Figure 12: Needs in data decision making

Digitization is rapidly transforming economies and is a central focus of development cooperation efforts.[50] With the growth and adoption of social media and online shopping, businesses have been able to seamlessly automate the consumer journey based on IP records, conversely consumers are also used to their social media feeds or suggested purchases to be reflective of their needs and desires. Similarly, we see that users require all future technology to present the same seamless user interface that aligns to the functionality of other apps and tools.

Cost and availability of data

80% of participants declared that their organisation would prefer to source directly from the internet through available materials, reports and research with only 30% of the group opting for paid subscription services. This demonstrates that an ongoing subscription model is only valid when the service is integral to the day to day workings of the organisation (such as air traffic control monitoring flights, or Bloomberg monitoring financial markets).

During the interviews, it became clear that many organisations also do not have the resources to allocate a member of staff to train in ongoing use of an additional data platform such as this. One interviewee stated that it would be more likely that an organisation would allocate a budget to pay for a a one-time service that provides the answers that this data tool could provide. This could be allocated on a per-project basis, rather than an ongoing commitment from the organisation.

These findings suggest that a consultancy model, where a data visualisation product can be provided as a service to a client would have greater value to commercial organisations than a monthly subscription model. This also supports the iterative development of the data product by allowing it to be developed for use internally, without the need to build a resilient, public-facing front end.

NEED? Framework points

- There is widespread support for visual learning to aid decision making amongst stakeholders
- Time is a critical resource for revenue-driven organisations
- Visualisation can help find efficiencies and cut costs
- Low support for having another business tool
- Low support for subscription based services.
- Organisations don’t want to allocate time and training for a new platform
- Product needs to have clear value proposition - how do the outputs cover the investment
- High support for a consultancy based service to deliver visualisation results

Conclusion

Improving food policy requires us to have a comprehensive understanding of the food system - an entity which is too large for one person to understand - therefore we need help from technology.

To achieve this, we need to look at relationships between its key actors: the countries, laws, government departments, markets, producers, consumers, ministers, regulators and more. Current efforts tend to describe the entities of the food system, rather than show the relationships, flows, tensions and feedback loops between them.

If we mine text documents, we can identify entities and infer relationships, then store this information about the entities that exist and how they relate in a knowledge graph; a structure designed for data about relationships.

Once we have these data we can reveal flows between entities, and model changes, to see what happens when we add or reduce dependencies. In our experience of working with knowledge graphs, the technologies allow us to make and effectively visualize small networks, but massive knowledge graphs that capture the detail and complexity of the food system can easily result in uninterpretable hairballs.

Therefore, we also need functionality - that allows us to aggregate/disaggregate, filter/select and query, so that we know what we are seeing, sometimes automatically, sometimes through human intervention.

Sophisticated algorithms are required to support this activity. These will ensure we present the data in ways that are interpretable and that interactions present the kinds of dynamism we describe and provide additional functionality to support sensemaking.

Some evidence suggests that policymakers are interested in such a solution. Our prototype systems achieve some of this and have been well received. They have also given us ideas about how to move forwards with new functionality.

We have developed methodologies that involve data experts closely in design, and that could result in a functional system, shaped by their needs, as they evolve in line with interaction with, and exposure to, data about their part(s) of the food system.

Interviews highlighted that there is very little market support for a data visualisation product which is a paid-for subscription service. Organisations don’t want to take on additional data platforms unless critically necessary, because of human resources required for ongoing responsibility and user training. However, the outputs of such a data product, e.g. scenario modelling, could provide great value on a per-project consultancy basis. This would allow organisations to set the scope and budget of their enquiry and allow the developers to query the knowledge graph and provide outputs.

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