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Food systems diagrams as boundary objects: tracing the users and uses of a visual thinking tool for food systems transformation

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Title: Food systems diagrams as boundary objects: tracing the users and uses of a visual thinking tool for food systems transformation

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Food systems transformation requires improved collaboration between system actors, but this is hampered by multiple and often differing perspectives within and of the system. Food system conceptual models, and the diagrams which represent them, can support comprehension, inform those seeking to understand what food systems are and what they include, and suggest what needs to be transformed. They have potential to be boundary objects; translation devices capable of spanning intersecting social and political worlds, facilitating communication, collaboration and cooperation, and as such, can have a potentially powerful influence on those who engage with them, and a role in system transformation. This study provides a critical analysis of one such tool – the food systems flower – which has been applied and adapted by food system actors of different types at different scales. This includes multiple applications to local level governance, for example by cities such as Glasgow, Chelmsford and Minneapolis. Using a novel methodological approach to visual content analysis – reverse image searching – the study traces and analyses how the model has been utilised. The findings reveal a range of uses involving varying levels of engagement - illustrative, explanatory, analytical, interactive - by a range of food system actors; primarily academic, but also those in the public, private and third sectors. It is used both as a framework for what is 'in' food systems, and as a tool to consider system interactions and leverage points for action. The flower thus aligns with the definition of a boundary object, facilitating understanding, dialogue, and perhaps even action between different parts of the food system and food policy, though it could be further leveraged for action. Future research opportunities include exploring how further development might help more users go beyond the tool's descriptive function, and apply it to actively organize for transition to more healthy, equitable and sustainable food systems.

Introduction

Food systems transformation to improve food system outcomes for human and planetary health, equity and resilience is urgently needed across a wide range of food-related

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activities (Rockstrom et al 2025; Willett et al 2019; Bridle et al 2025). Improving connectivity and harmonising the system goals across these different outcomes, or taking a holistic 'food systems approach', is in turn equally urgent (Ruben et al 2021; Matteis et al 2025).

This requires collaboration of multiple kinds, including working between different disciplines, transdisciplinary working between researchers and practitioners, such as in the public, private and third sectors, and 'multistakeholder' working between practitioners of different types (Horton et al 2025; Brunori et al 2020; Parsons, Hawkes and Wells 2019; Ericksen 2008).

One acknowledged barrier to progress in collaborating is the multiple contested views of food system transformation, for example in relation to the problems to be addressed, solutions to be enacted (Bene et al 2019; Vivero-Pol 2018; Gugganig et al 2023) and even more fundamentally, what food systems are (Brock 2023; Maye et al 2025).

Food system conceptual models and the diagrams which represent them, can support comprehension. They have the potential to inform those seeking to understand what food systems are and what they include, suggest what needs to change in those systems, and to act as boundary objects - translation devices capable of spanning intersecting social worlds, and facilitating communication, collaboration and cooperation (Hasnain and Hill 2025; Carolan 2022; Ingram and Thornton 2022; Kanwal et al 2019). As such, these tools can have a potentially powerful influence on those who engage with them, and a role in system transformation. This study provides a critical analysis of one such model – the food systems flower.

The following section provides background context on the concept of food systems, and the different mental and diagrammatic models which have emerged to operationalize it.

Background

The food system concept

Estimated to have entered into discourse in the 1970s (Maye et al 2025), usage of the food system concept has increased significantly in recent years, in scholarship, policy and practice (Brock 2023; Maye et al 2025). The heterogeneous views of food systems which have blossomed are underpinned by different epistemological assumptions, mental models, and disciplinary paradigms (Bene et al 2019; Maye et al 2025). The interpretive flexibility around the concept of food systems obfuscates that people may have very different framings, and that these may be deeply incompatible, due to their different prioritization of, for example, markets vs nature, or the role of power (Brock 2023; Maye et al 2025).

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Differences have manifested both in the mental models for conceptualising the food system and also in interpretations of what taking a 'food systems approach' means *in practice* – ie. how to operationalize the concept (Hasnain and Hill 2025; Carolan 2021; Hebinck et al 2021; Hospes and Brons 2016; Stefanovic et al 2020; Von Braun et al 2021; Bizikova et al 2021).

One key distinction which can be observed in the mental models for what constitutes a 'food systems approach' is between those taking a holistic view of the food system as a physical 'thing', a set of interrelated activities (Forrester 1994) where the supply chain dominates (Carolan 2022; Ingram et al 2025), and those which interpret it as a *way of thinking* about food as a system (Maye et al 2025; Ingram et al 2025).

In the former, mental models are dominated by a more rigid conceptualization about the physical activities or components of interest. The emphasis in taking a 'food systems approach' is primarily on *the* physical food system of interrelated activities. A food systems approach tends to be operationalized by expanding the boundary or focus on one aspect of the food supply chain, to bring into purview one or more other parts of the chain - often neighbouring parts. For example, zooming out from a focus on 'consumption'/'eating' to encompass retail. This provides a wider perspective on people's diets, which takes into account the food environment in which their eating occurs, and which shapes the activities of individuals (Turner et al 2018; Downs et al 2020). This boundary might be expanded further along the chain, to bring into view the role of agricultural production in shaping food environments and diets (Herforth and Ahmed 2015), and further still to bring in the role of trade activities (Hawkes 2006).

In the latter, mental models place primary emphasis on a 'systems approach' applied to food, as "a perspective, a language, and a set of tools" (Monat and Gannon 2015, p17) which is synonymous with systems thinking. There is no single agreed definition of systems thinking, and it is associated with a vast body of literature. A review of key literature concluded it can be characterised as "the opposite of linear thinking; that it focuses on relationships versus components, and integration versus dissection; that it recognizes and addresses the dynamic nature of systems and that system feedback loops are essential to understanding system dynamic behavior; that systems exhibit self-organization and emergent properties; and that systems thinking has great power in analyzing, understanding, and influencing complex business, socio-economic, and natural problems and behaviors"(Monat and Gannon 2015, p19).

Similarly, *food* systems thinking, is characterised by Maye et al (2025) by its intention to go beyond siloed thinking, make connections within food systems, connect the food system to other systems, understand interactions, including the trade-offs between different societal

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goals, embrace complexity and multi-causality, and expand beyond the linear food chain (cf the focus on this physical linear food chain in the contrasting mental model).

Underpinning this is a recognition of the challenges of food systems thinking, due to the "partiality inherent in taking a systems perspective, and the difficulty in communicating these different perspectives among stakeholders" (Pope et al 2021, p1), with a requirement to "overcome pervasive fixities, rigidities and ontological divides, including those between disciplines" (Sonnino et al 2019, p115, cited in Maye et al 2025).

Diagrammatic models

Different understandings of food systems are reflected and reinforced through the visual diagrams used to represent them. . A review of 32 different food system visualisations which were published between 1998 and 2020 (Bizikova et al 2021, no page number) noted that the primary aim of most food system visuals is "to support our understanding of the complexity of food systems…by bringing together food production with external influences and drivers that affect production, such as climate, population characteristics, and trade, along with system outcomes such as access to food, diets, and nutrition".

As noted above, such food system depictions function to inform those seeking to understand what food systems include (Carolan 2020; Hasnain and Hill 2025). They "can help answer the question of what exactly needs to be transformed" (Ingram and Thornton 2022, p881). As such, what is included in a depiction has a potentially powerful influence on those who engage with it.

Some of the more widely-applied diagrams include those developed by the High Level Panel of Experts on Food Security and Nutrition (HLPE 2017) Nourish Life (nourishlife.org), and ShiftN (ShiftN.com). The 'food system flower' (Parsons, Hawkes and Wells 2019) is another such example. An exhaustive review of food system diagrams is beyond the scope of this paper and not its primary focus. However, some broad reflections are provided here as context for the examination of use of the flower as one example.

Diagrams presenting the food supply chain of activities in varying levels of detail aim to diagrammatically capture the food system. They do so using different visual forms, which Bizikova et al (2021) divide into the three broad styles: concentric circles; components and linking arrows; and flow or linear diagrams. However, while the broad styles of diagrams dominated by a set of activities in a supply chain may differ, in many such examples the components are typically linked with a single connecting line or arrow between component A and B, between B and C, and so on.

In contrast, diagrams in the field of systems thinking tend to be focused on visualising "relationships, highlighting complexity and demonstrating how altering one variable in a

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system can influence others" (Bryant et al 2025, p132), often as a 'map' of a system of interest. In their review of system maps, Stankov et al (2024, p2) explain how "systems thinking or systems mapping approaches, focus on visually depicting the structure of systems through the creation of causal loop diagrams (CLDs) or stock and flow diagrams", using directional arrows with positive and negative polarities to represent causal relationships between variables, which form reinforcing and balancing feedback loops that represent the dynamics that govern the system's behavior, and often capture the mental-models of interest holders through an iterative consensus-building process.

As outlined further below, the 'food system flower' (Parsons, Hawkes and Wells 2019) (hereafter 'the flower') is a visual thinking tool developed to bridge conceptualisations of food systems as *things* with those grounded in a *way of (systems) thinking*. Indeed, its conception was in part a response to differing (disciplinary) interpretations of food systems within the research team responsible for its creation. The flower visual tool was the end-product of a process of iterative development of a framework to illustrate and make accessible the concept of 'food systems' undertaken by the authors in 2019, due to the rapidly permeating discourse in policy and practice at this time. The underpinning rationale is outlined in detail below.

This study explores how the flower has been used, in relation to its original aims. The purpose of exploring this is three-fold: firstly, to examine how a visual tool is used as part of food system communication and collaboration activities; secondly to test how usage of such diagrams can be traced; and thirdly to establish how such tools can be leveraged to galvanize active usage, shifting emphasis from describing the system to changing it.

Theoretical Framework

A number of existing studies and ideas, related to the object of study (the flower as a boundary object), its purpose (improving food systems literacy and communication) and its usage (tracing) have informed the approach taken in this study.

Food systems literacy

Images shape comprehension, and those related to food systems are no exception: "Food systems images matter by, for instance, focusing attention on what is foreground, deemphasizing what is background, and masking what is ignored" (Carolan 2022, p1). It has been noted that mapping food systems visually "may help scientists as well as decision makers to identify key interactions and the mechanisms, both natural and social, which regulate those interactions" (Von Braun et al 2021, p6), contributing to food systems literacy. The term food systems literacy refers to the capability to understand what food systems are, why they are important, and how we might act to improve food systems outcomes. Visualisations provide an important contribution to this understanding.

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Improving the delivery of food systems literacy is critical for addressing complex food system challenges (Martin et al 2025). This is particularly the case for food policymaking (Hawkes and Parsons 2019). The concept of food systems literacy is a response to the need for greater understanding of the food system as a complex adaptive system with many drivers and outcomes (Pope et al 2021). It is aligned with other emerging and related literacies such as food policy literacy, which argues that "making food policy processes, information, and training accessible to community actors can better prepare them to participate in, interpret, and control food system policies, especially at the municipal level" (Ramos-Gerena 2023, p1).

The role of food systems literacy in public and political communication

Communication can promote equity and challenge dominant narratives in the food system and contribute to food policy literacy (Candel 2022) among citizens young and old. This can support citizen navigation of difficult food choices.

However, contemporary political communication remains characterized by the linear or one-way model of communication defined by Lasswell (1948, p37) as: "who says what in which channel to whom with what effect". Communication of policy by government to the public is mediated and frequently one-way, often happening after policy is implemented, despite attempts at introducing more transparency in the policy making process to encourage more deliberative governance (for example in the UK's Food Standards Agency, with open online meetings, as explored by Hajer and Versteeg, 2009). This one-way approach to communicating policy persists despite information technologies offering an expansion of opportunities for citizen-policymaker interaction. Reflection and listening are required as well as simple expression, in an age of "communicative plenty", in order to facilitate more deliberative governance (Ecran, Hendriks and Dryzek, 2019 p19). The implication here is that public and political communication play an important role in enabling food democracy for citizens (Behringer and Feindt, 2024). Communication of policies and policy proposals can foster or hinder informed consent as part of the democratic process: voters should know the impact of their democratic choices on the food system and be able to take part in food policy debates and development

Diagrams can contribute to food democracy in several areas (Behringer and Feindt, 2024): participation where citizens deliberate or debate food choices and take part in civic planning; knowledge or food policy literacy - an understanding of the processes and outcomes of food policymaking; role of the state: rights protection where citizens have the right to food information and informed choice.

Boundary Objects

The notion of 'boundary objects' is associated with the seminal work on the subject by Star and Griesemer (1989). In the context of the heterogeneity of scientific work, which involves

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many different actors and viewpoints, and requires cooperation, they posited the need for and existence of boundary objects, defined as "translation devices capable of spanning intersecting social worlds, thereby helping to pave the way for effective communication, collaboration and cooperation" (Kanwal et al 2019, p101). They characterize boundary objects as "objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star and Griesemer 1989, p393). The definition is concretized further in Freeth and Caniglia's (2020) exploration of collaborative research and practice, which describes how boundary objects can take multiple forms; research questions, concepts, methods, fieldwork sites, roles or activities.

To date, the application of the boundary object to food systems is minimal. Citing Star and Griesemer, Brock (2023) states that the food system concept can be seen as a boundary object that brings people together without requiring full consensus. The notion of food system *diagrams* as boundary objects was touched on in a study of interdisciplinary collaboration (Sawyer et al 2025, p8, citing Freeth and Caniglia 2020), which notes how system maps have been proposed as an effective "epistemic boundary object" to enable stakeholders and researchers to create a shared visualization of the system, stimulating collaboration.

The proposition explored in this study is that its heterogenous use suggests the flower represents a useful boundary object (Star and Griesemer 1989; Freeth and Caniglia 2020; Trompette and Vinck 2009) which can support taking action on food systems; flexible enough to be moulded, yet robust enough to sustain commonality, and in theory able to support both inner (food systems thinking) and outer (food systems acting) transformations (O'Brien and Sygna 2013). We structure this exploration by applying Wenger's (1998), four dimensions of boundary objects (Table 1). Wenger proposes that a boundary object is characterized by how: it can facilitate dialogue between worlds, due to its abstract quality; it can be used for different activities or practices; different parts can be used independently; and the information it contains is standardized and can be understood by all who engage with it. These will be revisited in the discussion in light of the study findings.

Dimension	Details
Abstraction	It facilitates dialogue between worlds
Multi-tasking	Several activities or practices are possible
Modularity	Different parts of the object can serve as a basis of dialogue between actors
Standardisation of the information contained in the object	Information within it is in a form that each constituency knows how to deal with it locally

Table 1: Dimensions of boundary objects. Source: Authors from Wenger 1998

'Tracing' as a research practice

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As outlined further in the Methods, this study utilized the Google Lens 'Reverse Image Search' function to trace instances of a single visual depiction - the flower - informed by literature from the field of information management. Google Lens is a relatively new visual technology, which has been described as "emerging as a pivotal force shaping our interaction with information" (Salim et al 2024, p1). However, while RIS is a novel method, tracing is an established research practice, and therefore the application of object tracing in this study was inspired by several bodies of literature and related methods.

Tracing refers to a qualitative research strategy in which the investigator systematically follows the movements, transformations, and relational linkages of a particular entity—such as an object, idea, actor, document, or practice.

One such research practice is media ecology, which examines the influence of evolving technology on communication (Strate 2004; Scolari 2012; Lum 2009). Stemming from work in the 1960s which acknowledged the importance of the medium as much as the message (McLuhan 1964), media ecology scholars highlight how information proliferates in digital spaces and can powerfully accelerate the communication of ideas and frameworks (such as the flower diagram). New technologies also offer the ability to trace and follow images, ideas and frameworks through the digital space in a way that has not previously been possible. This approach has been utilized, for example, in a study tracing how scientific research into bowel cancer and dietary fibre moves from research, to press release, to press agency, to media outlet and onward to social media (Wells 2017).

Another influence on the study is academic research tracing objects relating to food, such as the 'Follow the Thing' methodology. This social science methodology was developed by human geographers Cook et al (2006) to follow the spatial journeys of food products in order to uncover the social, cultural and political economy of those products and the actors involved in the food chain.

The study was further shaped by applications of food systems concept tracing (Brock 2023; Maye et al 2025), and in particular by the approach taken in Clapp et al (2025), where the authors trace usages of their framework tool devised to support understanding and action related to food security.

While no applications of tracing an *individual* diagram could be identified in the existing literature, there are related studies (for example Nesbit and Adesope 2006; Umoquit et al 2011) examining use of diagrams and maps in research. None align closely with the type of object we are interested in – a conceptual model rather than a table or chart, or map of research results – but they offer useful examples of the study of non-text items, primarily in scholarship.

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The following section describes the flower and its rationale, situating it in the wider literature on food systems diagrams, then details the conceptual framework which scaffolds the study, thus also serving as a literature review.

Introducing the food system flower

The flower (Figure 1) was developed to help improve food systems literacy, in particular in policymaking, with an aim to support systems thinking about food, by emphasizing the need to recognize connections, and help to identify both synergies and dissonances as well as unintended consequences of policy actions, thus countering siloed policy making and advancing coherent policies for example those that address both health and climate Parsons, Hawkes and Wells 2019) In reality its applicability has extended beyond policy, into practice (for example by the private and third sectors) and research.

As noted above, the theoretical underpinning of the tool combines the complementary fields of systems thinking (Meadows 2008; Forrester 1994; Ison 2010; Cabrera, Cabrera and Midgley 2023) and food policy coherence (Parsons and Hawkes 2020; Dewi et al 2024i; Monticone et al 2023; Kidd and Reynolds 2024 etc).

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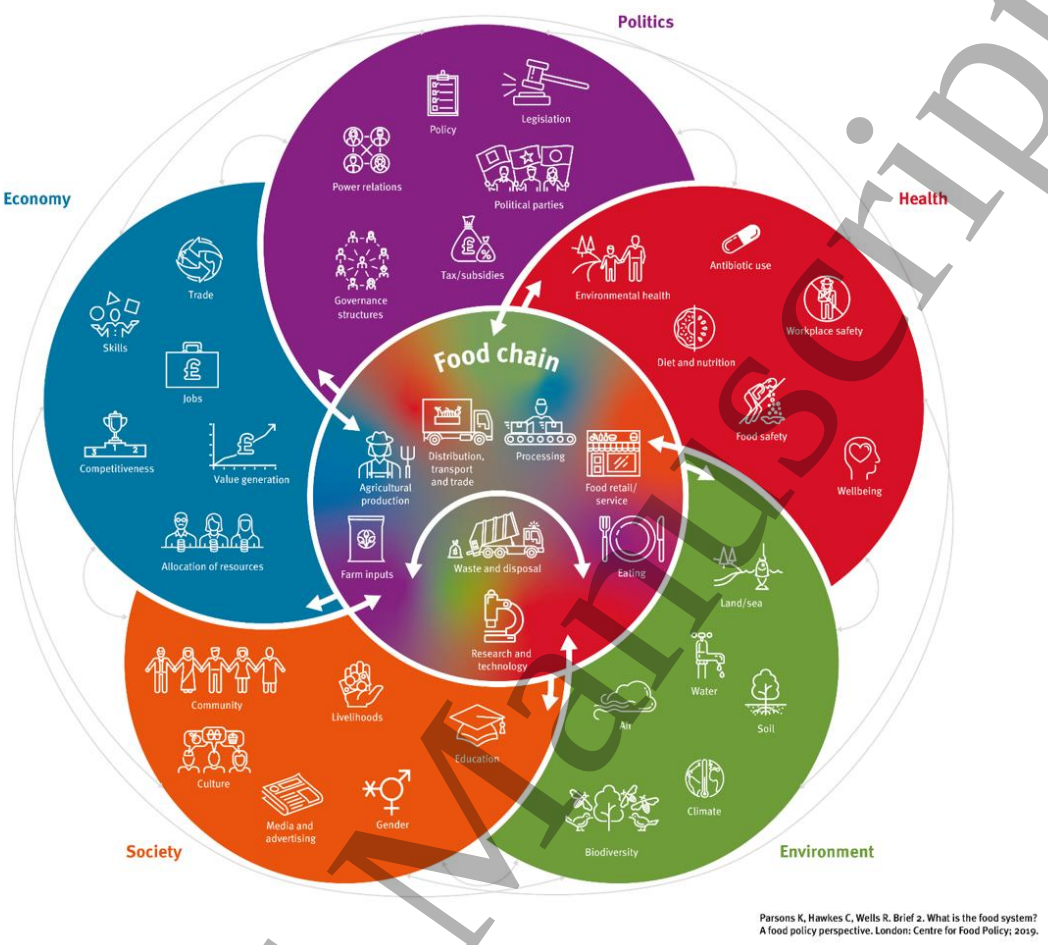

Figure 1 The Food System Flower. Source: Parsons, Hawkes and Wells (2019)

Echoing Clapp et al's (2025) rationale for development of their six-dimension food security framework, the flower tool was an articulation of the authors' thinking as informed by involvement in a number of projects related to food systems, including one to provide a series of practical guides for food policymakers on translating scholarly terms such as food systems, policy integration, policy coherence and governance into practice, and their experience of development and delivery of the Interdisciplinary Food Systems Teaching and Learning (IFSTAL) programme (Hawkes and Parsons 2019; Parsons 2019; Parsons and Hawkes 2019a; Parsons and Hawkes 2019b; Parsons and Hawkes 2019c; Parsons and Hawkes 2018; Parsons 2019a; Ingram et al., 2020; Pope et al 2021).

Responding to the potential to identify key interactions mentioned above, the policy brief on food systems in which the flower originally appeared (Parsons, Hawkes and Wells 2019) was further informed by a literature review on interactions between different food system activities and outcomes where policy incoherence has been identified (for example between agricultural production activities and environmental degradation outcomes, and between

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economic outcomes such as profitability, and human and planetary health outcomes). The resultant tool features a set of food system activities - or food chain - at the centre, stretching from inputs at one end, to eating at the other, and also including cross-cutting activities such as those related to food waste and research and technology. These activities are surrounded by a series of coloured 'petals', representing key dimensions of interest for food systems: health, environmental, social, economic and political. Within each petal, are representations of the key issues for consideration, for example in terms of the environment; climate, biodiversity, land/sea, air, soil, water. The petal dimensions may also be considered as other 'systems' with which the food system interacts or overlaps (see for example Hawkes 2020; Von Braun et al 2021) and are given greater prominence than the chain itself, to counter the tendency in other depictions to equate food systems with supply/value chains at the expense of other socio-ecological considerations (Carolan 2020). Presenting the dimensions in this way also allows users to address the system from their particular entry point of interest - for example health - and consider its relationship to other domains, such as environmental.

As noted above, food system transformation requires transformation of outcomes - for example, poor diet outcomes to better diet outcomes or poor working conditions to fairer conditions, through changes in food system activities (Ingram and Thornton 2022). Unlike many other depictions of food systems, the elements included in the flower are presented as both drivers of food system activities – i.e. influences *on* - and outcomes *of* food systems activities – i.e. influenced by - in recognition of the complexity of the system (Hasnain and Hill 2025). For example, climate is considered to be both an outcome of the activities in the food chain, in that food production and consumption lead to greenhouse gas emissions, and thus better outcomes would involve lower climate impacts, and a driver of those activities, in that climate change has impacts on food production.

The overlaps between the petals, and accompanying arrows, between and beyond the petals, illustrate the multiple complex and dynamic interactions which take place between the different activities and outcomes, characterised by messiness and unpredictability rather than ordered linearity.

The flower is more encompassing than many diagrams, in that it presents not only broad categories of outcomes (and drivers) such as 'health', 'environment' 'social' and 'economic', but also a more granular set of elements beneath. For example, within the social 'petal' are found 'community', 'livelihoods', 'culture', 'gender', 'media and advertising' and 'education'. Use of icons - interface objects that represent in a simplified pictorial fashion larger, more complex, and harder-to-grasp system objects (Wiedenbeck 1999) - supports use as a practice-focused visual thinking tool, in a way that depictions which consist largely of boxes, lines and words are less able to. It enables mental connections between these to be more readily made than representation by text alone (Wiedenbeck 1999). This aims to

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prompt the user to consider any potential impact of an action in one part of the system depicted, on elements elsewhere, with an on-the-ground empirical reality in mind. As such it responds to an interest in learning what food systems include, as demonstrated by Google Trends data cited by Carolan (2020) on the frequency of queries 'what is a food system' and 'food system definition'. In addition, the relationships within, "gives analytical and practical emphasis to interactions, integrations and relationalities between actors and activities within the food system and between food and other relevant systems" (Sonnino et al 2019 p115, cited in Maye et al 2025). It aims to do so without capturing every aspect of food systems, which leads to depictions which are hugely complicated and thus difficult to understand and apply.

As such, the flower's distinctiveness lies in its attempts to combine a framework for what a food system as a 'thing' includes, with a way of thinking about food. It does so by combining the familiar linear supply chain of activities at its centre, iconic representation of on-the-ground phenomena (such as land or antibiotic use) and less tangible phenomena (such as power relations or community), along with capturing the idea of complex and dynamic interactions, for example where outcomes can also be drivers, and overlapping subsystems. It is framed as a 'visual thinking tool' for this reason.

Since its publication in 2019 the flower has been, and continues to be, employed by a range of different food system actors, across public, private, third sectors, and by the research and education community. The authors have been gratified to see its use, for example, as the conceptual framework underpinning the national government of Northern Ireland's Food Strategy Framework (DAERA 2024) and several local level food policies, along with the £47m UK government research agency's Transforming UK Food Systems Programme (https://ukfoodsystems.ukri.org).

This study documents a formal exploration of how the flower tool has been used to support a food systems approach, building on, and extending existing studies on food system visualisations (Carolan 2022; Hasnain and Hill 2025) and on tool uptake (Clapp et al 2025). The research question being addressed is: how is the food system 'flower' diagram used, by whom, and how does its meaning and function vary across contexts?

Next, the methods, including use of reverse image searching, are described. The results section then provides a summary of the uses identified, including what type of user, and what type of usage, and these are subsequently explored and reflected on, along with the implications for future use and evolution of the tool, in the discussion and conclusion.

Methods

Visual content analysis

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The primary method employed was a visual content analysis using the Google 'Lens' image searching function as the main method of data collection. However, this study took a different approach to existing studies, where for example Google image searching has been utilised as a method for identifying food system visualisations. Carolan's (2020) review of food system depictions employed Google images to search the term 'food systems' and extract the top 100 images returned for content analysis.

The method employed in this study, Reverse image searching (RIS), is a way of image searching by uploading an image and looking for appearances on web pages. Other terms used for this method include reverse image lookup, backwards image search(ing), and content-based information retrieval (Nieuwenhuysen 2019). Lens "compares objects in your picture to other images, and ranks those images based on their similarity and relevance to the objects in the original picture", using its "understanding of the objects in your picture to find other relevant results from the web" (https://lens.google/intl/en- GB/howlensworks).

RIS was deemed the most appropriate method for several reasons. First, traditional academic literature searches were not appropriate, as the focus was on the use of the image itself rather than the publication in which it appears. Although databases for policy such as Overton exist, identifying the image within search results would have required screening a large number of documents, which was not feasible. Second, the study aimed to apply and explore this novel method of image searching and tracing, reflecting a long-term interest in food systems literacy and the role of communication, as well as its potential to provide an approach for others seeking to track the use of models and visualisations.

Sources and sampling

A systematic approach was taken, and a number of other search engines, identified as providing a similar functionality to Google Lens in the literature (Nieuwenhuysen 2019; Jones and Oyen 2022) were also searched (Table 2). All relevant search engines with this functionality identified from the literature were included. The image of the flower was uploaded to each search engine and number of returns recorded: exact matches and non-exact matches. Searches were conducted between 27th September and the 29th November 2024 by both authors independently. Each instance was recorded in an Excel spreadsheet, with date of retrieval, date of publication, description, and URL. The two spreadsheets were subsequently merged to create a single dataset. This was then deduplicated, with Google Lens returns given priority over any other search engines. This spreadsheet is included as supplementary material (S1), which includes weblinks to all instances. A word document was later created, and screenshots of each usage were saved.

Search Engine	Details
Google Lens	Function of the well-known general web search system Lens.google/intl/en-GB
Yandex	General web search system, popular mainly in Russia

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	Yandex.com
Bing	Microsoft-owned search engine Bing.com
Baidu	Chinese search engine Baidu.com
Tineye	System dedicated to search by image only Tineye.com

Table 2: Search engines included. Source: Authors adapted from Jones and Oyen, 2022 and Nieuwenhuysen, 2019

Inclusion/Exclusion Criteria

Inclusions using RIS are by their nature defined by delivery of the image uploaded. Returns were thus eligible to be included if they used the flower diagram in some way. Returns which used other similar diagrams, not based on the original flower (i.e. not an adaptation), were excluded. Returns where the links were broken were excluded, as were instances from the social media platform X that were no longer retrievable e.g. if accounts had been subsequently deleted.

Along with the returns from the RIS, added to the sample were examples which had been notified to the authors directly. This was either due to a request for permission to use (coded as 'IDR' for requested permission) or due to the usage being communicated to the authors (but without permission being sought) (coded IDN for notified). The decision to include these additional instances was taken due to the aim to identify a wide range of users and usages, rather than to perform a comprehensive systematic search aiming to capture every usage (Brock 2023). As such, these additions to the sample are considered to be a similar methodological approach to that taken in literature searching, where additional papers of interest identified but not returned in a database search, for example through snowball searching, are added (Page et al 2020). It should be noted that some of these requested and notified instances were published since the original RIS searches in 2024.

Coding

Following Carolan (2020) and other visual content analysis studies (Kerkhoven et al 2016; Pila et al 2017, cited in Carolan 2020), an emergent coding structure was utilised: the coding framework was inductively derived, through familiarisation with the data. The framework was further refined by pilot coding of the data. Broad user categories were identified and then tested jointly by both authors, while discussing any ambiguities. Similarly, broad usage categories were identified by the authors, and then iterated through application to the dataset. The final coding framework is presented in Table 3.

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The code for User applied a commonly used categorisation: academic, plus the so-called 'food policy triangle' of policy, industry, and civil society actors (Lang, Barling and Caraher 2009). Users which did not fit into these groupings were considered as 'other'. The code for Usage was designed to represent a spectrum of engagement with the tool, though it is acknowledged that as with any classification, the lines between can be blurred and overlapping. 'Illustrative' usage was defined as where users want to encapsulate the idea of a food system without much explanation of how food systems operate and/or what is involved, to involve the least engagement. 'Explanatory' usage offers some description of the food system or systems approach to food, with reference to some, or all, of the characteristics such as interconnectedness, or interactions, drivers, outcomes, areas for intervention, and complexity. Those applying the tool as an 'Analytical Framework', use it as a scaffold for organising an analysis, for example using domain headings - health, environment, economic, social, political, or activity areas - inputs, production etc. Finally, the use of the flower framework as a 'Mapping Aid' takes analysis one step further, through some kind of interactive engagement, often by groups in workshops, for example to map their food system and potential areas for transformation or impacts of an action across the system.

Code	Description
Search Engine	Which of the five search engines the instance appeared in
Type of Return	Exact/Non-Exact match (distinction made in some search engines)
Date	Date of publication of the usage
Source/Name of Retrieved Instance	Shorthand descriptor created by authors
URL	Link to the instance
Usage by Research Team	Whether the use was by one of the research team responsible for the Flower's creation (Parsons, Hawkes and Wells 2019)
Original or Adapted	Whether the usage presents the Flower in its original form, or if it has been adapted in some way by the user
Primary or Re-Share	If the instance represents the sharing of the original Flower or if it is a re-share of another instance of usage (for example a reference to an academic paper where the Flower was included)
User Type	Academic Policy Civil Society Industry Other
Usage Type	Illustrative: Used to illustrate the idea of a food system with very limited or no explanation

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	Explanatory: Used to explain the food system, or a systems approach to food, with reference to some or all of the characteristics such as interconnectedness, drivers, outcomes, areas for intervention Analytical Framework: Used as a scaffold for organising an analysis, for example using domain headings – health, environment, economic, social, political Mapping Aid: Used in workshops or other settings to map food system and potential areas for transformation

Table 3: Coding Framework. Source: Authors

The authors coded a proportion (10%) of the sample together before each coding half of the rest of the instances. Close contact was maintained during the coding process and there were frequent discussions between the two coders about the strict definition of codes and the underlying discourses of the flower usages, before coding was finalised in the spreadsheet. Instances were only coded to one user type and one usage type.

Results

The results of the analysis are presented below, with examples of instances of use of the flower diagram. A list of all instances of use in the sample can be found in supplementary file S1, rather than in the reference list.

Returns

Initial searches using multiple RIS search engines resulted in 102 total returns (Table 4).

Search Engine	Date	Returns
Google Lens	27/09/24	79
Microsoft Bing Images	29/11/24	10
Baidu	29/11/24	0
TinEye	29/11/24	0
Yandex	29/11/24	13
Total		102

Table 4: Number of returns from search engines. Source: Authors

Following merging and deduplication the total sample of RIS returns was as follows:

Returns from RISs n=62 (coded for analysis as ID01-ID62); returns from authors' records of requests for publication of the diagram n=7 (coded for analysis as IDR01-IDR07); returns from notifications to the authors of usage of the diagram n=12 (coded for analysis as IDN01-IDN12). During the analysis process 7 further returns were no longer retrievable due to

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broken URLs, and these were removed from the sample. The final sample of analysable returns was 74. Of the 74 returns there was an even spread (between 5 and 10 returns each year) across the years of the sample from 2019 to 2024 with a small number of notified and requests for uses being published in 2025. However, a large number of the returns were undated (n=23, 31%) and so a trend in publication over time is difficult to establish. Most usages returned in the larger sample are UK-based, but the sample also includes international examples, including from a Japanese conference (ID03), the Minneapolis Food Council (ID25), and in presentations by academics from countries including Chile (IDN09, Corvalan), Czech Republic (ID44, Jan Pivonka), and USA (ID46, Berman Institute).

The following sections provide descriptive statistics of the sample and a narrative description of the different usages, by actor, and by usage type, along with examples from the sample.

Who has used the flower?

Of the five actor types of user or publisher of the diagram, the largest proportion was Academic (55%), followed by Civil Society (20%), Policy (15%), Industry (5%) and Other (4%). Academic uses included academic research published in journal articles or in research project reports, but other forms of academic communication also appear, such as a research funder call (ID34) or conference calls for proposals (ID03); social media posts, for example on LinkedIn or Twitter (ID02; ID28), as well as examples in education such as course modules, course sessions or activities as well as a MOOC (ID26). Civil Society users include local food partnerships (e.g. ID19); alliance and advocacy groups (e.g. ID16); climate campaigners and social movements for land food and climate justice (ID47). Policy users span governance levels from local (ID04, ID09) to regional (ID32) to national (IDN10), as well as urban and rural user types. The diagram has been used in food strategy development, for example in Northern Ireland and by the UK government's Department for the Environment, Food and Rural Affairs (DEFRA) as well as being used in parliamentary briefings (POST, IDN11) and in evidence to the House of Commons EFRA Committee (ID10). The industry category was much smaller and only included 4 users, typically coming from larger organisations such as a multinational food company (ID29) or an industry body representing food industry organisations (ID12) . The 'Other' category only included three instances and these did not easily fit into the main categories: an individual (ID27), a think tank (ID52) and a producer/grower organisation (IDN02). Finally, it is noted that 13 of the 74 are uses by one of the original authors.

How the flower has been used

Usages of the flower were coded as either illustrative, explanatory, analytical framework or mapping aid, as described in the Methods. Table 5 provides a summary of usage types coded. From the data you can see that illustrative use by academics was the most common

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category, with 22% of the sample, while industry was the least frequent user with only 5% of the sample. Policy users mostly appear in the 'explanatory' category.

The second most common use is illustrative, with considerably fewer uses as an analytical framework or mapping aid. It is acknowledged that the sample may be skewed towards illustrative and explanatory uses, given that these are the instances most likely to be returned in RIS of an original image. There are 18 (25%) instances of analytical framework and mapping use, and half of these were identified through request or notification, rather than through RIS.

Academic	16 (22%)	15 (20%)	6 (8%)	4 (5%)	41 (55%)
Civil Society	6 (8%)	5 (7%)	3 (4%)	1 (1%)	15 (20%)
Policy	0 (0%)	8 (11%)	3 (4%)	0 (0%)	11 (15%)
Industry	1 (1%)	3 (4%)	0 (0%)	0 (0%)	4 (5%)
Other	2 (3%)	0 (0%)	1 (1%)	0 (0%	3 (4%)
Total	**25 (34%)**	**31 (42%)**	**13 (18%)**	**5 (6%)**	**74 (100%)**

Table 5: Total sample (n=74) by user type and usage type. Source: Authors

Illustrative - a shorthand for 'what is the food system'

In the illustrative instances, the flower visual is provided, but with little engagement with its contents or underlying message. For example, minimal or no explanation is given about what it illustrates or how this is relevant to the paper, report, or project it is included in. It has been used this way by several academic and civil society users, and there is one instance from industry. Many of the instances in the sample from social media are illustrative, which is unsurprising given a post does not allow room for more deep engagement, be that explanation or analysis.

Academic usage in this way includes in papers on food system-related topics, such as Gardiner et al 2025, (IDR01) on transforming urban food systems, community impacts of co-production processes, and food democracy and food citizenship. Civil society usages include as an illustration of the work done by the organisation (Propagate Scotland, ID42) and to illustrate the need for a 'food system lens' in thinking about a local food system (Shropshire Good Food partnership, IDN07). The illustrative usage by industry is from the UK website of food and drink company Nestlé, on a page about 'regenerative food systems'. Here, the flower is offered in original form without adaptation, along with some commentary on national food policy.

As an explanatory device

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Explanatory uses include academics providing the image to support a description of what the food system is in the context of a paper related to a particular food system issue, ranging from sustainable food systems evidence (ID49, Davies 2020), to reduction of negative food system externalities using microbial-based solutions and fermentative processes (ID43, Capozzi et al 2021). The Northern Ireland Government has used the flower as a guiding framework for the development and delivery of its Food Strategy, and instances appear multiple times in the sample, tracking the policy's development, from the initial consultation document (ID01), to presentation updating on progress (ID32), to the final strategy (IDN01). Here, the flower is used to illustrate the 'food systems approach' which is taken in the policy project, which "embraces all the elements and activities that are involved in feeding a population: the production, processing, distribution, supply, marketing, consumption of food and drink and handling of waste; and the consumer values and behaviours that influence these processes" (IDN01 p8). The document notes that this Food Strategy Framework "signals a radical change in approach to food policy for Northern Ireland" (IDN01 p8), and that this "will build strong alignment across linked policy areas such as agriculture, environment, economy, circularity, education, social and public health policies"(IDN01 p9).

Use of the flower to set the scope of the system of interest in this way is a common theme across different actor types. For example, industry user Greencore has developed an adapted version of the flower framework to position itself within the food system in its sustainability report (IDR04), describing how "Greencore exists within this system and is shaped by these influences" and also recognises it has responsibility and opportunities "to positively impact the environment" in which it operates. Use of the flower as the conceptual framework underpinning the UK Government's Transforming UK Food Systems (TUKFS) Programme, involved describing, as part of the Programme's purpose and aims, how it will consider "the complex interactions between health, environment, economic and behavioural factors across the food system" and "foster a joined-up approach linking nutritionally healthy and accessible diets with sustainable food production and supply, delivering coherent evidence to enable concerted action from government, business and civil society to help achieve dietary health, obesity reduction and net zero emission goals" (ID34, p1). Alongside the flower image, it also notes the importance of framing issues "in this systemic, holistic way because the different parts of the overall food system are highly interconnected, and can interact in complex and non-linear ways" and to avoid unintended consequences (ibid). Multiple projects funded by TUKFS have also used it, with varying levels of engagement, from illustrative and explanatory, such as Fix our Food (ID50, Fazey and Colvin 2023) and FoodSEqual (ID19) to more analytical and mapping activities in workshops (described below), such as by the ECR Network (IDR02, Lonnie 2024) and TRADE-led synergy project (IDR06, Burns 2024).

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Analytical - as a framework for organising analysis

Those that engaged more deeply with the flower tool went beyond using it to illustrate or explain what the food system is, to organise their thinking, or analysis. The subject is sometimes outward facing – i.e. the organisation is analysing something external - and sometimes inward facing – i.e. an organisation analysing itself. An example of the former is the EU research project ROBUST, which used the flower domains to organise a review of evidence on the impacts of, and considerations around, local food in relation to public sector food in Monmouthshire (IDN12). Another outward analysis is the network for local food partnerships, Sustainable Food Places, which included it in a guide to measuring impact, as a framework for identifying what can be measured in a food system (IDN03). There are several examples of the latter, inward-facing usage. It was used by the civil society organisation Sustain, in a presentation to the UKRI Transforming the UK Food System Programme (IDN05), as a framework to present the type of work and aims of the organisation (Sustain). Likewise, the NGO Eurocoop, which represents consumer cooperatives from across Europe has used the dimensions to illustrate its approach and the benefits of cooperation (IDN02). a mapping aid and for other interactive workshop activities.

Mapping Aid

An extension of use as an analytical tool, is doing so as part of an interactive mapping or other workshop activity. One example (ID20) from academic users is an assessment task at the University of Warwick, where students "work in groups to apply their Food System analysis skills". They "identify and diagnose an issue within a food system of their choice, and analyse the issues using concepts, frameworks and theories delivered within the module – or identified by the students as being complimentary - to develop a proposed intervention that addresses the situation". In a workshop for early career researchers working within the TUKFS Programme, the flower was used to create materials for identifying food system impacts and connections (IDR02). Also, as part of a TUKFS-related workshop, an adapted version of the flower was used in a workshop setting in an activity to try and agree a set of "fundamentals for food system transformation" (IDR06). There are several uses by civil society organisation Nourish Scotland, which involve interactive discussions on food system issues, using the flower as a prompt (for example IDN04). Further afield, it was used as part of a living lab in Barcelona (ID24), to facilitate "mutual learning among the complexity of the system of promotion of healthy and sustainable diets, identify a shared vision and leverage points where participants want to see change, and co-define strategic and actions plans as roadmaps for change".

Adaptations

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The majority of uses of the flower are in its original format. However, some users have chosen to adapt it in different and interesting ways. As noted above, organisations have used the framework to reflect on their own activities and amended the diagram with new wording reflecting these (e.g. IDN05 and IDN02). The food company Greencore adapted the flower to make it bespoke to the organisation's sustainability strategy. The food strategy team in the UK government Department for Environment, Food & Rural Affairs created a diagram depicting the problems of the food system, which the strategy will address, which is acknowledged to be inspired by the flower (IDN10). Often an adapted version was used in conjunction with the original used as an illustration. Beyond the study sample here, the authors of the flower also use multiple adapted versions, in teaching and other presentations, for example to illustrate the range of policies which target different food system activities and outcomes, and the potential synergies and conflicts between these, or to illustrate how an action in one part of the system can ripple across the rest, or have impacts up and down the food chain, or on multiple food system outcomes.

Discussion

This study has explored how a food system diagram – the food system flower - is used, by whom and in what way. The previous sections introduced the food system flower visual thinking tool, its rationale, and its usage by a range of different food system actors, in a range of ways. These usages were identified by application of the reverse image search (RIS) method, the resulting sample was combined with other instances which were known to the authors, through requests for permission to use, or through notification of usage (without permission being requested). Having presented the results of our search for usages of the food system flower tool, the remainder of the paper offers a discussion of the results, and a conclusion. The following detailed discussion is organised as follows: summary and interpretation of main findings; strengths and limitations of the method; implications for policy and practice; and unanswered questions and future research.

Key findings

Firstly, the tool is primarily used as an explanatory device. Secondly, users from academia, civil society, policy and industry employ the flower to explain the concept of interconnected food systems. These findings suggest the initial objective for developing the diagram - facilitating greater understanding of the concept of food systems as complex and interconnected with intersecting domains acting as both drivers and outcomes of the system - has been successful. This suggests the flower represents a boundary object, as discussed further below. The primary research contribution of this paper is a deeper understanding of how a visual thinking tool can be applied to support food system thinking and acting. It also provides a methodology for tracing influence of a visual depiction, conceptual framework diagram, or infographic, in the same way that might traditionally be applied to citations for impact.

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Interpretation of findings

The predominance of explanatory usage points to a key finding: within this sample, the diagram is used primarily to explain the concept of food systems. This aligns with Bizikova et al.'s (2021) analysis of food system visualisations, which concluded that their primary purpose was explanatory. Such uses may be understood as occupying the less engaged end of the engagement spectrum. However, examples of the diagram being used as an analytical framework or interactive tool suggest further potential for deeper forms of user engagement, as discussed in the section on future research below.

It comes as little surprise that the majority of usages identified were academic, given the authors of the tool are academics themselves. Though the audiences for academic work are not always known, except in cases such as journal articles, academic users may nevertheless act as brokers between research and other types of actors.
Certainly, in usages by the original authors the audiences have included policy, industry, and civil society. However, the authors are gratified that the flower has penetrated beyond academic circles, and into the 'real world' of food systems - engaging those charged with direct delivery of actions to transform it, be they from the public, private, or third sectors.

The flower as a boundary object

One of the inspirations for this study is the notion of system maps as boundary objects to support collaboration (Sawyer et al 2025; Freeth and Caniglia 2020; Trompette and Vinck 2009; Wenger 1998). For this reason, the discussion now revisits the dimensions of a boundary object proposed by Wenger (1998) - abstraction, multi-tasking, modularity, and standardisation - considering the results on usage of the flower (Table 6).

The fact that the flower has been used by different types of actors and for broad audiences, for example, in presentations and mapping workshops organised by food partnerships, which by their nature bring together diverse food system actors, suggests that the flower can facilitate understanding, dialogue, and perhaps even action "between worlds."(Wenger 1998). Multi-tasking is demonstrated in the varied uses, from papers and reports, to presentations, analytical frameworks and workshop materials. It is less obvious that different parts of the object can serve as a basis of dialogue between actors (Modularity), given that most instances feature the flower in its entirety, but there are instances in the sample of particular sections being used in isolation - such as the middle of the flower, the food chain activities part. It is also not always clear how mapping activities in workshops have utilized the whole and parts of the tool. Finally, while Wenger's fourth dimension is the most challenging to translate based on the description in the original text (Wenger 1998), various usages of the flower, and particularly its

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illustrative and explanatory uses to define, bound and explain what is 'in' the food system (Carolan 2020), suggests the information contained within is interpretable by different constituencies.

Dimension/Quality	Details	Application to the flower
Abstraction	Facilitates dialogue between worlds	Used by different types of actors, and to broad audiences, for example in presentations and mapping workshops of food partnerships which by their nature bring together many types of food system actor
Multi-tasking	Several activities or practices are possible	Varied uses: papers and reports, presentations, analytical frameworks; workshop materials
Modularity	Different parts of the object can serve as a basis of dialogue between actors	Several activities or Most uses are of the flower in its totality, but there are some instances of use of only elements, in particular the central circle illustrating activities in the food chain
Standardisation of the information contained in the object	Information within is interpretable by different users and participants ('constituencies')	Illustrative and explanatory uses to define, bound and explain what is 'in' the food system suggests the information contained within is interpretable by different constituencies

Table 6: Alignment of food system flower with dimensions of a boundary object. Source: Authors, using Wenger (1998).

Given usage of the flower identified in this study, which speaks to the dimensions identified by Wenger (1998), it is therefore credible to classify the tool as a boundary object for food systems thinking and acting. It provides a shared reference point - for example for use in papers, reports, presentations, while also allowing for local interpretation - such as adaptation to understand an organisation's role and aims in relation to the food system, or in workshops to scaffold a participatory exercise - where desired. Its function as a boundary object for food system transformation could be further leveraged, as discussed below under implications and future research.

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As discussed further below, whether the boundary object function is desirable is questioned in the wider literature. Brock (2023, p810) makes clear that "it is not adequate to see food systems as a kind of boundary object which can draw actors together despite their different understandings. As the food system world is rife with divisions, as seen so starkly through the UNFSS, not paying attention to how different actors enact food systems may ultimately create further divides".

The key message from this study is that the food system flower represents a valued tool for illustrating, explaining, analysing, and mapping food systems, by actors of different types, from academia, policy, industry and civil society, but with potential to go further.

Strengths and Limitations of the Methods

Reverse image search has provided a useful method to identify certain types of usage of a visual diagram, and has served its purpose for our study, which was interested in identifying a range of usages to understand the tool better and explore potential for extending it in future iterations. It also provides a potential additional tool for tracking research impact, a field which is dominated by a focus on citations in scientific journals, in a way that lags behind current best practice (see for example, https://sfdora.org).

There were a number of limitations regarding the methods using within this study. Firstly, regarding the RIS method, Google Lens and other such reverse image search engines have limitations. These have been widely discussed, for example reports of accuracy in finding matching images vary, and RIS can only find image matches available to it. The RIS sample provided in this study required a significant amount of cleaning, to make it ready for analysis. For instance, some usages (by a particular author) appeared in several instances, because they were hosted in several places, for example on a journal website, university repository, on academic platforms like Researchgate and Semantic Scholar, and on slide sharing platforms such as Scribd and Slideshare. Some entries were no longer available when it came to analyse the returns. Screenshots were only taken at the point of analysis, but a screenshot at the time of the RIS, when other data was collected such as title, link, would have saved time at the analysis stage and potentially resulted in a larger overall sample. Google Lens proved to be the most accurate with fewer returns from other reverse image searching search engines. However, the reach of Google Lens is unclear. Although the authors are aware of several publications of the diagram that were not picked up by it, this cannot be quantified.

In addition, this method is only able to locate usages where a diagram has been published somewhere on the internet. This may be in various formats, including but not limited to document, video, or slide-deck upload. The data source is itself dynamic and adaptive, and instances may be added or removed over time. Therefore, the sample identified is likely to

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be only a temporal snapshot and a proportion of instances of use which have taken place since the image was first published in 2019.

Another limitation of our method was the stage at which data extraction took place in relation to the RIS: screenshots of the image usage were only captured subsequent to the initial data extraction, which meant some web links were broken. Capturing a screenshot during initial extraction would have addressed this issue. There are limitations to how much data can be extracted from RIS returns. It was not always possible to tell how extensively the food system had been discussed by a user, in order to analyse whether the usage was illustrative or explanatory. For example, some powerpoint presentation slides which appeared in the search had no notes or audio available. These were coded as illustrative, assuming the lowest level of engagement, but may in reality have been associated with more in-depth explanatory uses. It is also not always possible, when instances are from slide decks, to identify which organisation is presenting, for example one slide deck is branded both International Labour Organisation and Euro Coop (IDN02), one instance is labelled both Telford Council and Shropshire Good Food Partnership (IDN07). Overall, the study design would have been strengthened had resource been available to conduct primary qualitative research - interviews, focus groups/workshops - with users, to understand their usage and engagement with the tool more deeply. This idea is returned to in relation to future research, below.

Lastly, this was the only method employed for identifying images. If time allowed, searching for citations of the original policy brief featuring the flower (Parsons, Hawkes and Wells 2019, for example in academic databases, and checking for any replication of the image, might have led to a larger sample. However, as noted in the methods, the aim was not to be exhaustive. In addition, the primary interest was use beyond academic papers by different types of food system actors.

Implications for policy and practice

The findings confirm the contribution which food system mental and diagrammatic models can make to food systems policy and practice, and extend our understanding of different ways they can be employed, from helping illustrate and explain what food systems are, in particular to heterogeneous audiences of food systems actors, which includes non-specialists (for example members of a food partnership). They can also be used to explain a set of principles which underpin how a food systems approach is being understood, for example policy principles around connection and collaboration as in the Northern Ireland food strategy, or research principles around interdisciplinarity as in the Transforming UK Food Systems programme. There is potential for more *engaged* use however, moving from illustrating a set of principles, to implementing these. In policy specifically, there is scope for applying the framework of the tool to analyse policy problems, inform policy design, and shape evaluation, in a way that has mainly been used so far in research or civil society. As

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discussed below, the development of guidance on how to use the models in an engaged way would support a more active utilization. This would demonstrate a shift from being a 'visual systems thinking tool', as originally framed, to a 'systems acting tool', which could be used to support higher level engagement and co-production between and within groups of policymakers and citizens. This could aid policymakers to listen to and reflect on the views of citizens about policy as well as simply expressing policy ideas, solutions or problems, potentially leading to more deliberative governance (Ecran, Hendriks and Dryzek, 2019).

The notion of further leveraging of the flower raises an additional question, around the neutrality of the framework, and the decision not to include any normative goals for the system but allow users to lay these over the tool. Several users (for example food company Greencore IDR04; civil society alliances Sustain IDN05 and Eurocoop IDN02) have adapted it with a normative interpretation, using the petal dimensions - health, environmental, social, economic, and political - to detail their goals for the system, or how their activities as an organisation deliver on these. Again, given that "visual representations do not just describe food worlds but hold the potential to enact them" (Carolan 2020, p1357), this is something the authors have deliberated. In particular, the warning from Carolan (2020, p1355) that "flat, apolitical, atemporal depictions of food systems fail to evoke meaningful conversations designed to tease out how change happens over time" and Von Braun et al (2021 p8), that a normative map "postulates a set of objectives and aims to shape the systems to serve the stated objectives". Whether a normative version of the tool would undermine its plasticity is an important consideration, given the inherent nature of boundary objects as enabling coordination but "without actually creating abridge between the perspectives and the meanings between the various constituencies" (Wenger 1998).

A practical implication of the study findings for generators of visuals and other tools, is how usage by an organisation which acts as a network or hub for other food system actors, leads to diffusion of additional usages. The methods applied do not allow for tracing of the diffusion of use (in the same way that one would be able to mine citations in scientific papers), but it is highly likely that brokers who share it such as the civil society organisation Nourish Scotland, and food partnership network Sustainable Food Places, contributed to usage by their wider network, such as by local food partnerships. Similarly, use as the conceptual framework for the TUKFS funding programme is likely to have contributed to the decision by several of the multiple funded projects to use it too, as described in Results. The implication here - for developers of tools - is that an explicit strategy to encourage adoption by knowledge brokers and network hubs could be an important way to increase reach and impact.

Implications for the flower tool itself include the potential for re-designing to take account of usages and negative data identified in the study, as outlined below under future research, and to consider dissemination through brokers, to facilitate wider use.

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It is also noted that the study may itself shape the activities of future users, who may find it helpful to read this paper in conjunction with its application, to understand the flower's rationale, potential usages, and limitations.

Unanswered questions and future research

This study has confirmed many avenues for future research, to inform further development of the tool. These are centred around the different ways its use could be expanded and evolved, to deliver wider and deeper engagement. Firstly, research is needed to review and potentially extend what is included in the flower. While the elements within the flower were not aimed to be exhaustive, there are a number of potentially important aspects of food systems which are not included. Examples of 'negative data' (Carolan 2020) within the flower are 'people' (Carolan 2020), and animal welfare, food security, and resilience, the latter two having risen to increased prominence in recent years. In some ways inclusion of themes such as 'food security' and 'resilience' is restricted by the organisation of the tool into activities and how these influence (outcomes), and are influenced by (drivers), the aspects within the petals. Some concepts - animal welfare, food security, resilience - do not fit neatly into either category. With resilience, for example, being a multi-layered quality, which encompasses many outcomes and drivers. What is included is also anchored to the context of the time; conflict, with the Ukraine war, and other conflict in the Middle East, is now a significant consideration and part of much food systems discourse in a way it was not in 2019. Likewise, trade is included in the economic dimension, but the context for this has changed considerably, which might have altered the narrative which accompanied the tool in the original publication. The notion of 'cascading risks' has become more prominent in recent years (see for e.g. Fan et al 2021; Khatri et al 2024) and this would be likely to be included in any narrative which describes the interconnectedness of the food system. Finally, it is noted that - following Hasnain and Hill (2025) - the flower omits any temporal dimensions and does not lend itself to a multi-level analysis. As such it is biased towards supporting horizontal coherence rather than vertical coherence, which reinforces the wider tendency within the field of food systems and food policy to pay less attention to the interactions between levels of governance. Therefore, a further question to be addressed is how the content of the model should be evolved to account for these important considerations for food systems.

Secondly, research into the psychology and behaviour associated with visual design, including the effectiveness and influence of visualisations, including use of icons (for example Padilla et al 2018), could be undertaken to inform future iterations. Existing evidence on desired food system competencies from studies on food systems literacy (Martin et al 2025, 2024) may act as a guide to expansion of the framework. Recent observations about political or policy education (Tam, 2023) make a plea for educational

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approaches that can impact the raising of democratic understanding and engagement. This is instructive for teaching in particular.

Research activities using participatory user co-design could be undertaken to inform guidance on using the model, and any subsequent changes to its design. For example, inspired by the mapping usages identified in the study, and in particular the creative ways in which the flower has been utilized in interactive activities, both in its original form and through adaptation, co-design of an interactive toolkit, with ready-to-use materials, and guidance documents, warrants consideration. In addition, production of bespoke versions for different actor groupings, or different levels of government, for different country contexts, or in other languages could be explored. In particular, there is a clear rationale for further examining how the flower could better support citizen understanding of food systems.

Research on food systems literacy has reinforced that "citizens should have a holistic understanding of food systems (i.e., from production to waste), so that they can be informed 'change agents' to change food systems" (Martin et al 2024, p4). A pertinent recommendation from these studies, is that different levels of complexity can be designed-in for different audiences: a simplified version for children, with further complexity added to new versions for higher age groups to adults.

Conclusion

This study has explored how a food system diagram – the food system flower - is used, by whom and in what way, in order to better understand the role of such tools in supporting food system collaboration, by helping to overcome the barrier of partial and contested views of the problems to be addressed, solutions to be enacted, interactions across the food system, and even more fundamentally, what food systems are. The findings suggest the initial aim for developing the flower - facilitating greater understanding of the concept of food systems as complex and interconnected with intersecting domains acting as both drivers and outcomes of the system - has been successful as evidenced by its use by academia, civil society, policy and industry to explain the concept of interconnected food systems. Its role in facilitating understanding, dialogue, and perhaps even action "between worlds" suggests the flower acts as a boundary object for collaboration. However, with much utilization being of a more passive nature, and fewer examples where the flower is applied as a framework for analysis, or as an interactive tool, there is a need to deepen the level of engagement of users. Future research and action to develop the tool to enhance its contribution to food systems thinking and action is planned. It is hoped this will enable a wider range of actors to organise for more rapid transition to healthy, equitable and sustainable food systems.

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