frontiers | Frontiers in Sustainable Food Systems

TYPE Community Case Study
PUBLISHED 18 June 2025
DOI 10.3389/fsufs.2025.1620974

OPEN ACCESS

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RECEIVED 30 April 2025
ACCEPTED 30 May 2025
PUBLISHED 18 June 2025

CITATION
Gilmour A, Ingram J and Zurek M (2025) Conceptualizing the Irish and UK food systems.
Front. Sustain. Food Syst. 9:1620974.
doi: 10.3389/fsufs.2025.1620974

Conceptualizing the Irish and UK food systems

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As with any food system around the world today, the food system pan-Ireland and the UK are considered unsustainable as it is adversely affecting the environment and failing to provide the entire population with food and nutrition security. Integrated food systems research is becoming evermore necessary as any interventions targeting food system transformation must consider not only production to consumption but also the wider environmental and socioeconomic context. This paper proposes a new food system conceptual framework (the *Food Co-Centre Conceptual Framework*) which was developed via multi-stakeholder collaboration through a mixed-methods approach of: interviews, focus groups, webinars and workshops. The conceptual framework conveys the components (activities, drivers, outcomes, feedbacks) encompassed in the Irish and UK food system. Visually representing the food system pan-Ireland and the UK will help stakeholders comprehend the multidimensionality of the food system as well as any trade-offs and synergies. Thus, it is a valuable tool for designing and discussing food system transformation policies and interventions.

KEYWORDS

conceptual framework, diets, trade-offs, transformation, participatory design, redesign

1 Introduction

While the current food system is satisfying the food needs and providing a livelihood for the majority of people worldwide, it faces numerous and complex challenges. It fails to meet 2.3 billion people's requirement for food and nutrition security (FNS; i.e., a healthy diet) and detrimentally impacts the environment (Baungaard et al., 2021; Westhoek et al., 2016; WHO, 2024). This situation was brought to the forefront of societal, political and science agendas at the *United Nations* (UN) *Food System Summit October 2021* where it was agreed that radical food system transformation is needed to achieve the Sustainable Development Goals (SDGs) by 2030 (United Nations, 2021). Many nations are now addressing this challenge of how to enhance food system health, livelihood and environmental outcomes, not least in the Republic of Ireland (RoI) and United Kingdom (UK) where opining has become mainstream due to national health and environmental concerns (CHA, 2023; Dimbleby, 2021).

A large proportion of the population in RoI and UK makes unhealthy food choices, with about 60% of the adult populations being overweight or obese (Department of Health and Social Care, 2022; Healthy Ireland, 2019). The prevalence of moderate or severe food insecurity in 2019–2021 was 6.5% in Ireland and 3.5% in the UK (FAO, 2022b). Overweight and obesity disproportionately affects those of a low socioeconomic status, with a 19-year difference in healthy life expectancy between those living in the most and least deprived areas (due to dietary intake, physical activity and limited healthcare access) (ONS, 2021). The societal gap has widened in recent years, as have health inequalities. Macro systematic shocks such as Brexit (2020), the COVID-19 pandemic (2020) and the Russo-Ukrainian War (2022) have massively disrupted the food system (House of

Commons, 2023). Subsequent geopolitical implications have affected the supply chain, increasing global food commodity prices (ONS, 2025).

Aside from dietary inequalities, the current state of the food system is transgressing planetary boundaries, particularly regarding greenhouse gas (GHG) emissions and biodiversity loss. In the RoI, agriculture contributes 38% of the total GHGs emitted by the country (EPA, 2024). Livestock farming is particularly damaging to the environment as 90% of the methane produced is due to ruminant animals and the remaining 10% is due to manure management (DEFRA, 2019).

In addition to health and environmental concerns, it is important to note that both the RoI and UK are highly reliant on imported foods as well as on each other (Benton et al., 2019; Kendall, 2021). For instance, food and live animals account for 34% of all Northern Irish (NI) imports to the RoI (Ward, 2022). Recognizing the interconnected food system challenges of environmental concerns, high reliance on imported goods, increasing obesity and social inequalities, *Food Vision 2030* (RoI) and *The National Food Strategy* (UK) have been published (Dimbleby, 2021; Government of Ireland, 2021). These documents report on the state of the present food system and propose ways in which the system can be improved for people, planet and profit.

The UN High Level Panel of Experts on food security and nutrition (HLPE) describes the food system as including (i) core food system activities from production to consumption, (ii) the social, economic, policy and environmental drivers shaping these activities, (iii) the outcomes of these activities (e.g., FNS, a prosperous food and drink industry), and (iv) feedbacks or relationships between these other three components (HLPE, 2017). Integrated food systems research is becoming necessary worldwide as intervention propositions must comprehend not only the core food system activities but also the wider context (i.e., infrastructure, environment, population, and institutions) (Borman et al., 2022; HLPE, 2017).

To grasp the extensiveness of the food system, numerous conceptual models of varying degrees of complexity have been published for an assortment of purposes. Zou et al. reviewed literature concerning food systems frameworks, stating that a CF is characterized by a "visual illustration of ideas, theories or concepts" (Zou et al., 2022, p. 5). Ideally, a food system CF should illustrate all the components across the food system (i.e., inputs, environment, people, processes, feedbacks etc.) (HLPE, 2014). Earlier food system CFs merely included the activities and outcomes before progressing to include drivers and feedback loops (Cash et al., 2006). For example, Ericksen's framework connects food system activities with outcomes contributing to FNS as well as demonstrating how exogenous drivers (e.g., socio-political context, biodiversity) interact to drive activities and subsequent outcomes (2008). This CF demonstrates that the food system is exposed to many interacting drivers and it is not merely primary production impacting FNS (Ingram, 2020). Later CFs consider spatial, temporal and jurisdictional scales in addition to visually representing interactions or linkages between biogeographical and human environments (Cash et al., 2006; Ericksen, 2008). One such example was developed by a project titled "Metrics, Models and Foresight for European SUStainable Food And Nutrition Security" (SUSFANS). The SUSFANS CF features feedback loops between the FNS and sustainability of the food system, which feedback to indirect drivers influencing the direct drivers (Zurek et al., 2016a).

A CF capturing the macro-level and abstract concept of a food system enables systems thinking regarding agriculture and FNS. It can be used as an analytical tool, enabling analysis of the interrelationships and feedbacks between components and activities spanning the food system. Thus, assisting policymakers or actors developing interventions to improve the food system outcomes (Cash et al., 2006; Ericksen, 2008; Ingram, 2020). A food system CFs should (i) order and visualize components to create a common understanding of the food system; (ii) be a logical tool which enables benchmarking and assessment of improvement; (iii) establish entry points for food system transformation; (iv) allow examination of trade-offs when policy or action is taken (i.e., weigh up positive change versus unintended consequences) (Ericksen, 2008; Zurek et al., 2016b). Further, a framework can help build a cohesive research agenda and serve as a checklist (Ingram, 2011).

This paper began by highlighting the challenges faced by the food system and section two explains why a conceptual framework (CF) is required for the Irish UK context. Next, section three details the methodological approach taken before section four which outlines the framework development and rationale. Lastly, section five discusses the framework and its potential uses.

2 Context

The RoI and UK have jointly launched the *Co-Centre for Sustainable Food Systems* as a large-scale research program in the areas of social and natural sciences, engineering and technology. Institutions involved in the *Co-Centre* span the two countries, with the governance jointly covering jurisdictions set by Dublin (for RoI), Belfast (for NI), and London (for Great Britain). The *Co-Centre*'s vision is to develop and promote innovative and transformative interventions that will encourage a move toward healthier diets and significantly enhance environmental, economic, safe and equitable food system outcomes by 2050, aiming to position Ireland and the UK as global leaders in research and innovation for positive and sustainable change (Co-Centre Sustainable Food Systems, n.d.).

The *Co-Centre* is building cooperation and consensus to advance the agri-food sector underpinning the RoI and NI economy as linked to the UK, while also transitioning toward a more sustainable and transparent agri-food sector. Given the multidimensionality of the Irish and UK food system a CF was deemed necessary for designing and implementing interventions endeavoring to transition toward a more sustainable food system across the jurisdictions. This paper describes this new CF, which should avoid siloed thinking and aid in collaboration, helping institutions build a cohesive research agenda.

It is acknowledged that there are multiple published food system CFs which serve distinctive functions for different actors, whose perceived value or priority of certain food system outcomes differ. Extant literature reviews have described a range of CFs and the function for which they are designed (Brouwer et al., 2020; Bustamante et al., 2024; Ingram, 2020; Ingram and Zurek, 2018). Accordingly, pre-existing frameworks have varying boundaries and scope (Ingram et al., 2010). However, an up-to-date, comprehensive framework conceptualizing the RoI and UK food system is warranted. As trade-offs vary across scales, entry points must be context-specific for targeted interventions that promote sustainable and healthy diets (Béné et al., 2019; Turner et al., 2018). Disaggregating individual

components of the food system and identifying possible entry points will facilitate multi-stakeholder collaboration and discussions concerning feedbacks and trade-offs in decision-making (Béné et al., 2019; Zurek et al., 2018). Moreover, the proposed framework may assist in establishing to what degree the current RoI and UK food system contributes toward achieving policy goals.

3 Methodology and detail to understand key programmatic elements

The aim was to design an optimal food system CF for use across the *Co-Centre*. Building on the Foresight4Food and Food and Agricultural Organization (FAO) of the UN food system frameworks (FAO, 2022a; Foresight4Food, 2019), the development of the CF was led by the authors in close collaboration with *Co-Centre* colleagues. Anticipated end-users were consulted in a collaborative-participatory design approach as multi-stakeholder collaboration is recommended when tackling the complexities of the food system (FAO, UNEP, UNDP, 2023). Qualitative data collection approaches were taken to garner input from stakeholders for progressive iterations of the framework (Figure 1). At each stage, feedback was sought pertaining to the purpose of CFs (i.e., activities, drivers and outcomes), individual components of the CF and its applicability. Stakeholders were considered "an inside and active contributor throughout each step" of the collaborative-participatory design process (Scariot et al., 2012, p. 2703).

External food system stakeholders were recruited for the semi-structured interviews ($n = 20$) plus the first day of the two-day workshop ($n = 22$). Actively engaging stakeholders is crucial for establishing buy-in which can lead to subsequent higher research impact (Boaz et al., 2018). Appropriate stakeholders were intentionally selected via non-probability sampling methods. Selection was based on their employment and a range of different sectors were sought to broadly cover different perspectives of the food system. Initially, purposive sampling was used—as this is ideal for exploratory studies—and *Co-Centre* colleagues introduced the researchers to their contacts. A weakness of purposive sampling is that while convenient, it can be subjective and limit the variety of individuals contacted. Thus, early participants were asked to invite their contacts working in other sectors of the food system to participate, in a snowball sampling method (Blumberg et al., 2014). It can be problematic identifying the best individuals and entry points from which to engage those employed in the food industry (Mela, 2025). In particular, there was difficulty engaging non-governmental organizations (NGOs). Twenty participants were consulted across 17 interviews. Participants' employment included public bodies ($n = 11$), industry ($n = 7$) and NGOs ($n = 2$). The majority were based in NI ($n = 9$) or Great Britain ($n = 7$), with fewer in the Republic of Ireland (RoI) ($n = 3$) or both the RoI and NI ($n = 1$). Although sample sizes for each stage of the research methodology were relatively small, saturation was reached and utilizing a variety of qualitative research methods meant that a consensus was formed (Hennink and Kaiser, 2022).

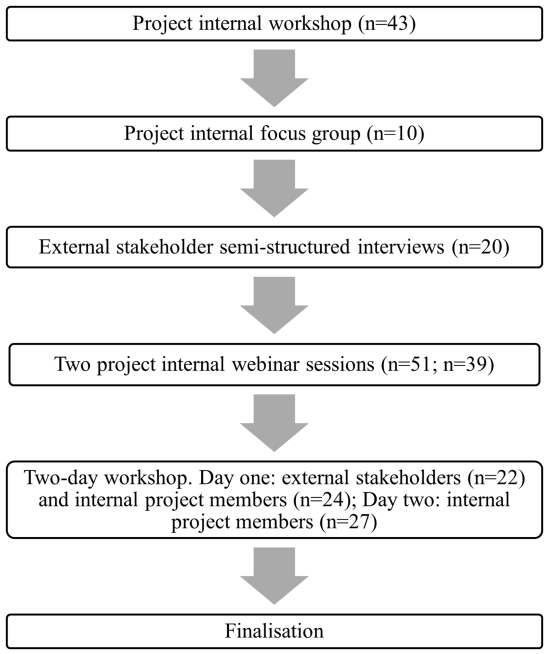

FIGURE 1
Flow chart demonstrating the research stages taken in the collaborative-participatory design of the *Food Co-Centre Conceptual Framework*.

Interviews lasted between 25- and 60-min (Supplementary material 1). Six participants partook in face-to-face interviews conducted in NI and the remaining interviews were facilitated via *Microsoft Teams* and transcribed verbatim using *Otter.ai* or *Microsoft Teams* to assist. Participants received a *Microsoft Word* document of their interview transcription and were able to amend this if desired. *QSR NVivo 14* was used to thematically analyze and categorize the transcripts. The thematic analysis was discussed among the authors before making any modifications were made to the CF.

Interview participants were invited to attend the first day of the two-day workshop and 40% ($n = 8$) joined, plus other external stakeholders were also recruited. No NGOs attended, but public bodies ($n = 16$) and industry ($n = 6$) were represented. As there is a large academic cohort involved in the project, individuals with the greatest influence across non-attending *Co-Centre* colleagues were invited to attend. Attendees viewed the latest version of the *Co-Centre* CF and gave both verbal and written feedback on modifications that would improve the completeness, readability or comprehension of the framework. The usefulness of such framework was also deliberated. The second day of the workshop involved only *Co-Centre* colleagues and aimed to discuss the CF feedback received on day one, build awareness of the research across the project and pinpoint how the CF may be used. Materials from the workshops as well as the researcher's notes were written up and categorized in order to finalize the CF.

Overall, a collaborative and participatory approach was taken to inform the design and development of the presented food system CF. This paper details the rationale behind design decisions which were based upon stakeholder feedback and the researcher's expertise. The applicability of the framework is also outlined.

4 The *Food Co-Centre Conceptual Framework*

The CF presented in this paper displays the context and totality of the Irish and UK food system. As one participant stated: "We used to

say 'farm to fork,' but it's probably a bit before farm and a bit after the fork." The holistic quality of the framework has an implicit One Health approach, considering the health of humans, animals and the environment as one entity which is inextricably linked (Rushton et al., 2021; WHO, 2017). Taking a multi-disciplinary food system, integrated One Health approach purports to "balance and optimize the health of people, animals and ecosystems" (WHO, 2017).

Findings will be presented related to (i) the purpose of the *Food Co-Centre Conceptual Framework*; (ii) the framework constituents: core food system activities; food system drivers; food system outcomes and feedback loops; (iii) framework applicability.

4.1 Framework purpose

The purpose of this food system CF was established during the first *Co-Centre* internal workshop and focus group. Six key purposes emerged for the final framework. Primarily, the framework required a geographic and conceptual boundary to be set. Having clear **boundaries** as to what is relevant and feasible within the scope of the *Co-Centre* project is important, as is setting the geographic boundary as "Ireland and the UK." A second key purpose of the framework was to create **mutual understanding** of the food system for those involved in the *Co-Centre*, serving as a checklist (Ingram, 2011) Next, in order to use the framework as a useful **communication** tool, a balance must be sought between "being overly complicated and actually including what you want to include." As part of this, common language and terminology was chosen so that the framework is understood by a large audience. The target audience will include *Co-Centre* researchers, those working in industry, policymakers, NGOs and society at large. Further, the framework should display the **connections** or relationships between diverse components. These connections support an integrated vision and collective, "joined-up approach" and help researchers to work jointly rather than in silos. Next, the framework ought to be used for **gap identification** and identifying where there are technology, data or policy gaps. As part of this, knowing where *Co-Centre* colleagues sit across the food system and where there are gaps in research or knowledge is invaluable. Another function of the framework is that by holistically encompassing all food system components, a **baseline assessment** can be done to understand what the food system currently provides to people and planet. This will remind individuals about unforeseen negative feedbacks, helping to frame and identify where particular interventions may or may not be effective.

4.2 Framework components

The *Food Co-Centre Conceptual Framework* (Figure 2) conceptualizes the Irish and UK food system, showing the flows and relationships between various components.

4.2.1 Core food system activities

Some food system actors (e.g., retailers, civil servants) span multiple activities (Ingram, 2011). During the semi-structured interviews, participants were shown an image displaying solely the core activities of the food system (producing, processing, retailing, consuming, storing and disposing). The image was alike a cropped version of the existing Foresight4Food and FAO frameworks (FAO, 2022a; Foresight4Food, 2019). The inclusion of these activities depicts how a food product moves from conception through various stages of production and delivery before reaching final consumers as well as how waste is managed alongside this (HLPE, 2017). Conversely, some participants felt that it was "very, very flat" and "linear" as this image omitted global influences such as climate change or the regulatory environment. The wording below each icon was modified throughout.

Figure 3 displays the food system core activities. Stakeholders strongly felt that a cow icon should be added to "producing" to epitomize the dairy and beef industry across NI and the RoI. These industries make a valuable annual contribution to the NI economy with outputs for dairying (£892 m) and cattle (£568 m) (DAERA, 2024). Compared to the aforementioned frameworks (section three), "& manufacturing" has been inserted to processing, representing the wider manufacturing processes that are a part of the food system rather than merely focusing on food production (FAO, 2022a; Foresight4Food, 2019).

At the workshop, "& food services" was added to retailing to encompass out-of-home food consumption which constitutes 23% of the average UK adult's food consumption expenditure (DAERA, 2024). The waste icon needed to represent circular economy, hence why the icon is now titled "managing waste & surplus food" to better reflect farming and producing, as well as waste valorization, biogas and composting (Despoudi et al., 2021). Further, the change from a single dustbin to inserting the universal recycling icon is more representative of the actions occurring at this activity.

Aside from the icons and their titles, the energy flows between core activities were much discussed. Each arrow has been labeled a-f for descriptive purposes. First, during the two initial stages of the design process, "a" was a bi-directional arrow to illustrate that food could move backwards. Yet, with the wording and icon change to "managing waste & surplus food," the diagram now demonstrates that any waste from the line of core activities would undergo waste management before re-entering the linear core activities. The dashed unidirectional arrow "b" signifies farmers markets or subsistence agriculture; for example, allotment holders and those that grow their own food. It is acknowledged that this makes up a minor part of the food consumed pan-Ireland and the UK, yet stakeholders felt it was important to include this. A 2022 survey from the RoI *Central Statistics Office* (CSO) found that 40% of those surveyed were growing their own fruit and/or vegetables (CSO, 2022). However, it was important to visually represent this direct interaction between actors; such as farmers and consumers at farmers markets.

Three arrows—"c," "d," and "e" have a thicker arrow from the linear core activities to "managing waste & surplus food." As aforementioned, waste and food will re-enter the food system, but this tends to be a smaller proportion to that which is finitely removed, hence a narrower arrow illustrating the upwards flow back into the linear core activities. During the two-day workshop, there was much discussion around the requirement to have a unidirectional arrow (f) from consuming as surplus food is not received by a consumer unless it re-enters the chain earlier (i.e., waste bananas being processed into a new food stuff; surplus food from supermarkets being redistributed by either retailers or food service such as the *Olio* app). A study of nine large food redistribution organizations in the UK found that 404 million meals were redistributed in 2022 (WRAP, 2023), and this is represented by the narrow "e" arrow.

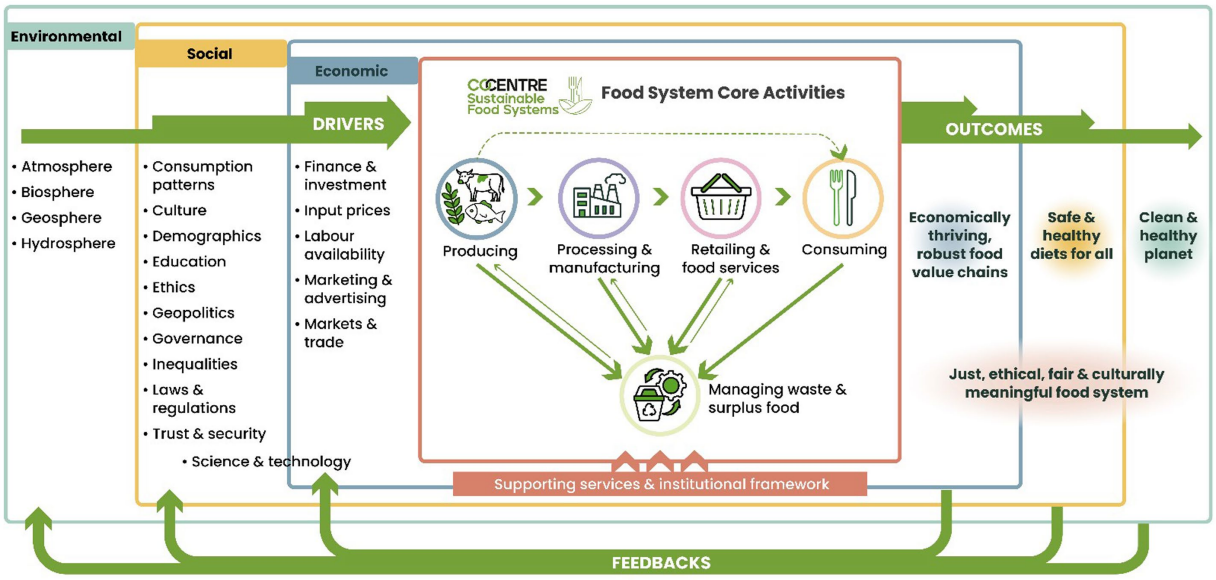

FIGURE 2
Food Co-Centre Conceptual Framework. The *Food Co-Centre Conceptual Framework* is intended to be used iteratively, and is non-hierarchical: consideration of the food system can begin or end anywhere in the framework. The central "food system core activities" box contains a linear food value chain (producing to consuming) and the flow of food and other associated activities may enter "managing waste and surplus food" before re-joining the food value chain. The CF acknowledges though that in reality connections in the food system are non-linear. The wider context of environment (green), social (yellow) and economics (blue) affect the food system core activities. Drivers do not operate independently of each other and although the driver words are listed, they should be regarded as interacting. The influence of a particular driver or combination of drivers fluctuates and may be more powerful in influencing the food system activities than at another time. "Supporting services and institutional environment" comprises energy, water, transport, communications, IT, data infrastructure, logistics and packaging, and the civil service. Outcome words are normative in order to indicate the goal of a particular food system outcome and to map tightly to the Co-Centre vision statement. Feedback and feedforward arrows show interrelationships between components and are vital for analyzing the complexities of the food system.

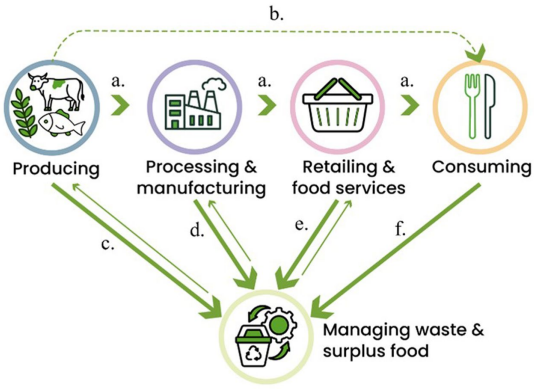

FIGURE 3
Core activities in the *Food Co-Centre Conceptual Framework*.

4.2.2 Food system drivers

The "inputs" driving the food system are important to identify as interventions at this level can lead to food system transformation. The HLPE identifies five key driver categories of the food system: (i) biophysical and environmental drivers; (ii) innovation, technology and infrastructure drivers; (iii) political and economic drivers; (iv) socio-cultural drivers; (v) demographic drivers (HLPE, 2017). Despite this, there is no universal definition for food system drivers, resulting in an inadequate understanding of possible system level changes (i.e., policy implementation or interventions) (Béné et al., 2019).

Most stakeholders had a driver they perceive as critical in influencing the food system; yet, if all these words were to be incorporated, the resulting framework would be visually cluttered. Therefore, the framework is to be viewed alongside a table displaying frequently articulated drivers (Supplementary material 2), which are categorized into the larger "bucket" driver terms as seen in the framework (Figure 3). A food system CF should display the context surrounding food system activities: environment, social, economic and political (Ericksen, 2008). Therefore, in the manner of the FAO (2022a) framework which separates the wider system into "environmental," "socioeconomic," and "agrifood," the *Co-Centre* CF also separates the context into three sections titled "environmental," "social" and "economic." These drivers are important to feature as they influence the dynamics of the food system activities in addition to food system outcomes (FAO, 2022a, p. 8).

The "Environmental" context of the food system features four high-level words. It is expected that this vocabulary is universally understood by the end-user of the framework; plus, the accompanying table provides a good indicator of what each driver constitutes. In sum, these are: hydrosphere (fresh & marine water), geosphere (land & ocean), atmosphere (air) and biosphere (life). Next, there are numerous "social" drivers and this section above all resulted in differences of opinion. While some stakeholders thought their specific driver word was missing and more words needed to be included, others supposed that this section was overcrowded or that the wording was misrepresentative. For instance, "consumer behavior" is a term commonly used; yet, this poses a semantic issue as it puts the onus onto the consumer when food consumption is essentially shaped by

retailers and the wider food environment (Lake and Townshend, 2006). The FAO framework describes these "social" drivers (i.e., governance, consumer awareness, technology) as key triggers for influencing and driving the food system (FAO, 2022a).

During the interviews, stakeholders spoke about how it is a "cost-driven food system" as "affordability is the single biggest issue" and the "consumer purse drivers a lot of factors." In the presented CF, issues around affordability and the cost-of-living crisis would fall under "disparities" which relates to "inequalities." The *Food Foundation's* 2025 report highlights that 1,000 kcal of unhealthy food costs half as much as equal calories of healthy food; limiting access to a healthful diet for those most affected by the cost-of-living crisis (Davies et al., 2025). Especially among the NI stakeholders, "urban–rural" was much discussed during interviews, with regards to rural consumers experiencing difficulty "accessing choice and value for money" if they were reliant on infrequent bus timetables. In NI, 40% of consumers are impacted by a lack of access to discounter stores (i.e., Lidl) and this limits price comparisons plus the ability to shop around (Consumer Council NI, 2024). Urban–rural is ascribed under both "demographics" and "inequalities." There was some debate among stakeholders working in policy as to whether "governance" should be an additional outer context, surrounding the "environmental" box. Those in favor of this stated that "regulation plays a vital role" and "regulation generally is a massive driver."

The "Economic" context is positioned closest to the food system core activities to represent its importance and direct influence on the core activities. Although agricultural productivity supports economic growth, the income of the wider socioeconomic context is built on primary products which then has value added via the core activities (FAO, 2022a). Further, "input prices" was inserted as the cost of fertilizer, energy, seeds, equipment all drive food system activities. This is in concordance with research showing that farm input costs increased by an average of 44% between 2019 and 2024 (AHDB, 2024). In this category, "labor availability" is placed as a driver in its own right whereas in earlier versions, this driver fell under the "demographics" social driver. "Science & technology" spans both social and economic as some sub-items include "data literacy" which is a social determinant and "artificial intelligence" which is an economic factor. Investment in agricultural technology and state-of-the-art AI spans the food system: food processing, farming, smart irrigation and crop data analysis (Kakani et al., 2020).

4.2.3 Food system outcomes and feedbacks

Though the term "outcome" is used, the four phrases on the right-hand side of the framework all refer to the societal goals of the Irish and UK food system, reflecting SDGs (United Nations, 2021). In the original version of the framework shown during the stakeholder interviews, four examples of each "societal goal" were displayed, aiming to cover the key food system outcomes stakeholders are interested in. The outcome wording was derived from Hebinck et al.'s *Sustainability Compass.* The *Compass* was developed for use in Europe to visualize trade-offs and synergies across outcomes when assessing food system innovations by presenting a comprehensive set of performance and progress indicators; enabling assessment to support decision-making and sustainability governance (2021). Although the wording of the 16 phrases on the right-hand side of the framework was refined throughout the first four stages of the design and development process, the sheer quantity of text was perceived as "overwhelming." Consequently, at the two-day workshop it was decided that to improve the readability of the framework, solely the societal goals/key food system outcomes should be included. The perceived importance of individual food system outcomes (i.e., FNS, socio-economic and environmental outcomes) depends on whom the actor is and in what sector or industry they work for (Brouwer et al., 2020).

In the presented framework, the outcomes "clean & healthy planet" and "economically thriving, robust food value chains" are identical to the innermost quadrant wording of the *Compass* (Hebinck et al., 2021). With regards to "clean & healthy planet," stakeholders described how it was important to consider the offshoring of environmental damage and holistically consider how decisions may "affect the global climate." In Ireland, there are policies and investments focused on reducing the environmental harm of the food system (FAO, 2021). However, two of the *Compass* quadrant wording were changed to better meet the needs of the CF's end-user. The societal goal named "just, ethical and equitable food systems" led to much confusion, with only one of the stakeholders interviewed understanding what environmental justice meant. Another stakeholder stated that "just" was a highly subjective term, and measurement would depend on whether it was an individual working in industry, a farmer or an NGO: "I think the other things can be measured more and [are] clearer." Other research has been found that shows people involved in food system initiatives often struggle to conceptualize justice and understand the nuances (de Bruin et al., 2024). Stakeholders also feedback that "connectivity in terms of enjoyment of food" and the "emotional aspect" was missing; accordingly, "culturally meaningful" was added. This outcome is now worded "just, ethical & culturally meaningful food systems." The second set of outcome wording changed was "healthy, adequate and safe diets for all" to "safe & healthy diets for all." The word "adequate" is omitted as stakeholders felt that in the RoI and UK context, adequacy is a non-issue and should go "hand-in-hand" with being a high-income country.

Aside from the four outcomes, feedback and feedforward arrows were deliberated during the design and development of the CF. One stakeholder recognized that there are feedback loops and that this is a vital part of the food system: "So it's all the way through the consumer and obviously the impact on the consumer to what we do at the end, which potentially can always go back to the start again, cannot it?" Additionally, Béné et al. stated that feedbacks need to be "more central to the analysis, acknowledging complexity, multiple unintended consequences" (Béné et al., 2019, p. 125). The thickness and direction of arrows within the "core food system activities" has already been described (see section 4.2.1.), but hereby the three focal arrows will be outlined. The drivers arrow originates in the "Environmental" context box and becomes progressively thicker as it moves rightward. This represents how drivers amalgamate and then influence the core food system activities. The outcomes arrow should be read as vice versa, commencing at the activities and then showing that the food system produces outcomes across an economic, social and environmental context (FAO, 2021). The feedbacks arrow from outcomes to drivers symbolizes all known and unforeseen feedbacks that impact the food system (Ericksen, 2008).

4.3 Framework applicability

A food system CF should support policymakers and stakeholders in taking a systems approach when considering the overall impact of

TABLE 1 Table showing how the *Food Co-Centre Conceptual Framework* may be applied.

Communication • Create joint understanding • Reporting success • Storytelling and recruitment • Setting the scene • Use internally and externally to show the benefits, need or purpose, e.g., improved outputs, better value for money • Communicating representation • Contextualizing the complexity and breadth of the food system • Outreach and engagement tool for working with stakeholders	Mapping • See interaction between stakeholders and their connections and/or synergies • Identify distinctiveness and uniqueness • Demonstrate connectivity • Ensure system thinking and avoid siloing • Identifying collaborators • Map different perspectives across the food system
Measurement • Use to build an analytical framework • Measure progress and target hitting • Extent to which drivers influence food system activities • Analysis of baseline and gaps • Life cycle assessment/environmental impact analysis	Staying within boundaries • Helps stick to food as the topic • Demonstrate relevance of your own research • Course correcting • To show alignment to platform objectives or goals • Show any system (dis)connection • Limit the data to be included

new policies and actions (UNICEF and GAIN, 2018). The interviews and two-day workshop asked participants how they could use the CF in their work. 75% (n = 15) interview participants had used a food system framework before, with non-users stating that their focus was on "what we are doing rather than what the system looks like" and those who saw benefit in a framework being more akin to "a big thinking and a top-down approach." One explained that having a comprehensible framework would assist when talking to colleagues whose eyes "glaze over" when a whole systems approach is mentioned. The table below (Table 1) shows the four significant ways in which the *Co-Centre* CF could be applied:

Although the CF presented in this paper has been participatorily designed, as one participant explains: "…we never get these frameworks 100% right, you know. We get them as good as we can based on our knowledge of today." Therefore, the applicability and comprehensibility of the new framework will need to be assessed at intervals for its usability in terms of communication, mapping, measurement and staying within boundaries.

5 Discussion

The *Food Co-Centre Conceptual Framework* provides a generic illustration of the flows and relationships across drivers, core food system activities and outcomes throughout the Irish and UK food system. Taking a systems-based approach to the food system is important as the Irish and UK's food systems are becoming increasingly globalized and have inherent complexities and multiple feedbacks among a range of activities and outcomes (Ingram et al., 2013). Further, incorporating stakeholder interests and insights via the collaborative-participatory design approach should ensure that the CF represents a coherent, shared understanding of the entire food system across disciplinary boundaries and that end-users better identify with the CF (Scariot et al., 2012).

Although extant literature calls for food system transformation, governance decision-making typically prioritizes economics or commercial interests, sacrificing population health, social and environmental issues (Garg et al., 2022; Juri et al., 2024). However, policies are required to support the One Health vision of balancing natural systems, people and businesses (Rushton et al., 2021). Therefore, utilizing a food system CF to support abstract-level, actionable food system thinking could help decision-makers comprehend and identify paths toward transformation (i.e., via understanding the dynamics and trade-offs), leading to more desirable outcomes (Béné et al., 2019; Borman et al., 2022). Conversely, food system studies can be overly descriptive and lack realistic insights and entry points for transformation (Brouwer et al., 2020). The *Co-Centre* CF considers strategic leverage points to support transformation at a policy and practice level, allowing policymakers and practitioners to comprehend food system component linkages.

Moreover, the *Co-Centre* CF has avoided omissions found by Zou et al.'s review of 50 CFs whereby 82% did not state their target audience; many excluded the food disposal stage; and, most failed to include "institutional/political dimension/indicators" (Zou et al., 2022). It is anticipated that the CF has multiple uses not only within the *Co-Centre* but also for external food system stakeholders: (i) government (i.e., to formulate food policy by assessing the efficacy and costs of regulation, subsidies and taxes), (ii) food businesses (i.e., to instigate better practices to improve enterprises nutritional and environmental impact), (iii) NGOs and civil society groups (i.e., development of stronger arguments for advocacy and lobbying), (iv) researchers (i.e., gap analysis, identification of areas for future work, development of a cohesive research agenda) (Ingram, 2020). Within the *Co-Centre*, the CF will be used as a living document to establish the baseline of food system sustainability across the RoI and UK as well as a tool to avoid siloed thinking.

6 Acknowledgement of any conceptual or methodological constraints

The framework is conceptually limited as it remains static, failing to capture the dynamic nature of the food system in terms of the strengthening or weakening of feedbacks or feedforward arrows. It is recognized that the static nature of a CF means changes across time, space and jurisdictions cannot be represented. Further, the distribution of power cannot be conveyed. Nevertheless, capturing the complex nature of trade-offs and synergies would make visualization and interpretation challenging, the presented CF may be considered a simplification of the food system.

Secondly, a methodological constraint is perhaps non-probability sampling techniques introduced bias toward governmental and industry perspectives. Stakeholder diversity is imperative and the authors were open to engaging with various NGO representatives however struggled to garner their involvement in the study. In any future CF iterations, broader and more equitable stakeholder engagement will be a fundamental aim.

Lastly, an absence of any empirical testing of the CF means that pragmatic validity cannot be ascertained. However, the principal purposes of the CF (see section 4.1.) include setting boundaries, a joint language as well as to show the interrelationships between drivers, activities, outcomes and feedbacks—which will guide further *Co-Centre* collaboration and research. The CF is a starting point for which work considering food system outcomes can be based upon and this will provide real world applicability as the tool should allow policy makers and practitioners to make more holistic decisions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the School of Geography and the Environment at University of Oxford (Ethics number SOGE C1A 24113). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. JI: Conceptualization, Funding acquisition, Supervision, Validation, Visualization, Writing – review & editing. MZ: Conceptualization, Funding acquisition, Supervision, Validation, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This publication has emanated from research conducted with the financial support of Research Ireland, Northern Ireland's Department of Agriculture, Environment and Rural Affairs (DAERA), UK Research and Innovation (UKRI) via the International Science Partnerships Fund (ISPF) under Grant number 22/CC/11147 at the Co-Centre for Sustainable Food Systems.

Acknowledgments

The authors acknowledge those that engaged in the collaborative-participatory design approach of the *Food Co-Centre Conceptual Framework*. This includes both external stakeholders and *Co-Centre* colleagues. In particular, the input from those whom participated in a semi-structured interview or attended the workshop is much appreciated.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1620974/full#supplementary-material

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