Mapping the Welsh food system and identifying places to intervene to create a dietary shift

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Executive summary

A web of interconnected factors limits our options for what food to consume. This web is our food system. The food system comprises of "…*all of the elements – natural and man-made – that combine to produce, process, market and sell the food we eat and the connections between them…, everything from the sun and the soil to the till at the corner shop"* ([Dimbleby, 2021](#)). What this system looks like though in Wales will be different to that of other countries. The purpose of this commissioned project was to understand the system of factors which influence dietary choices of Welsh households, to visualise this system, and to identify potential places for policy intervention. The longer-term objective is for this insight to help encourage a shift towards a healthier and more sustainable population diet. This would have beneficial public and planetary health implications, and contribute to towards the ambitions within the [Future Generations Act](#), the [Healthy Weight, Healthy Wales strategy](#), and the [Net Zero plan](#).

Methodology

This project had six stages: 1) a **systematic review** to create a "big picture" system map of a generic food system; 2) a **workshop** with Welsh Government officials to tailor the map to the Welsh context; 3) testing the assumptions of the Welsh Food System Map against community perspectives by drawing on a published government reports; 4) creation of **causal loop diagrams** (CLDs) to better explain parts of the Welsh Food System Map; 5) a **workshop** with Welsh Government officials and review of the "Food Matters: Wales" document to determine what actions / policies were being taken across the Welsh food system; and, 6) a **Scenario Field Analysis** to identify opportunities for additional government intervention, based on analysis of influential factors in the CLDs, and the extent to which Welsh Government could intervene.

Main findings

What does the Welsh food system look like?

The Welsh Food System Map includes 136 factors across 11 different sub-systems (or themes). This map – developed around nine published system maps and a workshop with seven Welsh Government officials – illustrates the interconnected and systemic factors which influence dietary intake at the household level. More complex sub-systems include **food production**, the **school environment**, the influence of the **wider determinants**, and the power of **marketing and advertising**. These sub-themes respectively provide an outline for the processes and considerations when producing food in Wales, the design of- and policies within- schools and how they sculpt food consumption of young people, how where we live and the conditions that we live in influence the opportunities for a healthy and sustainable diet, and how the marketing strategies employed by large food and drink companies shape food preferences. **Social influences** also formed a substantive part of this map, highlighting how the food preferences of significant others (friends, family, or role models/influencers), affect what we too purchase and consume.

We also identified less complex sub-systems relating to **individual / household knowledge and skills**, **food preferences**, **purchasing decisions**, and **availability of food in the household**. These four sub-systems are highly interconnected and interdependent; changes to one sub-systems would likely affect the others. For example, people who are knowledgeable about food may make more informed decisions about what to purchase, leading to certain types of food being available in the household. A small sub-system around **food availability** was also created, illustrating how the physical environment – the availability of shops, supermarkets, and fast-food outlets – influences the opportunity to purchase and consume certain foods. The final sub-system was the wider **policy context** – and policy decision making processes – which feed into many of the other sub-systems.

How do the different sub-systems work?

We created seven CLDs to better understand the dynamics within the Welsh food system. These CLDs aimed to simplify the sub-systems and highlight key feedback mechanisms (e.g. how the school environment can make it challenging for young people to have positive experiences with food). We worked closely with 24 Welsh Government officials to create these CLDs.

The **food availability** CLD (16 factors, four feedback loops) illustrates how different food products, particularly those regarded as more or less healthy, are made available to customers. At present, the fast-food market dominates, making it challenging for other businesses to viably supply healthier products. Socio-economic factors also played a large role in this CLD.

The **food preferences** CLD (24 factors, five feedback loops) explains how our preferences for certain foods are shaped by myriad factors, but that cost and convenience, supply and demand, and social norms mean that unhealthy diets currently dominate at the population level. Unhealthy diets are characterised as higher in fat, salt or sugar.

The **food production** CLD (28 factors, six feedback loops) elucidates how local-, national-, and international- factors influence the ability to produce and process food in Wales, and moreover, how this is interconnected to broader environmental and climate issues. Dietary choices are consequently influenced via various mechanisms.

The **marketing and advertising** CLD (15 factors, four feedback loops) highlights how marketing and advertising strategies – particularly those producing highly profitable unhealthy products – can shape, and re-shape, dietary norms whilst simultaneously maximising business profits.

The **school environment** CLD (24 factors, seven feedback loops) centres around the ability of schools – be that intended or not – to influence young people's diets via their culture, the investment in staff and structures, the focus of the curriculum, and the national / international prioritisation of academic attainment and pupil health and wellbeing.

The **social influences** CLD (16 factors, five feedback loops) explains how various socio-cultural values can shape the diet quality of the Welsh population, including the role of intergenerational norms, the norms and beliefs of local communities, the role of social media, and the potential unintended consequences of having a high-quality diet.

And lastly, the **wider determinants** CLD (26 factors, eight feedback loops) draws attention to the upstream factors such as the cost of living, governmental policies and subsidies, employment structures, and the quality of housing and how they influence the opportunity for a high- quality diet.

What action is currently happening across the system?

Seventy-four actions were identified by Welsh Government officials and from the "Food Matters: Wales" document. When overlaid on the Welsh Food System Map, the majority (37 actions) targeted the food production sub-system (clustering around climate impacts, food waste, and primary food production), the school environment (11 actions), and the knowledge and skills sub-system (seven actions). Little to no action was noted across the social influences, wider determinants, marketing and advertising, or household food sub-systems. This analysis solely reflects the data collected, and as such, it is likely that other actions – less known to workshop attendees – are being taken across other sub-systems.

The 74 actions were analysed using the Action Scales Model (ASM, right) - a systems science tool to understand the amount of leverage that actions may hold. The ASM includes four "weights" (events, structures, goals, and beliefs) with larger

weights representing stronger places to intervene. At the broadest level, events represent the problems that we see arising from the system, whilst the other weights describe the forces at play which cause these problems to occur. We found that 55% targeted the system *structures*. Actions at this level aim to re-organise the structure of the system to prevent issues from occurring in the future. A third of actions were at the *event* level, holding the least amount of leverage, as they typically react to the issues that we can see (e.g. educating people about healthier diets). Ten actions explicitly aimed to change *goals* within the system, holding a substantial amount of leverage for creating meaningful system change. By changing the goals that a system, or sub-system is working towards, means that it is then easier to re-organise the parts of the system (for example, by aiming to provide all children with a nourishing and hot meal at school [the goal], then schools and governments can put provisions in place to enable this to happen [structures], such as universal free school meals).

Where are the potential opportunities to intervene?

We applied a Scenario Field Analysis to the CLDs to identify aspects of the Welsh food system where there are opportunities for Government intervention – referred to as "steering factors". Steering factors exert a relatively high degree of influence over other factors in the system due to the cumulative effect of their outgoing connections, where higher stakeholder-assigned weights on certain connections can amplify their influence, even with fewer overall links. In our case, steering factors were decided upon based on a weighting system that slightly prioritised control over impact, meaning that factors with stronger control over others were emphasised as primary drivers in the system, even if their direct impact was more limited. Targeting intervention at steering factors may change the dynamics within the system. Our analyses focused on four sub-system CLDs due to their alignment with perceived Welsh Government influence: food availability, food preferences, food production, and the school environment. It is important to note that the Scenario Field Analyses should prompt further, and deeper investigation, into these parts of the system, rather than being an end point in themselves.

Sixteen factors were included in the **food availability** sub-system analyses, with *fast-food business profitability* and *socio-economic status* both coming out as steering factors. Within the **food preferences** sub-system, the *quality of school food provision and practices* was the only steering factor identified from the 24 factors included in the analysis. *Individual cooking skills* and *time availability* also seemed worthy of further exploration. Regarding the **food production** sub-system, four steering factors emerged from the 28 included in the analysis: *Just-in-Time processing*, *consumer demand, profitability*, and *climate impacts.* The *governmental prioritisation of academic attainment and / or pupil health*, the *degree of school funding,* and the *overall quality of dietary intake in Wales* were found to be steering factors in the **school environment** sub-system, comprising 24 factors. Our analyses also identified factors which may help to monitor change within sub-systems – known as "measuring factors".

Implications

Given the ambition of the Welsh Government to create a dietary shift in Wales to one which is healthier and more sustainable, it is imperative to understand the web of factors influencing population dietary intake. The comprehensive Welsh Food System Map and the accompanying CLDs aim to do this, reflecting what is known in the research literature and crucially drawing on the extensive knowledge of Welsh Government officials.

The Welsh Food System Map and the CLDs can help illustrate the complexity of the task at hand. They can allow people, both within and outside of government, to see their role within the Welsh food system. They can highlight the various parts of the system which can be influenced by Welsh Government and associated partners. Furthermore, the map and CLDs can draw attention to the aspects of the system which require support from the UK Government or international agencies. The CLDs in particular are useful tools to think deeply about action within a system; they illustrate how a change in one part of the system may have positive or negative implications elsewhere.

As we have also shown, it is possible to overlay actions onto the Welsh Food System Map to depict current policy efforts. However, this work could be taken further, to explore the interconnections between these actions across the system, to examine their coherence (are efforts pushing in the same direction?), and to critically reflect on the leverage that current actions hold. A similar exercise could be undertaken to determine who – people, organisations, and sectors – are currently involved across the Welsh food system. Doing so will also reveal who else needs to be sought out and engaged to achieve the Government ambition.

The Scenario Field Analysis provides insight as to the parts of the system worthy of further investigation. The analysis identified where intervention may be particularly fruitful for creating system change, and other aspects which may be more helpful to monitor than intervene in. Given the time constraints of this project, we could only apply this analysis to four of the seven CLDs, however we have created a practical methodology that could feasibly be applied by the Welsh Government to the remaining three. This would provide a more comprehensive analysis of the Welsh food system.

Limitations

This project does have several noteworthy limitations. First and foremost, the Welsh Food System Map and CLDs do not aim to be exhaustive; they reflect the collective knowledge of those who were involved in the workshops, and as such, may be omitting certain insights and foregrounding others. This work sought to provide Welsh Government officials with greater exposure to systems science and associated methodologies, and so the workshops – each between one and three hours in duration – provided an introduction. Thus, the outputs (Welsh Food System Map, CLDs, and Scenario Field Analysis) should therefore be interpreted with this in mind. Similarly, to make the data collection and analyses feasible, the Welsh Food System Map was broken down into sub-systems, meaning that some of the interconnections between sub-systems are de-emphasised. Additional insight could be gleaned from analysing the whole system.

Future work can now build on these foundations by investigating the feedback structures and loops that contain coalescing steering factors, and drawing on alternative methodologies that propagate influence throughout the causal architecture. This may include matrix multiplications and fuzzy cognitive mapping to further confirm or challenge intuition, initial evidence, potential points of power, and existing intervention actions.

Contents

1. Introduction

1.1. Project objective

The purpose of this project, commissioned by the Welsh Government, was to understand the Welsh food system and identify potential places for intervention to change how the system functions. This project would draw on group-model building to gather intelligence from Welsh Government officials, alongside the published academic evidence, to visually map out the factors and interconnections which influence the food system. The project would then use this map, and through a participatory process, identify the places where Welsh Government could feasibly intervene in the food system. In turn, the hope is that these interventions / policies, if enacted, will help shift Wales towards a more health promoting and sustainable population diet.

1.2. Governmental ambition

Wales is a devolved administration, meaning that the responsibility for the health and care of its population is largely held by the Welsh Government rather than that of the UK Government. The Welsh Government also holds power over matters such as education, highways and transport, housing, the environment, and agriculture. In the context of this project, there are therefore a set of levers available to the Welsh Government, independent to that of the UK Government, that can be used to intervene in the food system. These levers may be available nationally or more locally.

The Well-being of Future Generations (2015) Act (WFGA) set the backdrop for the 2019 Healthy Weight, Healthy Wales strategy (updated in February 2023). The WFGA aims to improve the social, economic, environmental and cultural wellbeing of Wales. It emphasises the need for all sectors and government agencies to play their part in working towards seven wellbeing goals (Figure 1). Collectively, this creates a shared vision for what Wales should be like now and in the future. As such, well-being is central to decision and policy making within Wales.
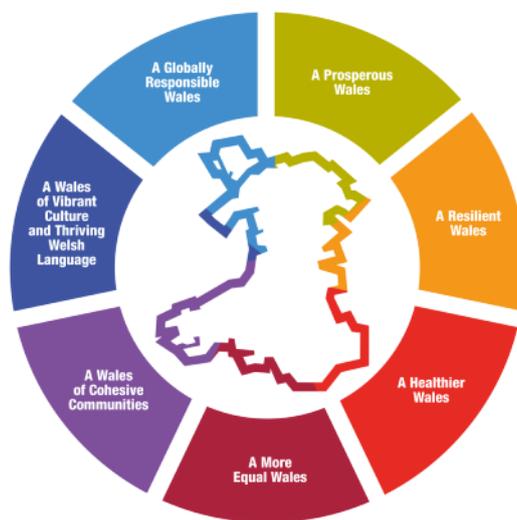
Figure 1: Future Generations Act - Wellbeing Goals

The Healthy Weight, Healthy Wales strategy builds upon this. It highlights that a systems approach is required to prevent and reduce obesity in Wales by 2030. It spans across four main themes: 1) Healthy Environments, 2) Healthy Settings, 3) Healthy People, and 4) Leadership and Enabling Change. The food system is interwoven throughout several of these themes, especially the Healthy Environments work within the Food Environments sub-theme. This work is also closely aligned to the 2022 Net Zero plan. Understanding the factors which influence household dietary choices, and identifying places to intervene, would directly contribute towards these collective ambitions.

With regards to the Welsh Government goal to reach net zero greenhouse gas emissions by 2050, one of the key identified pathways to achieve this is to reduce emissions across agriculture and consumer behaviour (Notman, 2023). The Climate Change Committee's (2020) "balanced pathway" scenario highlights the symbiotic relationship between agriculture and consumer behaviour, whereby 60% of agriculture-related emissions could be reduced through shifts in consumer food waste and meat / dairy consumption. These ambitions, in conjunction with the national directive to improve diet-related health and reduce inequalities, provide the rationale for exploring how to achieve an equitable dietary shift in Wales.

1.3. Patterns of dietary intake in Wales

When taken as a whole, there are some signals that the Welsh diet has improved between 2009 and 2017 (Welsh Government, 2019): red- and processed- meat consumption has demonstrated a downward trend over time, as has fat and salt consumption, and the proportion of young people, particularly boys, consuming sugar-sweetened beverages has reduced. Total energy intake across all age and sex groups in Wales has remained stable and is below the recommended 2000 and 2500kcal per day for women (1556kcal/day) and men (1965kcal/day) respectively. That said, intake of red- and processed- meat is still much higher than recommended for adults, as is sugar consumption in young people and adults. Fruit and vegetable consumption has remained relatively stable, albeit that their average consumption is below the recommended five portions per day (3.8 portions per day), and intake of vitamins, minerals and dietary fibre remain lower than recommended too. These data are however based exclusively on self-reporting which are known for misreporting by 20-30% (Ravelli & Schoeller, 2020).

Looking at inequalities in diet quality, these tend to be more pronounced in Wales when compared to the broader UK (Welsh Government, 2019). Fruit and vegetable consumption, sugar consumption, salt intake, are typically poorer for those with lower household incomes. Meat consumption is greater, on average, for higher income households and particularly amongst men. These results do however relate to the National Diet and Nutrition Survey, which was last conducted in Wales, in 2017 (Welsh Government, 2019). As such, the findings are out-of-date and do not account for the profound cost-of-living changes that have occurred in the last five years. For example, in 2021-22 (Figure 2), those living in the most deprived quintile of the *UK* population would need to spend approximately half of their disposable income on food to meet government recommendations for a healthy diet (Food Foundation, 2023). This proportion is likely to be much higher now considering current inflation.
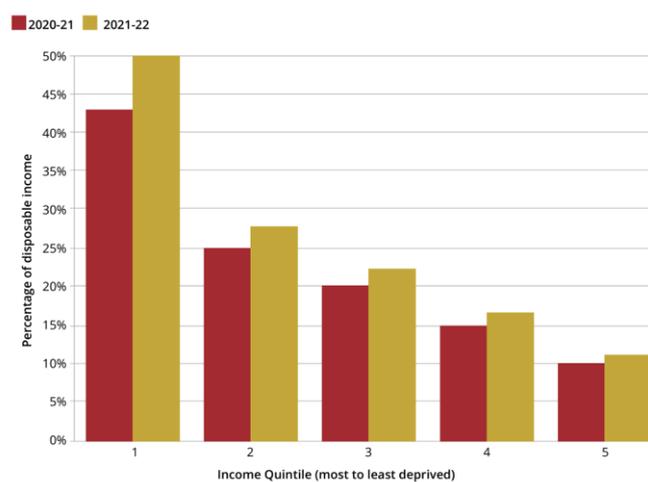
Figure 2: Proportion of disposable income required to afford a "healthy diet", 2020-21 vs 2021-22 (UK data)

1.4. Drivers of dietary intake in Wales

In 2021, the Welsh Government commissioned a detailed analysis of consumer and shopper profiles (Four, 2021). The analysis drew on survey data from 17 000 consumers in Wales and married this with a secondary analysis of social and digital media insights. The results identified six consumer profiles for the Welsh population, highlighting major factors influencing food purchasing and dietary intake.

These profiles include those with a *busy lifestyle* (~9% population), whereby food purchasing decisions are predominantly driven by speed and convenience. Then there are *ethical eaters* (~13% population), who's decisions are shaped by the sustainability and ethical sourcing of the ingredients and packaging. There are those for whom a *healthy lifestyle* (~15% population) is a major driver – with decisions made based upon the impact of food products on health and wellbeing. In Wales, more so than the UK, there is a large sub-group of *traditionalists* (~25% population), who make food related decisions based on the familiarity of products and recipes. And the last two profiles are *food lovers* (~23% population) and *adventurers* (~15% population), whose decisions are influenced respectively by the ritual of cooking and quality, and aiming for unique and varied culinary experiences.

These data – similar to the National Diet and Nutrition Survey – are drawn from before the cost-of-living crisis, and also do not account for the stark inequalities that exist within populations. Purchasing patterns are likely to be very different for those living in rural, as opposed to urban areas, in Wales due to food accessibility. Recent data from Clear Channel (a large out-of-home media and infrastructure company) found that 75% of people in the *UK* have significantly adjusted their purchasing behaviours in light of the cost-of-living crises (Clear Channel, 2023). This has the potential to vastly shift the picture as reported by Four (2021). Clear Channel found that many people now abstain from impulse and luxury purchases; cost being a more prominent driver than it was five years ago – findings echoed by the 2024 House of Lords report on fixing the broken food system. The longer-term implications as to the cost-of-living on dietary intake remain to be seen.

1.5. The [complex adaptive] food system

Decisions about which foods to purchase, and subsequently consume, are not made in a vacuum; they are influenced by a plethora of interconnected factors which make up a complex adaptive system. The National Food Strategy (Dimbleby, 2021) eloquently described this system as "… *the combination of all of the elements – natural and man-made – that combine to produce, process, market and sell the food we eat and the connections between them. It can be said to include everything from the sun and the soil to the till at the corner shop*" (p31). However, what characterises a complex adaptive system is that it *adapts*, it is ever changing in response to the social-, political-, environmental-, commercial- and technological- landscapes in which it is situated. For instance, 20 years ago, social media played little to no role in our lives. Now, social media is used heavily to create highly tailored adverts to cross sections of the population, especially children and young people (Melendez-Illanes *et al.,* 2022; Cancer Research UK, 2020).

A complex adaptive system is also characterised by interdependency, feedback, self-organisation, and emergence (Nobles *et al.,* 2021). The component parts of the system influence one another (interdependence), reinforcing or stabilising outcomes as they begin to emerge (feedback). For example, the increasing supply of cheap convenience food reduces the need for people to cook. In turn, this reinforces the market demand for such food and leads to a greater supply, simultaneously and over time, reducing the capability of populations to cook at home. Other factors such as marketing of convenience food, the cost and availability of ingredients and the legislation around food policy all contribute to this complex interplay; an emergent feature, among other things, being an increasing dependency on convenience food consumption. The eminent systems theorist, Donella Meadows, argues that complex adaptive systems cannot be controlled, and instead, should be danced (or interacted) with (Meadows, 2012). Meadows also stated that such systems can only be understood in

general – or abstract – ways; it is not possible to understand them in their entirety, and especially how they might work over a longer period of time (Meadows, 2012).

1.6. Intervening in these systems

If we can gain a more comprehensive and systemic understanding about what is driving population dietary intake through the lens of a complex adaptive system, then in doing so, we may be able to identify possible places to intervene or act. In systems theory, these places are often referred to as leverage points (Meadows, 2008; Nobles et al., 2021; Senge, 1990). These are modifiable points within a system that, if altered, can aim to change how the system works rather than simply *reacting* to problems which arise from it. For example, whilst education-based campaigns may be helpful in raising awareness about diet-related ill health, they do very little to prevent the system from heavily producing products which might be regarded as unhealthy (e.g. high fat, salt or sugar and / or ultra-processed).

The identification of leverage points is deemed critical for considering how to meaningfully intervene with systems. Meadows (2008) has pioneered much of the work around leverage points, and throughout her career, highlighted 12 places to intervene in systems, sequenced by their perceived degree of leverage (Figure 3). On the basis of this seminal work, other tools have been created which collapse the number of leverage points into four or five categories (Mahli et al., 2009; Nobles et al., 2021). At the heart of these models is the notion that the structures, rules, goals, and paradigms of the system need to be targeted in a coherent manner to maximise the likelihood of bringing about different emergent outcomes. By gaining a better understanding how systems work, through methods such as group model building and the development of causal loop diagrams (Barbrook-Johnson & Penn, 2022), we can begin to identify such places to intervene.

Figure 3: Hypothetical places to intervene in systems (taken from Nobles et al., 2021)

1.7. Objectives

This project had <u>four objectives</u> as set by the Welsh Government:

1. To develop insight around the system of factors which influence dietary choices at the household level
2. To produce an easily accessible system map (one or several) which demonstrates the complexities of the Welsh food system
3. To examine the relationships between the factors in the system which influence household dietary choices
4. To use the outputs from objectives 1-3 to identify potential policy levers to change how the Welsh food system effects household dietary choices.

2. Methodology

A six-stage process (Figure 4) was followed to create a qualitative map of the Welsh food system and to identify a list of potential places for policy action.

Stage 1: Developing a draft food system map

Stage 2: Tailoring the food system map to the Welsh context

Stage 3: Integrating the community perspective into the system map

Stage 4: Identifying key feedback loops within the system

Stage 5: Understanding current action across the Welsh Food System

Stage 6: Using the system map(s) to identify places for policy intervention

Figure 4: Overview of the six-stage process

2.1. Stage 1: Developing a draft food system map

We conducted a systematic review of the evidence base between February and September 2023 to locate all published "maps" of a food system. PubMed and Web of Science, as well as MEDLINE, CINAHL, PsycINFO via EBSCOhost, were searched through 4th April 2023. Relevant search terms related to food intake (e.g. food, diet, nutrition, consumption, intake) and system mapping (e.g. concept map, cognitive map, fuzzy map, causal loop diagram, group model building) were searched for in each database, with MeSH terms utilised where appropriate. Reference lists of eligible studies and relevant review articles were also searched. No publication date or language restrictions were applied.

Titles and abstracts of records were screened by two reviewers against a pre-determined eligibility criteria. Full text articles were then retrieved and screened by two reviewers. Studies were included if they: 1) focused on understanding a food system (or aspects of); 2) related to a high-income OECD country, and 3) applied a system mapping method (using methods listed above). For both screening phases, any discrepancies were discussed between reviewers until consensus was reached. The system maps from the included records were extracted ready for synthesis.

We then aimed to build a single, comprehensive map of a food system by amalgamating the published system maps. We started this process using the most academically robust map as a foundation. We made the food system map more accessible by only including factors noted in two or more of the published maps. A sensitivity analysis was conducted based on factors included in three or four of the published maps. The rationale for this simplification was in line with previous literature ([Brennan *et al.*

2015). We identified themes within the map (i.e. clusters of factors with a common or shared focus) to enhance its visualisation and ease of interpretation.

2.2. Stage 2: Tailoring the food system map to the Welsh context

An in-person stakeholder workshop was delivered in September 2023 to refine the draft system map via group model building (Barbrook-Johnson & Penn, 2022). We worked with the project commissioners to identify a range of Welsh Government officials, from across the system (based on the draft system map), to invite to the workshop. Stakeholders covered a breadth of sectors in the Welsh Government to ensure that diverse influences of household dietary choices were identified and mapped.

The workshop (three hours) was divided into two sections. The first section introduced stakeholders to systems thinking concepts and included several associated activities (including inter-relationship diagrams). In the second section, the draft system map was presented, broken down by sub-systems to facilitate interpretation and understanding. Stakeholders were then asked to self-organise based upon their area of expertise to create small groups around sub-systems. There was sufficient time for stakeholders to work on two or three sub-systems of the Welsh food system. Stakeholders were asked to add, remove or refine the factors and relationships within the sub-system, and come to a collective consensus that the final sub-system map accurately reflected the Welsh context and populations.

We further amended the draft food system map based on the workshop outputs. This resulted in a single map for the Welsh food system, depicting the factors and relationships perceived to influence dietary intake at the household level in Wales.

2.3. Stage 3: Integrating the community perspective into the system map

We tested the assumptions made in the Welsh Food System Map against published documents relating to public perceptions about the factors influencing dietary choices in Wales. Our intention was to ensure that the final Welsh Food System Map held face validity across different population groups. To do this, we reflected on the validity of the map against the findings in the following documents and through discussion with the authors / associated research teams:

- Community Food System Map
- Future Diets project (Kantar) & Healthier Foods Workshops
- Insight from Community Food Box Scheme (Cardiff University)

2.4. Stage 4: Identifying key feedback loops within the system

In order to identify feasible places to intervene in the Welsh food system, it is important to gain a deeper understanding about the dynamics at play within it. One means of doing this is to identify feedback loops through the creation of causal loop diagrams (CLDs). A CLD is a simplified depiction of the system, or the sub-systems (i.e. themes), with a stronger focus on the relationships between factors. They centre around feedback loops; cyclical patterns of behaviour within a system that cause outcomes to occur (positive and negative). Feedback loops are important to identify as they represent opportunities for intervention. We therefore sought to create CLDs for the Welsh food system to help delineate the potential places for intervention. The CLDs were created via a three-step process.

> *Step 1*: *Identifying sub-systems* | We took the Welsh Food System Map (i.e. the output of stage 2), and pulled out the factors included within a sub-system and those directly connected (i.e. one stage removed).

> *Step 2*: *Creating the initial CLD* | We followed the process of Barbrook-Johnson & Penn (2022) to create the initial CLDs. We took one factor at a time and questioned the extent to which it helped to explain the overarching functioning of the sub-system. If we perceived factors to be

superfluous or exogenous, they were not included in the CLD. The aim was for the CLD to include approximately 20 factors, working on the basis of the Pareto Principle, whereby 80% of a system can be explained by 20% of the included factors. We questioned every interconnection and only included it if there was a clear and direct connection between two factors. This kept the interconnections to a minimum whilst also increasing the robustness as to how the system works. Our decision-making processes were guided by the overarching Welsh Food System Map, the discussion within the stakeholder workshop (stage 2), and our own professional expertise and judgement (Sterman, 2000). In a final sub-step, we identified pertinent feedback loops which help to explain the key dynamics within the sub-system.

Step 3: *Testing the CLDs* | We then held 11 online workshops (February to May 2024) with Welsh Government officials to test the assumptions / hypotheses made within the sub-system CLDs. Stakeholders were invited to the workshops based on their expertise of a sub-system, some of whom had attended the initial workshop (stage 2). We provided stakeholders with an overview of the process to date and walked through pertinent feedback loops within the respective CLD. The intention was that stakeholders could then comment on the extent to which the CLD, and its feedback loops, explained the dynamics within the sub-system of interest. Stakeholders suggested modifications to the CLD as and where required. Following the workshop, we finalised the draft CLD based on the stakeholder feedback, and sent this to the participating stakeholders for final member checking.

The end product was a series of CLDs depicting the key dynamics within the Welsh food system. To further support CLD interpretation, we identified a range of systems archetypes within the finalised CLDs (see box below). Archetypes were created for illustrative purposes only.

Systems Archetypes

Systems archetypes are identifiable and recurrent patterns of behaviour within a system. The archetypes are typically comprised of two or more interconnected feedback loops. We can use systems archetypes to explain why systems – or parts of the system - produce their respective outcomes, and also explain how these patterns of behaviour can be altered to produce a different outcome. Given that feedback loops can be changed, the identification of the systems archetypes means that we can potentially find meaningful places to intervene.

The research team present several illustrative systems archetypes within the results of this report, using orange boxes like this one. Further information about systems archetypes – including a list of eight common archetypes – is available in Appendix A.

2.5. Stage 5: Understanding current action across the Welsh food system

We used two approaches to determine what actions were being undertaken across the Welsh food system. The first was based on the knowledge held by Welsh Government officials, and the second based upon a review of the Food Matters: Wales (2024) document.

A final, three-hour participatory workshop was held in July 2024 with policy officials to identify current actions, and to identify opportunities for new intervention (see Stage 6). In the first part of the workshop, stakeholders chose a sub-system CLD which they were knowledgeable of and worked in small groups to audit current actions. The action audit asked stakeholders to record: 1) the name and description of the action; 2) the organisation or department responsible for delivering the action; 3) where in the CLD the action sought to intervene; 4) what the anticipated outcomes were; and 5) whether the action aligned with other actions. Stakeholders were able to contribute to two or three sub-systems in this 90-minute activity. The second half of the workshop is described in Stage 6.

The second source of actions was the Food Matters: Wales (2024) document. Here, we systematically reviewed the document and identified any additional actions which had not been captured in the stakeholder workshop. A description of each action was ascertained to support subsequent analysis.

These actions (from the workshop and document review) were overlaid onto the Welsh Food System Map to delineate where current policy efforts are focused. They were also analysed against the Action Scales Model (ASM; Nobles et al., 2021); a pragmatic tool to help identify leverage within systems and to categorise actions against (i.e. determine which actions hold different degrees of leverage). The ASM (Figure 5) includes four "weights" (events, structures, goals, and beliefs) with larger weights representing stronger places to intervene, albeit often more difficult to address. At the broadest level, *events* represent the problems that we see arising from the system (e.g. potholes in roads, young people consuming energy drinks, the dominance of fast-food outlets on the high street), whilst the other weights describe the forces at play which cause these problems to occur. Intervening at the events level would not prevent the issue from occurring again in the future. The ASM originates from Donella Meadows' 12 Places to Intervene (Meadows, 2008) (see Figure 3). In analysing the current actions against the system map and the ASM, it is possible to gain a more comprehensive understanding as to the likelihood of creating a dietary shift in Wales.
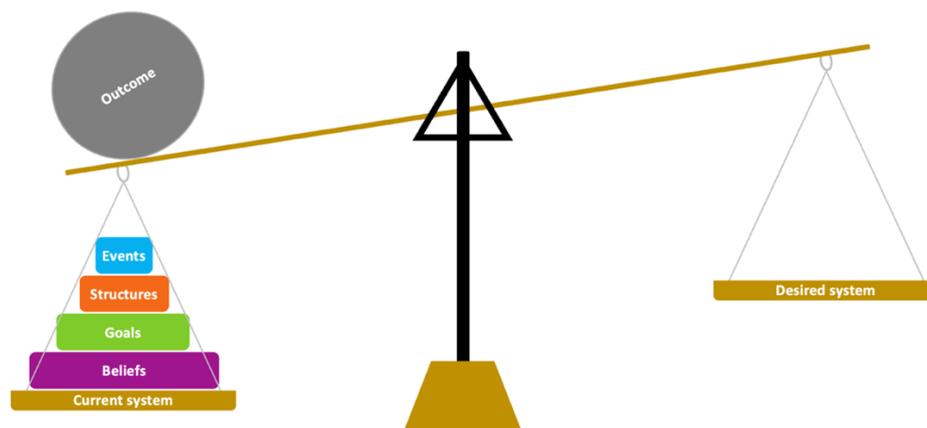
Figure 5: Action Scales Model

2.6. Stage 6: Using the system map(s) to identify places for policy intervention

The final stage of the analysis aimed to identify places within the Welsh food system where government intervention could be most impactful. To achieve this, we used a cross-impact analysis combined with a Scenario Field Analysis. This approach draws from the scenario management and planning literature (Gausemeir et al., 1998; Schlange, 1995), to evaluate stakeholder-identified relationships between factors in the system, with a focus on identifying critical or influential factors for intervention.

During the final three-hour stakeholder workshop (see Stage 5), stakeholders also had time to review sub-system CLDs. The workshop focused on four sub-systems: food availability, food preferences, food production, and the school environment. These were chosen because of their alignment with perceptions of Welsh Government influence. In small groups based on their expertise, stakeholders assigned impact and leverage scores to each connection within their CLD. The impact score (1 to 3, low to high) captured the degree of influence one factor exerts on another, while the leverage score (also 1 to 3, low to high) represented the Welsh Government's perceived ability to influence each connection.

We subsequently transformed the annotated CLDs into matrix format to support a cross-impact analysis. The matrix consisted of rows and columns corresponding to factors and relationships in the system (Figure 6 provides an example from the food availability sub-system). Along each row, Active Impact Scores (AIS) and Active Leverage Scores (ALS), were summed to provide the Active Impact Value

(AIV) and Active Leverage Value (ALV) respectively. Similarly, down each column, Passive Impact Scores (PIS) and Passive Leverage Scores (PLS), provided the Passive Impact Value (PIV) and Passive Leverage Value (PLV). See box below for key definitions.

Impact of ↓ on →	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		AIV	ALV
	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C		
1 <link> School-level factors	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	1	3
2 Fast food business profitability	0	0	X	X	0	0	0	0	3	1	3	1	3	1	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	12	4
3 Fast food price appeal	0	0	0	0	X	X	3	1	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2
4 Fast food sales	0	0	3	1	0	0	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1
5 Fast relative to healthy food marketing	0	0	0	0	3	1	3	1	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2
6 Fast relative to healthy food store density	0	0	0	0	0	0	3	1	0	0	X	X	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2
7 Food delivery services	0	0	0	0	0	0	3	1	0	0	0	0	X	X	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2
8 Healthy food business profitability	0	0	0	0	0	0	0	0	3	1	0	0	3	1	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2
9 Healthy food sales	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	X	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
10 High street/town planning strategies	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	X	X	0	0	0	0	0	0	0	0	0	0	0	0	3	3
11 Intergenerational change	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	X	0	0	3	1	0	0	0	0	0	0	3	1
12 Pandemics/external environmental factors	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	X	X	0	0	0	0	0	0	0	0	3	1
13 Perceived benefits of healthy food	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	X	X	3	1	0	0	0	0	4	2
14 Positive messaging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	X	X	0	0	0	0	1	1
15 Rurality	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	X	1	1	3	3
16 Socioeconomic status/factors	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3	1	0	0	0	0	X	X	7	3
PASSIVE IMPACT VALUE (PIV)	0		3		3		15		6		10		7		3		10		3		0		0		8		3		0		1			
PASSIVE LEVERAGE VALUE (PLV)	0		1		1		5		2		6		3		2		5		1		0		0		6		1		0		1			

Figure 6: Example cross-impact analysis

The summed values were carried over to a new spreadsheet, forming four columns: AIV and PIV, and ALV and PLV. The aim was to balance the actual or perceived influence that a given factor has with the controllability of that influence. For example, a factor may confer a strong perceived impact on another factor; however, the stakeholder group may find this effect challenging to control in practice. Conversely, a factor may be relatively easy to control, yet have only minimal influence on other factors.

To contextualise these data, the active and passive impact values were plotted across a system grid. These values were adjusted to account for government leverage and normalised to facilitate interpretation with axes spanning 0-100. Further detail on this weighting and normalisation can be found in Appendix B. The system grid plots are divided into quadrants to help identify potential places where targeted intervention could shift local, and possibly wider, system dynamics. The bottom left quadrant refers to autonomous factors, the top left to steering factors, the bottom right to measuring factors, and the top right to ambivalent factors (see box below for definitions). The quadrants of particular interest are steering factors (i.e. potential sites for intervention) and measuring factors (i.e. helpful for monitoring change within the system). See Figure 7 for an example system plot (relating to food availability sub-system). It is important to note that these insights should be used to prompt further discussion or evaluation, rather than being an end point in themselves.

Figure 7: Example system grid

Axes: y-axis — "Degree of influence the factor has" (0–100); x-axis — "Degree the factor is influenced by others" (0–100). Quadrant labels: Steering factors (top left), Ambivalent factors (top right), Autonomous factors (bottom left), Measuring factors (bottom right).

Figure 7: Example system grid

Scenario Field Analysis: Key terms and considerations

The **impact value** refers to the extent to which a factor directly *influences* other immediate factors in the system. The **active impact value (AIV)** more specifically measures the total *cumulative influence* a factor exerts across all of its outgoing connections to nearby factors.

The leverage value refers to how much *control* the Welsh Government has on interconnection between two factors. The **active leverage value (ALV)** more specifically measures the total *cumulative control* that Welsh Government has on a given factor relative to outgoing connections.

Passive impact refers to the extent to which a factor is directly *influenced* by other immediate factors in the system. The **passive impact value (PIV)** more specifically measures the total *cumulative influence* a factor receives from its closest incoming connections.

Steering factors exert strong influence and control over other *local* factors (i.e. those it is connected to), often making them interesting places for considering intervention. These factors have more meaningful outgoing influences than those incoming, allowing them to initiate reinforcing behaviours and effects throughout the system.

Measuring factors within a system have more incoming influences than outgoing ones, positioning them as sensitive indicators of system change. They serve as valuable monitoring points to track system status and can be critical when gaining insights into systems change.

Ambivalent factors represent a mix of incoming and outgoing relationships. They therefore act in a dual capacity, as both drivers and responders, however never necessarily excelling at one thing. They can be hard targets for change given the interplay of multiple factors and relationships.

Autonomous factors are characterised by low active and passive influence. They neither exert strong effect or drive change, nor receive influence or control. They tend to operate more independently in the system, demonstrating consistency and relative stability, and are therefore less important places for intervention.

Consideration | The analyses only focus on the relationships between first-order constructs (the relationship between factor A and those it is directly linked to). As such, this analysis does not account for all the dynamics at play within a feedback loop, and so it only identifies potential places for intervention rather than leverage points (as per definitions in systems dynamics).

3. Mapping the Welsh food system

3.1. Creating the draft food system map

Included studies | A total of 3166 records were screened against the eligibility criteria, with 41 going through to full text screening. Nine met the inclusion criteria and their respective system maps were extracted for synthesis. The PRISMA flow diagram (Figure 8) documents the process of identifying and screening studies for inclusion in this review.
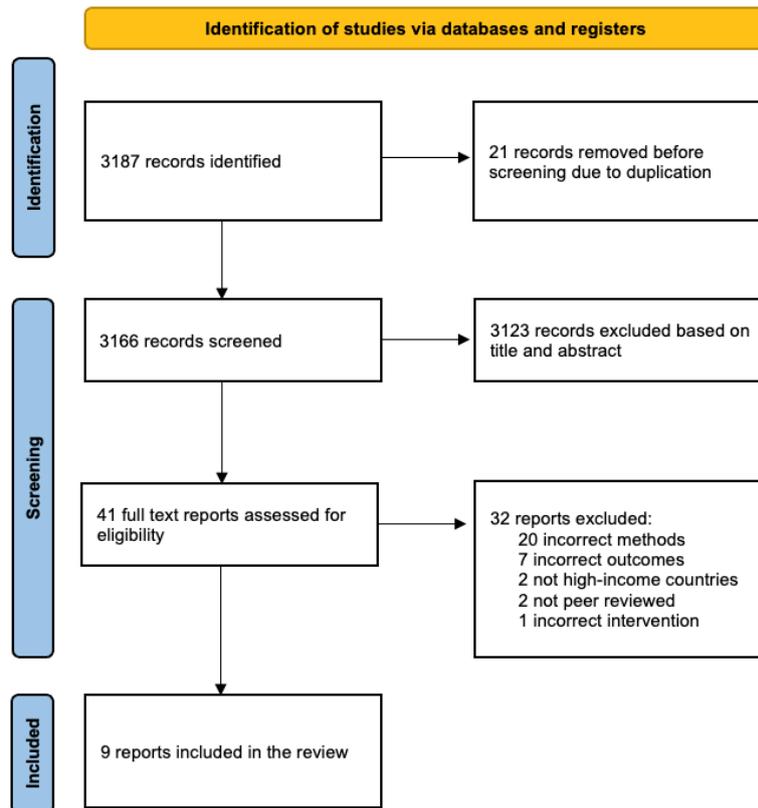
Figure 8: PRISMA Flow Diagram

Description of included studies | The nine included studies had maps which were developed through participatory processes (e.g. group model building, cognitive mapping interviews, concept modelling workshops) or via evidence reviews (n=3). These processes led to the creation of causal loop diagrams (n=6), a system map (n=1), a composite cognitive map (n=1), and an ecological system map (n=1). The specific focus of the included maps ranged from fruit and vegetable intake in children, to the school food system, to determinants of inequities in healthy eating, to the commercial determinants of dietary behaviour in adolescents. As such, the populations of interest between studies also varied, from children and adolescents, to low-income households, to general populations. Empirical studies were based in United Kingdom (n=2), Australia (n=2), and New Zealand (n=2). More than 700 people were included in the process of developing these six maps, with 590 people being involved in the Brennan *et al.* (2015) study. Participants included community members, children and adolescents, parents, and policy / practice experts. Table 1 provides an overview of the included studies.

Synthesising the maps | The draft food system map creation commenced by using the Sawyer *et al.* (2021) causal loop diagram as a foundation, given the robustness of their methodology and the similarity of their topic. Sawyer *et al.* (2021) completed a comprehensive systematic umbrella review of 43 studies which focused on understanding the determinants of dietary intake in low-income groups. The 43 studies led to a causal loop diagram comprising of 60 factors across five sub-systems (1: Geographical Accessibility, 2: Household Finances, 3: Household Resources, 4: Individual Influences, and 5: Social and Cultural Influences). These 60 factors, and their interconnections, were re-mapped to start the process of synthesising the nine maps in this review.

The factors, and the interconnections, from the remaining eight maps were then added one at a time. Identical or similar factors were merged into a single factor within the synthesised map. Labels are provided next to each factor to denote the study which they relate to, based upon the initials of the first author (e.g. [AS, SG1] relating to Sawyer *et al.* and Gerritsen *et al.* papers). This synthesis led to a system map with 174 factors (Appendix C). This map was then simplified based on factors included in

two or more studies (n=72 factors). Factors were organised into 11 sub-systems (Figure 9) to finalise the draft system map.

Table 1: Table of included studies

Author (Year)	Location	Focus	Map type	Participants and Method
Brennan *et al.,* (2015)	Australia	Healthy eating, active living and childhood obesity	Causal Loop Diagram	Group model building used in 49 communities in Australia between 2010 and 2013 (half-day workshops). 590 individuals participated in developing a total of 50 causal loop diagrams. Synthesised these maps based on variables which were identified in 20% of communities.
Bryant *et al.,* (2023)	United Kingdom	School food systems	Systems map	Eight group model building workshops carried out with 80 children and 11 workshops with 82 adult stakeholders (inc. parents, school staff, voluntary sector staff). Different participants attended each workshop. Journey mapping used with children. Group model building with adults (seven exploratory workshops, three confirmatory).
Chavez-Ugalde *et al.,* (2022)	England	Commercial determinants of dietary behaviour in adolescents	Causal Loop Diagram	Three one-hour online group model building workshops with 11 adolescents. Same participants attended all. One workshop with six policy makers and public health practitioners.
Frerichs *et al.,* (2015)	n/a - review	Influence of school architecture and design on healthy eating	Causal Loop Diagram	Mixed methods systematic narrative review of 102 studies. Used literature to identify connections between determinants to develop a causal loop diagram.
Friel *et al.,* (2017)	Australia	Determinants of inequities in healthy eating	Causal Loop Diagram	Two collaborative concept modelling workshops with 12 policy experts (three-hours each). Same participants attended all.
Gerritsen *et al.,* (2019)	New Zealand	Fruit & vegetable intake in children	Composite cognitive map	Cognitive mapping interviewing (CMI) undertaken with 16 policy and / or practice officials. CMI used to produce causal maps for each individual before being combined into a composite map.
Gerritsen *et al.,* (2019)	New Zealand	Fruit & vegetable intake in children	Causal Loop Diagram	Three group model building (three-hours each) workshops with 17 community members. Same participants attended all.
Mills *et al.,* (2017)	n/a - review	Health and social determinants of home cooking	Ecological systems map	Narrative synthesis of 38 cross sectional studies. Ecological conceptual model developed by mapping determinants to outcomes against individual, community and cultural domains.
Sawyer *et al.,* (2021)	n/a - review	Complex food environment underlying inequities in dietary intake in low-income groups	Causal Loop Diagram	Systematic umbrella review of 43 studies assessing determinants of dietary intake and / or food environment. Systems-based analysis used to develop a comprehensive causal loop diagram (and sub-system maps).

Figure 9: Thematic Food System Map (n=72 factors)

3.2. The Welsh Food System Map

The draft food system map was refined in a three-hour, in person workshop with seven members of the Welsh Government, representing three departments (1: Public Health Wales, 2: Local Government, Housing, Climate Change and Rural Affairs, and 3: Health, Social Care, and Early Years). This workshop resulted in 64 new factors being added to the map, creating a contextually relevant map of the Welsh food system with a total of 136 factors across the 11 sub-systems, all of which are highly interconnected. The final map is shown in Figure 10. A description of the 11 sub-systems and their respective factors are included below.

Food availability | The food availability sub-system is made up of ten factors, four of which were identified in the workshop. This sub-system describes the factors which influence the availability of food to customers, from the layout of high streets and density / proximity of supermarkets, to the emerging online food delivery services and volume of fast food outlets. Many factors within, and outside this sub-system, influenced the accessibility and convenience of healthy food in the local area.

Food preferences | This sub-system comprised four factors relating to the preferences people hold towards foods which have different health offerings (e.g. high fat, salt and sugar products). Although this sub-system has only four factors, these are highly connected to those in other sub-systems (e.g. marketing and advertising).

Food production | The food production sub-system is the most complex in the map, including 28 factors, 23 of which were identified in the workshop. Factors here relate to the processes, pressures/demands, costs, resources, and infrastructure required to produce food in Wales. Many of the factors here, and elsewhere, were noted to have an influence upon the cost of producing food in Wales (and the viability of doing so).

Household food | This is a smaller sub-system of three factors, which includes the availability and accessibility of food within the household. The shelf-life of fresh food was also added to this sub-system via the workshop. The availability of healthy food in the household was highly influenced by factors from other sub-systems.

Knowledge and skills | This sub-system includes six factors all identified through the review. These include having the skills to cook food within the household, the knowledge people have about diet and health, the attitudes towards particular diets, and whether health is a driving factor in determining what people eat. Here, many external factors had an influence on the potential for cooking / making food at home, including wider determinants related to housing, income, and time availability.

Marketing and advertising | The marketing and advertising sub-system had 12 factors, six resulting from the workshop. The factors here speak to the strategies employed to promote certain food products and increase their purchasing potential. Thus, many factors here were seen to influence (positively or negatively) consumer demand for healthy food.

Policy context | The policy sub-system was developed extensively through the workshop, with 12 of the 14 factors being added, with links to many of the other sub-systems. Factors here included political will and leadership, the influence of policies, the ability to use fiscal measures and introduce new legislation, and how the Welsh Government is situated within the broader UK political landscape.

Purchasing decisions | This sub-system, consisting of six factors, was deeply connected to many others, particularly regarding factors which influence – or are influenced by – the intentional decisions people make about what food they purchase. This sub-system included other factors about the perceived or actual cost of healthier foods relative to other foods, the budget available to buy food, and whether cost and satiety (i.e. whether food is likely to make people feel "full") dictate decision making.

School environment | The school environment sub-system was created based on the review findings and included 11 factors. Factors here spanned several different topics, from the food available in the

school premises, to the education provided to pupils around food and nutrition, to the policies, leadership, and finances of the school.

Social influences | This sub-system is concerned with the social and cultural factors which influence dietary choices, directly or indirectly. It includes 14 factors, six identified through the workshop, which include social, community, cultural and ethnic values and norms (not just relating to dietary choices), the impact of intergenerational food preferences, and how specific food products represent membership of certain groups (e.g. energy drinks and young people). Many of these factors contribute to a social model of consumption, often at odds with the health model of consumption above.

Wider determinants | This final sub-system is one of most complex in the map, with 22 factors, 12 originating from the workshop. These factors include issues relating to housing quality, employment and work conditions, the need for multiple incomes in a household, urbanicity and rurality, food poverty, and the availability of "free time". This was a highly connected sub-system, both within itself and with other sub-systems.

3.3. Considerations

It is important to mention that this Welsh Food System Map reflects the factors ascertained from the systematic review and the perspectives of workshop attendees. It does not attempt to include every factor that may influence dietary choices of the Welsh population and nor can it. It was built and refined based on the expertise, experiences, and perspectives of those attending the workshop. Some sub-systems, such as the food production sub-system, resulted in greater refinement due to the composition of the stakeholder group. This limitation was accounted for when planning stage four of this work (Identifying key dynamics within the system).

Figure 10: Final Welsh Food System Map

4. Identifying the key dynamics within the system

The final system map, presented in Figure 10, provides a detailed overview of the factors which influence dietary intake of households across Wales. As a next step, this project aimed to understand the feedback loops and key dynamics within the system to identify potential opportunities for intervention. We developed a causal loop diagram (CLD) for each of the 11 sub-systems before holding a series of hour-long workshops with 24 members of Welsh Government to refine them (Table 2; several stakeholders attended more than one workshop). Several sub-systems were combined into single CLDs following these workshops. The final seven CLDs, and pertinent feedback loops, are described below. High-resolution versions of the CLDs, and the Welsh Food System Map, are available in a supplement.

Table 2: Description of workshop attendees

Sub-system	Description of workshop participants
Food availability	Seven stakeholders representing: 1) Health, Social Care, and Early Years; 2) Local Government, Housing, Climate Change and Rural Affairs; 3) Economy, Energy, and Transport; and 4) Education, Culture and Welsh Language.
Food preferences (and household food)	Four stakeholders representing: 1) Health, Social Care, and Early Years, and 2) Local Government, Housing, Climate Change and Rural Affairs.
Food production	Five stakeholders from Local Government, Housing, Climate Change and Rural Affairs.
Knowledge and skills	Five stakeholders representing: 1) Health, Social Care, and Early Years, and 2) Local Government, Housing, Climate Change and Rural Affairs.
Marketing and advertising	Five stakeholders from Health, Social Care, and Early Years.
Policy context	Five stakeholders representing: 1) Public Health Wales, and 2) Local Government, Housing, Climate Change and Rural Affairs.
Purchasing decisions	Six stakeholders representing: 1) Economy, Energy, and Transport; 2) Health, Social Care, and Early Years; and 3) Local Government, Housing, Climate Change and Rural Affairs.
School environment	Three stakeholders representing: 1) Education, Culture and Welsh Language, and 2) Economy, Energy and Transport.
Social influences	Three stakeholders representing: 1) Local Government, Housing, Climate Change and Rural Affairs, and 2) Health, Social Care, and Early Years.
Wider determinants	Five stakeholders representing: 1) Education, Culture and Welsh Language; 2) Local Government, Housing, Climate Change and Rural Affairs, and 3) Health, Social Care, and Early Years.

Interpreting causal loop diagrams

Causal loop diagrams (CLDs) are simplified depictions of complex systems that highlight the relationships and interactions between factors. They emphasise feedback loops, which are cyclical patterns of behaviour that reinforce or counteract changes within the system. There are two main types of feedback loop, reinforcing and balancing.

Reinforcing feedback loops: These loops cause a change / outcome to keep moving in one direction, be that towards growth or decay (e.g. if fast food is all that is available in a local area, then people more likely to keep consuming fast food).

Balancing feedback loops: These loops seek to find an equilibrium, thus dampening or restricting the effect of a reinforcing feedback loop (e.g. as the volume of food in the house starts to drop, then people buy more food to keep cupboards/fridges stocked).

CLDs are also concerned with the *nature of a relationship* between factors, be that positive (+) or negative (-). A positive relationship suggests that as one factor increases or decreases, the other factor changes in the same direction. A negative relationship suggests the opposite, that as one factor increases, the other decreases (or vice versa).

The final aspect is *time*. For many relationships, there is a time delay between a change in one factor and a change in the other factor. This isn't always the case, however where significant delays do exist, these are denoted in a CLD with a || symbol along the relational line.

4.1. Food availability

Summary | The food availability CLD includes 16 factors and four reinforcing feedback loops. This CLD illustrates factors concerned with how different food products, particularly those regarded as healthy / less healthy (e.g. fast- or convenience- food), are supplied to customers. As such, the CLD focuses on the dominance of the fast-food market, the challenge for other businesses selling "healthier" products, and how socio-economic factors play into this.

Pertinent Feedback Loops | The first feedback loop recognises the challenges facing those trying to supply healthier foods – the **healthy food decline** (R1). This loop is inherently linked to the second – **fast-food dominance** (R2). The assumptions made here is that healthy food suppliers are consistently on the back foot, whereby the density of healthy food stores cannot compete with those supplying fast-food or less healthy products (this can be both private and multinational corporations holding a market monopoly). There is a delay between profits generated and infrastructure change, however this delay is relative given the length of time it may take to reverse the societal-health implications should R2 dominate.

There are similar dynamics at play with the final two feedback loops, the **healthy food fight** (R3) and **fast-food rise and fall** (R4). These two loops operate antagonistically and continually fight for loop dominance. For example, as the (perceived) benefits of healthy food are either marketed or realised (R3), this will reduce the likelihood of fast-food being purchased, reducing profitability for these companies, and their likely dominance on the high-street. In turn, this would enable growth of healthy food vendors, their profitability, and their ability to increase their marketing strategies. However, the R3 loop is in direct competition with the R4 loop, as there may be greater price elasticity for those selling fast-food. If fast-food companies are able to adjust their prices, or have more appealing product prices in contrast to healthier food suppliers, this may sway consumers towards purchasing less healthy options. Should this occur, and fast-food sales – relative to healthier food sales – increase, then the fast-food loop becomes dominant again (via increased profits, visibility on the high-street, more marketing etc…). This interplay between the two loops (R3 & 4) depicts the "success to the successful" archetype…

Success to the Successful systems archetype

In this CLD, we have an example of the **Success to the Successful** archetype. It shows a self-reinforcing system that amplifies the presence and profitability of fast-food at the expense of other options. The primary dynamic is that fast-food success creates structural incentives that further strengthens its dominance, not only through consumer demand but also through influence on urban planning and market availability. When fast-food business profitability rises, this financial success may influence high street town planning, often resulting in more fast-food outlets. They out-compete other businesses.

The question the Welsh Government may therefore ask is: How does the profitability of fast-food establishments shape town planning decisions? What incentives or pressures are at play that encourage the placement of more fast-food options in certain areas, especially when this aligns poorly with public health goals? Furthermore, food delivery services play a critical role in this feedback loop. As fast-food profitability increases, food delivery services become more accessible and widespread, particularly in urban areas. Delivery services tend to prioritise high-calorie, quickly accessible options which frequently means fast-food over healthy alternatives. This effect is geographically uneven, as rural areas see a decline in both fast food and healthy food access, limiting consumer choice further. Thus, the Welsh Government should explore the underlying reasons for this geographic disparity and address how delivery services could also support healthier food options, especially in regional areas.

The key takeaway is that unless the Welsh Government actively shifts policies to counterbalance these reinforcing structures, such as by incentivising healthy food businesses, adjusting town planning frameworks, or supporting diverse food delivery options, the system will naturally continue to favour fast- food outlets.
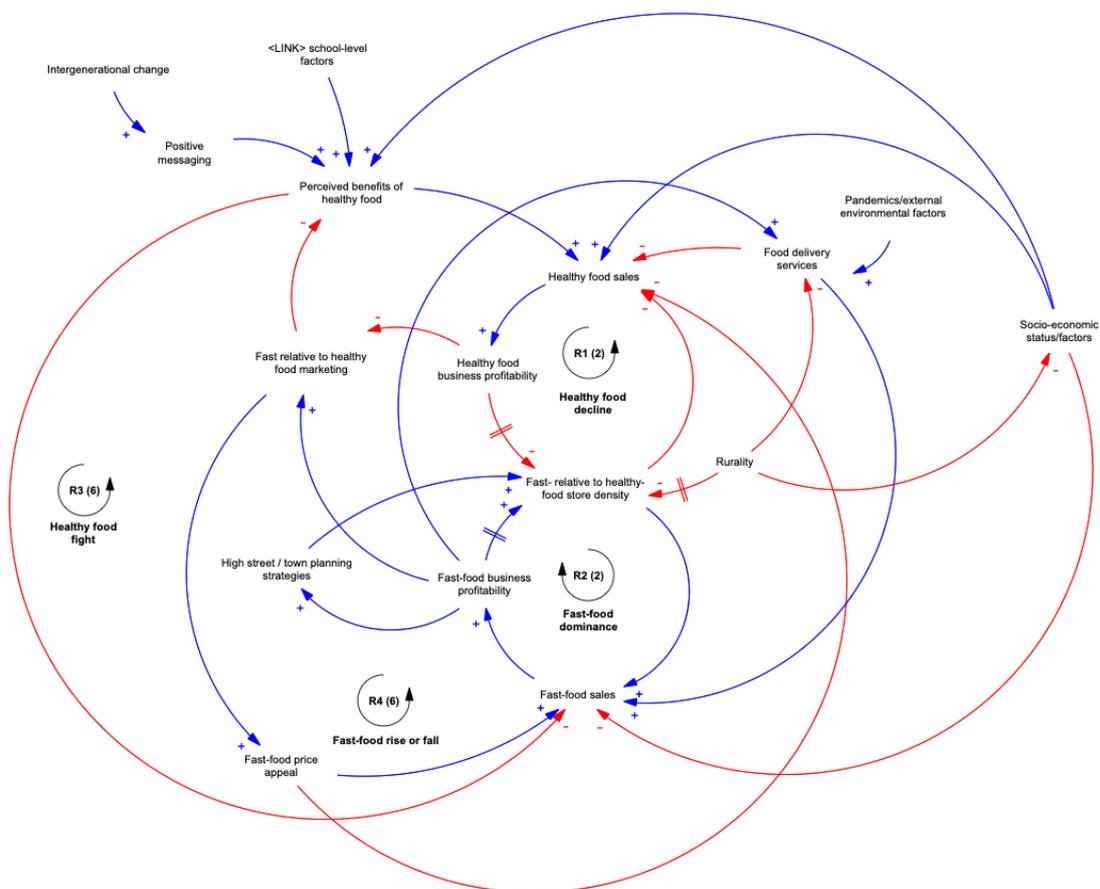

Figure 11: Food availability CLD

4.2. Food preferences

Summary | This CLD includes 24 factors and five notable feedback loops. It amalgamates the factors from four sub-systems due to their considerable overlap (food preferences, knowledge and skills, purchasing decisions, and household food). The dynamics within the CLD explain how an individual's preferences for certain foods are shaped by myriad factors, but that cost and convenience, supply and demand, and social norms around dietary behaviours currently lead to unhealthy diets dominating at the population level. Unhealthy diets are those characterised as being high in fat, salt or sugar and / or ultra- processed food.

Pertinent Feedback Loops | All five feedback loops were reinforcing, meaning that if they go unaddressed, the emergent behaviour or outcome (e.g. purchasing of unhealthy food) will continue to grow / reduce if left unchecked.

The first loop relates to the **supply and demand of unhealthy food relative to healthy food** (R1), highlighting a vicious reinforcing cycle, whereby the marketing of unhealthy food increases the likelihood of purchasing unhealthy food, which reinforces our taste preference for such food, leading to an increased demand. As demand increases, so does the supply/availability of unhealthy food, which in turn leads to greater marketing on this type of food. Of note, and further reinforcing this vicious cycle, the purchasing of unhealthy relative to healthy food, increases business profits, which further drives the marketing of unhealthy food.

The second, third and fourth loops (R2-4) all highlight vicious reinforcing cycles relating to **cost and convenience overpowering health beliefs**. Reinforcing loop 2 is an extension of loop 1, illustrating that increased marketing of unhealthy foods affects people's perceptions of the cost of unhealthy foods, whereby unhealthy food is perceived to be relatively inexpensive compared to healthy food. This perceived affordability of unhealthy food takes priority, for many, over health as a primary consideration when purchasing food, which results in an increase in the purchasing of unhealthy relative to healthy food, which as described in R1, then reinforces the marketing of unhealthy food.

Reinforcing loop 3 (R3) is also describes a vicious cycle, highlighting that the purchasing, and therefore consumption, of unhealthy food relates to a decrease in vitality and wellbeing, which will negatively affect the strength of people's health related beliefs, which in turn leads to a reduction in health as a primary consideration when purchasing food, which reinforces the purchasing of unhealthy food.

Reinforcing loop 4 (R4) illustrates an additional vicious cycle that ultimately leads to a decrease in health as a primary consideration when purchasing food. In this cycle, the purchasing of unhealthy food, often in the form of take-aways or convenience foods that required no food preparation, over time leads to a decrease in cooking skills. This decrease in the ability to cook food from scratch further drives the need for convenience food, which in turn decreases health as a primary consideration when purchasing food. This loop highlights a likely important intergeneration consequence.

The final pertinent reinforcing feedback loop (R5) relates to a **positive social model and learned preferences driving dietary intake**. This vicious cycle illustrates how a decrease in cooking healthy meals from scratch is one of the factors (others being intergenerational and cultural practices, and nutrition and health knowledge and education) that negatively affects the home food environment and practices. Coupled with a poor social model of healthy food consumption, this leads to a reduced acceptability of / learned preference for healthy food, which in turn leads to a taste preference towards unhealthy food, which in turn ultimately leads to purchasing of unhealthy food.
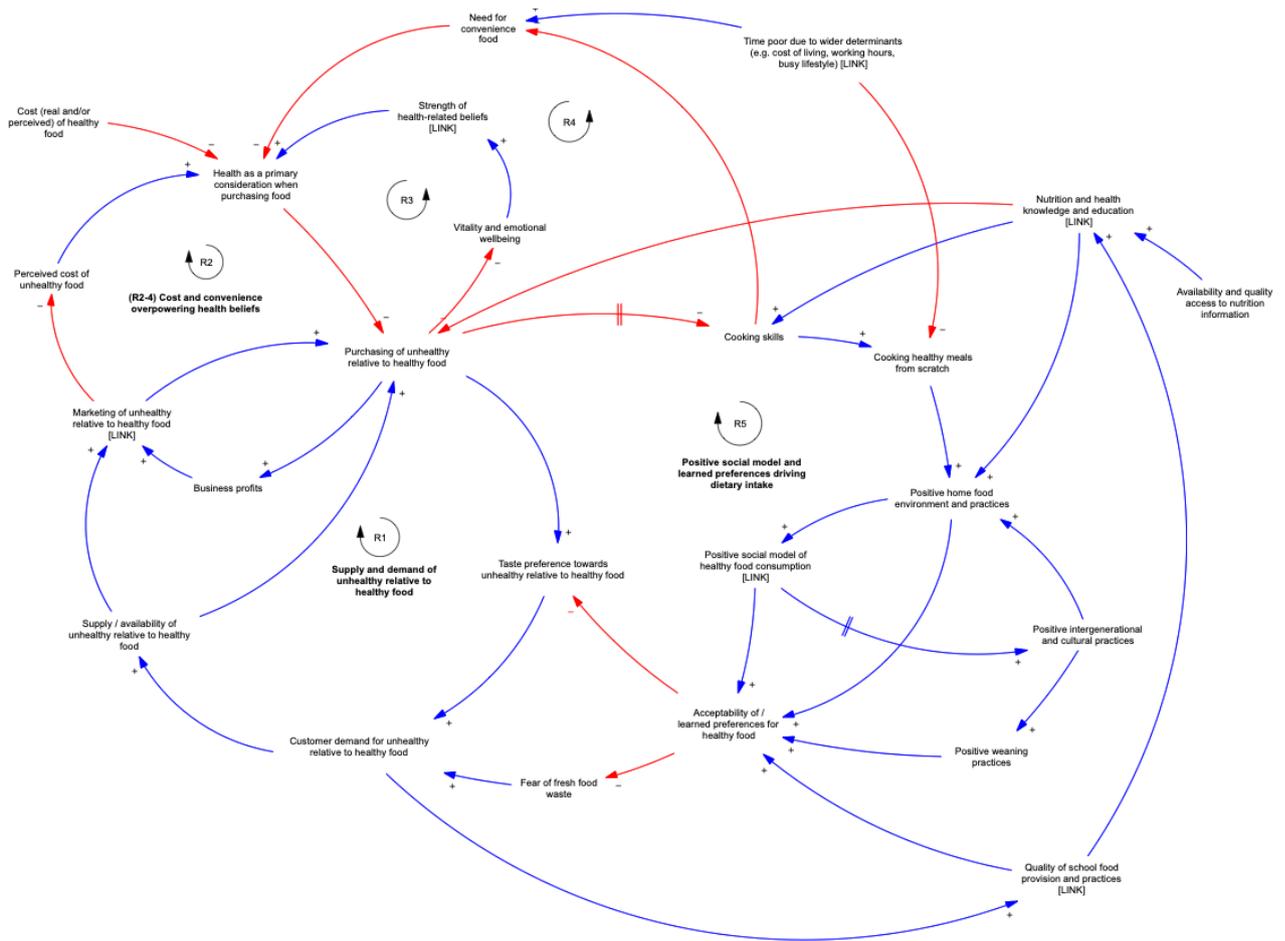
Figure 12: Food preferences CLD

4.3. Food production

Summary | This CLD includes 28 factors and six feedback loops of interest. This sub-system seeks to explain how local-, national-, and international- factors influence the ability to produce food in Wales, and moreover, how this is interconnected to broader environmental and climate issues. The CLD – through various feedback loops – highlights how dietary intake is affected.

Pertinent Feedback Loops | Four of the six feedback loops were reinforcing. The first (R1) illustrates how **environmental impact drives change** in farming practice and produce. This is a vicious reinforcing cycle, whereby an increase in food processing has the potential to harm the environment (through emissions), which overtime may reduce usable farmland. As a result, farmers may then respond by changing their practices or what they produce, but this can also lead to even more intensive processing and further environmental decline. These changes may have further consequences, as the processing of different produce will likely require investment in infrastructure such as specialist equipment. Investment in infrastructure is usually to support further intensification of production which drives further environmental degradation. The critical aspect of R1 is the availability of land which may increasingly decline over time given the effect of climate, environmental degradation, and rising demand (i.e. population dynamics and growth).

The second feedback loop (R2) – "**Demand and Supply**" – begins with changing farming practices. As farms begin producing different goods in response to changing customer demand or land availability, this creates the need for additional food processing. As processing expands, food production rises, resulting in more units of food produced. This increase in production supports food distribution, ultimately boosting the food available to consumers. With greater food availability, consumer demand grows, creating a feedback effect that further encourages shifting farming practices and produce. This

cycle reinforces itself, with each step amplifying the others, leading to sustained growth in food production and availability.

The **process-production limits** loop (B1) describes the balancing dynamic between primary food processing and the capacity of local processing infrastructure to keep pace. If the capacity of local processing infrastructure is reached, or is approaching its limit, it will hit a ceiling in terms of the capacity to process the volume of food being produced by farms. A drop in capacity may lead to a drop in primary food processing, limiting further growth. These dynamics interact though with international trade and the broader UK food system, as much of the processing of Welsh food produce is conducted in England for cost / infrastructure for reasons connected with the Just-in-Time business models operating in the UK food system.

The **Waste Cycle** (R3) introduces added complexity by highlighting how increased food consumption generates more waste/by-products (e.g. single use plastic, food waste, associated emissions), which can adversely impact the environment. This environmental strain – as eluded to above (R2) – can shift farming practices (e.g. specialisation or farm intensification), potentially improving processing and distribution efficiencies and lowering food costs. Reduced costs, in turn, stimulate further purchasing and consumption, leading to further waste and waste products. This loop overlaps with elements from other reinforcing cycles, especially the Demand and Supply (R2) loop, while adding a distinct waste component. Ultimately, rising food demand drives increased production and consumption, leading to waste accumulation and environmental degradation.

The final two feedback loops, **consumption stabiliser** (B2) and **growth-driven food supply** (R4) represent additional dynamics that shape behaviours in the food production system. In the consumption stabiliser system (B2), as food availability increases, the cost of food decreases, which leads to higher food consumption per capita. This reduces the food available, increases the cost of food, thus producing the stabilising behaviour. In Wales, this loop is seen in the fluctuating prices and production of milk and lamb. The growth-driven food supply loop (R4) represents a reinforcing dynamic where increasing food distribution drives further production to meet raising consumer demand. The system is effectively expanding to accommodate increasing needs however it could be that the type of food changes.
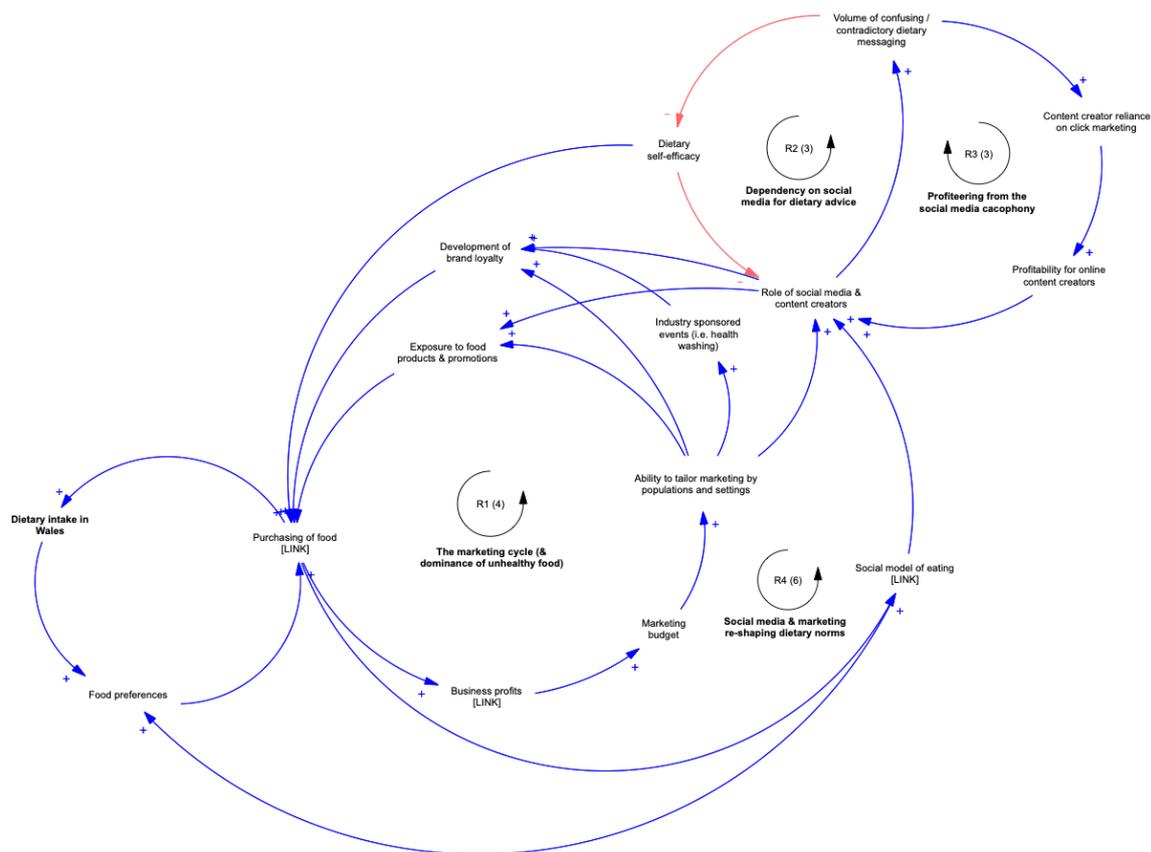

Shifting the Burden systems archetype

This CLD also provides an example of the **Shifting the Burden** archetype. This archetype centres around the use of a short-term solution to a systemic challenge. Overtime, this can create over dependency on the quick fix solution and long-term negative unintended consequences.

In this CLD, we see this archetype at play regarding the use of Just-in-Time processing. For several reasons, there is limited food processing infrastructure and capacity in Wales, meaning that much of the processing is reliant on Just-in-Time processing or outsourced (i.e., shifted) to England. Whilst this approach can help with the immediate processing demands, it reduces the need for investment in local processing infrastructure.

In the longer term, this may increase the dependency on Just-in-Time processing and process outsourcing and weaken local processing capability. If external or Just-in-time processing were to become unavailable, then the local system would be unlikely to cope with demand due to underdeveloped local infrastructure.

Figure 13: Food production CLD

4.4. Marketing and advertising

Summary | The marketing and advertising CLD includes 15 factors and has four feedback loops of interest (all reinforcing). The dynamics at play here are interconnected with, and present in, other CLDs. This CLD goes into more depth though to explain how marketing and advertising strategies can shape, and re-shape, dietary norms whilst simultaneously maximising business profits.

Pertinent Feedback Loops | The first feedback loop – **the marketing cycle** – sits at the heart of the CLD. As the purchase of particular food products increases, business profits increase; more sales, higher margins, more profit. This profit can subsequently increase the marketing budget, and with that, companies are able to invest more money in tailoring marketing strategies to different population groups, via different mechanisms (e.g. online, point of sale, outdoor advertising) and in different settings (e.g. schools, retail, online, metaverse, TV, transport). Doing so increases exposure to food products and promotions (e.g. BOGOF, point of sale, meal deals) and also influences brand loyalty, both of which affect food purchasing decisions.

The second and third feedback loops relate to the role of social media in shaping dietary intake. The first (R2) describes the processes by which people can become **dependent on social media for dietary advice** and the second (R3) highlights how content creators can **profiteer from the social media cacophony**. These outcomes emerge due to the high volume of confusing or contradictory messages circulating on social media, which in turn may reduce an individual's confidence in making informed dietary choices. In addition, social media influencers can capitalise by creating content which speaks to their audience's confidence deficits.

The final feedback loop (R4) – **social media & marketing re-shaping dietary norms** – speaks to the social model of consumption, whereby people's dietary choices are influenced by what they see others eating. Content creators and marketers understand this, and so use their strategies to promote certain foods and promotions to specific audiences. This influences the purchasing of food, the consumption of food, and therefore people's food preferences. As more of this food is purchased and consumed, this reinforces the social model of eating.

Figure 14: Marketing and advertising CLD

4.5. School environment

Summary | This CLD is comprised of 24 factors and has seven noteworthy feedback loops. The CLD speaks to both the primary- and secondary- school systems, whereby some factors may be more or less present and / or influential in these different contexts (e.g. peer influence likely greater in secondary school). This CLD explains how the school environment can influence the dietary intake of young people via its culture, its investment in staff and structures, the focus of the curriculum, and the national / international agendas.

Pertinent Feedback Loops | The first feedback loop illustrates how a **focus on sustainability may change pupil purchasing preferences** (R1). Discussions within the stakeholder workshops emphasised how pupils may be more sensitive to sustainability messaging rather than health messaging, meaning that they are more likely to change dietary choices if there is an environmental impact than a health one. Should these collective attitudes shift towards a more sustainable diet, this will likely influence food purchases made in the school setting.

If pupils have healthier and more sustainable diets, this will begin to **create a supportive food culture** within the school (R2). Young people may start to get more involved in decision making processes, the culture itself begins to influence the school food policy, which in turn shapes the quality of the school food provision. As such, this shapes the food which is available for purchasing and reinforces the overall diet quality. This can also be influenced by school staff through dietary role modelling. This **culture could drive further change** (R3) as policies become more supportive of a healthy & sustainable diet. For example, the timing of the lunch break may extend, or the quality of the dining hall / facilities may improve. This will continue to reinforce a positive / healthy school food culture.

The fourth and fifth feedback loops highlight how **improved diets support governmental agendas and school funding** (R4&5). These feedback loops work on the assumption that improved diets will

contribute to improved academic attainment over time. If this were to happen, a doubling down on improved diets would both reinforce the policy direction, and the amount of funding allocated to schools. This could, in turn, ensure that good quality food provided in schools and further reinforcing high quality pupil diets. The same also applies for school leadership too, where leaders (e.g. head teachers and leadership teams, governors, local authorities) reap the benefits of a healthier school.

The **long-term investment in high-quality nutritional education** represents the sixth feedback loop (R6). As school funding increases or decreases, schools may become more / less able to attract and retain passionate and skilled staff to deliver high quality education. In turn, we would then see improved nutrition and health knowledge of pupils which may inform their dietary choices. If so, this will influence purchasing decisions, the quality of their dietary intake, and feed into higher average academic attainment, fulfilling governmental- and school- agendas. There is the potential for significant time delays here.

The final feedback loop (R7) posits that **food purchasing data may also drive change**. If the availability of food purchasing data were to increase (i.e. what pupils have purchased), and be fed back to parents, this will provide insight around their child's food purchasing habits. Dependent on what is being purchased, and the parental attitudes towards this, parents can then apply pressure to the school leadership to change school food policies and the quality of the school food provision.
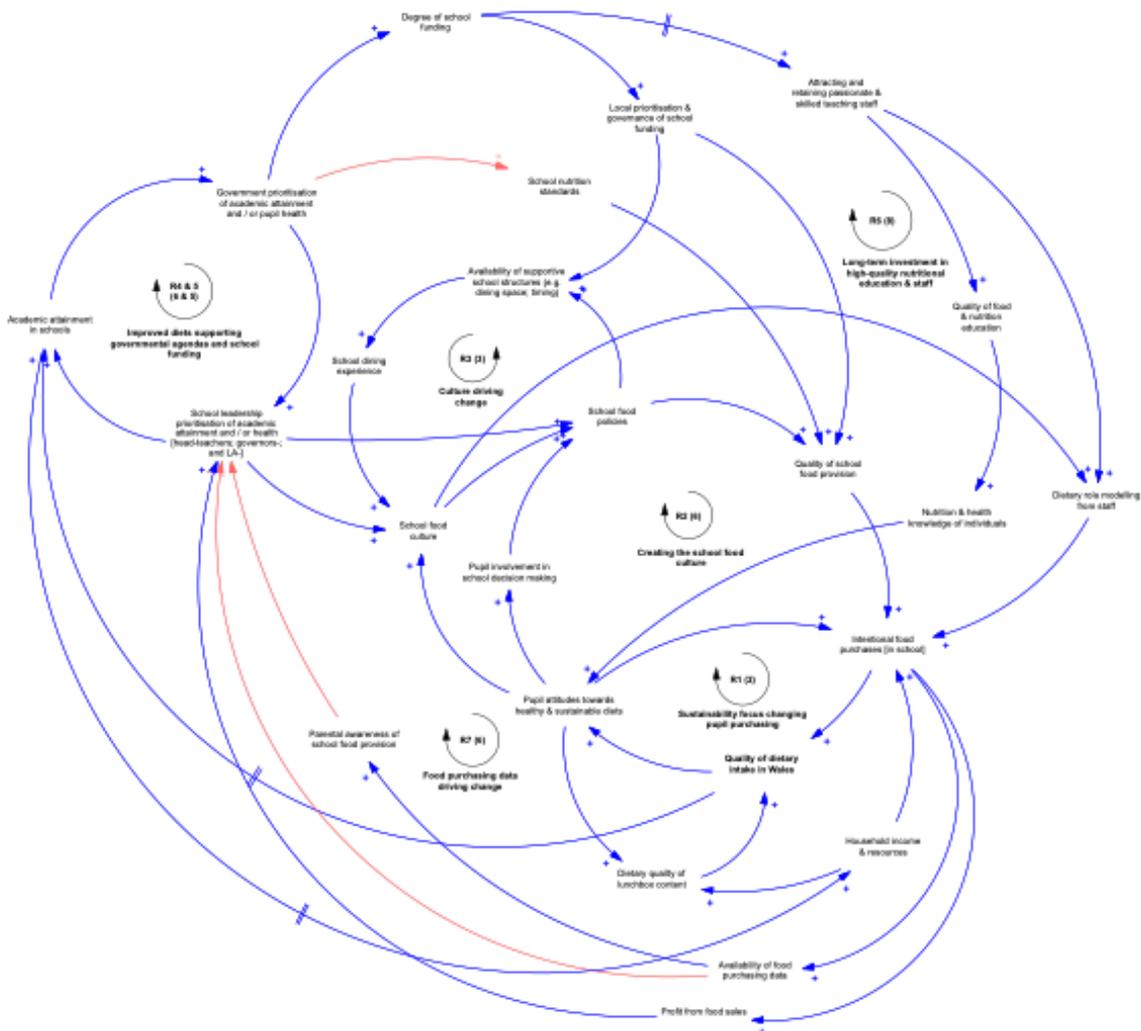
Figure 15: School environment CLD

4.6. Social influences

Summary | This CLD includes 16 factors and five feedback loops (all reinforcing). This CLD explains how various socio-cultural values can influence the diet quality of the Welsh population, including the role of intergenerational norms, the norms and beliefs of local communities, the role of social media, and the potential unintended consequences of having a high-quality diet.

Pertinent Feedback Loops | The first feedback loop (R1) – **social response** – illustrates a dynamic interplay whereby sociocultural values and norms towards an unhealthy diet reinforce the social model of consumption (i.e. we are more likely to consume what others around us consume), which can discourage healthy dietary practices. However, if a shift towards a healthy diet occurs, it can enhance individual vitality, enriching family/group leisure time. Improved vitality and leisure activities can bolster health beliefs and norms. Strengthened health beliefs can, in turn, challenge and potentially transform sociocultural values and norms towards healthier diets. There is however a potential negative consequence to consider here. If people do start consuming a healthier diet, feel more vitalised, and then take up other health promoting activities (e.g. structured physical activity), this could increase the time constraints. This may lead to an increased reliance on convenience food.

The second and third loop are in direct competition with one another. On the one hand is the **healthy habits loop** (R2) and on the other is the **status quo** loop (R3). The dominance of the healthy habits loop (R2) is somewhat dependent on the strength of health beliefs (at individual, family, community, and population levels). In turn, these beliefs influence the likelihood of consuming a health promoting diet, which will further impact vitality levels. As previously noted, this can then encourage further health promoting behaviours and thus reinforce the dominance of the health belief. However, this loop competes against the prevailing status quo loop (R2). Here, an unhealthy diet is normalised through social modelling, which undermines a health promoting diet and diminishes vitality. The reduction in vitality leads to less active family leisure time, eroding health beliefs. This erosion further drives the unhealthy diet, perpetuating a reinforcing cycle of poor dietary choices within the community. This interplay between the two loops is another example of the Success to the Successful archetype.

The final loop speaks to the **pride in local produce** across Wales (R4). Stakeholders in several workshops highlighted the pride in, or desire to increase pride in, purchasing and consuming local produce. The assumption here is that as the value of "Welshness" increases in the population, it will increase the likelihood of purchasing local (or Welsh) produce. This will then start to have ramifications on the socio-cultural values and norms towards local produce, which over time, may become an entrenched intergenerational norm / preference. This loop may depict a goal or desired state rather than the current dominant state.
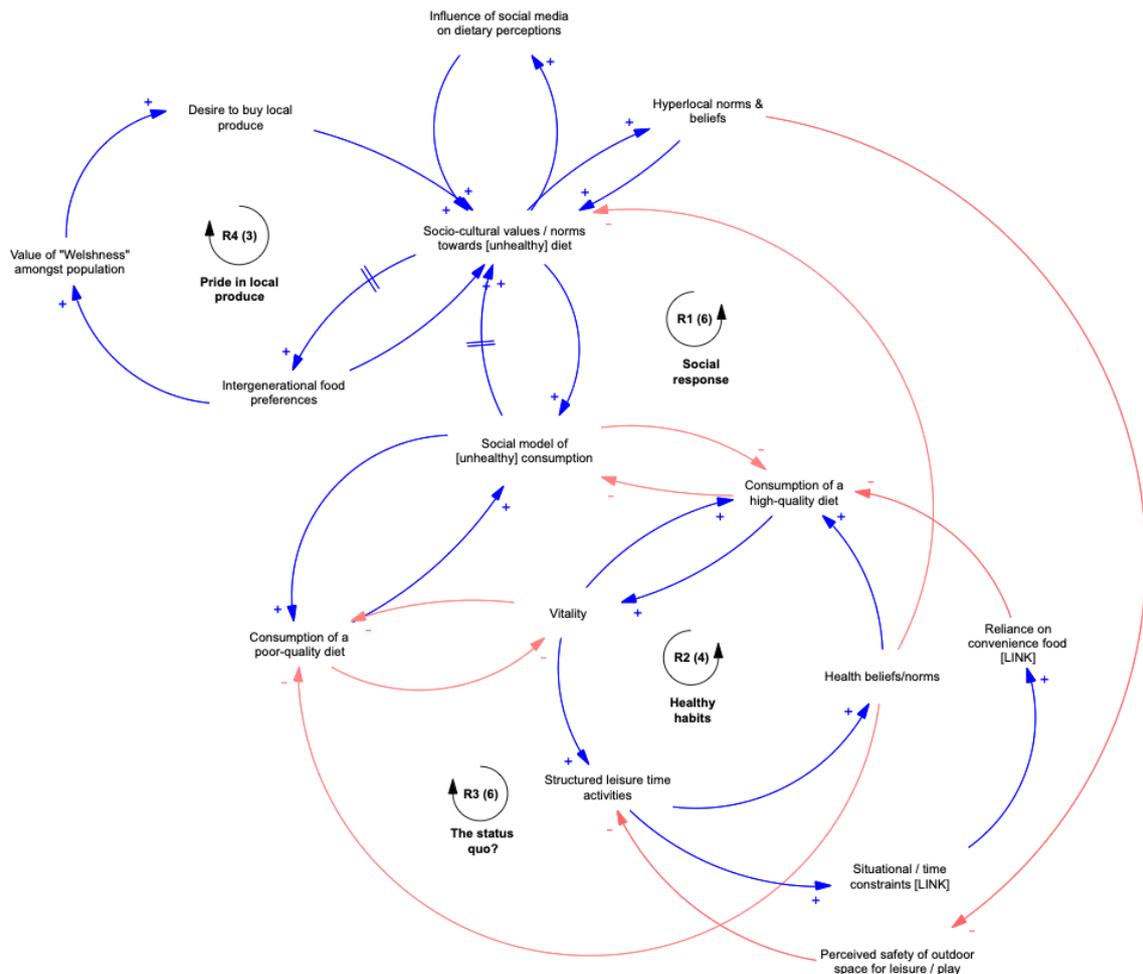
Figure 16: Social influences CLD

4.7. Wider determinants

Summary | The wider determinants CLD includes 26 factors and eight pertinent feedback loops. This CLD explains how upstream determinants such as the cost-of-living, governmental policies and subsidies, employment structures, and housing quality influence dietary intake.

Pertinent Feedback Loops | The first four feedback loops illustrate how the quality of employment has several ramifications for dietary intake (R1-4). The first (R1) explains how **high-quality employment may reduce the reliance on multiple incomes** should better salaries be offered. If there were a higher household income, this may reduce the need for multiple incomes, which in turn could also reduce the number of time constraints (i.e. working less hours). This could reduce the reliance on convenience food and offer more time for cooking. The same is also true in the second feedback loop (R2) whereby high-quality employment may allow **flexible working arrangements and provide time for healthier habits.** Both of these would have knock-on effects for dietary quality, improved health and wellbeing, and subsequently, an individual's ability to work.

The third feedback loop (R3) – **Employment increasing access to high-quality housing** – also works through household income. If household income were to increase, this may open up more options for high-quality housing, which may have better facilities for cooking and storing food, therefore increasing the ability to cook at home. The last feedback loop associated with high-quality employment is how **employment may reduce food insecurity** (R4), based on the assumption that higher household income would provide people with more money to spend on food. The same knock-on effects as for R1&2 may occur in R3&4 too, whereby employers would benefit from a healthier workforce.

The fifth feedback loop (R5) pertains to the **Government's role in enabling parents to work**. The provision of government support for families will enable more parents to access childcare. This increases their ability to work, their access to high-quality employment, and therefore opportunities to increase household income, and in the long term, change their socio-economic position, reducing the need for continued government support.

The next revolves around the **cost-of-living widening health inequalities** (R6). At the broadest level, the greater socio-economic adversity that an individual / family has, the greater the relative impact of the cost-of-living crises will be on individuals. If people therefore have less money due to increased spending on basic essentials, this will reinforce, or worsen their socio-economic position if equitable support is not available. This has ramifications throughout the system, which links to the final two feedback loops depicting the **socio-economic driven reliance on convenience food** (R7&8). Dependent on an individual's socio-economic position, and the relative impact of the cost-of-living crises, this will impact their household income. This then places a greater reliance on multiple incomes, increasing time constraints, and thus increasing the reliance on convenience food. This feeds back on itself through poorer diet quality, health outcomes, the ability to work / productivity, through to household income. The same loop operates through the (in)ability to access high-quality housing.

The "Growth and underinvestment" systems archetype

In the Growth and Underinvestment systems archetype, an initial reinforcing feedback loop drives growth, yet this expansion encounters balancing pressures as demands increase, especially if resources, time, or skill development remain insufficient. Without timely and appropriate investment, growth may decelerate, stagnate, or even reverse.

In this context of the wider determinants, dietary intake and household cooking fall within this archetype. Growth begins as increased household cooking improves health and well-being, thereby enhancing individuals' resilience and capacity to manage busy lifestyles. This positive feedback creates a reinforcing loop, where the ability to cope supports even more household cooking, promoting a cycle of improved dietary quality and health gains. However, external time pressures eventually strain this cycle, elevating reliance on convenience foods. This reliance dampens the momentum of the household cooking loop, introducing a balancing effect whereby time constraints and convenience dependency lower cooking frequency and, consequently, dietary quality.

The reliance on convenience food would, all else equal, drive a perceived need to invest in resources or time devoted to cooking. When steps are taken to set aside time for preparing nutritious meals and building cooking skills, dietary quality improves over time, ultimately reducing convenience food dependency and stabilising the system. But, if this investment is delayed or insufficient, as often the case, reliance on convenience food intensifies, undermining health improvements from a Welsh population perspective.

This model demonstrates key elements of the Growth and Underinvestment archetype: while the reinforcing loop initially fosters growth, mounting time pressures necessitate targeted investment in resources, cooking skills, and time management to sustain gains. Insufficient investment can result in a reliance on convenience foods, which limits household cooking and curtails growth potential.
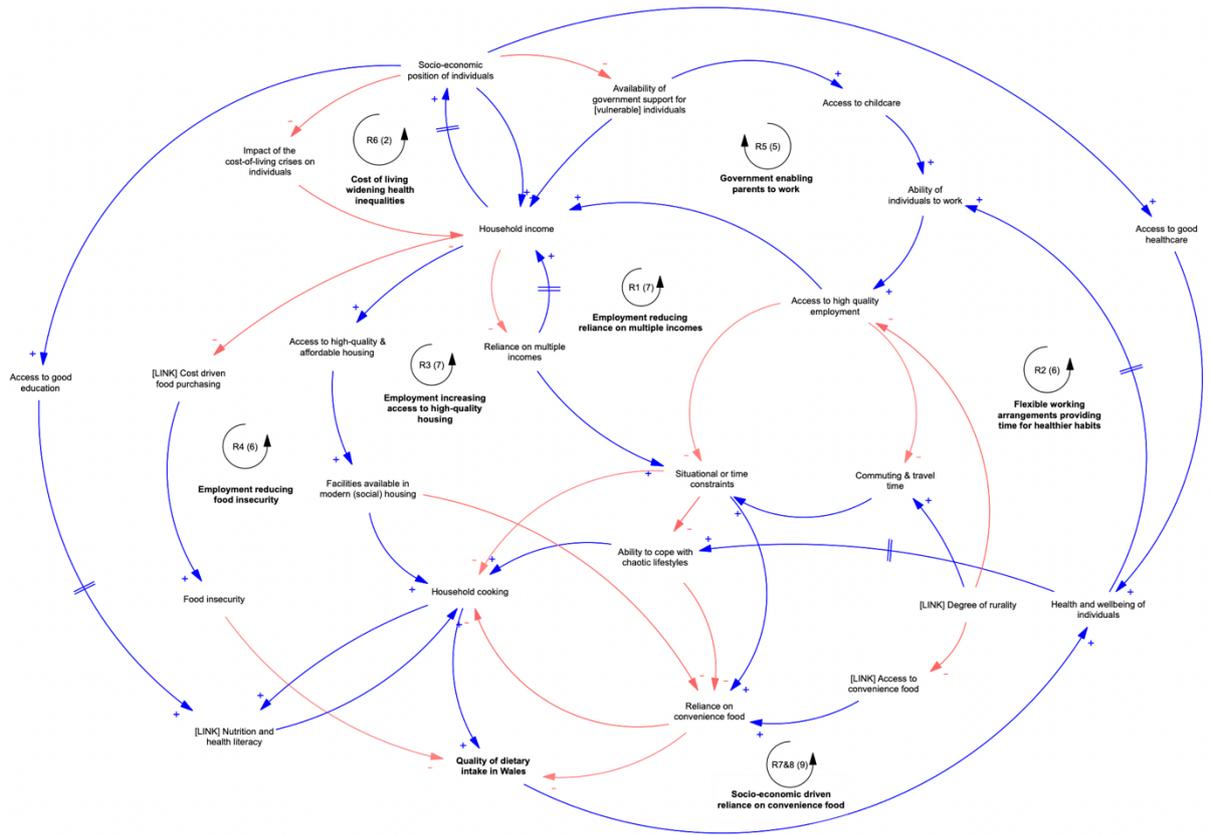
Figure 17: Wider determinants CLD

5. Current policy and action

Seventeen stakeholders from Welsh Government attended the final three-hour, in person workshop. Stakeholders represented 1) Health, Social Care and Early Years, 2) Local Government, Housing, Climate Change and Rural Affairs, 3) Economy, Energy and Transport, 4) Education, Culture and Welsh Language, and 5) Public Health Wales. This workshop was split into two parts, whereby the first half focused on understanding what actions were currently being taken by the Welsh Government across the food system. The second half was concerned with identifying future opportunities for intervention (see section 6). Forty-four actions were identified through the first part of the workshop (light green). An additional 30 actions were extracted from the Food Matters: Wales (2024) document (darker green). All actions were then overlaid on the Welsh Food System Map to illustrate where within the system they were perceived to influence (Figure 18). Please note, some were strategies rather than single actions (e.g. Healthy Weight, Healthy Wales). It was not practically feasible to go into each strategy and analyse the respective actions within them.

5.1. Current actions mapped against the system

As can be seen from Figure 18, 50% of the actions operated within the food production sub-system, with many congregating around food production processes, food waste, and climate change. A range of actions were also being taken across the school environment sub-system (11 actions). There were pockets of activity in the knowledge and skills (seven actions), marketing and advertising (three actions clustered around exposure to advertising), and the wider determinants (five actions clustered around food insecurity) sub-systems. Actions in orange denote those which are in *consultation* rather than implementation.
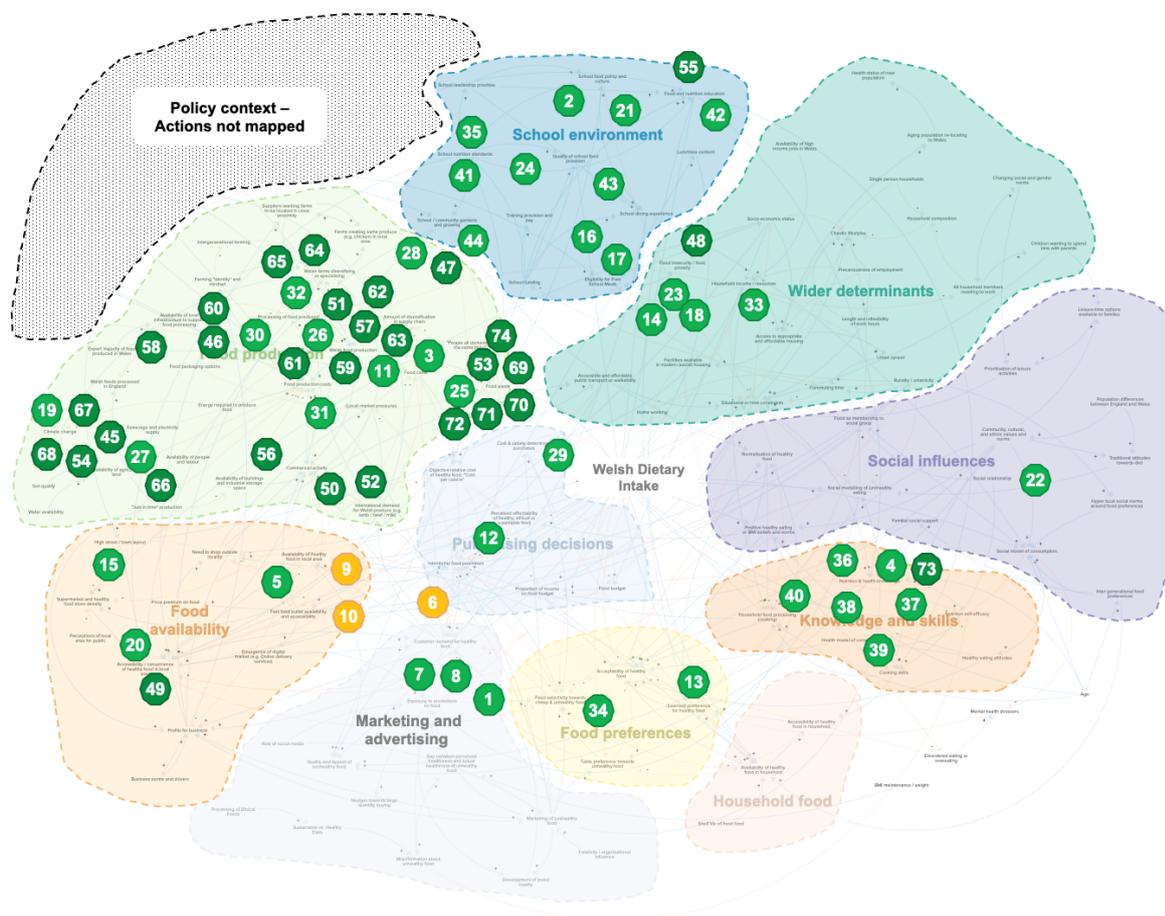
Figure 18: Current actions being taken across the Welsh food system (n=79)

5.2. Current actions coded against the Action Scales Model

All actions were then analysed against the Action Scales Model (ASM) to determine the degree of leverage that actions hold (Figure 19). Actions at the *events* level (blue) hold the least leverage, with those at the *structures* level (orange), *goals* level (green), and *beliefs* level (purple) holding greater leverage respectively. 55% of actions targeted structures and 30% targeted events within the system. Ten actions (12%) aimed to change the goals of the system, and two actions were explicitly targeting beliefs within the system. Eleven actions were coded across two levels of the ASM. A list of all actions, coded against the ASM, is available in Appendix G.
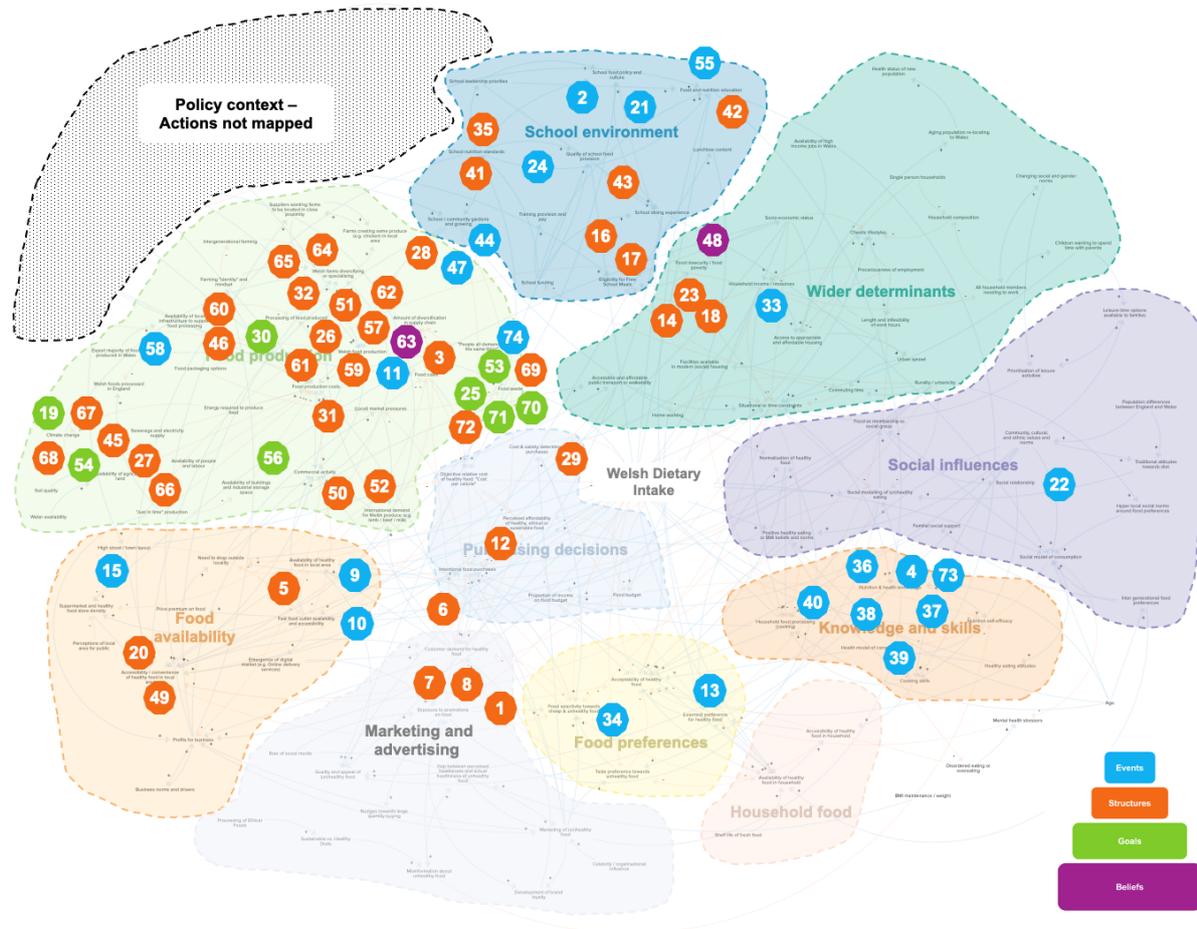
Figure 19: Current actions categories against the Action Scales Model (Nobles *et al.,* 2021)

6. Hypothetical places to intervene

This stage of the analysis aimed to identify places within four sub-systems (food availability, food preferences, food production, and school environment) where government intervention could be most impactful. The system grids, presented below, are divided into four quadrants: the bottom left refers to autonomous factors, the top left to steering factors, the bottom right to measuring factors, and the top right to ambivalent factors (see pg.17 more detailed definitions). The factors within each CLD are represented by letters in the system grids. As the factors of most interest, the steering factors and measuring factors are outlined, with full lists of all factors available in Appendix H to K. In addition to the system grids, the CLDs are presented for each sub-system with the steering and measuring factors highlighted.

Steering factors are those which are considered to hold a relatively high degree of immediate influence (or driving power) over other elements in the system due to their numerous outgoing connections, with relatively few incoming dependencies. These factors act as hubs of control first, and influence second (due to our weighting configuration), and thereby potential places where targeted intervention could shift local, possibly wider, system dynamics. The next phase for the Welsh Government could involve examining the specific feedback loops and interactions that these steering factors participate in, to understand how they interact with other factors in reinforcing or balancing dynamics. By identifying clusters of steering factors or "coalescing" influences, the Welsh Government may be able to pinpoint where coordinated interventions might yield systemic improvements.

We also highlight the measuring factors which have been identified in the analysis. Measuring factors are relatively highly influenced from other local factors and have a relatively low degree of immediate influence (or driving power) over other elements in the system due to their limited number of outgoing connections. This indicates they are more reactive in nature and shaped by the immediate system environment, positioning them as sensitive indicators to gain insights into systems change.

6.1. Food availability

Fast-food business profitability and *Socio-economic status/factors* were the only factors categorised within the **steering factors** quadrant of the system grid for the food availability sub-system (Figure 20). *Fast-food business profitability* has immediate influence over four other factors within the sub-system, whilst *Socioeconomic status/factors* has immediate influence over three. Other factors worth exploring as potential places for intervention, and highlighted as steering factors in Figure 21, were *Fast-food price appeal*, *Healthy food business profitability* and *Fast- relative to healthy- food marketing*. Even though categorised within the autonomous quadrant in the system grid, these factors have a relatively high degree of immediate influence over other elements in the food availability sub-system and thus have the potential to direct system behaviour.

Five factors were categorised within the **measuring factors** quadrant of the system grid for the food availability sub-system. Of note, although identified as measuring factor, *Fast- relative to healthy- food store density* possesses a relatively high degree of immediate influence over other elements. This factor therefore may also have a driving role within part of the system and should be explored as a potential place for intervention, whilst remaining conscious that changes to this factor may also provide insight into changes to other parts of the system.
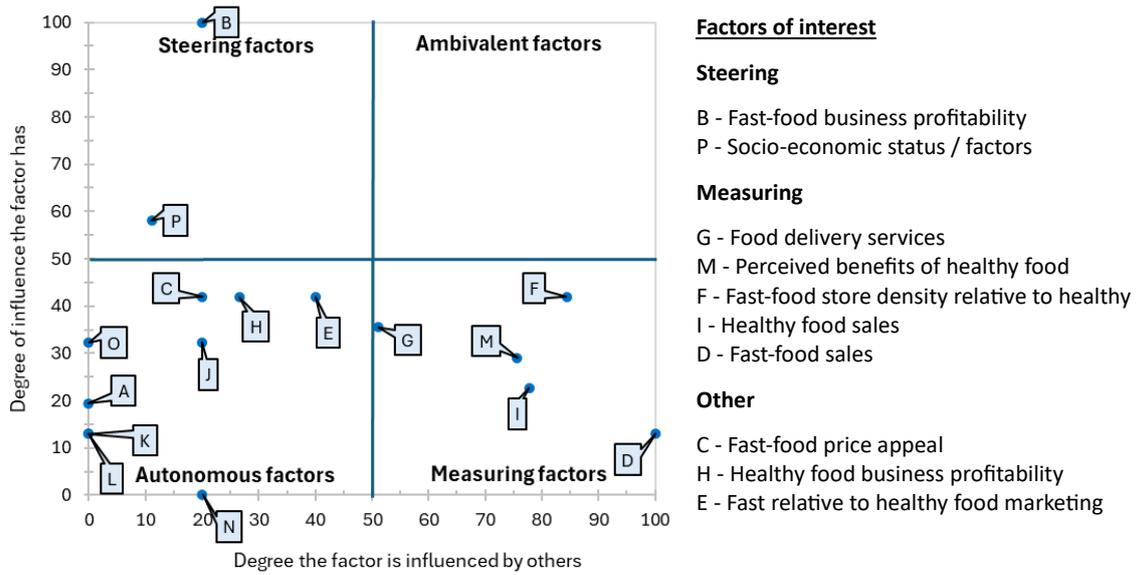
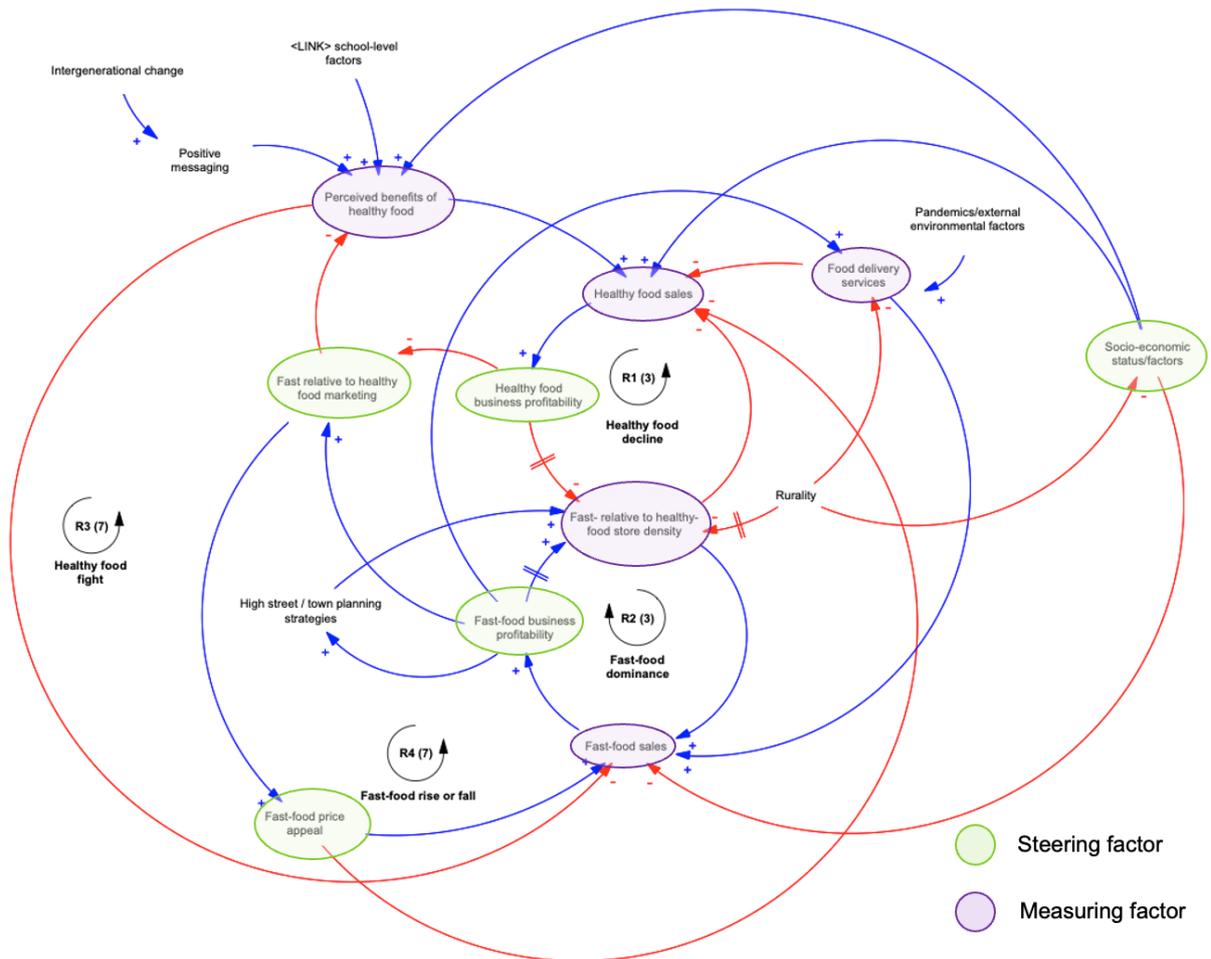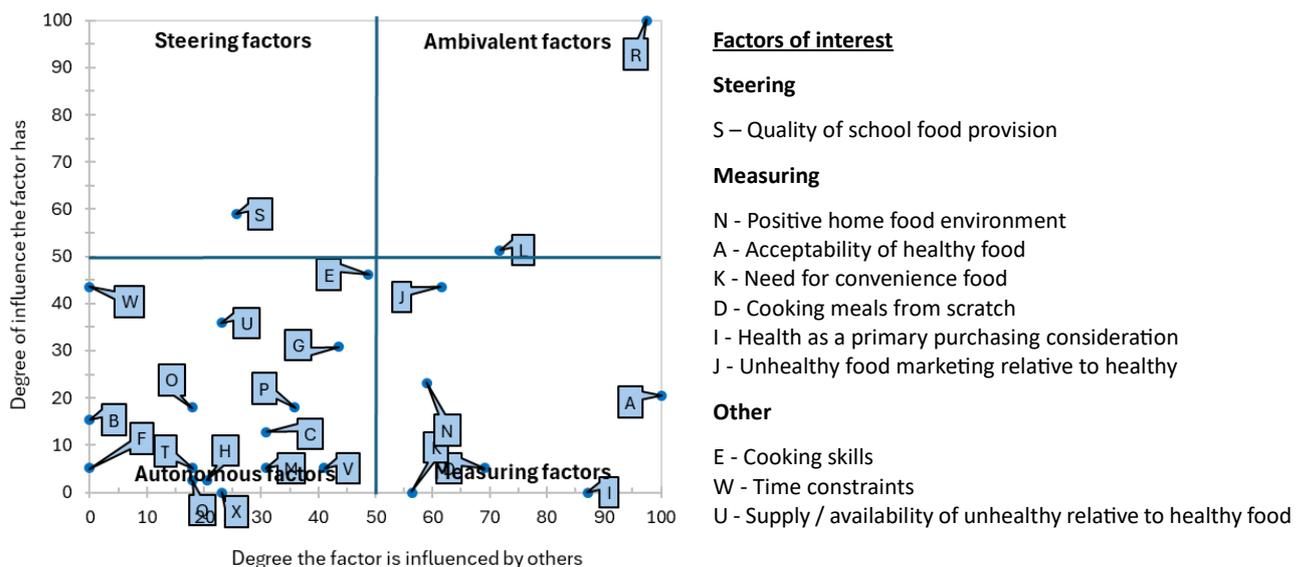**Figure 20: Food availability system grid**

Figure 21: Steering and measuring factors within the food availability CLD

6.2. Food preferences

The *Quality of school food provision and practices* was the only factor categorised within the **steering factors** quadrant of the system grid for the food preference sub-system (Figure 22). It has immediate influence over the *Acceptability of / learned preference for healthy food* and *Nutrition and health knowledge and education* factors within the sub-system. Other factors worth exploring as potential places for intervention, and highlighted as steering factors in Figure 23, were *Cooking skills*, *Time poor due to wider determinants* and *Supply / availability of unhealthy relative to healthy food*. Even though categorised within the autonomous quadrant in the system grid, these factors have a relatively high degree of immediate influence over other elements in the food preference sub-system and thus have the potential to direct system behaviour.

Six factors were categorised within the **measuring factors** quadrant of the system grid for the food preference sub-system (Figure 23). These factors are distributed throughout the system and the identified feedback loops, making then important places to consider as markers of change with the system. Of note although identified as measuring factor, *Marketing of unhealthy relative to health food* is positioned near the centre of the system grid plot and possesses a relatively high degree of immediate influence over other elements. This factor therefore may also have a driving role within part of the system and should be explored as a potential place for intervention.

Factors of interest

Steering

S – Quality of school food provision

Measuring

N - Positive home food environment
A - Acceptability of healthy food
K - Need for convenience food
D - Cooking meals from scratch
I - Health as a primary purchasing consideration
J - Unhealthy food marketing relative to healthy

Other

E - Cooking skills
W - Time constraints
U - Supply / availability of unhealthy relative to healthy food
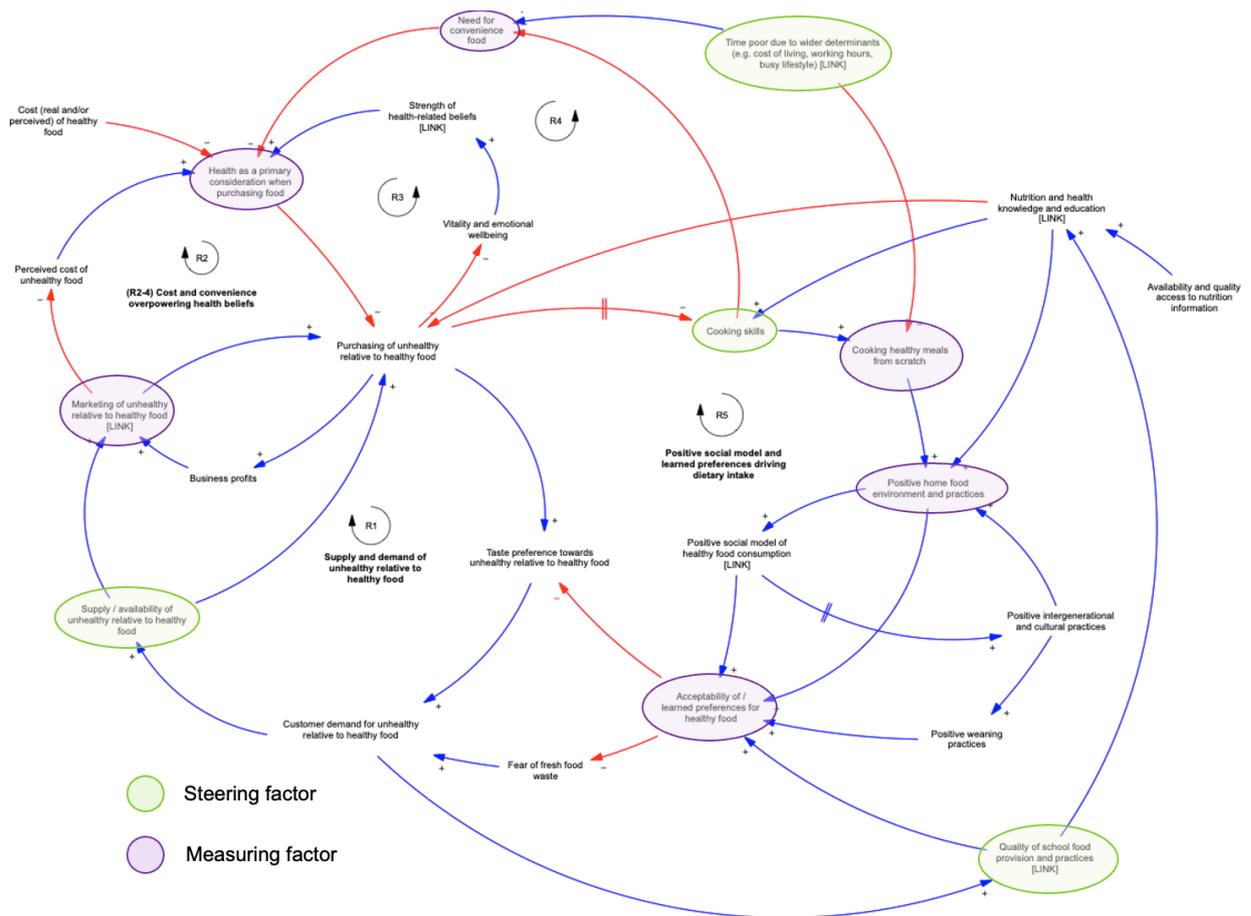
Figure 22: Food preferences system grid

Figure 23: Steering and measuring factors within the food preferences CLD

6.3. Food production

Four factors were categorised within the **steering factors** quadrant of the system grid for the food production sub-system (Figure 24). In addition, even though categorised within the autonomous quadrant in the system grid, *Food distribution* had a relatively high degree of immediate influence over other elements in the food production sub-system and is highlighted as steering factors in Figure 25 due to its potential to direct system behaviour.

Five factors were categorised within the **measuring factors** quadrant of the system grid for the food production sub-system. Three of these, *Land availability*, *Changes to farming practices / produce* and *Environmental impact* and in close proximity with the CLD, suggesting this is a key hub to consider as a marker of change with the system.
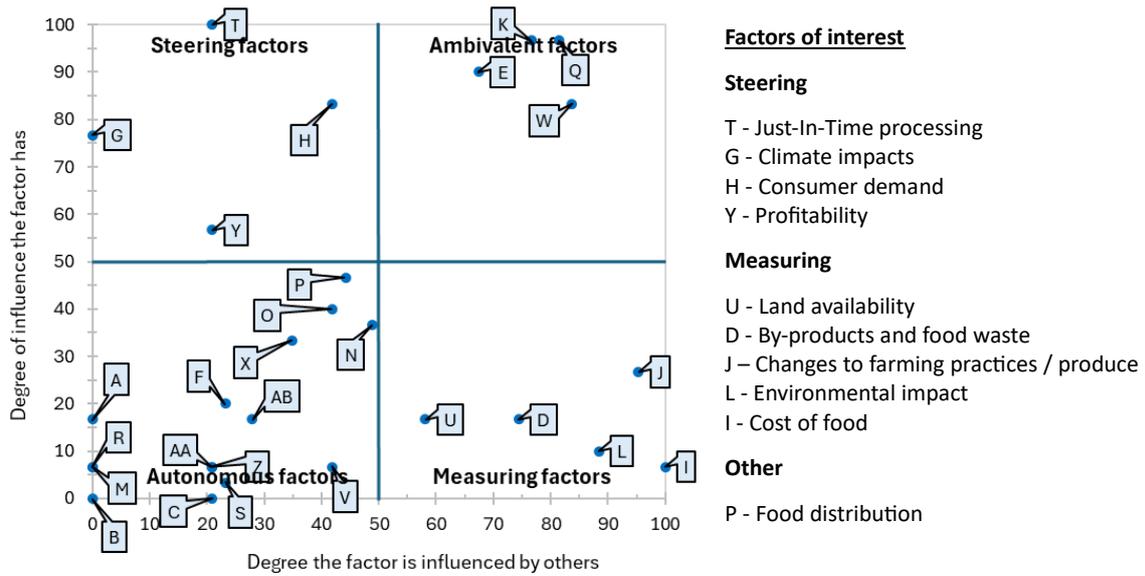
Figure 24: Food production system grid
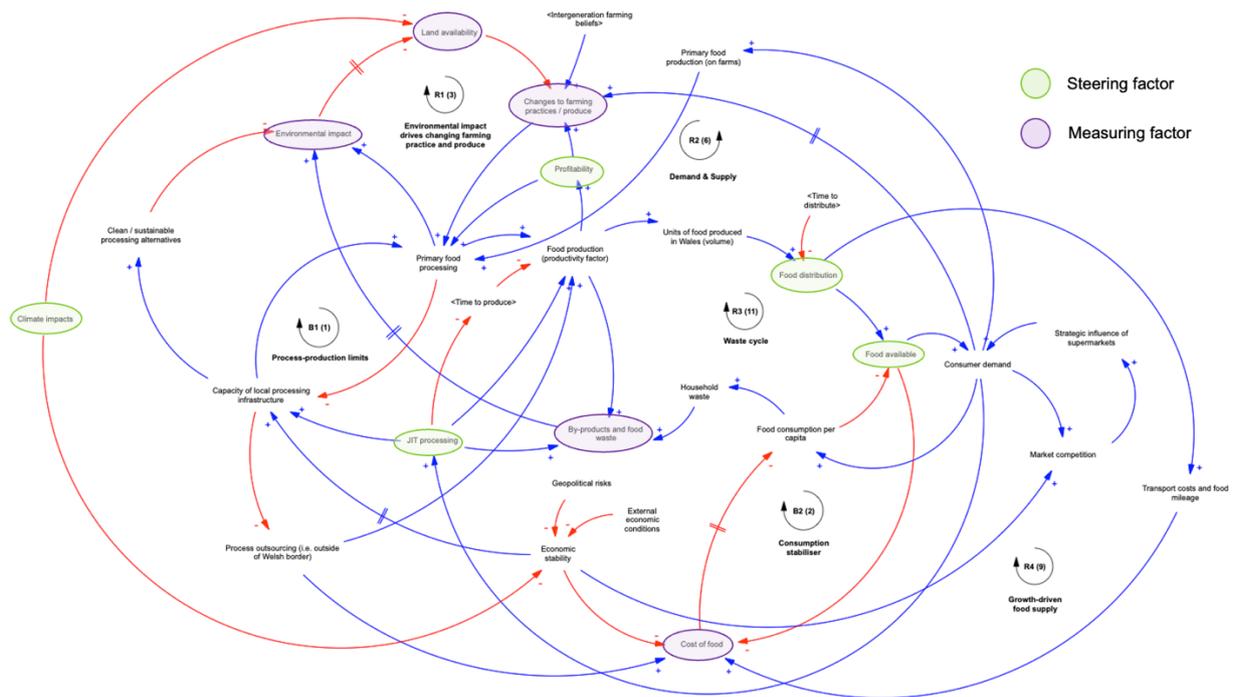
Figure 25: Steering and measuring factors within the food production CLD

6.4. School environment

Governmental prioritisation of academic attainment and / or pupil health, *Degree of school funding* and *Quality of dietary intake in Wales* were categorised within the **steering factors** quadrant of the system grid for the school environment sub-system (Figure 26). In addition, even though categorised within the autonomous quadrant in the systems gird plot, *Household income and resources* had a relatively high degree of immediate influence over other elements in the food production sub-system and is highlighted as steering factors in Figure 27 due to its potential to direct system behaviour.

Four factors were categorised within the **measuring factors** quadrant of the system grid for the school environment sub-system. Of note although identified as measuring factor, *School food policies* possesses a relatively high degree of immediate influence over other elements.
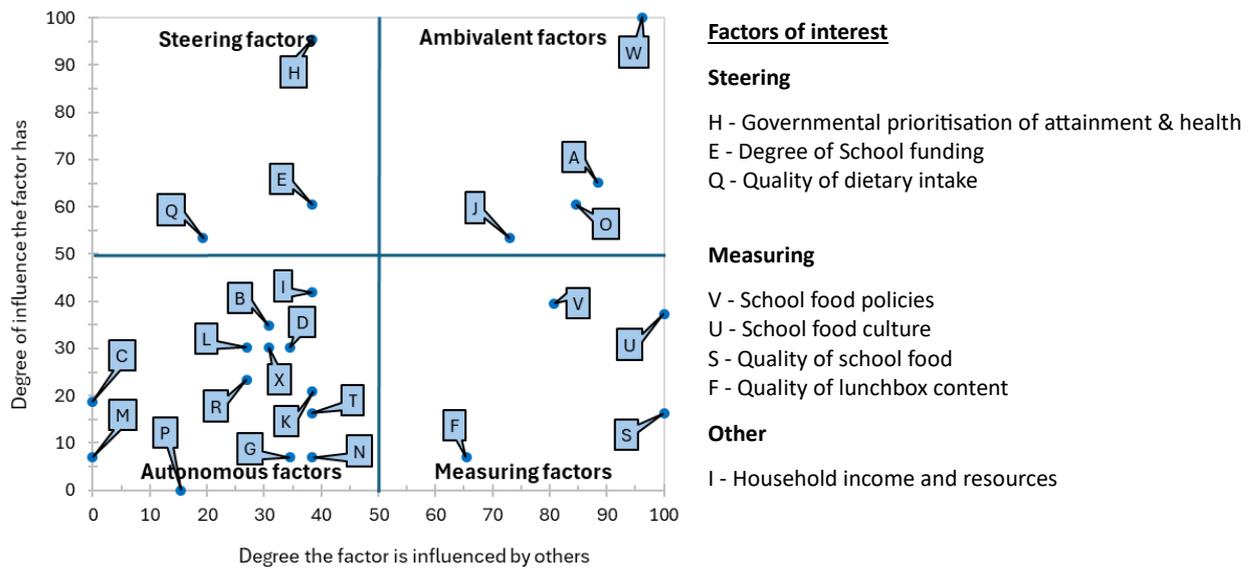
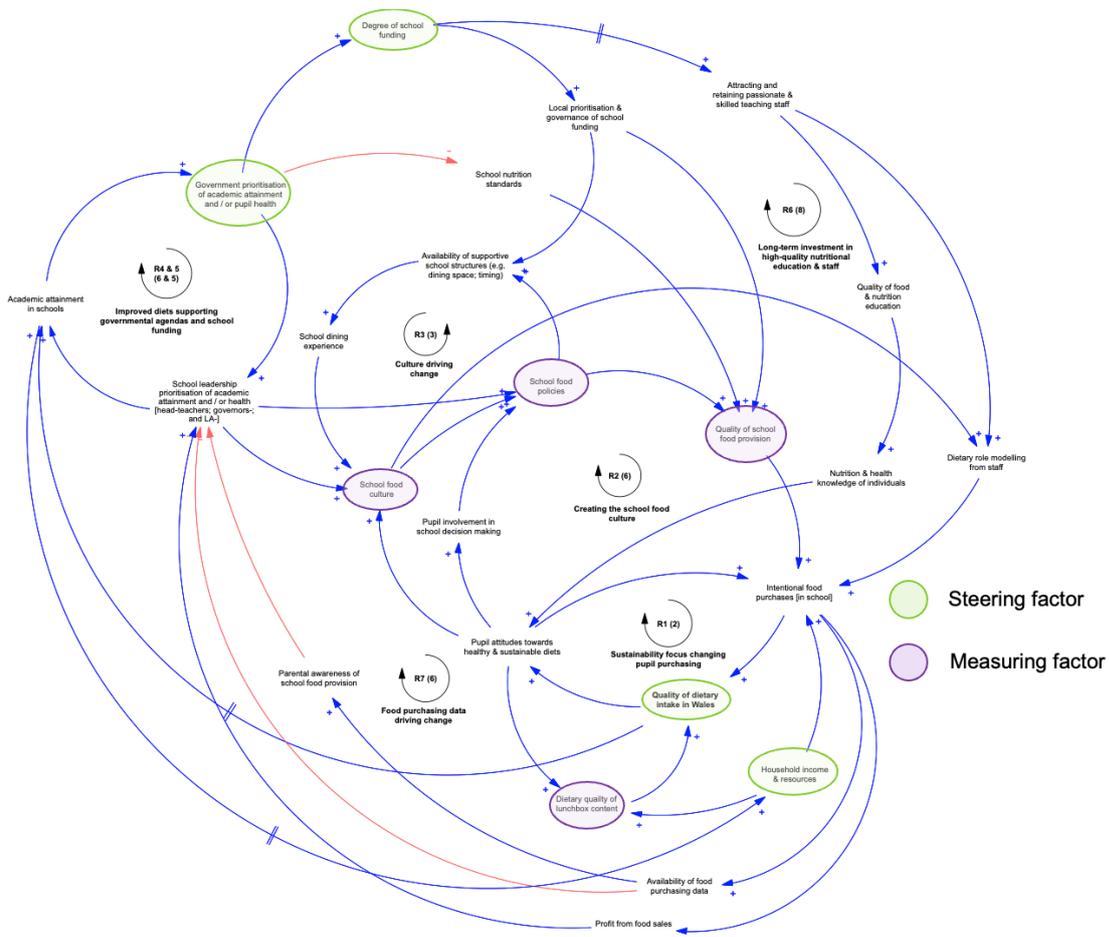

Figure 26: School environment system grid

Figure 27: Steering and measuring factors within the school environment CLD

7. Concluding remarks

7.1. Project summary

Given the ambition of the Welsh Government to create a dietary shift in Wales to one which is healthier and more sustainable, it was imperative for this work to understand the web of factors influencing population dietary intake. In this project, we drew extensively on the published literature and the extensive knowledge and lived experience of Welsh Government officials. Collectively, this resulted in the Welsh Food System Map; comprised of 136 factors, spread across eleven different sub-systems. At the next step, the Welsh Food System Map was disaggregated into seven CLDs to better account for the complex feedback dynamics at play. Here, we also identified several examples of systems archetypes – the recurring patterns of behaviour within a system that help explain phenomena of interest and pose as opportunities for intervention.

It was possible though to do much more with the CLDs. We went beyond current uses for CLDs and applied a Scenario Field Analysis to quantify aspects of the CLDs, using this to systematically identify potential places for government intervention. The analysis revealed key steering factors and measuring factors across the food availability, food preferences, food production, and school environment sub-systems from the perspective of the Welsh Government (note that other organisations with other levers might result in different findings). We hope that this analysis provides new insight and understanding with regards to the challenge at hand, the dynamics at play, and offers inroads to engage with the complexity of the Welsh food system.

Future work can also build on these foundations by investigating the feedback structures and loops that contain coalescing steering factors, and drawing on alternative methodologies that propagate influence throughout the causal architecture. This may include matrix multiplications and fuzzy cognitive mapping to further confirm or challenge intuition, initial evidence, potential points of power, and existing intervention actions.

7.2. Implications

Making the most of the Welsh Food System Map and accompanying CLDs

The Welsh Food System Map and CLDs can be used to:

- Illustrate and describe the complexity of the system driving dietary intake at the population level. These outputs can be included in presentations, meetings, or reports where the intention is to highlight the breadth of the Welsh food system.
- Allow stakeholders, both within and outside of Government, to see their role in helping to create a dietary shift. When having conversations with wider colleagues (i.e. those who would not traditionally see the food system as "their business"), the outputs can serve as a tool to demonstrate where they, and their organisation, have influence in the food system.
- Highlight the interconnectivity and interdependence within the Welsh food system, how intervening in one part of the system may have ramifications (positive or negative) elsewhere in the system. When thinking – or designing – actions, the CLDs can be used to create hypothetical scenarios about what may happen if actions are implemented (e.g. If we do this, what might happen to that?).
- Understand the aspects of the system which can and cannot be influenced by Welsh Government or associated partners. This may help with building the case, and communicating, the need for aligned policy making nationally, within the UK, and internationally.

Reflecting on current actions

As we have also shown, it is possible to overlay actions onto the Welsh Food System Map to depict current policy efforts. This work could however be taken further, to explore the interconnections between these actions across the system and examine their coherence (are efforts pushing in the same

direction?). To do so would likely require bringing together stakeholders from across policy areas to discuss how – as a collective – their actions could have greater impact. This process would also allow stakeholders to critically reflect on the leverage that current actions hold, using tools such as the Action Scales Model, and again, ask what additional work is needed to generate greater leverage. For example, most of the current actions target events and structures. Yet, to meet the ambition of a dietary shift, further action may be required at the belief level (e.g. are system leaders all aligned in their vision for a healthier Wales?) and the goals level (e.g. are leaders all working towards the same, or complementary, policy or strategic goals?). These reflections, and subsequent action efforts, would increase policy coherence.

There is also the opportunity to gain further information by ascertaining who (people, organisations, and sectors) is involved in designing, implementing, and monitoring current actions. This knowledge – if contrast against the Welsh Food System Map – would allow stakeholders to understand the current network, the strength (or interconnectivity) of this network, and strategically identify who else needs to be involved to bring about the desired dietary shift.

Intervening within the Welsh food system

The Scenario Field Analysis reveals aspects of the system worthwhile exploring further. These insights can be used to:

- Consider where intervention may be particularly fruitful for creating system change, by seeking out steering factors. These factors – all of which were mathematically adjusted based on the ability of Welsh Government to intervene – pose as *potential* opportunities for intervention.
- Identify aspects of the system which may be better to monitor rather than intervene in. Data may already be gathered for many of the measuring factors, and so this is a tangible next step, to systematically determine what data is being collected in these parts of the food system.
- As part of our analysis, we intended to overlay current actions against the steering and measuring factors so that Welsh Government can see how and where they are intervening at present. However, the information on current actions was limited, and therefore, a useful next step will be to gather further information relating to each action, and additional actions, and overlay these on the connections within the respective CLDs.
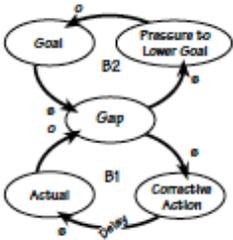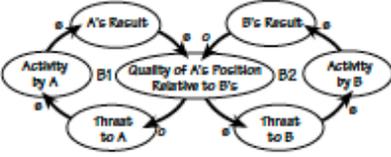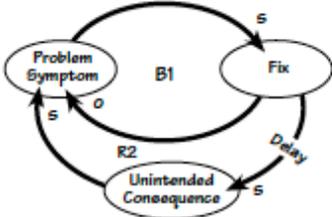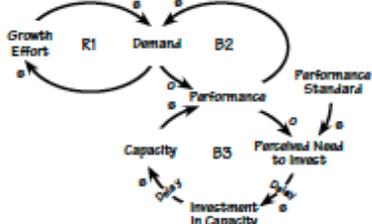
Given the time constraints of this project, we could only apply this analysis to four of the seven CLDs. Our intention though was to create a practical methodology that could feasibly be applied without academic involvement. As such, guidance is available that will allow Welsh Government officials to conduct the Scenario Field Analysis on the remaining three CLDs, and / or, apply this to analyses of other CLDs.

7.3. Limitations

This project does have several noteworthy limitations. First and foremost, the Welsh Food System Map and CLDs do not aim to be exhaustive; they reflect the collective knowledge of those who were involved in the workshops, and as such, may omit certain insights and foreground others. If this process were repeated with a different stakeholder group, the outputs and learning would likely look different. This work sought to provide Welsh Government officials with greater exposure to systems science and associated methodologies, and so the workshops – all between one and three hours in duration – provided an introduction. Thus, the outputs (Welsh Food System Map, CLDs, and Scenario Field Analysis) should be interpreted with this in mind. Similarly, to make the data collection and analyses feasible, the Welsh Food System Map was broken down into sub-systems, meaning that some of the interconnections between sub-systems are de-emphasised. Additional insight could be gleaned from analysing the system as a whole.

8. Appendices

Appendix A: Systems archetypes (Kim, 2000)

ARCHETYPE	DESCRIPTION	GUIDELINES
Drifting Goals	In a "Drifting Goals" archetype, a gap between the goal and current reality can be resolved by taking corrective action (B1) or lowering the goal (B2). The critical difference is that lowering the goal immediately closes the gap, whereas corrective actions usually take time. (See *Toolbox*, October 1990).	• Drifting performance figures are usually indicators that the "Drifting Goals" archetype is at work and that real corrective actions are not being taken. • A critical aspect of avoiding a potential "Drifting Goals" scenario is to determine what drives the setting of the goals. • Goals located outside the system will be less susceptible to drifting goals pressures.
Escalation	In the "Escalation" archetype, one party (A) takes actions that are perceived by the other as a threat. The other party (B) responds in a similar manner, increasing the threat to A and resulting in more threatening actions by A. The reinforcing loop is traced out by following the outline of the figure-8 produced by the two balancing loops. (See *Toolbox*, November 1991.)	To break and escalation structure, ask the following questions: • What is the relative measure that pits one party against the other and can you change it? • What are the significant delays in the system that may distort the true nature of the threat? • What are the deep-rooted assumptions that lie beneath the actions taken in response to the threat?
Fixes That Fail	In a "Fixes That Fail" situation, a problem symptom cries out for resolution. A solution is quickly implemented that alleviates the symptom (B1), but the unintended consequences of the "fix" exacerbate the problem (R1). Over time (right), the problem symptom returns to its previous level or becomes worse. (See *Toolbox*, November 1990).	• Breaking a "Fixes that Fail" cycle usually requires acknowledging that the fix is merely alleviating a symptom, and making a commitment to solve the real problem now. • A two-pronged attack of applying solution will help ensure that you don't get caught in a perpetual cycle of solving yesterdays "solutions."
Growth and Underinvestment	In a "Growth and Underinvestment" archetype, growth approaches a limit that can be eliminated or pushed into the future if capacity investments are made. Instead, performance standards are lowered to justify underinvestment, leading to lower performance which further justifies underinvestment. (See *Toolbox*, June/July 1992.)	• Dig into the assumptions which drive capacity investment decisions. If past performance dominates as a consideration, try to balance that perspective with a fresh look at demand and the factors that drive its growth. • If there is potential for growth, build capacity in anticipation of future demand.

ARCHETYPE	DESCRIPTION	GUIDELINES
Limits to Success 	In a "Limits of Success" scenario, continued efforts initially lead to improved performance. Over time, however, the system encounters a limit which causes the performance to slow down or even decline (B1), even as efforts continue to rise. (See *Toolbox*, December 1990/January 1991).	• The archetype is most helpful when it is used well in advance of any problems, to see how the cumulative effects of continued success might lead to future problems. • Use the archetype to explore questions such as What kinds of pressures are building up in the organization as a result of the growth? • Look for ways to relieve pressures or remove limits before an organizational gasket blows.
Shifting the Burden/Addiction 	In a "Shifting the Burden," a problem is "solved" by applying a symptomatic solution (B1) which diverts attention away from more fundamental solutions (R1). (See Toolbox, September 1990). In an "Addiction" structure, a "Shifting the Burden" degrades into an addictive pattern in which the side-effect gets so entrenched that it overwhelms the original problem symptom. (See *Toolbox*, April 1992.)	• Problem symptoms are usually easier than the other elements of the structure. • If the side-effect has become the problem, you may be dealing with an "Addiction" structure. • Whether a solution is "symptomatic" or "fundamental" often depends on one's perspective. Explore the problem from differing perspective in order to come to a more comprehensive understanding of what the fundamental solution may be.
Success to the Successful 	In a "Success to the Successful" archetype, if one person or group (A) is given more resources, it has a higher likelihood of succeeding than B (assuming they are equally capable). The initial success justifies devoting more resources, its success diminishes, further justifying more resource allocations to A (R2). See *Toolbox*, March 1992.)	• Look for reasons why the system was set up to create just one "winner." • Chop off one half of the archetype by focusing efforts and resources on one group, rather than creating a "winner-take-all" competition. • Find ways to make teams collaborators rather than competitors. • Identify goals or objectives that define success at a level higher than the individual players A and B.
Tragedy of the Commons 	In "Tragedy of the Commons" structure, each person pursues actions which are individually beneficial (R1 and R2). If the amount of activity grows too large for the system to support, however, the "commons" becomes experiences diminishing benefits (B1 and B2). (See *Toolbox*, August 1991.)	• Effective solutions for "Tragedy of the Commons" scenario never lie at the individual level. • Ask questions such as: "What are the incentives for individuals to persist in their actions?" "Can the long-term collective loss be made more real and immediate to the individual actors?" • Find ways to reconcile short-term cumulative consequences. A governing body that is chartered with the sustainability of the resources limit can help.

Appendix B: Further details on methodology Stage 6

The final stage of the analysis aimed to identify places within the Welsh food system where government intervention could be most impactful. To achieve this, we used a cross-impact analysis combined with a Scenario Field Analysis approach. This approach draws form the scenario management and planning literature (Gausemeir *et al.*, 1998; Schlange, 1995), to evaluate stakeholder-identified pairwise relationships between factors in the system, with a focus on identifying critical or influential factors for intervention. Associated with a Scenario Field Analysis is a type of influence diagram (referred to as "system grids").

Data collection

During the final stakeholder workshop (see Stage 5), stakeholders reviewed each subsystem CLD. In small groups based on their expertise, stakeholders assigned impact and leverage scores to each connection within their assigned CLD. The impact score (1 to 3, low to high) captured the degree of influence one factor exerts on another, while the leverage score (also 1 to 3, low to high) represented the Welsh Government's perceived ability to influence each connection through a known mechanism of control.

Cross-impact analysis

We subsequently transformed each stakeholder annotated CLD into matrix format to support a cross-impact analysis. The matrix consisted of rows and columns corresponding to factors and relationships in the system, with each factor represented by two vertical columns (see Figure 6): one to record impact scores and one to record leverage scores. Here, j represents pairwise relationships between two factors, while i denotes each individual factor in the matrix. Along each row, Active Impact Scores (AIS_{ij}) and Active Leverage Scores (ALS_{ij}), were summed to provide the Active Impact Value (AIV_i) and Active Leverage Value (ALV_i). Similarly, down each column, Passive Impact Scores (PIS_{ij}) and Passive Leverage Scores (PLS_{ij}), provided the Passive Impact Value (PIV_i) and Passive Leverage Value (PLV_i).

The summed values were carried over to a new spreadsheet, forming four columns: AIV and PIV, and ALV and PLV. This format facilitated analysis of the influence and controllability of each factor. We next developed a method to integrate these four values into a raw Weighted Active Value ($rWAV_i$) and raw Weighted Passive Value ($rWPV_i$). The aim of this integration was to balance the actual or perceived influence that a given factor has with the controllability of that influence. For example, a particular factor may be highly influential within the system; however, the Welsh Government may equally consider it to be difficult to control or modify. Conversely, a factor may be relatively easy to control, albeit its influence or effect on other factors might be minimal.

Applying a weighting formula

The $rWAV_i$ was calculated using the following formula which contains two components: (i) an expression for impact; and (ii) an expression for control, weighted at 40% impact and 60% leverage.

$$rWAV_i = \left(W_{impact} \sum_{j=1}^{N} AIS_{ij} \right) + \left(\{1 - W_{impact}\} \sum_{j=1}^{N} ALS_{ij} \right)$$

Where:

- W_{impact} represents the weight assigned to impact (40%)

- The 1-W_{impact} represents the weight given to leverage (60%)

- AIS_{ij} and ALS_{ij} represents the Active Impact Score and Active Leverage Score, respectively, for each relationship j in the dataset.

- This formula is also applied for $rWPV_i$ but uses PIS_{ij} and PLS_{ij} instead.

Normalising the rWAV$_i$ and rWPV$_i$

Next, the rWAV$_i$ and rWPV$_i$ were normalised to a 0.0 to 1.0 range using the minimum and maximum values of the dataset k:

$$nWAV_i = \left(\frac{rWAV_i - \min(rWAV_k)}{\max(rWAV_k) - \min(rWAV_k)} \right).100$$

Where:

- rWAV$_i$ is the raw Weighted Active Value for factor i.

- min(rWAV$_k$) and max(rWAV$_k$) represent the minimum and maximum values of rWAV across all factors in dataset k.

- This formula is similarly applied to normalise rWPV$_i$.

Normalising the data in this way ensures consistent interpretation, making it possible to compare different subsystems and scenarios despite differences in their raw values.

Appendix C: Synthesised system map (all 174 factors)

Key: AS = Sawyer *et al.* (2021), LB = Brennan *et al.* (2015), LF = Frerichs *et al.* (2015), MB = Bryant *et al.* (2023), SF = Friel *et al.* (2017), SG1 = Gerritsen *et al.* (2019), SG2 = Gerritsen *et al.* (2019), SM = Mills *et al.* (2017), YCU = Chavez-Ugalde *et al.* (2022). Key applies to Appendix D & E.

Appendix D: Synthesised system map (n=72 factors included in two or more studies)

Appendix E: Synthesised system map (n=38 factors included in three or more studies)

Appendix F: Welsh Food System Map (n=136 factors)
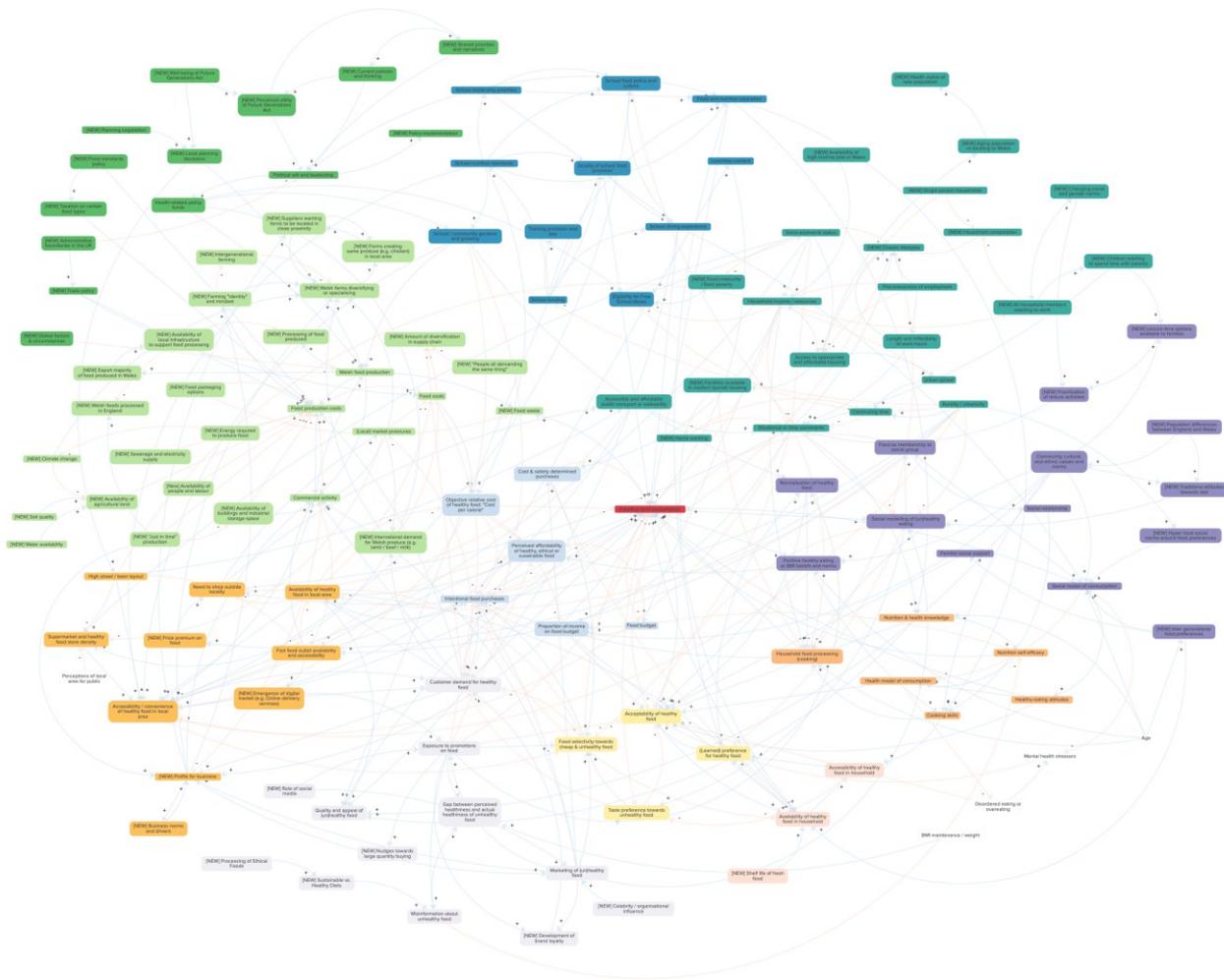
Appendix G: Current Welsh Government actions

ID	Name of action	ASM (1)	ASM (2)
Actions identified in stakeholder workshop			
1	Energy drink sponsorship	Structure	
2	Guidance for schools	Event	
3	Product reformulation	Structure	
4	Climate Action Wales	Event	
5	HFSS legislation Wales and UK	Structure	
6	Energy drink restriction	Structure	
7	UK TV & Online Advertising Limits	Structure	
8	Outdoor advertising and Transport for Wales	Structure	
9	Consultation Healthy Food	Event	
10	Consultation around the retail sector	Event	
11	Food innovation centres	Event	
12	Insight programme	Structure	
13	"Healthy Weight, Healthy You" website	Event	
14	Healthy Start Scheme / Vouchers	Structure	Event
15	Local systems	Structure	

#	Action		
16	Free School Milk Scheme	Structure	Event
17	Free School Meals	Structure	Event
18	Tackling Food Poverty	Structure	Event
19	Just Transition Framework	Goals	Structure
20	Velindre NHS Trust Food Mission	Structure	Goals
21	Daily Active	Event	
22	Healthy and Active Fund	Event	
23	Minimum wage legislation	Structure	
24	Trade Development Programme	Event	
25	Strategic vision for food and drink industry	Goals	
26	Agri policy and support	Structure	
27	Agriculture Wales Act 2023 & Sustainable Farming Scheme	Structure	
28	Community Food Strategy, Local Food Partnership & Allotment Policy and Support	Structure	
29	Healthy Weight, Healthy Wales	Structure	
30	B. Corp & SALSA Accreditation	Goals	
31	Food economic appraisal & export bulletin	Structure	
32	Innovation strategy	Structure	
33	Tackling Fuel Poverty	Event	
34	Work with supermarkets to support healthy food choices	Event	
35	Review of Healthy Eating in Schools (Nutritional Standards & Requirements) Regulations 2013	Structure	
36	UK Government ECO labelling scheme	Event	
37	"Eat Them to Defeat Them" campaign	Event	
38	Food Hour	Event	
39	Come and Cook with your Child (and similar)	Event	
40	Nutrition Skills for Life Training	Event	Structure
41	Food and Nutrition in Schools Standard	Structure	Goals
42	Curriculum for Wales	Structure	
43	School building programme	Structure	
44	Big Bocs Bwyd	Event	
	Actions identified in Food Matters document		
45	UK Joint Fisheries Statement and Framework	Structure	
46	Community Assets Commission	Structure	
47	Local Places for Nature	Event	
48	Child Poverty Strategy	Beliefs	Structure
49	Planning Policy Wales	Structure	
50	Economic Mission	Structure	
51	Wales Procurement Policy Statement & Act 2023	Structure	
52	Visitor Economy Policy / Food Tourism Toolkit	Structure	
53	Beyond Recycling Strategy	Goals	
54	Net Zero Wales Carbon Budget 2	Goals	Structure
55	Eco-Schools Wales & Size of Wales	Event	
56	Economic contract	Goals	
57	Cywain	Structure	
58	Export Support Programme	Event	
59	Food and Drink Skills Wales	Structure	
60	Food Business Networking and Clustering	Structure	
61	Backing Local Firms Fund Food Projects	Structure	
62	Buying Food Fit for the Future	Structure	

63	Food Sense Wales	Beliefs	
64	Farming Connect	Structure	
65	Farm Liaison Service	Structure	
66	Small Grants Schemes (Efficiency / Horticulture)	Structure	
67	Environment Act (Wales) 2016	Structure	
68	Prosperity for All - A Low Carbon Wales	Structure	
69	Wales Food Waste Routemap	Structure	
70	The Courtauld Commitment 2030	Goals	Structure
71	Workplace Recycling Regulations	Goals	
72	Environmental Protection (Single Use Plastics) Wales Act 2023	Structure	
73	"Love Food, Hate Waste" Campaign	Event	
74	"Be mighty" campaign	Event	

Appendix H: Factors in the food availability system grid

ID	Name of factor
A	School-level factors [LINK]
B	Fast food business profitability
C	Fast food price appeal
D	Fast food sales
E	Fast relative to healthy food marketing
F	Fast relative to healthy food store density
G	Food delivery services
H	Healthy food business profitability
I	Healthy food sales
J	High street/town planning strategies
K	Intergenerational change
L	Pandemics/external environmental factors
M	Perceived benefits of healthy food
N	Positive messaging
O	Rurality
P	Socioeconomic status/factors

Appendix I: Factors in the food preference system grid

ID	Name of factor
A	Acceptability of / learned preferences for healthy food
B	Availability and quality access to nutrition information
C	Business profits
D	Cooking healthy meals from scratch
E	Cooking skills
F	Cost (real and/or perceived) of healthy food
G	Customer demand for unhealthy relative to healthy food
H	Fear of fresh food waste
I	Health as a primary consideration when purchasing food
J	Marketing of unhealthy relative to healthy food [LINK]
K	Need for convenience food
L	Nutrition and health knowledge and education [LINK]

M	Perceived cost of unhealthy food
N	Positive home food environment and practices
O	Positive intergenerational and cultural practices
P	Positive social model of healthy food consumption [LINK]
Q	Positive weaning practices
R	Purchasing of unhealthy relative to healthy food
S	Quality of school food provision and practices [LINK]
T	Strength of health-related beliefs [LINK]
U	Supply / availability of unhealthy relative to healthy food
V	Taste preference towards unhealthy relative to healthy food
W	Time poor due to wider determinants (e.g. cost of living, working hours, busy lifestyles)
X	Vitality and emotional wellbeing

Appendix J: Factors in the food production system grid

ID	Name of factor
A	Intergeneration farming beliefs
B	Time to distribute
C	Time to produce
D	By-products and food waste
E	Capacity of local processing infrastructure
F	Clean/sustainable processing alternatives
G	Climate impacts
H	Consumer demand
I	Cost of food
J	Diversification of farming practices
K	Economic stability
L	Environmental impact
M	External economic conditions
N	Food available
O	Food consumption per capita
P	Food distribution
Q	Food production
R	Geopolitical risks
S	Household waste
T	JIT processing
U	Land availability
V	Market competition
W	Primary food processing
X	Process outsourcing
Y	Profitability
Z	Strategic influence of supermarkets
AA	Transport costs and food mileage
AB	Units of food produced in Wales

Appendix K: Factors in the school environment system grid

ID	Name of factor

A	Academic attainment in schools
B	Attracting and retaining passionate & skilled teaching staff
C	Availability of food purchasing data
D	Availability of supportive school structures (e.g. dining space; timing)
E	Degree of school funding
F	Dietary quality of lunchbox content
G	Dietary role modelling from staff
H	Government prioritisation of academic attainment and / or pupil health
I	Household income & resources
J	Intentional food purchases [in school]
K	Local prioritisation & governance of school funding
L	Nutrition & health knowledge of individuals
M	Parental awareness of school food provision
N	Profit from food sales
O	Pupil attitudes towards healthy & sustainable diets
P	Pupil involvement in school decision making
Q	Quality of dietary intake in Wales
R	Quality of food & nutrition education
S	Quality of school food provision
T	School dining experience
U	School food culture
V	School food policies
W	School leadership prioritisation of academic attainment and/or health
X	School nutrition standards