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How to monitor the progress towards a circular food economy: A Delphi study

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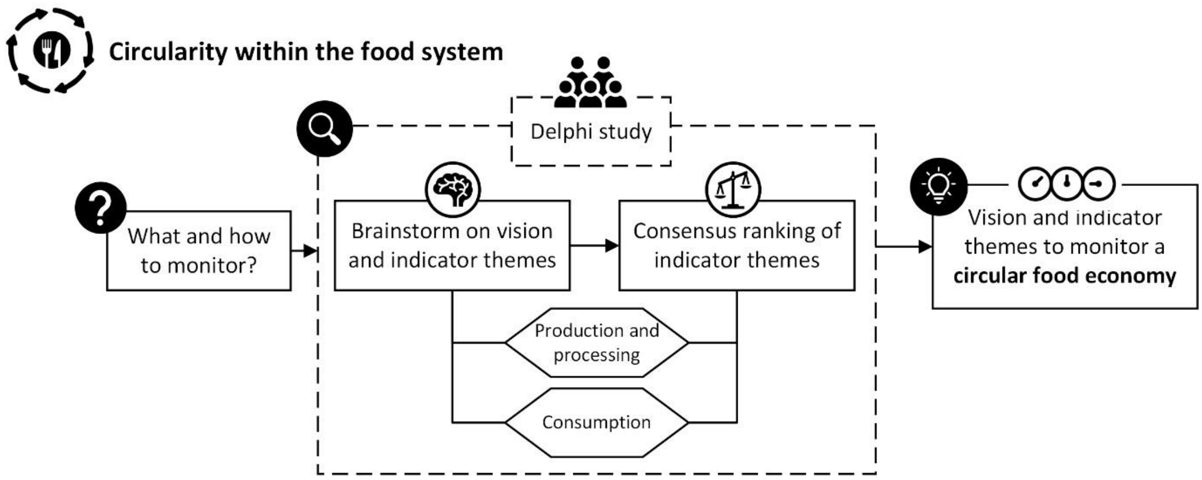
Abstract

Within the food sector, the implementation of a circular economy (CE) can reduce resource consumption and emissions to the environment by moving away from a linear and unsustainable system. This necessitates a clear vision on what circularity for food means, which will provide a much-needed foundation to develop a monitoring tool that reveals insights into the progress being made towards a CE, and to expose the bottlenecks and opportunities. This research study contributes to the development of a shared vision for circularity within the food system, and defines and prioritizes a set of indicator themes to monitor a circular food economy (CFE). A two-round Delphi study was performed, including a brainstorming session with experts and the construction of a consensus ranking of indicator themes, considering the production and processing and the consumption stage. The Delphi results provide a shared vision on a CFE, and a blueprint for researchers and policy-makers on its monitoring, which will stimulate the progression from a linear to a circular system.



Keywords

Circular economy; monitor; indicators; food; Delphi study; best–worst scaling

1. Introduction

Growing economic production and consumption can lead to scarcity and unequal access to resources, which comes with many sustainability concerns. Over-exploiting natural resources and not managing them in a sustainable way can put entire ecosystems and the well-being of people at risk (Bansard and Schröder, 2021). A circular economy (CE) aims to extend the value and utility of products, and uses waste as a secondary resource, which should lead to a decrease in environmental impacts (Mayer et al., 2019). Nowadays, the CE takes a prominent place in research and (inter)national policy (for example, the circular economy action plan of the European Commission; European Commission, 2020a).

The adoption of a CE has received specific attention from the food sector (Garcia-Saravia Ortiz-de-Montellano and van der Meer, 2022; Haigh et al., 2021; Sousa et al., 2021). The food system entails all processes required to provide the food and drinks necessary to meet human demand for nutrition. Current production and consumption patterns in the food system have a high material demand and contribute to numerous adverse environmental impacts (OECD, 2021; Willett et al., 2019). Considering that approximately one-third of the food produced globally is wasted somewhere along the food chain, many opportunities exist to improve its circularity (Corrado et al., 2019). In 2020, the European Commission presented its Farm-to-Fork strategy, as part of the European Green Deal, which will contribute to achieving a CE – from production to consumption – by working on better-informed citizens, production efficiency, sustainable processing, healthy consumption, reduction of losses and waste, and better packaging and storage (European Commission, 2020b).

An assessment of the progress towards a CE for food is needed, but is still an issue of ongoing debate (Alaerts et al., 2019; Mayer et al., 2019). The CE is defined as a broad concept, leading to diverse applications depending on stakeholders' interests (Mayer et al., 2019). Also, the CE can be monitored at different levels, including assessments at the product or company level, regional level, or international scale. In addition, circularity for food requires a unique approach as it entails some specific features that are not automatically encountered in products upon which a CE typically focuses, such as cars, electric appliances, and packaging. First, it is difficult to reuse inputs in closed-cycle systems when they have to re-enter natural biochemical cycles to be regenerated (Navare et al., 2021). Second, it is key to account for the inevitable single-use and biological nature of food products. Traditional CE strategies to increase the number of uses per product cannot be applied within the food system. For example, in other systems such as 'mobility' and 'consumer goods', cars and clothing can be traded second-hand, while this strategy fails for the system of food. Third, the food system is complex, crossing multiple policy domains like agriculture, environment, and health. Finally, the system is closely intertwined with the demand for biomass in general, and hence the entire bio-economy. These system-related characteristics call for a system-specific approach regarding a CE monitor for food.

A CE monitor for food aims to provide indicators that measure and guide the transition towards a CE and give feedback to policy-makers and other decision-makers. However, the selection of CE monitoring indicators is value-loaded, which makes it necessary to first delineate a vision for a CE. Therefore, the present study will contribute to the novel development of a shared vision for a CE for food and define and prioritize a set of CE indicators themes to monitor the food system. The remainder of this paper is structured as follows. First, the literature is reviewed on related research on the CE in the food sector. Second, the research method is explained. Third, the research results are presented in terms of shaping and monitoring circularity for food. In the last sections, the results are further discussed, limitations are disclosed, and conclusions are drawn.

2. Literature Review

A CE can be monitored at the macro level (at (supra)national or regional scale), the micro level (at product or company scale), and the meso level (linking the macro and micro scales) (Alaerts et al., 2019; ISPRA et al., 2021). The meso level measures a CE at the level of the fulfilment of societal needs, which were inspired by the major consumption domains of households: housing, mobility, food, and consumer goods. The economy is a system that fulfils needs through offering products and services, and a transition to a CE will involve major modifications in those products and services. Monitoring at the meso level creates a better understanding of each system, the associated material requirements and impacts, and allows for more up-to-date monitoring of the progress towards a CE. An example of the use of meso indicators for a CE monitor was developed for the system of 'mobility' and 'consumer goods' (Alaerts et al., 2019; Reich et al., 2022). A CE assessment, whether it is regional or national, should include all major systems that are parts of our economy, such as housing, mobility, consumer goods, and food, and the system-specific meso indicators are crucial to address features that are inherent to a specific CE system.

Food systems today face the triple challenge of needing to provide sufficient food while ensuring fair livelihoods and contributing to environmental sustainability (OECD, 2021). Consequently, assessment strategies within the food system mostly focus on the triple bottom line (TBL) approach to monitor sustainability impacts (including economic, social, and environmental issues) (Silvestri et al., 2022). Although there is a close connection between sustainability and circularity, CE indicators should monitor the food system with the aim of preserving functions, products, components, materials, or embodied energy, while using the linear economy as a reference scenario (Moraga et al., 2019). Also, previous research on CE monitoring has prioritized the assessment of abiotic rather than biotic resources (Navare et al., 2021). The biological cycles, containing the flows of renewable biotic resources moving in and out of the biosphere (Navare et al., 2021), are an important part of the food system, and require specific attention while monitoring the CE for food.

When defining a set of (CE) indicators, a thorough understanding of the market and policy environment is necessary (Van Schoubroeck et al., 2020). There are two approaches to select indicators: a literature review and a participatory approach (Mascarenhas et al., 2015). Poponi et al. (2022) started focusing on the biotic system by performing a literature review to develop a dashboard of 102 CE indicators specifically for the agri-food sector. However, policy-makers need to pay attention to spatial and cultural considerations affected by CE implementation, which can better be assessed by applying a regional and participatory approach, going beyond the use of document analysis and literature review (Avdiushchenko, 2018). Design validation of the selected indicators can be increased by using expert judgements for their selection (Bockstaller & Girardin, 2003). Therefore, the present study was applied to the region of Flanders (Belgium) and experts were involved in drafting a vision and selecting indicators to monitor a CE for food. The region of Flanders in Belgium made for a good case study as it has the stated ambition of having a circular economy by 2050 (Flemish Government, 2016). The participatory approach and methods used within this study can be applied to other regions as well.

A well-known participatory approach for vision-building is the Delphi method, which involves experts in defining a shared vision and selecting relevant indicators. The Delphi method is "used to obtain the most reliable consensus of a group of experts by a series of intensive questionnaires interspersed with controlled feedback" (Dalkey & Helmer, 1962). Previous studies have used the Delphi for vision-building and indicator selection (Rikkonen et al., 2019; Van Schoubroeck et al., 2019), also within the field of the CE (de Jesus et al., 2019; Gebhardt et al., 2022; Padilla-Rivera et al., 2021). Padilla-Rivera et al. (2021) used the Delphi method in previous CE research to select social circularity indicators. They highlighted the advantage of documenting the various considerations in a decision-making process in a CE context. Within this paper, the Delphi method will be applied to the circular food system, using a regional approach.

3. Method

The Delphi method was initially developed by the RAND Corporation in the United States to obtain a consensus of a group of experts (Dalkey & Helmer, 1962). It is an iterative process that allows anonymous interaction between experts by gathering opinions and creating follow-up rounds based on these opinions (Okoli & Pawlowski, 2004). The aim of the current Delphi study was twofold. On one hand, it was used to involve the expertise of a wide set of stakeholders in Flanders to define a vision for a CE for food. On the other hand, it was used to identify relevant indicator themes to monitor the food system. To gather this information on circularity within the food system in Flanders, a two-round Delphi study was constructed. In the first round, open-ended questions were asked, which allowed for unlimited response and delivered new insights. In a second round, closed questions were constructed following a best–worst scaling format. The best–worst scaling (BWS) technique is a choice modelling technique, asking respondents for the 'best' and 'worst' options in a subset of options. By using the BWS approach, scaling interpretation problems of traditional rating scales (such as the Likert scale) will be avoided, and discrimination will be provoked between the indicator themes (Finn and Louviere, 1992; Lee et al., 2008). Both Delphi questionnaires were created using Qualtrics Software (Qualtrics, Provo, UT) and were distributed by e-mail to experts. The full questionnaire can be found in Supplementary Information (SI).

A circular food system should minimize the material and associated environmental impacts over the entire life cycle. This requires both the production and processing stage and the consumption stage (including waste management) to be part of a circular food system (Jurgilevich et al., 2016). To encompass both of these aspects, a diverse group of stakeholders was required, not all of whom could be expected to possess knowledge on every individual stage of the value chain. In order to gather sufficient expertise within the region of Flanders, the Delphi study presented in this paper addressed both stages separately to allow participants to respond there where their expertise applies most. This distinction between the production and consumption stage will be maintained throughout the present paper.

3.1 Delphi round 1: Brainstorm

In the first Delphi round, two open-ended questions were asked (in Dutch) to obtain experts' opinions on circularity for food in Flanders. The first was: "Describe (in full sentences or keywords) what a circular food system in Flanders looks like to you: (a) in terms of 'production and processing', and (b) in terms of 'consumption'." This first question is referred to hereafter as the 'vision' question. The second question was: "Which indicators should be measured to monitor circularity in the Flemish food system? (a) in terms of 'production and processing', and (b) in terms of 'consumption'." This question is further referred to as the 'indicator theme' question.

In Delphi studies, a minimum of 12 respondents is considered to be sufficient to enable final consensus among experts (Vogel et al., 2019). However, the final validity of the results will depend largely on group dynamics, and sample sizes might vary depending on the scope of the study. The first Delphi round was sent to 138 individual experts from 54 unique organizations in Flanders (Belgium). In total, 52 responses were obtained from 36 organizations. The respondents had to indicate whether they had sufficient expertise in 'production and processing' or/and 'consumption' or/and the 'circular economy'. Forty-nine respondents had sufficient expertise in both 'production and processing' and 'consumption'. Two respondents were categorized as having only expertise in one of the two; one in 'production and processing' and another in 'consumption'. One respondent was removed from the survey due to a lack of expertise. The remaining 51 experts from 35 organizations were divided into four different stakeholder categories: research and education (n=14), governmental bodies (n=19), sector federations and commercial organizations (n=9), and non-profit organizations (n=9). The group of experts includes 20 males and 31 females, most of whom hold a master's or a doctoral degree (n=48). Open coding was used to analyze the answers given by the experts in the first Delphi round. The open coding method is used for qualitative data analysis by identifying 'codes' or 'keywords' to attach underlying concepts to the observed data (Strauss & Corbin, 1998).

3.2 Delphi round 2: Best–worst scaling

For the second Delphi round, a total of 19 subsets, each featuring four indicator themes, were constructed and shown to each participant. The respondents had to indicate which indicator themes they considered as the 'most' and the 'least' relevant to evaluate the CE of the Flemish food system for both 'production and processing' and 'consumption'. The experimental design of the BWS exercise was created using the Sawtooth Software (SSI Web platform). Each indicator theme appeared the same number of times and there was a positional balance within the subsets, which made the design orthogonal. Three different versions were created and randomly assigned to the same participants who provided their expertise in the first Delphi round.

A total of 40 different experts responded to the second Delphi round (that is, a response rate of 77 percent). The experts were again divided into four different stakeholder categories: research and education (n=10), governmental bodies (n=15), sector federations and commercial organizations (n=7), and non-profit organizations (n=8). Thirty-eight respondents had expertise in both 'production and processing' and 'consumption'. Of the two other respondents, one had expertise in 'production and processing' and the other in 'consumption'.

The BWS choices were analyzed using the Hierarchical Bayes (HB) method from Sawtooth Software to estimate the preference scores towards each indicator theme, for each respondent. HB is a "data borrowing" technique, stabilizing part-worth estimates for each individual borrowing information from other respondents within the same data set (Sawtooth Software, 2009). Next, a consensus ranking of indicator themes was derived by calculating the average utility scores of the indicator themes, across all the respondents. An overview of the full research procedure of the Delphi study is provided in Figure 1.

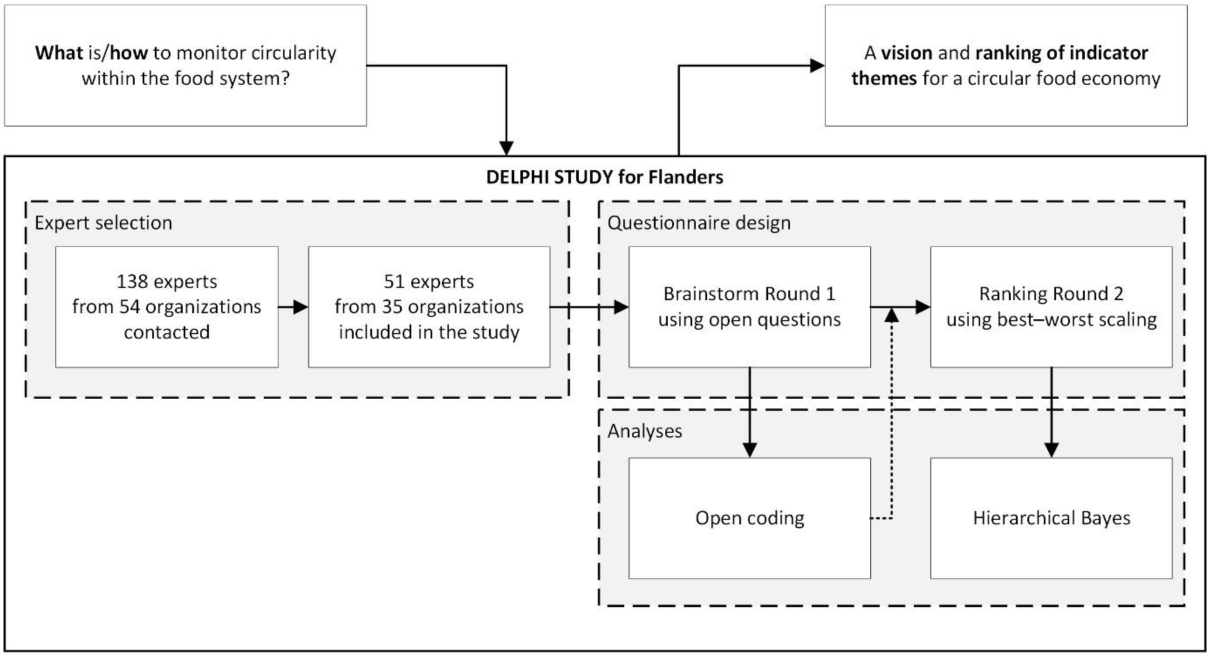


Figure 1. Research procedure of the Delphi study

4. Results

The Delphi study was comprised of two rounds, where the results of the first round were used as input for the second round. In the first Delphi round, the respondents were asked two main questions: one general question regarding their vision towards a CE for the food system, and another question regarding the indicators that are necessary for its monitoring. Both questions were divided into a subsection for the 'production and processing' phase and a subsection for the 'consumption' phase of the food system. The information derived from the first Delphi round was used to identify the key aspects that should be included in a CE monitor for food. In the second Delphi round, a consensus ranking of indicator themes was developed, showing their relative importance.

4.1 Results, Delphi Round 1

An overview of the results of the coding procedure, for both 'production and processing' and 'consumption', is provided in Figure 2 and Figure 3, respectively. Seven main areas of focus were identified: the 'use of inputs' (at the production and processing stage), 'consumption pattern' (at the consumption stage), 'residual streams', 'logistics', 'environmental impact', 'innovation', and 'others' (with relatively small subcategories 'policy', 'system boundaries', 'economic feasibility', and 'social inclusion'). Figure 4 and Figure 5 show how the keywords, defined by the coding analysis, are divided over the different respondents for both the 'vision' and 'indicator theme' questions. Note that when a code was used multiple times in a respondent's answer, it was only counted once. For most keywords, similar frequencies of coding were noticed for both 'vision' and 'indicator theme'. However, the frequencies were lower when identifying indicators, especially at those themes when difficulties regarding their quantification would be suspected.

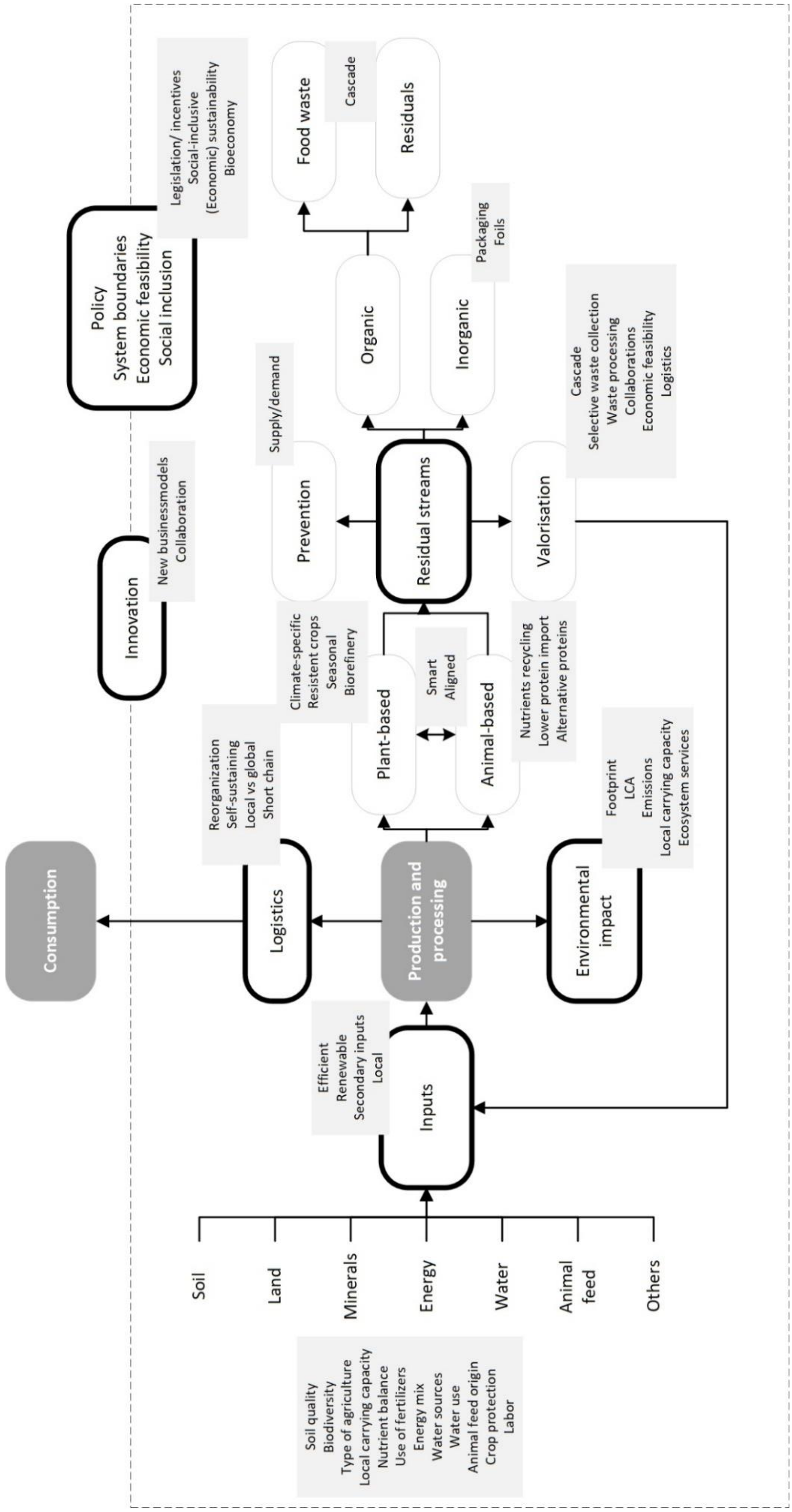


Figure 2. Schematic overview of responses to the 'vision' question using keywords for 'production and processing'.

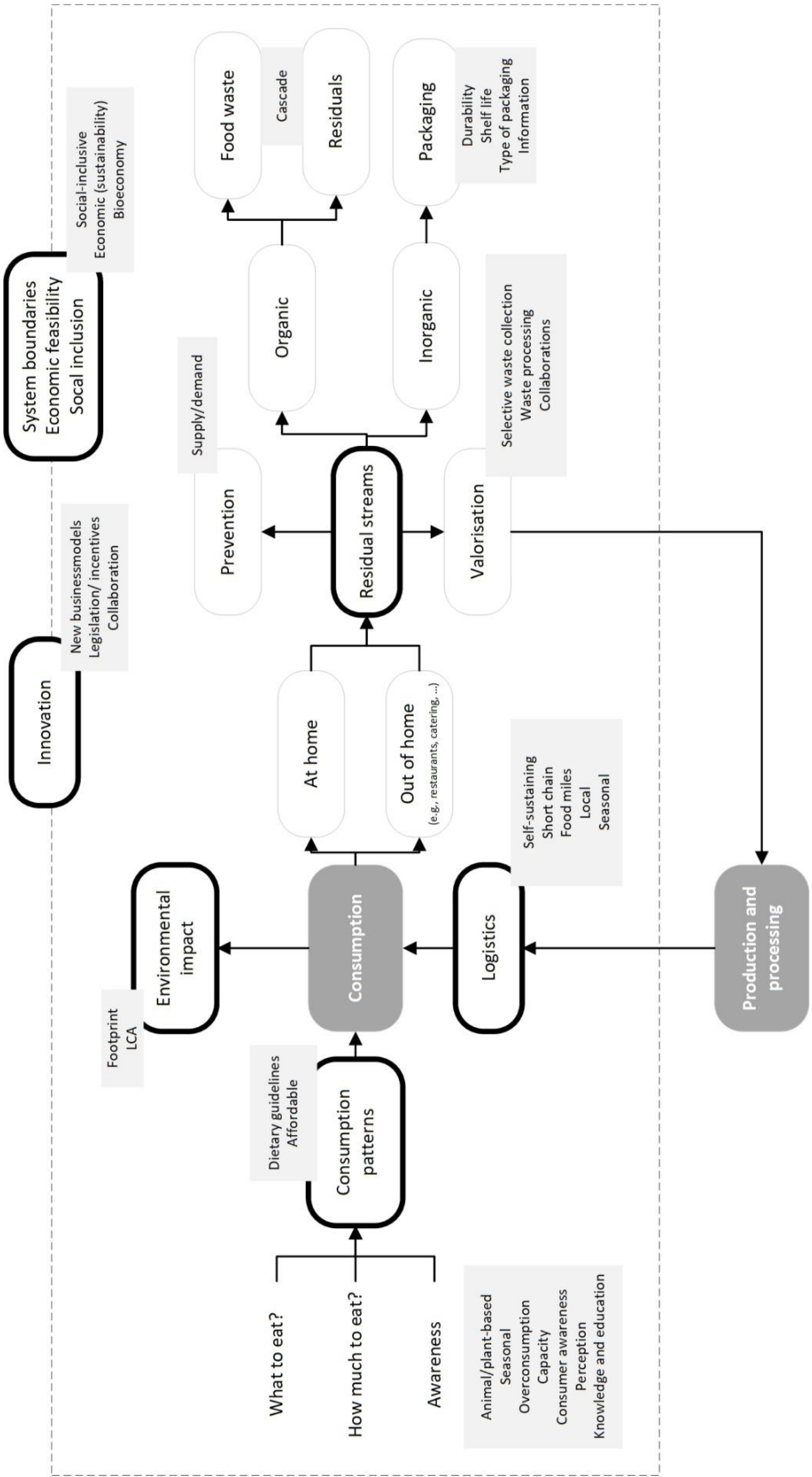


Figure 3. Schematic overview of responses to the ‘vision’ question using keywords for ‘consumption’.

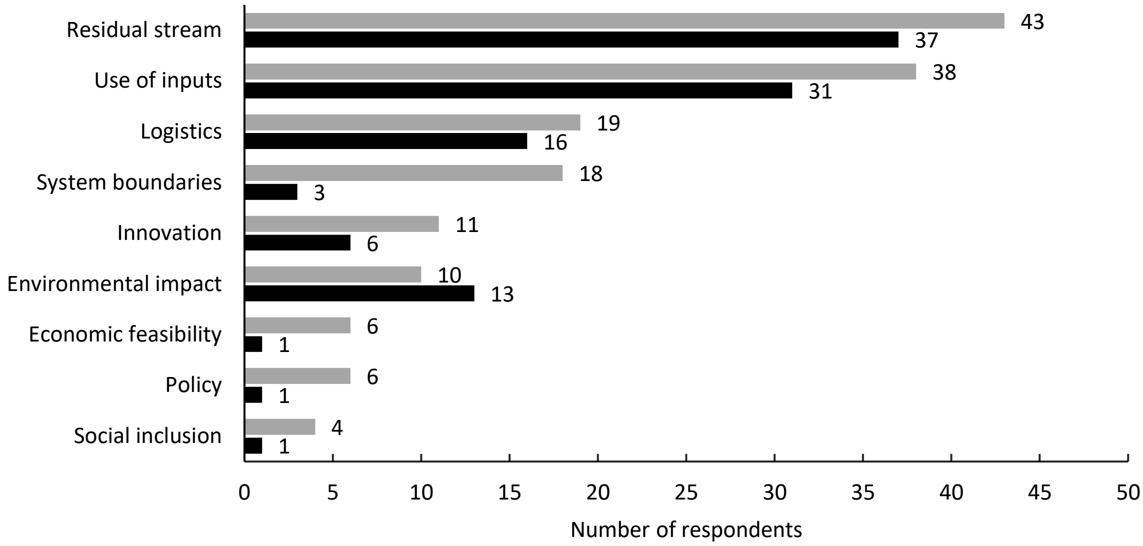


Figure 4. Coding frequency in Delphi Round 1, based on the 'vision' (in grey) and 'indicator theme' (in black) questions for production and processing. Total respondents = 50.

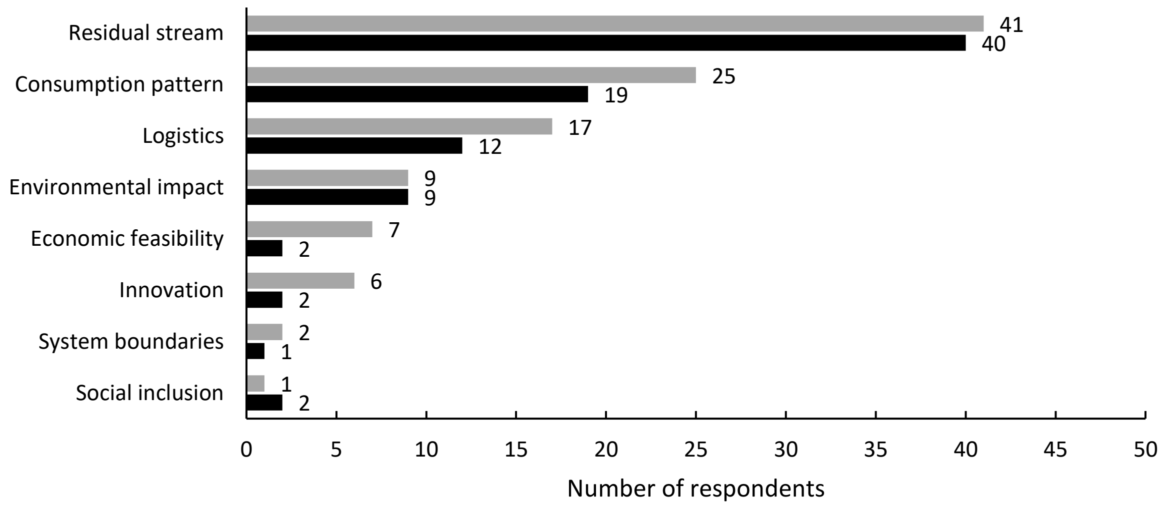


Figure 5. Coding frequency in Delphi Round 1, based on 'vision' (in grey) and 'indicator theme' (in black) question for consumption. Total respondents = 50.

The keyword *'residual streams'* was discussed by 43 out of 50 respondents for 'production and processing' and by 41 out of 50 respondents for 'consumption', making this the most mentioned keyword by the experts. For the production and processing stages, these residual streams could be divided into organic (that is, food waste) and inorganic (mostly concerning packaging) waste. The organic residual stream was emphasized as a key aspect to be dealt with in the CE. Both prevention and valorization were mentioned, with the cascade of value retention as an important guide towards the hierarchical use of waste (Braekevelt et al., 2020; Lansink, 1979). At the consumption stage, experts focused on the organic waste stream resulting from both edible and inedible biomass. Prevention and valorization are key areas to consider, both at the household level and in the hospitality industry. Respondents emphasized that the collection and processing of this waste play a major role in the establishment of an efficient waste management system. The more selectively a stream can be collected, the better it can be repurposed. Through the development of new processes in bio-refineries, more and more high-level valorization pathways become available for residual streams. Novel processes could, for example, allow for the recovery of nutrients for human consumption from residual streams that are inedible (Van Zanten et al., 2019).

The *'use of inputs'*, a keyword specifically identified at the production and processing stage, was mentioned by 38 out of 50 respondents. They either discussed the use of inputs in general, with keywords such as 'renewable inputs', 'sustainable inputs', and 'efficiency', or they mentioned the use of specific inputs, for which six input-groups were identified*:* 'land-use', 'water', 'energy', 'soil', 'minerals', and 'animal feed'. Important concerns within these groups are the type of agriculture (that is, intensive versus extensive farming), water sources, soil quality, the use of (synthetic) fertilizers, animal feed origin, and a safe labor environment. In general, inputs can be optimized by examining what products are produced and how they are produced. 'What is produced' comes down to the choice of product (and amount), while 'how it is produced' comes down to the choice of production method.

Specifically at the consumption stage, 25 out of 50 respondents mentioned the importance of the *'consumption pattern'*. In a CE, the nutritional need of citizens should be met with a balanced and healthy diet, while minimizing the material input and associated impacts. This can be achieved by minimizing food waste and surplus consumption and shifting diets towards low-impact food choices.

'Logistics' was mentioned as being an essential part of the food value chain for both 'production and processing' (by 19 out of 50 respondents) and 'consumption' (by 17 out of 50 respondents). According to the experts, striving for a CE could entail a reorganization of transport, shorter food supply chains, and more local production and processing, which must go along with a reduction of the environmental footprint. Regarding consumption, an improvement of the logistics to foster a CE is often associated with a seasonal and local supply of food for the consumers, which is directly linked to the consumption patterns they follow. Again, these local supply chains could only benefit from a CE when positive impacts on the environment and economy can be achieved. By producing products when the circumstances are opportune, input requirements can be lowered, while the impact from transportation is minimized.

'Innovation' was mentioned by 11 respondents for 'production and processing' and by six respondents for 'consumption'. Innovation can entail new business models, innovative production methods, and new collaborations among stakeholders. The digital economy presents opportunities to use data for smarter input use or to better align supply and demand. For example, an extension of the food's shelf life or smart data management systems to better align supply and demand can both contribute to a CE, and are closely linked with the prevention of food waste. In general, transitioning the food system to a CE could make use of technological innovation to optimize current cycles, but also product, market, and organizational innovation that can adapt and improve the size of current cycles within the limits set by the planetary boundaries (Coudel et al., 2013). New business models at the consumption stage can be developed, for example, in the hospitality sector, concerning the prevention of food waste (such as zero-waste products), the establishment of local collaborations, and a renewed focus on food quality (versus quantity). New revenue models can contribute to the creation of profitable business cases for circular food.

The *'environmental impact'*, mentioned by 10 respondents for 'production and processing' and nine for 'consumption', is a unique keyword in the sense that it deals with the impact of the system, whereas the other keywords are related to the processes itself. Closing product life cycles should benefit the global environment and lower emissions (such as nitrate and carbon emissions). For example, the use of fertilizers in agriculture is a major contributor to the disruption in the biogeochemical cycles of nitrogen and phosphor, for which the safe operating space set in the planetary boundary framework has already been surpassed (Steffen et al., 2015). Considering the total life cycle of a food product, the consumption and end-of-life phases also hold some environmental concerns. This is related to the ability of consumers to make environmental-friendly choices, which is linked to transparent product information, such as through labels and packaging. However, to provide adequate product information concerning a 'circular product', a CE for food should be more clearly defined. In general, the environmental impact should be minimized over the entire value chain, while maximizing yield and profits (that is, economic gains) and/or social aspects.

Four remaining categories were identified because it was difficult to position them in the six categories above; these new categories were *'policy'*, *'system boundaries'*, *'economic feasibility'*, and *'social inclusion'*. The discussion on 'system boundaries' was addressed in 18 out of 50 responses within the production and processing stage. The system boundaries refer to the temporal and spatial systems that are included when assessing a CE. When these boundaries are widened, collaborations between multiple sectors and regions become possible. System boundaries are difficult to define for a CE for food because the food system is closely entwined with that of the wider bio-economy. Furthermore, the food system is currently very globalized, raising questions among some stakeholders regarding whether circles should be closed at the regional, national, European, or international level. The other categories – 'policy', 'economic feasibility', and 'social inclusion' – are all related to the notion that the transition to a CE should be a fair and inclusive one, using effective policy incentives to stimulate circular production and processing, and consumption

4.2 Results, Delphi Round 2

Based on the answers provided in Round 1 on both 'vision' and 'indicator theme' questions, a list of indicator themes was constructed to monitor the circular economy of the food system in Flanders. Table 1 shows this list of indicator themes and adds a short definition to all themes that was used to better inform the respondents in the second Delphi round.

Table 1. List of indicator themes

	Indicator theme	**Definition**
Production and processing	Land use	The use of land: amount (e.g., for plant- or animal-based food) and management (e.g., intensive or extensive use)
	Soil	The use of soil as input (including soil fertility, soil biodiversity, etc.)
	Minerals	The composition and (re)use of minerals and the losses to the environment (including nitrogen, phosphorous, potassium, and other trace elements)
	Energy	Source and (re)use of energy
	Animal feed	Origin, composition, and use of animal feed
	Water	Source and (re)use of water
	Food loss	Food loss (edible) such as food surpluses on the land and food losses in the industry, retail, and auctions: amount and (cross-sectoral) reuse concerning waste collection and processing, taking into account the cascade of value retention
	Residues	Residues (non-edible) such as surpluses on the land and losses in the industry: amount and (cross-sectoral) reuse concerning waste collection and processing, taking into account the cascade of value retention
	Industrial packaging and other waste streams	Industrial packaging and other waste streams (e.g., foils and rock wool) in the production and processing of food: origin, use and (cross-sectoral) reuse concerning waste collection and processing
	Logistics and transport	Logistics and transportation in the production and processing of food: logistics organization (e.g., central or decentralized), food miles, and its final destination (local, national, European, or international)

	Innovation	Product and process innovation in the production and processing phase of food, like the design of products (e.g., concerning durability), digitalization, and new processes concerning end-of-life
Consumption	Food loss	Food loss (edible) at households and the hospitality industry: amount and reuse concerning waste collection and processing, taking into account the cascade of value retention
	Residues	Residues (non-edible) at households and the hospitality industry: amount and reuse concerning waste collection and processing, taking into account the cascade of value retention
	Consumer packaging	Packages used at the consumption stage: origin, use and reuse concerning waste collection and processing
	Price	Price (trends) of circular food, considering the environmental and/or social costs and the affordability of circular food
	Education and product knowledge	Knowledge of circular food: education, awareness, transparency and knowledge sharing, through e.g., labels and packaging
	Innovation	Innovative business models for a circular economy concerning consumption (e.g., new revenue models)
	Consumption pattern concerning origin	The share of local and seasonal food in consumption patterns, considering food miles
	Consumption pattern concerning diet	The share of animal- versus plant-based food, healthy food (e.g., 'Nutri-score' or food triangle), and overconsumption

Table 2 and Table 3 represent the outcome of the second Delphi round. The best–worst scaling (BWS) exercises were analyzed using HB regression. All the respondents reached a fit statistic, a Root Likelihood, higher than a minimum of 0.25, showing that the respondents were consistent while assessing the indicator themes (Sawtooth Software, 2009). The second column shows the average results of the HB analysis. These HB scores are rescaled preference scores, showing the average preference of the experts towards a certain indicator theme. The third and fourth columns represent a counting analysis, which calculates the proportion at which an indicator is picked as the most and the least relevant. For example, the indicator theme 'food loss' was shown a total of 156 times to all respondents, and chosen 86 times as 'most relevant' in a choice set, which represents a best-count proportion of 0.55. 'Logistics and transport', also shown 156 times to all respondents, was selected 71 times as the 'least relevant' theme, and therefore has the highest worst-count proportion (0.46) of all indicator themes selected for 'production and processing'.

Table 2. Best–worst scaling results for 'production and processing'. Total respondents = 39. HB = Hierarchical Bayes.

Indicator theme	**Average HB scores**	**Best-count proportion**	**Worst-count proportion**
Food loss	19.19	0.55	0.05
Residues	14.37	0.42	0.13
Water	12.53	0.31	0.08
Minerals	10.72	0.27	0.12
Soil	10.18	0.32	0.25
Industrial packaging and other waste streams	6.36	0.15	0.34
Energy	6.19	0.16	0.29
Land use	6.15	0.21	0.39
Innovation	5.95	0.17	0.35
Animal feed	4.31	0.07	0.29
Logistics and transport	4.05	0.12	0.46

Table 3. Best–worst scaling results for 'consumption'. Total respondents = 39. HB = Hierarchical Bayes.

Indicator theme	Average HB scores	Best-count proportion	Worst-count proportion
Food loss	27.19	0.57	0.03
Consumption pattern concerning diet	18.51	0.43	0.21
Consumption pattern concerning origin	17.30	0.37	0.15
Residues	9.68	0.16	0.29
Innovation	7.17	0.12	0.29
Price	7.06	0.13	0.40
Consumer packaging	6.93	0.09	0.32
Education and product knowledge	6.15	0.12	0.31

Based on the average HB preference scores, the five most relevant indicators for production and processing are 'food loss', 'residues', 'water', 'minerals', and 'soil'. 'Animal feed' and 'logistics and transport' were considered the least relevant indicator themes. For the consumption category, 'food loss' was again the clear winner in the ranking, followed by the indicator themes concerning consumption patterns on diet and origin. 'Consumer packaging' and 'education and product knowledge' are ranked at the bottom for the consumption category. However, it is important to note that the indicator themes are scaled relative to one another and should be interpreted as such. For example, for production and processing, the indicator theme 'food loss' is considered almost five times as relevant as 'logistics and transport' to assess the CE of food in Flanders. It is not the aim of this BWS experiment to provide an absolute ranking of indicator themes. Even though the experts considered 'food loss' more relevant than 'logistics and transport', this would never imply that 'logistics and transport' is irrelevant to assess towards a CE. All the indicator themes in Table 2 and Table 3 were initially mentioned by the experts in the first Delphi round as being part of a circular economy for the Flemish food system.

The 38 respondents who had expertise in both 'production and processing' and 'consumption' were also asked to assess the relevance of 'production and processing'-related indicator themes compared to 'consumption'-related themes. Thirty out of 38 experts indicated that both categories were equally important. Five of the 38 voted for 'production and processing'-related indicators, and three voted for 'consumption'-related indicators.

5. Discussion

5.1 A vision for a circular economy for food

Based on the results of the first Delphi round, a vision for a CE for food in Flanders is developed in this discussion section. By applying the Delphi approach, it was possible to gather existing expertise on circularity and food in Flanders over multiple policy domains. The Delphi approach allows all stakeholders to be heard in an equal format, giving each expert an equal opportunity to share their vision. The Delphi allows for experts' independent thought, as it is an anonymous process that does not require proximity or face-to-face meetings (Dalkey & Helmer, 1962). Through the open coding process, the captured expertise was turned into a vision statement. All the information provided by the experts on the defined keywords was further examined, both on consensus and diverging arguments.

The resulting 'landscape' reveals that a circular food economy (CFE) aims to optimize the use of inputs, end products, and residual streams. A CFE aims to minimize the environmental impacts associated with the food system and decrease the resource dependency of the region, while still fulfilling the demand for food. The entire food system should remain within the boundaries of a safe operating space for humanity. A CFE should enhance food security and food safety and optimize trade-offs between economic and environmental impacts. In order to achieve a CFE in Flanders, transparency, flexibility, social inclusion, and innovation are key areas of improvement to encourage circular thinking in the food system, and stimulate cooperation between value chain actors. In addition, logistics should be optimized, matching supply and demand.

When optimizing the use of inputs, efficiency in use and sourcing of materials are crucial. More efficiency can decrease total input use and the required inputs should come from sustainable sources. Furthermore, it must be ensured that the loss of inputs to the environment does not have adverse effects on ecosystems. Which inputs are required, and in what volume, is determined by what is produced, how much of it is produced, and which production system is used. Finding a healthy balance between plant-based and animal-based production in Flanders is key, and both production systems should be smartly aligned to optimally use each other's residual streams as inputs.

When considering optimizing the use of food products, consumption patterns play a major role. Decisions regarding what is eaten and how much are influenced by consumer awareness. By tackling excesses in consumption patterns, like overconsumption and food loss, diets become less resource-intensive. Knowledge dissemination and education are key strategies in addressing current consumption patterns in the food system.

When considering optimizing the use of residual streams, a CFE in Flanders systematically closes material and energy cycles, within and across value chains. All residual streams generated during production, processing, and consumption, should be maximally prevented or otherwise valorized as secondary resources, within or across sectors, according to the cascade of value retention (that is, keeping its material value as high as possible). Here, collaborations between actors and selective collection are key.

The experts discussed the importance of 'local production' for a CFE. Some stakeholders highlighted the importance of self-sufficiency, short chains, and food miles, while others pointed to a rather limited share of transport in the final environmental impact of food products and the advantages of producing certain products in certain locations (seasonality). Additional research performing environmental life cycle analysis and a face-to-face round table with experts from multiple policy domains, could benefit further consensus building among all stakeholders.

5.2 Sustainability of circularity

The progress towards a circular system is interlinked with that of a sustainable system (Walzberg et al., 2021). Food systems today face a triple challenge of needing to provide sufficient food while ensuring fair livelihoods and contributing to environmental sustainability (OECD, 2021). Béné et al. (2019) described a sustainable food system as paying attention to "diet quality and nutrition, the environmental 'food print' (i.e. the environmental impact) of production and distribution of food commodities, and the socioeconomic imprints of supply chains" (Béné et al., 2019). The definition of a CE is focused on the minimization of the material footprint, aiming to reduce environmental impacts and moving away from a linear economy (Alaerts et al., 2019). Circularity in and of itself does not ensure sustainability (including social, economic, and environmental performances) (Walzberg et al., 2021). Previous research showed that a CE is perceived as a necessary condition for sustainability, a beneficial relationship, but also a trade-off (Geissdoerfer et al., 2017). In other words, the relationship between the concepts is not made explicit, which makes it difficult to define their system boundaries.

Based on the suggested CFE vision defined in this study, overlap with a sustainable system can be noted as economic, social, and environmental aspects were all mentioned by the Delphi participants. Future research could explore their relations and broaden the indicator themes defined in this study to cover both circularity and sustainability, moving to a sustainable CFE.

5.3 Preference heterogeneity

Four different stakeholder categories were defined in the Delphi study (research and education, governmental bodies, sector federations and commercial organizations, and non-profit organizations). It would be interesting to investigate whether the preferences of experts, analyzed after the second Delphi round, differ based on the category they belong to. However, when the sample size per category is smaller than 10, the HB analysis can have difficulty distinguishing between heterogeneity and error. For that reason, a separate HB analysis to derive four different rankings per stakeholder category was not performed. Additional research with a larger sample size would be necessary.

However, a more indirect way to find differences between the stakeholder categories is a "natural" segmentation analysis. In this way, one can examine whether there is within-group homogeneity of various groups. A latent class analysis can be used for this purpose (Goodman, 1974; Little et al., 2021). A latent class estimation process starts by selecting random estimates of each group's utility values (Sawtooth Software, 2012). The estimated group's utilities are then used to fit each respondent's data and estimate the relative probability of each respondent belonging to that group. These probabilities are then used as weights to re-estimate the logit weights for each group. This is an iterative procedure that continues until the log-likelihood over all groups fails to improve significantly. The latent class estimation procedure leads to a "natural" segmentation and can indicate the preference heterogeneity among the identified stakeholder categories. Four groups were defined by the latent class analysis that have similar preferences regarding the provided indicator themes. Table 4 and Table 5 provide an overview of the preference scores for each segment. Table 6 and Table 7 provide an overview of the number of experts within a stakeholder category that belong to a defined group.

Table 4. Preference scores for 'production and processing' within each group, analyzed using latent class analysis. Total respondents = 39.

Indicator themes	**Latent class analysis – Rescaled scores***			
	Groups			
	1	**2**	**3**	**4**
Food loss	13.73	21.37	15.41	19.06
Residues	1.04	22.10	18.44	10.80
Water	16.70	7.19	19.59	9.92
Minerals	3.79	8.82	5.75	17.96
Soil	8.72	1.88	10.90	19.31
Industrial packaging and other waste streams	13.75	13.38	2.04	1.16
Energy	8.17	3.12	18.16	3.01
Land use	16.04	2.48	0.71	10.06
Innovation	6.82	8.36	2.75	3.03
Animal feed	0.99	5.25	4.23	4.89
Logistics and transport	10.26	6.03	2.00	0.80

* These preference scores are calculated differently compared to the HB preference scores. Latent class provides a discrete model of respondent heterogeneity, whereas HB assumed a continuous model of heterogeneity following a multivariate normal distribution (Sawtooth Software, 2012).

Table 5. Preference scores for 'consumption' within each group, analyzed using Latent Class analysis. Total respondents = 39.

Indicator themes	Latent class analysis – Rescaled scores*			
	Groups			
	1	2	3	4
Food loss	21.81	29.43	29.74	16.56
Consumption pattern concerning diet	27.33	0.70	28.58	3.53
Consumption pattern concerning origin	21.71	9.60	9.41	32.24
Residues	1.25	23.97	14.31	2.57
Innovation	6.17	18.04	4.02	3.91
Price	13.61	0.42	3.69	11.05
Consumer packaging	1.04	10.62	7.96	13.75
Education and product knowledge	7.07	7.23	2.29	16.40

* These preference scores are calculated differently compared to the HB preference scores. Latent class provides a discrete model of respondent heterogeneity, whereas HB assumed a continuous model of heterogeneity following a multivariate normal distribution (Sawtooth Software, 2012).

Table 6. Distribution of different stakeholder categories in the four defined groups for 'production and processing'.

Stakeholder category				
	Groups			
	1	2	3	4
Research and education	2	3	2	3
Governmental bodies	1	5	1	7
Sector federations and commercial organizations	2	2	2	1
Non-profit organizations	0	3	2	3
Total experts in a group	5	13	7	14

Table 7. Distribution of different stakeholder categories in the four defined groups for 'consumption'.

Stakeholder category				
	Groups			
	1	2	3	4
Research and education	2	2	6	0
Governmental bodies	7	3	4	1
Sector federations and commercial organizations	1	1	1	3
Non-profit organizations	2	2	2	2
Total experts in a group	12	8	13	6

For 'production and processing', the respondents seem to be quite evenly divided over the different groups, taking into account the group sizes and the number of experts belonging to a certain stakeholder category. For 'consumption', it can be noted that relatively more stakeholders from governmental bodies are represented in Group 1 and more stakeholders from research and education in Group 3. On average, governmental stakeholders have a higher preference for 'consumption pattern concerning origin', while 'food loss' is considered more important by academic stakeholders. The scoring numbers cannot be compared with the general preference scores in Table 2 and Table 3 because they are based on different types of analysis. In order to report on the differences between the general ranking and the identified groups, the rank positions should be compared. For Group 1, higher preferences were noted towards 'consumption pattern concerning diet' and 'education and product knowledge' than the average HB preference ranking, while less preference was given to ‘residues’. Compared to the average HB preference ranking, Group 3 has a higher preference towards the indicator themes ‘residues’ and ‘consumer packaging’, while the ‘consumption pattern concerning origin’ is moved to a lower-ranking position.

5.4 Limitations

This study focused on drafting a first vision for a CFE in Flanders and selected and prioritized indicator themes for its monitoring. However, we did not identify specific sub-indicators that can be calculated within those identified themes. Future research is particularly important to create a practical CE monitoring tool, where the CFE in a certain region (such as Flanders) can be assessed. Examples of food indicators matching the identified indicator-themes are water use, energy consumption, land use, total consumption, shifts to plant-based diets, etc. The selection and quantification of these indicators will be dependent on data availability, data quality, and their relevance within an indicator theme. The prioritization of indicator themes within the present study can be used as the foundation for future research on specific indicator selection at the meso level. Also, the results of this paper are relevant to the food system within the region of Flanders, so they cannot be directly extrapolated to other CE systems and regions. Nevertheless, the methodological approach applied within this study can be used for vision drafting and indicator selection in other CE systems and regions where needed.

6. Conclusions

Within the present study, a vision has been drafted for a CFE and indicator themes have been selected to assess the progress towards circularity. A two-round Delphi study was performed including a brainstorm and the construction of a consensus ranking of indicator themes. The first Delphi round resulted in the development of a shared vision of what is important to a CFE according to a variety of experts, and also a list of indicator themes that were necessary according to the experts to assess a CE for food. Next, these indicator themes were ranked using best–worst scaling (BWS) exercises, asking the respondents to indicate the most and least relevant indicator themes in a given subset.

In general, this Delphi study shows how the experts reflect upon a CFE, and which key indicator themes should be present for its monitoring. A CFE should optimize the use of inputs, end products and residual streams. All three elements are part of the vision statement of a CE for food, based on which indicators to monitor the transition towards a circular economy should be selected. The BWS experiment concluded that, for the entire value chain of food, ‘food loss’ is the number-one indicator theme to assess when promoting a CFE. For the production and processing stage, this is followed by ‘residues’-related indicators, and for the consumption stage by ‘consumption patterns’.

A concrete and scientifically substantiated approach was followed to provide a blueprint for researchers and policy-makers on the monitoring of a CFE, which will stimulate the progression from a linear to a circular food system. Future research should consider the Delphi results when new CFE progress indicators are developed and data are collected. In addition, the same research approach should be used within other policy domains, also outside the CE, to define a shared vision, select indicators, and to create stakeholder support for value-loaded policy topics.

7. Credit authorship contribution statement

Sophie Van Schoubroeck: Conceptualization, Methodology, Expert selection, Open coding analysis and Best-worst scaling analysis, Writing – full article and review. Veerle Vermeyen: Conceptualization, Expert selection, Open coding analysis, Writing – full article and review. Luc Alaerts: Conceptualization, Expert selection, Writing – review and editing, Project administration. Karel Van Acker:

Conceptualization, Supervision, Writing – review and editing. Steven Van Passel: Conceptualization, Expert selection, Supervision, Writing – review and editing.

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9. References

Alaerts, L., Van Acker, K., Rousseau, S., De Jaeger, S., Moraga, G., Dewulf, J., De Meester, S., Van Passel, S., Compernolle, T., Bachus, K., Vrancken, K., & Eyckmans, J. (2019). Towards a more direct policy feedback in circular economy monitoring via a societal needs perspective. *Resources, Conservation and Recycling*, *149*(November 2018), 363–371. https://doi.org/10.1016/j.resconrec.2019.06.004

Avdiushchenko, A. (2018). Toward a Circular Economy Regional Monitoring Framework for European Regions: Conceptual Approach. *Sustainability*, *10*(12), 4398. https://doi.org/10.3390/su10124398

Bansard, J., & Schröder, M. (2021). The Sustainable Use of Natural Resources. In *Still One Earth policy brief series*.

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., de Haan, S., Prager, S. D., Talsma, E. F., & Khoury, C. K. (2019). When food systems meet sustainability – Current narratives and implications for actions. *World Development*, *113*, 116–130. https://doi.org/10.1016/j.worlddev.2018.08.011

Bockstaller, C., & Girardin, P. (2003). How to validate environmental indicators. *Agricultural Systems*, *76*(2), 639–653. https://doi.org/10.1016/S0308-521X(02)00053-7

Braekevelt, A., Vanaken, N., & Roels, K. (2020). *Actieplan voedselverlies en biomassa-(rest)stromen circulair 2021-2025: Vol. D/2020/502*.

Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O. J., Hauser, H.-E., van Holsteijn, F., Liu, G., Östergren, K., Parry, A., Secondi, L., Stenmarck, Å., & Sala, S. (2019). Food waste accounting methodologies: Challenges, opportunities, and further advancements. *Global Food Security*, *20*, 93–100. https://doi.org/10.1016/j.gfs.2019.01.002

Coudel, E., Devautour, H., Soulard, C. T., Faure, G., & Hubert, B. (2013). *Renewing innovation systems in agriculture and food*. Wageningen Academic Publishers. https://doi.org/10.3920/978-90-8686-768-4

Dalkey, N., & Helmer, O. (1962). *An Experimental Application of the DELPHI Method to the Use of Experts*.

de Jesus, A., Antunes, P., Santos, R., & Mendonça, S. (2019). Eco-innovation pathways to a circular economy: Envisioning priorities through a Delphi approach. *Journal of Cleaner Production*, *228*, 1494–1513. https://doi.org/10.1016/j.jclepro.2019.04.049

European Commission. (2020a). *Circular Economy Action Plan*.

European Commission. (2020b). *Farm to Fork Strategy*. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf

Flemish Government. (2016). *VISION 2050 A long term strategy for Flanders*.

Garcia-Saravia Ortiz-de-Montellano, C., & van der Meer, Y. (2022). A Theoretical Framework for Circular Processes and Circular Impacts Through a Comprehensive Review of Indicators. *Global Journal of Flexible Systems Management*, *23*(2), 291–314. https://doi.org/10.1007/s40171-022-00300-5

Gebhardt, M., Spieske, A., & Birkel, H. (2022). The future of the circular economy and its effect on supply chain dependencies: Empirical evidence from a Delphi study. *Transportation Research*

Part E: Logistics and Transportation Review, *157*, 102570. https://doi.org/10.1016/j.tre.2021.102570

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Goodman, L. A. (1974). The Analysis of Systems of Qualitative Variables When Some of the Variables Are Unobservable. Part I-A Modified Latent Structure Approach. *American Journal of Sociology*, *79*(5), 1179–1259. https://www.jstor.org/stable/2776792

Haigh, L., Wit, M. de, Daniels, C. von, Colloricchio, A., Hoogzaad, J., Fraser, M., Sutherland, A. B., McClelland, J., Morgenroth, N., & Heidtmann, A. (2021). The Circularity Gap Report 2021. In *Circle Economy*. https://www.circularity-gap.world/2021#downloads

ISPRA, EEA, & EPA Network. (2021). *Bellagio Declaration: Circular Economy Monitoring Principles*. https://epanet.eea.europa.eu/reports-letters/reports-and-letters/bellagio-declaration.pdf/view

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., & Schösler, H. (2016). Transition towards Circular Economy in the Food System. *Sustainability*, *8*(1), 69. https://doi.org/10.3390/su8010069

Lansink. (1979). *Waste hierarchy: Lansink's ladder*. https://www.recycling.com/downloads/waste-hierarchy-lansinks-ladder/

Little, D. H. W., Robertson, T., Douketis, J., Dionne, J. C., Holbrook, A., Xenodemetropoulos, T., & Siegal, D. M. (2021). Management of antithrombotic therapy after gastrointestinal bleeding: A mixed methods study of health-care providers. *Journal of Thrombosis and Haemostasis*, *19*(1), 153–160. https://doi.org/10.1111/jth.15111

Mascarenhas, A., Nunes, L. M., & Ramos, T. B. (2015). Selection of sustainability indicators for planning: combining stakeholders' participation and data reduction techniques. *Journal of Cleaner Production*, *92*, 295–307. https://doi.org/10.1016/j.jclepro.2015.01.005

Mayer, A., Haas, W., Wiedenhofer, D., Krausmann, F., Nuss, P., & Blengini, G. A. (2019). Measuring Progress towards a Circular Economy: A Monitoring Framework for Economy-wide Material Loop Closing in the EU28. *Journal of Industrial Ecology*, *23*(1), 62–76. https://doi.org/10.1111/jiec.12809

Moraga, G., Huysveld, S., Mathieux, F., Blengini, G. A., Alaerts, L., Van Acker, K., de Meester, S., & Dewulf, J. (2019). Circular economy indicators: What do they measure? *Resources, Conservation and Recycling*, *146*, 452–461. https://doi.org/10.1016/j.resconrec.2019.03.045

Navare, K., Muys, B., Vrancken, K. C., & Van Acker, K. (2021). Circular economy monitoring – How to make it apt for biological cycles? *Resources, Conservation and Recycling*, *170*, 105563. https://doi.org/10.1016/j.resconrec.2021.105563

OECD. (2021). *Making Better Policies for Food Systems*.

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management*, *42*(1), 15–29. https://doi.org/10.1016/j.im.2003.11.002

Padilla-Rivera, A., do Carmo, B. B. T., Arcese, G., & Merveille, N. (2021). Social circular economy indicators: Selection through fuzzy Delphi method. *Sustainable Production and Consumption*, *26*, 101–110. https://doi.org/10.1016/j.spc.2020.09.015

Reich, R., Vermeyen, V., Alaerts, L., & Van Acker, K. (2022). How to track the circular economy transition: A holistic method compiling policy monitors. *Submitted*.

Rikkonen, P., Tapio, P., & Rintamäki, H. (2019). Visions for small-scale renewable energy production on Finnish farms – A Delphi study on the opportunities for new business. *Energy Policy*, *129*, 939–948. https://doi.org/10.1016/j.enpol.2019.03.004

Sawtooth Software. (2009). The CBC / HB System for Hierarchical Bayes Estimation Version 5.0 Technical Paper. In *Sawtooth Software Technical Paper Series*. www.sawtoothsoftware.com

Sawtooth Software. (2012). *Latent Class v4.5*.

Silvestri, C., Silvestri, L., Piccarozzi, M., & Ruggieri, A. (2022). Toward a framework for selecting indicators of measuring sustainability and circular economy in the agri-food sector: a systematic literature review. *The International Journal of Life Cycle Assessment*. https://doi.org/10.1007/s11367-022-02032-1

Sousa, P. M., Moreira, M. J., de Moura, A. P., Lima, R. C., & Cunha, L. M. (2021). Consumer Perception of the Circular Economy Concept Applied to the Food Domain: An Exploratory Approach. *Sustainability*, *13*(20), 11340. https://doi.org/10.3390/su132011340

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sorlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223). https://doi.org/10.1126/science.1259855

Strauss, A., & Corbin, J. M. (1998). Open coding. In *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed., pp. 101–121). Sage. https://doi.org/10.4135/9781412957397.n342

Van Schoubroeck, S., Springael, J., Van Dael, M., Malina, R., & Van Passel, S. (2019). Sustainability indicators for biobased chemicals: A Delphi study using Multi-Criteria Decision Analysis. *Resources, Conservation and Recycling*, *144*, 198–208. https://doi.org/10.1016/j.resconrec.2018.12.024

Van Schoubroeck, S., Thomassen, G., Van Dael, M., Malina, R., & Van Passel, S. (2020). *A Techno-Sustainability Assessment of Biobased Chemicals - a Microalgae Case*.

Van Zanten, H. H. E., Van Ittersum, M. K., & De Boer, I. J. M. (2019). The role of farm animals in a circular food system. *Global Food Security*, *21*, 18–22. https://doi.org/10.1016/j.gfs.2019.06.003

Vogel, C., Zwolinsky, S., Griffiths, C., Hobbs, M., Henderson, E., & Wilkins, E. (2019). A Delphi study to build consensus on the definition and use of big data in obesity research. *International Journal of Obesity*, *43*(12), 2573–2586. https://doi.org/10.1038/s41366-018-0313-9

Walzberg, J., Lonca, G., Hanes, R. J., Eberle, A. L., Carpenter, A., & Heath, G. A. (2021). Do We Need a New Sustainability Assessment Method for the Circular Economy? A Critical Literature Review. *Frontiers in Sustainability*, *1*. https://doi.org/10.3389/frsus.2020.620047

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L. J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J. A., De Vries, W., Majele Sibanda, L., … Murray, C. J. L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, *393*(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4