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Food system futures in Finland: How do experts evaluate changes in resilience up to 2030?

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ABSTRACT

Food security has received much attention since sudden shocks like Covid-19 and the Russian invasion of Ukraine. Resilience to sudden changes and disruptions is called for to maintain food availability in societies. In this study, potential disruptions and changes in the Finnish food system's operating environment were evaluated. We focused on two future challenges: 1) what key disruptions will confront the food system until 2030; and 2) how will the Finnish food system change based on the experts' views, and what measures will develop resilience up to 2030? We used the Delphi technique for data gathering. According to the results, the most significant shock at all three levels, national, EU, and global, was the disruptions caused by climate change (the increase in extreme climate and weather phenomena). An increase in the efficient recycling of nutrients was seen as most desirable, and an increase in the costs associated with recovery from disturbances and shocks was seen as most likely. Reducing inputs' dependence on imports was seen as a key measure for developing resilience. Two constructed scenarios were presented, which highlight the determinants and uncertainties in the development of resilience in Finland.

1. Introduction

Recent events such as Russia's attack on Ukraine, the rise of production inputs and food prices, and the coronavirus pandemic risk the realisation of food security throughout the world. They have increased understanding of the importance of anticipating disruptions to food supply and food security to respond to increasing uncertainty about the future, highlighting the need to build food system resilience (Rimhanen et al., 2023a, 2023b; Rikkonen et al., 2023; Devereux et al., 2020; Laborde et al., 2020; Maye et al., 2018). Resilience refers to the system's ability to maintain its structure and functions, and when necessary, to adapt and reorganise (Holling, 1973; Holling & Gunderson, 2002; Folke, 2006; Folke et al., 2010; Bullock et al., 2017). In the food system context, resilience is defined as the 'capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances' (Tendall et al., 2015).

To understand the need to develop a more resilient food, it is important to anticipate what kinds of future paths and alternatives there are. In general, the majority of food system scenario studies consist of analysing traditional farming, that is, conventional and modern agriculture. There are also scenario studies on emerging novel food systems, but a feature of these studies is that they are very focused on certain novel products or technology (see e.g. Dick et al., 2019; Pippinato et al., 2020; Räty et al., 2023). Future scenarios and the development of resilience in food systems are seldom studied, but the importance of foresight in resilience building has gained

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attention in the last five years (e.g. Himanen et al., 2016; Rimhanen et al., 2023a, 2023b; Rikkonen et al., 2023).

Scenario methodologies can be used to evaluate necessary means to maintain and develop responsiveness and adaptive capacity in the food system's operating environment. Scenario planning has been introduced as an efficient tool for envisioning and testing strategies for the future. According to Hebinck et al. (2018), food system foresight can serve three different roles: 1) pre-conceptualising the transformation by providing ideas, tools, and discussion for the purpose of future-oriented thinking; 2) creating actor networks, which are vital when approaching the future of the food system at a structural level; and 3) developing concrete action plans with a committed group of actors. These roles often become intertwined during a scenario process, especially if conducted in collaboration with the stakeholder, something that has become a commonly favoured approach when researching national or regional food system scenarios (see e.g. Lehtonen et al., 2021; Mitter et al., 2020).

Food system foresight has therefore gained rapid momentum in recent years in both academic and policymaking domains. At the global scale, exploratory scenarios have been used to project changes in land use and food security in different development pathways (Mora et al., 2020). Dietary changes have also been a fertile ground for scenario analysis, where the effects on agriculture, land use, and water scarcity have been analysed for alternative dietary variants (Röös et al., 2017; Westhoek et al., 2014). In Finland, Lehtonen et al. (2021) have applied shared socioeconomic pathways (SSPs) to envision trends and long-term visions in Finnish agriculture in collaboration with the food system stakeholder. The visions portray the interconnectedness of the various food system actors and the importance of accounting for global development trajectories when envisioning food system futures in Finland. More practically, Huan-Niemi et al. (2020) have examined projected changes in emissions, product portfolios, and economic operating conditions in different national diets. Drastic changes in dietary habits would significantly reduce the Finnish food system's emissions but would require major investment and policy intervention to support domestic primary production during the transformation. Although Finnish food system actors emphasise environmental quality more than their global peers (Lehtonen et al., 2021), the literature generally suggests a shift to more environmentally friendly farming practices, coupled with an enormous dietary change in the direction of plant- and fish-based diets.

While environmental concerns are prominent drivers of the transformation, the economic conditions of Finnish primary production have also sparked prolonged political and media discussion in Finland. The increasing costs of production inputs, especially energy and fertilisers, have hampered the profitability of the already poor profitability of primary production (Luke Economy Doctor, 2023). Although Finnish food system actors generally agree about maintaining a high level of domestic primary production, poor profitability makes it somewhat unlikely, with the current food production structure and global trends affecting economic conditions. Kuhmonen and Kuhmonen (2023) have suggested the Finnish food system has entered a phase of conservation in which there should be an emphasis on resilience-building measures. Historically, system conservation can only be maintained for a limited period before the system collapses under external pressures and internal tensions.

A high resilience capacity allows the system to recalibrate around a new equilibrium point to maintain its identity and primary purpose without a sharp collapse in between (Tendall et al., 2015). However, it remains a question whether the current global disturbances and prolonged system weaknesses in the Finnish food system favour system conservation or reorientation. This especially applies to political decision making, which can greatly stimulate system shifts or opt to maintain the status quo (Geels, 2014). Regardless of the direction of action, resilience building remains an important but rather poorly understood phenomenon when analysing food system dynamics and futures. Anticipating system readiness and the potential for different disturbances enables a more nuanced analysis of system status vis-à-vis the future external and internal shocks the Finnish food system may face.

Finnish food system, especially primary production is characterised by its northern climate and self-sufficiency in most major agricultural products (Niemi & Väre, 2019). In primary production, the number of farms has halved between 1995 and 2021, amounting to 42,427 agricultural and horticultural enterprises in 2023, and in the same period, the average farm size increased from 22 ha to 53 ha (OSF, 2023). The agricultural production lines (livestock, crop, and horticulture production) are regionally concentrated. Farm size is largest in Southern Finland and smallest in Eastern Finland, and almost half of the arable land is in Southern Finland. Finnish agriculture is almost exclusively based on family farms – some 85% of all farms – while farming syndicates and farms owned by heirs and limited liability farms represent about 9% and 5% respectively. The amount of arable land has been quite stable – a total of almost 2.3 million hectares.

The economic role of agriculture has declined in terms of GNP and employment in primary production, but with the food industry and forestry, it constitutes a significant part of the Finnish economy: 12% of employed people and 17% of output (Torvelainen et al., 2020). The two main sectors in the Finnish food industry are the dairy and meat processing industries. Together, they accounted for 43% of the food industry's turnover in 2016 (Niemi & Väre, 2019). In the Finnish retail sector, the consolidation trend has continued for an extended period, resulting in the two largest chains having a market share of around 80% in the 2010s (Niemi & Väre, 2019). The weak point of the Finnish food system, in terms of resilience, is the high dependence on external inputs, such as chemicals, fuels and additives, as well as the workforce, which threatens the functioning of food systems if problems with their availability exist (Lehikoinen et al., 2021).

In this paper, we analyse food system expert views on food system future development. This study's main aim is to identify key change factors, changes, and trends for the food system, taking the need for the development of resilience into account. During the Delphi process, the chosen experts also evaluated desirable and probable future developments and the need for change in the national food system. The study forms a practice-oriented perspective on food system actors' views of the future. The paper has three research questions:

1. What does the Finnish food system expert community see as the key disruptions confronting the food system?
2. Based on the expert's views of the future, how will the Finnish food system change up to 2030?

3. With these disruptions and changes, what will be the key measures for enhancing the development of resilience?

The paper is constructed as follows: first, the background of the study is presented from the perspective of future food system scenarios; second, the method and data used, namely the Delphi method, are presented; third, the results of the Delphi study are analysed and special attention is paid to the differences and emerging topics within the questions and views of the future; finally, the results are discussed, and conclusions are drawn in the light of the literature from the perspective of future food system scenarios.

2. Material and methods

An expert-based Delphi method is used in this study. The Delphi method consists of the judgement of experts through successive iterations of given topics to show any convergence of opinion and identify dissent or non-convergence (Linstone & Turoff, 1975). The Delphi method often uses surveys and interviews in anticipating the future. The Delphi method is considered one of the most used methods in the field of futures studies, especially for long-range studies (20 to 30 years). It has often also been used in food system foresight (see e.g. Rikkonen, 2005a; Rikkonen & Tapio, 2009; Himanen et al., 2016; Rimhanen et al., 2023a, Rimhanen et al., 2023b, Rikkonen et al., 2023). In this study, the Delphi expert panel included all the major food system actors, from primary production to the input and processing industry, retail, as well as research, governance, policymaking, and advisory support systems, as the its target group. Fig. 1 shows the participants and their background for the future evaluation of the determinants of a resilient food system.

According to Kuusi (1999), the method for selecting the Delphi panel is one of the most critical phases of a Delphi study. In their actor analysis, the Delphi facilitator should consider the most important stakeholders and interest groups, the most important substance (expert competence), and the terms of delivering information in a Delphi process. An expert panel's selection should be done as explicitly as possible. Information policies depend on three kinds of interacting factors: the expert's personal competences; the respondent's organisation's norms; and the organisers of foresight studies. An expert panel is established to obtain the best possible information as a basis for preparing strategies and subsequently decisions, meaning the improvement of food system resilience in this

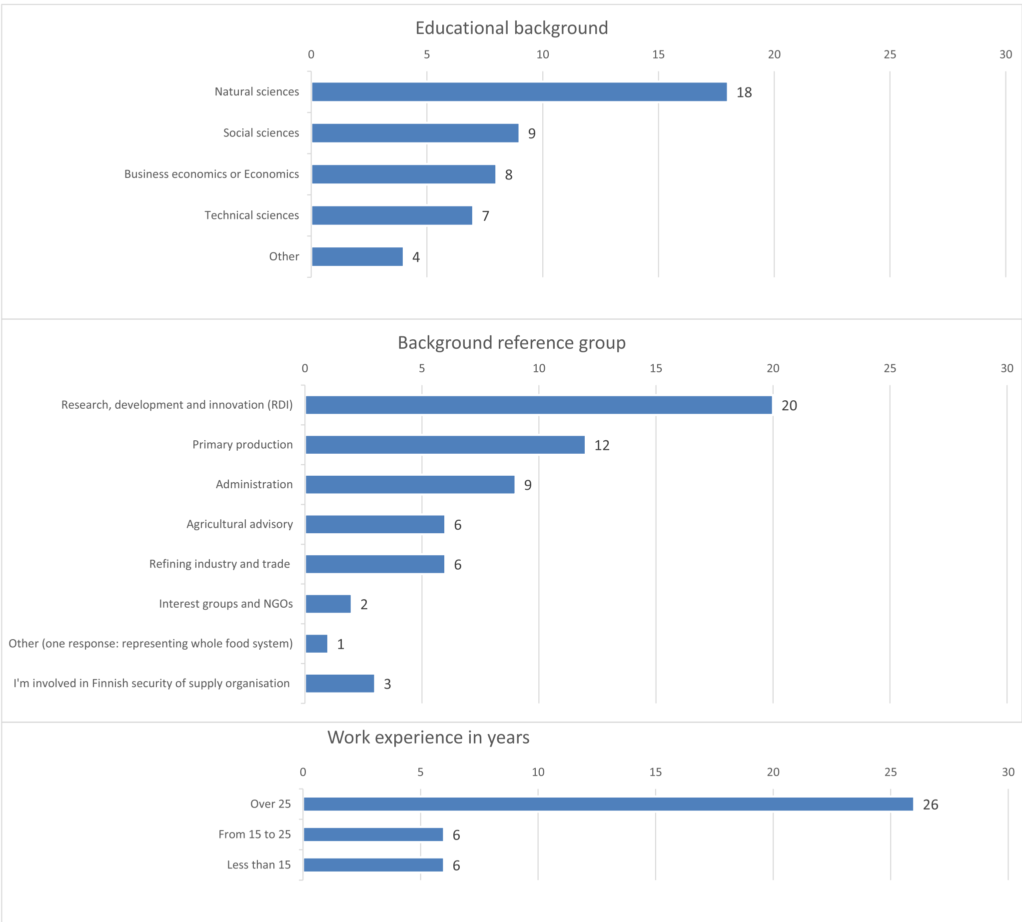

Fig. 1. The educational background, background reference group, and work experience of the Delphi panel (n = 38; a respondent could answer in more than one education and reference group).

case. Generally, the Delphi process can involve from 10 to several hundred or even thousands of respondents in the panel (Bell, 1997; Kuusi, 1999; Rikkonen & Tapio, 2009).

To define the determinants of resilience and thus the key foci of food system foresight, we used a three-step expert evaluation process. The first step, conducted using interviews, defined the determinants of food system foresight with food system actors close to the national security of supply (see Rimhanen et al., 2023a, 2023b). This step set the scene for two Delphi rounds. Based on the results of step one, step two tested the determinants of the current food system's resilience (see Rikkonen et al., 2023). Furthermore, during this Delphi round, views of probable and desirable futures in the Finnish food system were sought reflecting the changes in the operating environment until 2030. Based on these views of the future, the experts also assessed the need for improvements in resilience. In addition to views of the future, the expert panel gave their views on stated disruptions and shocks. In doing so, an expert could also present their ideas about additional shocks and disruptions.

Finally, two future narratives were constructed based on the data to outline trends and divergences between desirable and probable future developments. The aim of the future narratives was to combine the independent answers about views of the future into larger desirable and probable futures, and to explore the interaction between the views of the future these answers implied. The Delphi process's researchers (i.e. Delphi facilitators) wrote their own future narratives independently based on the results of the analysed Delphi data. The most prominent views of the desirable and probable futures were taken as the starting points of each narrative and further strengthened with wider data generated in the statistical analysis. The initial narratives were then compared to distinguish commonalities and differences the researchers had detected. Based on this comparison, combined narratives were created by fitting the elements of initial narratives together. Finally, the combined narratives were evaluated by all the researchers to ensure the views of the future and interactions they contained were considered plausible, and the included independent views of the future and developments did not contradict each other.

3. Results

The results consist of two sections from the Delphi survey process: 1) the evaluated disruptions the food system confronts; and 2) views of the probable and desirable future development of the Finnish food system.

3.1. Key disruptions confronting food system

In the first Delphi round, the respondents were asked about the various shocks and disruptions the food system might confront according to Rimhanen et al. (2023a, 2023b) in the 2020s. These were asked about their probability of happening and about how they saw the level of preparedness in society. Both dimensions were asked about on a Likert scale from one to five (see Fig. 2).

According to the results, the three most likely disruptions were: 1) an increase of extreme climate and weather phenomena; 2) the spread of animal diseases (e.g. ASF virus and Covid-19; and 3) the spread of plant diseases, pests, and alien species. In general, society's level of preparedness for the shocks and disruptions enquired about was assessed as relatively low, while the 5-step Likert scale was

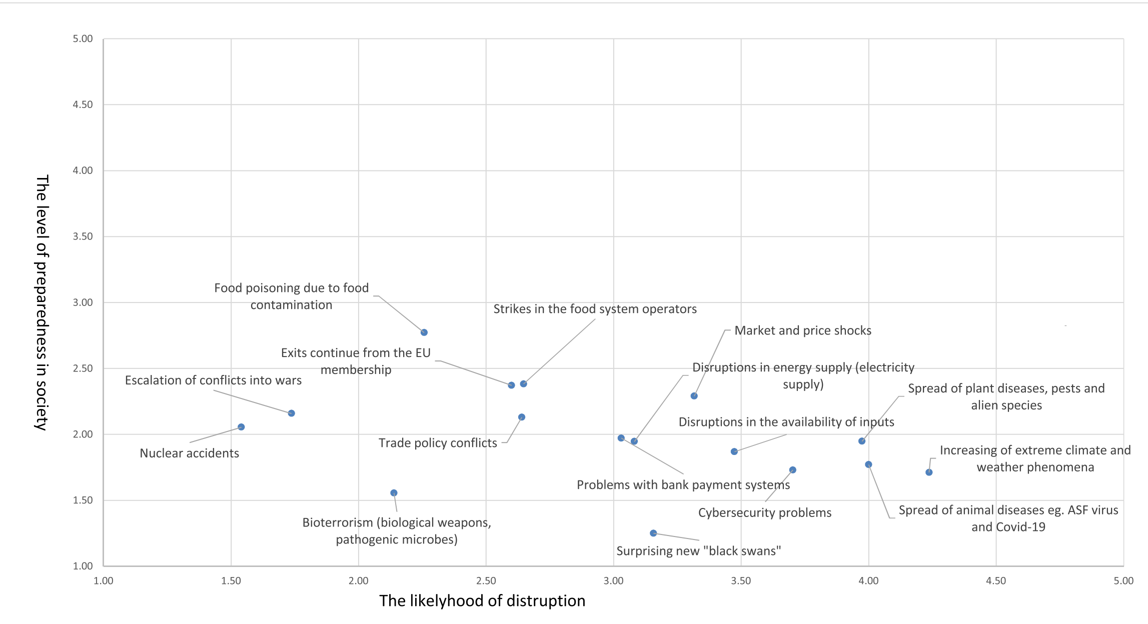

Fig. 2. The experts' responses about the likelihood (x-axis) and level of preparedness (y-axis) of shocks and disruptions on the food system (mean value). The scale was from one to five (1=low or not likely at all; 5=high or very likely).

widely used to evaluate the likelihood of the shocks and disruptions. In addition to questions about likelihood and preparedness, the experts were asked to name an additional two main shocks and disruptions at different scales – namely in Finland, the EU, and globally. A summary of these is presented in Fig. 3.

The disruptions caused by climate change were seen as most significant at all three spatial levels, namely national, EU, and global. At the national level, the following two were the disturbances of input availability and disease epidemics. At the European level, market disruptions and disease epidemics were seen as second and third. At the global level, the second was societal and political crises, and the third was market disturbances.

3.2. *How do experts evaluate the future development of the food system until 2030*

The experts in the Delphi panel were asked about the food system's future development paths. A total of 51 questions was included in which a respondent answered about their view of future development. A Likert scale from −2 to 2 was used, in which −2 refers to a

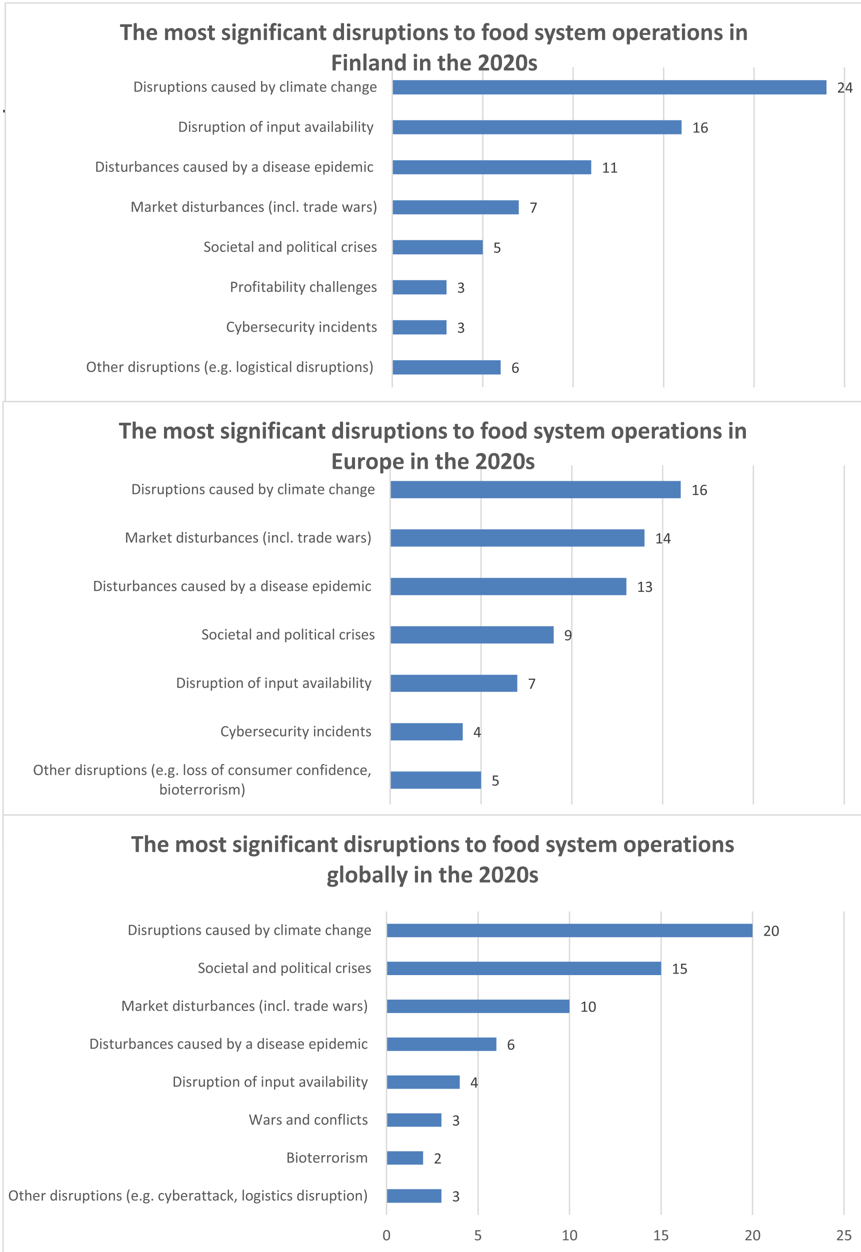

Fig. 3. Summary of the expert evaluation of the main shocks and disruptions at national, EU, and global levels (divided into classes according to the number of mentions in open answers).

substantial decrease from the present level, 0 refers to no changes from the present level, and 2 refers to a substantial increase from the present level. Views of the future are presented in Tables 1–4, representing the mean and standard deviation values of questions related to the drivers, changes, and trends of a resilient food system.

According to the results (Table 1) no significant changes were seen in the cultivated arable land and the volume of production. The view of the probable future indicated that the structural development was progressing, and there was something of an increase in environmentally friendly production – that is, increasing measures to improve soil fertility and the diversification of crop selection and rotations. The view of the desirable future suggested growth in the protein crop production sector and organic production. It was also hoped that the workforce could be found in the home country. However, the amount of foreign labour was likely to increase. Furthermore, what was most desired was to improve the soil's fertility and to diversify crop selection and crop rotations. New production technologies were hoped for more moderately than they were considered likely.

According to the results (Table 2), primary production's lack of profitability was seen as a concern. There was considerable hope that there would be an increase in profitability. The results indicated that food retail would also retain its profitability in the future. There was also a strong hope that there would be extensive investments in security of supply and self-sufficiency, and they were also considered likely, but more moderately. The experts wanted to get rid of inputs' dependence on imports, but they did not regard it as likely. It was believed that energy production and nutrient cycling would substantially increase; in all these areas, it was hoped that growth would be brisk, and it was considered likely somewhat moderately. It was believed contracts in international trade and food imports would increase. Similarly, it was believed market price volatility would increase, although it was strongly hoped that there would be more stable development. The cost of both preventing disruptions and recovering from them would probably increase.

It is hoped that the enterprise structure would become more diverse (Table 3). However, it was believed the number of operators and the increase in diversity would probably remain unchanged. It was also hoped that the food system would be local, but this was not seen as likely. Greater emphasis was placed on the comprehensive management of the food system, understanding of interactions, and leadership skills in sudden situations. These were also seen as highly desirable. There was a great desire to invest in the wellbeing of employees.

The views of the preferred future included a significant increase in the recycling of nutrients and in farms' energy self-sufficiency (Table 4). Views on the most probable future indicated an increase in the costs associated with recovery from disturbances and shocks and the efficient recycling of nutrients. It was notable that an increase in the efficient recycling of nutrients was seen as both desirable and probable. This was a key topic of consensus among the food system experts. The biggest difference between desirable and probable views of the future was considered to be market price volatility and the costs associated with recovery from disturbances and shocks. This was also considered a key divergent topic by the experts.

Table 1
Views on primary production and its productivity measures.

	Desirable, mean [StD] (−2…+2)	Increase ↗, decrease ↘ or remain at current level↔	Probable, mean [StD] (−2…+2)	Increase ↗, decrease ↘ or remain at current level↔
Primary production in Finland				
Volume of domestic primary production	0.74[0.72]	↗	-0.03[0.83]	↔
Cultivated arable land in Finland	0.08[0.82]	↔	-0.22[0.71]	↔
Protein crop production area	1.49[0.61]	↑	0.97[0.56]	↗
Organic production area	1.13[0.74]	↑	0.73[0.56]	↗
Size of farms	0.20[0.93]	↔	0.82[0.87]	↗
Foreign labour force	-0.42[0.89]	↗	0.86[0.49]	↗
Productivity measures in primary production				
Measures to improve the soil fertility	1.53[0.69]	↑	0.84[0.65]	↗
Irrigation of crops	0.16 [0.55]	↔	0.46[0.65]	↗
New production technologies (e.g. cellular agriculture, vertical farming)	0.61[0.86]	↗	0.76[0.55]	↗
Domestic plant breeding	1.16[0.64]	↑	0.22[0.82]	↔
Diversification of crop selection and crop rotations	1.53[0.60]	↑	0.78[0.67]	↗
The share of grasses and other deep-rooted plants in crops	1.32[0.67]	↑	0.62[0.76]	↗

Table 2
Views on future profitability, the functionality of markets, and security of supply.

	Desirable, mean [StD] (−2…+2)	Increase ↗, decrease ↘ or remain at current level↔	Probable, mean [StD] (−2…+2)	Increase, decrease or remain at current level
Profitability of food chain				
Profitability of primary production	1.50[0.80]	↑	-0.17[0.85]	↔
Profitability of the processing industry	0.50[1.01]	↗	0.16[0.55]	↔
Profitability of the food retail	-0.08[1.05]	↔	0.41[0.72]	↗
Functionality of markets				
Food imports	-0.53[0.73]	↓	0.62[0.72]	↗
International trade	0.32[0.77]	↗	0.65[0.75]	↗
Market price volatility	-0.97[0.83]	↓	0.89[0.70]	↗
Contracts between operators	1.05[0.74]	↑	0.56[0.56]	↗
Costs associated with the prevention of disruptions and shocks	-0.31[1.12]	↗	0.86[0.60]	↗
Costs associated with recovery from disruptions and shocks	-0.65[0.95]	↗	1.03[0.61]	↑
Security of supply and self-sufficiency in Finland				
Self-sufficiency in terms of inputs	1.50[0.60]	↑	0.43[0.83]	↗
Safety stocks of agricultural inputs	0.95[0.73]	↗	0.28[0.61]	↗
Emergency stockpiling of liquid fuels	0.73[0.77]	↗	0.06[0.42]	↔
Safety stocks of food products	0.68[0.75]	↗	0.26[0.56]	↗
Dependence on imports	-1.19[0.70]	↓	0.47[0.84]	↗
Protection of information systems	1.39[0.64]	↑	0.81[0.78]	↗
Energy production and nutrient cycle				
Domestic renewable energy production	1.50[0.65]	↑	0.81[0.78]	↗
Energy self-sufficiency of farms	1.58[0.50]	↑	0.70[0.62]	↗
Reserve power systems for electricity generation in rural areas	1.27[0.65]	↑	0.69[0.58]	↗
Efficient nutrient recycling	1.68[0.47]	↑	0.97[0.44]	↗

We also asked what the most important and influential measures or factors were for enhancing resilience. Answers were sought on a Likert scale from one to five (on = not important at all; 5 = very important). According to these results, the 10 (of 23 asked about) most important resilience-building measures or factors were:

1. Reducing input dependence on imports
2. The low economic profitability of primary production hinders the development of resilience
3. Increased cooperation between actors in food systems
4. Ensuring the safety stocks of agricultural inputs and products
5. Preparing for crisis situations with adequate backup systems to maintain food security
6. Growing the protein crop area in primary production
7. Diversification of plant selection and crop rotations
8. Increasing domestic renewable energy production
9. Increasing system-level understanding and management in the food system, enabling a quick response, decision making, and process changes if necessary

Table 3
Views of the future of food system structure, risk management, and cooperation.

	Desirable, mean [StD] (−2…+2)	Increase ↗, decrease ↘ or remain at current level↔	Probable, mean [StD] (−2…+2)	Increase, decrease or remain at current level
Production structure in the food system				
Diversity of the business structure (variation in size, production branches, specialisation, and diversification)	1.24[0.49]	↑	-0.08[0.95]	↔
Locality of food systems	1.27[0.61]	↑	0.17[0.91]	↔
Number of actors in the food system ensuring the availability of food	0.84[0.87]	↗	-0.22[0.93]	↔
Diversity of food system actors (e.g. diversity in function, size, responsiveness)	1.18[0.69]	↑	0.14[0.93]	↔
Risk management in food system activities				
Management of infectious risks in primary production	1.21[0.74]	↑	0.62[0.59]	↗
Management of infectious risks in industry and trade	1.22[0.79]	↑	0.67[0.68]	↗
Bribery in the food system	-1.56[0.75]	↓	-0.09[0.71]	↔
Backup systems to prevent interruptions in food production	1.27[0.61]	↑	0.44[0.56]	↗
Wellbeing of workers in primary production and processing industries	1.58[0.55]	↑	0.11[0.66]	↔
Competence in managing the food system as a whole				
Leadership skills in sudden change situations	1.45[0.65]	↑	0.35[0.68]	↗
Holistic management of the food system	1.47[0.60]	↑	0.41[0.72]	↗
Understanding the interactions of the food system	1.55[0.55]	↑	0.62[0.59]	↗
Cooperation and communication within the food system				
Communication between food system operators about disturbances and resilience	1.45[0.65]	↑	0.49[0.65]	↗
Communication between authorities and food system operators about disturbances and resilience	1.55[0.60]	↑	0.57[0.60]	↗
Cooperation between all food system actors (including public authorities)	1.55[0.55]	↑	0.54[0.65]	↗
Citizens' awareness of the nutritional quality of food	1.53[0.56]	↑	0.57[0.65]	↗
Citizen participation in food communities	1.05[0.66]	↑	0.54[0.56]	↗
Consumer–producer low-threshold interaction platforms	1.29[0.65]	↑	0.57[0.69]	↗

10. The costs of promoting resilience should be evenly distributed between food system operators

3.3. *Scenario narratives based on the data*

Next, based on the views of the future (Tables 1–4), two scenarios are presented. In the scenario storylines, the divergent views are highlighted to keep them concise. However, the views of the future that are considered codirectional are also important because they indicate the directions that can be kept as basic premises in current development and strategies.

3.3.1. *Desirable: playing into strengths – cooperation, diversity, and self-sufficiency*

In the desirable future, the Finnish food system will operate in a more coordinated manner and will rapidly generate self-sufficiency in all major inputs. Having learned from the crises of 2019–2023, the Finnish food system actors will begin to operate in close co-ordination to envision and develop the food supply chain as a more self-sufficient, profitable, and resilient system. Locality, circularity, and agency will form the agroecological heart of the new system, where more attention will be paid to improving soil health in particular. Domestic organic fertilisers will be widespread and accessible, and crop diversity will increase, expanding towards protein crop production especially. The new system will be more distributed and diversified, not only in agriculture but also in the food industry and energy generation. The system's local nature will deepen trust between local actors, and new forms of cooperation will emerge in which food and energy systems will be flexibly combined. Diversity and enhanced trust between actors will generate a more

Table 4
The top 5 views of the future on the most probable, preferred, and divergent changes (in cases of the same values, all with the same values are listed).

Views of the preferred future (scale of −2 to +2)	Views of the most probable future (scale of −2 to +2)	The biggest difference between views of desirable and probable futures (by subtraction)	Most divergent in views of desirable or probable futures (by standard deviation)
1. Efficient recycling of nutrients [+1.68]	1. Costs associated with recovery from disturbances and shocks [+1.03]	1. Market price volatility [1.87] (Desirable −0.973 vs Probable +0.892)	1. Costs associated with preventing disturbances and shocks [1.12]
2. Energy self-sufficiency of farms [+1.58]	2. Efficient recycling of nutrients [+0.97]	2. Costs associated with recovery from disturbances and shocks [1.68] (Desirable −0.649 vs Probable +1.028)	2. Profitability of food trade [1.05]
3. Wellbeing and coping of primary and processing industry workers [+1.58]	3. Protein crop production sector [+0.97]	3. Profitability of primary production [1.68] (Desirable 1.50 vs Probable −0.167)	3. Profitability of the processing industry [1.01]
4. Understanding the systemic interactions of the food system [+1.55]	4. Market price volatility [0.89]	4. Dependence on imports [1.66] (Desirable −1.189 vs Probable +0.472)	4. Costs associated with recovery from disturbances and shocks [+0.95]
5. Communication between the authorities and actors on disturbances and resilience [+1.55]	5. Foreign labour force [+0.86]	5. Wellbeing and coping of primary and processing industry workers [+1.47] (Desirable +1.579 vs Probable +0.108)	5. Diversity of the business structure (variation in size, production branches, specialisation and diversification) [0.95]
6. Measures to improve soil fertility [+1.55]		6. Bribery in the food system [1.47] (Desirable −1.559 vs Probable −0.088)	

resilient system in which flexibility, actors' agency, and functioning networks will be central. Information and material will be swiftly relocated and effectively used in times of need, which will reduce the average cost of disturbance recovery. Food system actors will be confident in investing in domestic production, and citizens will welcome environmentally friendly, clean, and high-quality products. The profitability of domestic food production will thus increase due to the expanded product portfolio and system stability. Improved economic conditions will allow investment in employees' wellbeing and increase the appreciation of food system actors. As a result, the food sector will increasingly attract more domestic workers, reducing reliance on foreign labour. Actors will further be encouraged to invest in new farming solutions, products, and production technologies, which will enable the Finnish food system to be at the forefront of developing and piloting emerging new food production solutions.

3.3.2. Probable: paying the price – maintaining national food security in a changing world

The probable future sees the Finnish food system developing means of resilience while maintaining its established product portfolio. As 2019–2023 saw major disturbances affecting global food systems, Finland has recognised the need to enhance its preparedness to anticipate and manage potential future shocks. Food system cooperation has been enhanced to allow more coordination in the event of future crises. Actors in food and energy systems have been encouraged and partly mandated to make further investments in buffers and backup systems which can be harnessed in times of need to ensure continuous food supply. While widely agreed and deemed necessary, investment costs will hit primary production and the food industry hardest as sectors that have already struggled with poor profitability. This will prevent cooperation from achieving its full potential, as a sense of injustice will hinder the building of trust between food system actors. Actors will therefore approach resilience more independently and disconnectedly. The rise of environmental values in society combined with more resilience-oriented thinking will see domestic production inputs gaining a stimulus in protein crop production and nutrient cycling in those farms that find the capital for investment. The structural development in primary production will thus continue, and some actors will find their profession unprofitable and vulnerable to disturbances, thus reducing the actor base's overall diversity. Finland will continue to rely on outputs from global markets and foreign labour in key areas, thus exposing the system to price shocks and other international disturbances. Globalisation will open new market opportunities for Finnish products, which will compete with larger producing countries with lower production costs.

4. Discussion and conclusions

In this paper, we analysed food system experts' views about how the food system will develop in the 2020s. The study's main aim was to identify key change factors, changes, and trends for the food system from the perspective of resilience. We analysed the experts' view on the key disruptions confronting the Finnish food system, and they then gave their views on desirable and probable future developments.

The narratives created presented the most probable configuration of interactions between the different answers the data provided. However, the authors recognised that other configurations between variables were plausible. In many cases, interaction between two linked trends could not be considered unidirectional in their causality. Due to the high complexity of food system dynamics and the temporal aspect being somewhat ambiguous in the narratives, multiple developments were expected to reinforce each other simultaneously. In a reinforcing loop, implying a definitive starting point for development risked giving a misleading picture of the system's function. For example, the current literature remained undecided about whether trust between local actors was a prerequisite for the emergence of the local food system or vice versa. Instead, attention should be paid to the self-reinforcing dynamic between these two variables.

The background for the scrutiny is based on futures studies, and especially on scenario planning. The starting point is the understanding of the role hindsight and insight plays in foresight (see MacKay & McKiernan, 2004). The three important aspects of any kind of future planning must above all be familiar with historical development, that is, hindsight. Second, as we study the future and try to prepare for it, we need an information and knowledge base that is founded on today's circumstances and experiences, that is, insight. Third, as we refine today's information and knowledge into scenarios or future images, for example, we foresee alternatives of desirable, probable, or feasible future development, and this is when we extend our perspective on foresight (Rikkonen, 2005b; Mackay & McKiernan, 2004).

In the last 10 years, new visions and strategies have been presented that are sufficiently bold to embrace transitions in the food system, but they somewhat lack a perspective on resilience. Sustainability, environmental concerns – especially water protection – and biodiversity loss in current production systems have received most attention, as has system resilience for some time, especially during the Covid-19 pandemic. Due to these rapid changes and disruptions in the operating environment, strategic analysis and scenario development should be linked more than hitherto, especially when the resilience of societies is being developed. Linking these two will enable a learning experience which will influence the destiny of the involved activities, people, and organisations. Scenarios can contribute directly to the thinking and action that proceed from the classic stages of strategic decision making: understanding the strategy context; identifying alternatives; developing alternatives; choosing between alternatives; and executing the chosen strategy (Fahey & Randall, 1998).

According to Kahn and Wiener (1967, p.6), scenarios are hypothetical sequences of events, built with the intention of attracting attention to causal processes and points of decision. This is done to demonstrate how they can evolve. A scenario is thus an internally consistent story about the path from the present to the future. According to Van der Heijden (1996), at least two scenarios are needed to reflect uncertainty. Each of the scenarios must be plausible. This means they must grow logically (in a cause–effect way) from the past and the present. Furthermore, they must be internally consistent. Events within a scenario must be related through cause–effect lines of argument which cannot be flawed. Scenarios must also be relevant to the issues under scrutiny. To be challenging, scenarios must consider potential surprises that may cause future discontinuities. A frequently used method for constructing scenarios is the Delphi method. It studies future prospects by gathering information from experts as views for the future for systematically developing various alternative future images or scenarios for public policy purposes, for example (Tapio, 2002; see also Armstrong, 2001).

In this study, we followed scenario planning principles and used experts' views of the future to construct two alternative scenarios that implied the desirable and probable views of the Finnish food system expert community. We started by asking about the key disruptions causing uncertainty in food system development, especially from the perspective of resilience. Having listed the main drivers, changes, and trends in the format of an expert survey, we then received views of both preferred and probable futures. We presented these as alternative future images and pinpointed five top views of the future to the most probable, preferred, and divergent future changes. Having written the scenario narratives, two scenarios, namely 'Paying the price – maintaining the national food security in a changing world' and 'Playing into strengths – cooperation, diversity, and self-sufficiency' were presented. To learn from such futures studies requires them to be discussed with the target groups – in this case, food system actors (see e.g. Lehtonen et al., 2021).

In general, it seems it is quite difficult for experts to break away from the present situation in future development evaluations, and negative developments especially are not considered likely. An example of this is question about the likelihood of escalation of conflicts into wars and nuclear accidents. These were not considered likely, even though the Delphi rounds were conducted in the spring and summer of 2021, half a year before Russia attack on Ukraine. It is also notable that interpretation of shocks and disruptions between respondents may vary, and the shocks and disruptions asked about are not commensurate; there may be direct impacts, or the impacts may arrive through a long chain of indirect consequences. Finally, it can be concluded that we need to engage actors at different levels of society to ensure transparent discussions to increase understanding of the potential disruptions in the food system. Scenario analysis can be seen as an effective tool for enhancing such an insight into potential future developments. They can be used as feed in storylines that at best increase preparedness among actors for different shocks and disruptions. As the scenarios usually construct a broad picture of the changing operating environment, the cause–effect linkages between different systems (e.g. food and energy systems) become more visible, and holistic understanding increases.

5. Conclusions

At least four conclusions can be drawn from this Delphi study. First, the likeliest changes were considered to come with climate change: an increase of extreme climate and weather phenomena; the spread of animal diseases; and the spread of plant diseases, pests, and alien species. The disruptions caused by climate change were also seen as most significant at all three spatial levels: national; EU; and global.

Second, the food system expert community saw society's level of preparedness for the shocks and disruptions as quite low. This may refer to the drastic changes and general uncertainty that the world has met recently globally – for example, Covid-19 and the Russia-Ukraine war – and the new preparedness or a lack of it that has arisen to develop security of supply in societies.

Third, in the desirable future, the Finnish food system will operate in a more coordinated manner and will be able to rapidly generate self-sufficiency in all major inputs. It will be preferred that Finnish food system actors will begin to operate in close coordination to envision and develop the food supply chain as a more self-sufficient, profitable, and resilient system. Locality, circularity, and agency will form the agroecological heart of the new system. The views of the preferred future will include a significant increase in the recycling of nutrients and farms' energy self-sufficiency.

Fourth, in the probable future, the Finnish food system will develop means of resilience while maintaining its established product portfolio. Actors in food and energy systems will be encouraged to make further investment in buffers and backup systems which can be harnessed in times of need to ensure continuous food supply. It is considered that investment costs will hit primary production and food industry hardest. Finland will also continue to rely on outputs from global markets and foreign labour in key areas, thus exposing the system to price shocks and other international disturbances. However, globalisation will also open new market opportunities for Finnish products. The most probable views of the future indicated an increase in the cost associated with recovery from disturbances and shocks and the efficient recycling of nutrients.

In conclusion, developing resilience is not only a question of security of supply, but there should also be a strategic, coherent, and holistic approach to identifying needs and enhancing resilience in the food system. Until now, a strategy purely for resilience has been lacking in Finland, but it seems that recent societal debate has generated the recognition that one needs to be developed.

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CRediT authorship contribution statement

Pasi Rikkonen: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Karoliina Rimhanen:** Conceptualization, Investigation, Validation, Writing – original draft. **Kalle Aro:** Conceptualization, Investigation, Validation, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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References

Armstrong, J. S. (2001). Principles of forecasting. *A handbook for researchers and practitioners*. Boston/Dordrecht/London: Kluwer Academic Publishers.

Bell, W. (1997). *Foundations of Future Studies — Human Science for a New Era* (vol. 1, p. 1997). New Brunswick: Transaction publishers.

Bullock, J. M., Dhanjal-Adams, K. L., Milne, A., Oliver, T. H., Todman, L. C., Whitmore, A. P., & Pywell, R. F. (2017). Resilience and food security: rethinking an ecological concept. *Journal of Ecology, 105*(4), 880–884. https://doi.org/10.1111/1365-2745.12791

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19′s impacts on household food security. *Food Security, 12*(4), 769–772. https://doi.org/10.1007/s12571-020-01085-0

Dick, Arianna, Bhandari, Bhesh, & Prakash, Sangeeta (2019). Review 3D printing of meat. *Meat Science, 153*, 35–44. https://doi.org/10.1016/j.meatsci.2019.03.005

Fahey, L., & Randall, R. M. (1998). Integrating strategy and scenarios. In Liam Fahey, & Robert M. Randall (Eds.), *Learning from the future. Competitive foresight scenarios* (pp. 22–38). New York: John Wiley & Sons,.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Glob Environ Change, 16*(3), 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society*. https://doi.org/10.5751/ES-03610-150420

Geels, F. W. (2014). Regime resistance against low-carbon transitions: Introducing politics and power into the multi-level perspective. *Theory, Culture & Society, 31*(5), 21–40. https://doi.org/10.1177/0263276414531627

Hebinck, A., Vervoort, J. M., Hebinck, P., Rutting, L., & Galli, F. (2018). Imagining transformative futures: Participatory foresight for food systems change. *Ecology and Society, 23*(2), 16. https://doi.org/10.5751/ES-10054-230216

Himanen, S. J., Rikkonen, P., & Kahiluoto, H. (2016). Codesigning a resilient food system. *Ecology and Society, 21*(4), 16. https://doi.org/10.5751/ES-08878-210441

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology, Evolution, and Systematics, 4*(1), 1–23. https://doi.org/10.1146/annurev.es.04.110173.000245

Holling C.S., Gunderson L.H. (2002) Panarchy: understanding transformations in human and natural systems. Island Press, Washington, DC. https://vtechworks.lib.vt.edu/handle/10919/65531.

Huan-Niemi, E., Kaljonen, M., Knuuttila, M., Niemi, J., & Saarinen, M. (2020). The impacts of dietary change in Finland: Food system approach. *Agricultural and Food Science, 29*(4), 372–382. https://doi.org/10.23986/afsci.95282

Kuhmonen, I., & Kuhmonen, T. (2023). Transitions through the dynamics of adaptive cycles: Evolution of the Finnish agrifood system. *Agricultural Systems, 206*. https://doi.org/10.1016/j.agsy.2023.103604

Kahn, H.& Wiener, A.J. 1967. The Year 2000: A framework for speculation on the next thirty-three years. New York: MacMillan.

Kuusi, O. 1999. Expertise in the future use of generic technologies. Epistemic and methodological considerations concerning Delphi studies. Helsinki: HeSE Print.

Laborde, D., Martin, W., Swinnen, J., & Vos, R. (2020). COVID-19 risks to global food security. *Science, 369*(6503), 500–502. https://doi.org/10.1126/science.abc4765

Lehikoinen, E., Kinnunen, P., Piipponen, J., Heslin, A., Puma, M. J., & Kummu, M. (2021). Importance of trade dependencies for agricultural inputs: A case study of Finland. *Environmental Research Communications, 3*(6). https://iopscience.iop.org/article/10.1088/2515-7620/ac02d0.

Lehtonen, H., Aakkula, J., Fronzek, S., et al. (2021). Shared socioeconomic pathways for climate change research in Finland: Co-developing extended SSP narratives for agriculture. *Regional Environmental Change, 21*, 7. https://doi.org/10.1007/s10113-020-01734-2

Linstone H.A., Turoff M. The Delphi Method. 1975. Techniques and applications. Online documents available at URL: http:// www.is.njit.edu/pubs.php. Accessed 5 Jan 2023.

Luke, Economy Doctor. 2023. Profitability ratio by production type. Cited 5.9.2023. https://portal.mtt.fi/portal/page/portal/economydoctor/farm_economy/timeline/profitability_ratio_by_production_type/.

MacKay, R. B., & McKiernan, P. (2004). The role of hindsight in foresight: Refining strategic reasoning. *Futures, 36*(2), 161–179. https://doi.org/10.1016/S0016-3287(03)00147-2

Maye, D., Chiswell, H., Vigani, M., & Kirwan, J. (2018). Present realities' and the need for a 'lived experience' perspective in Brexit agrifood governance. *Space Polity, 22*(2), 270–286. https://doi.org/10.1080/13562576.2018.1519390

Mitter, H., Techen, A. K., Sinabell, F., Helming, K., Schmid, E., Bodirsky, B. L., Holman, I., Kok, K., Lehtonen, H., Leip, A., Le Mouël, C., Mathijs, E., Mehdi, B., Mittenzwei, K., Mora, O., Øistad, K., Øygarden, L., Priess, J. A., Reidsma, P., Schaldach, R., & Schönhart, M. (2020). Shared Socio-economic Pathways for European agriculture and food systems: The Eur-Agri-SSPs. *Global Environmental Change, 65*, Article 102159. https://doi.org/10.1016/j.gloenvcha.2020.102159

Mora, O., Le Mouël, C., de Lattre-Gasquet, M., Donnars, C., Dumas, P., Réchauchère, O., et al. (2020). Exploring the future of land use and food security: A new set of global scenarios. *PLoS ONE, 15*(7), Article e0235597. https://doi.org/10.1371/journal.pone.0235597

Niemi J., Väre M. (2019) Agriculture and food sector in Finland 2019. Natural resources and bioeconomy studies 37/2019. Natural Resources Institute Finland, Helsinki 2019. https://jukuri.luke.fi/bitstream/handle/10024/544349/luke-luobio372019.pdf?sequence=1 Accessed 6 February 2024.

OSF, Official Statistics of Finland. (2023) Structure of agricultural and horticultural enterprises 2023. Natural Resources Institute Finland. Available at: https://www.luke.fi/en/statistics/structure-of-agricultural-and-horticultural-enterprises/structure-of-agricultural-and-horticultural-enterprises-2023-provisional Accessed 6 Feb 2024 Accessed 6 Feb 2024.

Pippinato, L., Gasco, L., Di Vita, G., & Mancuso, T. (2020). Current scenario in the European edible-insect industry: A preliminary study. *Journal of Insects as Food and Feed, 6*(4), 371–381. https://doi.org/10.3920/JIFF2020.0008

Rikkonen, P. (2005a). Scenarios for future agriculture in Finland: a Delphi study among agri-food sector stakeholders. *Agricultural and Food Science, 14*(3), 205–223. https://doi.org/10.2137/145960605775013227

Rikkonen, P.(2005b). Utilisation of alternative scenario approaches in defining the policy agenda for future agriculture in Finland, Agrifood Research Reports 73, http://www.mtt.fi/met/pdf/met73.pdf.

Rikkonen, P., & Tapio, P. (2009). Future prospects of alternative agro-based bioenergy use in Finland - Constructing scenarios with quantitative and qualitative delphi data. *Technological Forecasting and Social Change, 76*(7), 978–990. https://doi.org/10.1016/j.techfore.2008.12.001

Rikkonen, P., Rimhanen, K., Aro, K., & Aakkula, J. (2023). The determinants of a resilient food system for Finland in the 2020s—Three opinion polls for improvements based on a Delphi study among food system experts. *Journal of Futures Research, 11*, 2. https://doi.org/10.1186/s40309-023-00215-z

Rimhanen, K., Aakkula, J., Aro, K., Rikkonen, P.(2023a). The elements of resilience in the food system and means to enhance the stability of the food supply. Environment Systems and Decisions. https://doi.org/10.1007/s10669–022-09889–521.2023.

Rimhanen, K., Aro, K., & Rikkonen, P. (2023b). Prioritising key variables for assessing food system resilience in Finland. *Acta Agriculturae Scandinavica, Section B — Soil & Plant Science, 73*(1). https://doi.org/10.1080/09064710.2023.2256341

Räty, N., Tuomisto, H. L., & Ryynänen, T. (2023). On what basis is it agriculture? A qualitative study of farmers' perceptions of cellular agriculture. *Technological Forecasting and Social Change, 196*. https://doi.org/10.1016/j.techfore.2023.122797

Röös, E., Bajželj, B., Smith, P., Patel, M., Little, D., & Garnett, T. (2017). Greedy or needy? Land use and climate impacts of food in 2050 under different livestock futures. *Global Environmental Change* (Volume 47,, 1–12. https://doi.org/10.1016/j.gloenvcha.2017.09.001

Tapio, P. 2002. The limits to traffic volume growth. The content and procedure of administrative futures studies on Finnish transport CO2 policy. Available on the Internet: ⟨http://ethesis.helsinki.fi/julkaisut/maa/limno/vk/tapio/⟩.

Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., Kruetli, P., Grant, M., & Six, J. (2015). Food system resilience: defining the concept. *Global Food Security, 6*, 17–23. https://doi.org/10.1016/j.gfs.2015.08.001

Torvelainen J., Forsman L., Outa-Pulkkinen P., Salo-Kauppinen R., Söderkultalahti P. (2020) E-yearbook of Food and Natural Resource Statistics for 2019: statistical facts on agriculture, forestry, fisheries and hunting in Finland, p 115. http://urn.fi/URN:ISBN:978-952-380-064-9 Accessed 6 Feb 2024.

Van der Heijden K. 1996. Scenarios - the art of strategic conversation. Chichester: John Wiley & Sons.

Westhoek, Henk, Lesschen, Jan Peter, Rood, Trudy, Wagner, Susanne, De Marco, Alessandra, Murphy-Bokern, Donal, Leip, Adrian, van Grinsven, Hans, Sutton, Mark A., & Oenema, Oene (2014). Food choices, health and environment: Effects of cutting Europe's meat and dairy intake. *Global Environmental Change, 26*. https://doi.org/10.1016/j.gloenvcha.2014.02.004