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Title: What is a food system scenario made of? Review of scenario elements in Finnish, European and Global studies

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Review of scenario elements in Finnish, European and Global studies

Abstract

Scenarios are a powerful tool to imagine futures of food systems. A variety of methodologies exists to construct such scenarios, with differences in selected frameworks, data collection techniques, and analysis approaches, all of which affect the resulting scenarios. We reviewed 19 scenario studies pertaining food systems to establish a set of dichotomies which highlight the variety of different methodological approaches and scenario elements. We found six prominent dichotomies, which affect the scenario design in the food system context and are partially applicable to wider range of scenario studies. We also propose a set of four scenario types which represent scenarios in food system foresight literature and discuss their use with stakeholders. Our work provides an overview of different methodological elements present in the recent food system scenario literature with examples from contemporary studies. The results provide tools to students and scholars to make sense of and evaluate the different methodological elements and scenario types commonly encountered in the food system foresight literature.

Keywords: food system; foresight; scenario methodology; review

1. Introduction

Food systems are facing pressures in both national and global domains. While globalisation has generated an increasing degree of interconnectedness in food systems, the national and regional context of geography, weather conditions, political institutions, and societal norms greatly affects the food system dynamics. Food systems can be defined as consisting of the activities and infrastructure needed to produce food: input industries (e.g. fertilisers); primary production; processing; packaging; distribution; retail; and consumption (Ericksen 2008). All processes have social, cultural, economic, environmental, and political aspects, including governance. A food system can be defined by geography, but it often has many connections and interdependencies with other spatial scales (e.g. inputs, or the import and export of products).

Food systems are complex systems, and scenarios are powerful tools to imagine futures in such systems. While the use of scenarios is well established in many fields of science, e.g. energy studies with a multitude of proven scientific solutions (e.g. Heinonen, Karjalainen, and Ruotsalainen 2016; Kalt et al. 2020; Kishita et al. 2017; Rikkonen and Tapio 2009; Tapio et al. 2017), the role of food system scenarios has become important in the face of ecological drivers such as climate change, biodiversity loss, and when the global phenomena of population growth and food security gained increased attention on the global political agenda (van Dijk and Meijerink 2014; e.g. FAO 2018; Flies et al. 2018; Holman et al. 2017; van Meij et al. 2018; Millennium Ecosystem Assessment 2005; Nakicenovic et al. 2000; O'Neill et al. 2017; Reilly and Willenbockel 2010). It is also notable that a majority of food system scenario studies consists of traditional farming i.e. conventional and modern agriculture. There are scenario studies on emerging novel food systems, but descriptive for those are that the studies are very focused on certain novel products or technology (see e.g. Pippinato et al. 2020; Dick et al. 2019).

While there exists a variety of food system scenarios constructed with a wide range of methodological approaches, the literature on how to compare these approaches is limited. The aim of this article is to explore the variety of scenario elements present in contemporary food system scenarios. We reviewed food system scenarios with three spatial scales (Finland, Europe and global) which contain different methodological and thematic elements that affect the scenario construction in food system foresight. The following questions were analysed through the reviewed literature:

1. What kind of scenario elements are present in food system studies?

2. What types of scenarios are present in food system scenario literature?

1.1 Scenarios in brief

The scenario techniques migrated to the business world via the RAND Corporation and Royal Dutch Shell after the scenario planning was first initiated in the military (US Department of Defense) (Bell 2003; Bradfield et al. 2005; Wack 1985). As a result, scenarios are widely used by organisations and communities for strategic planning (e.g. Bradfield et al. 2005; Godet 2000), governments for political decision making (e.g. Ehlers et al. 2022), and of course, researchers in different contexts. In addition to the requirement that there should usually be more than one scenario, scenarios need to be relevant, coherent, transparent, and plausible (Durance and Godet 2010; Godet and Roubelat 1996).

Various scenario typologies have previously been identified, e.g. predictive, explorative, and normative, based on probable, possible, or preferable futures (Amara 1991). *Predictive* scenarios present probable futures, e.g. contains forecasting. *Explorative* scenarios present possible futures, i.e. external or strategic (internal) scenarios. Finally, *normative* scenarios present preferable futures, i.e. preserving or transforming scenarios. (Börjeson et al. 2006) Transforming scenarios such as backcasting scenarios have their starting point in the future as a prioritised target or vision (Börjeson et al. 2006). Backcasting is especially utilised when a great change is envisioned and required, i.e. current developments are leading to unwanted futures (Höjer and Mattsson 2000). Backcasting scenarios are inherently normative and can be constructed either using participatory methods or desk research. They can also include quantitative aspects, i.e. a mixed methods approach (van Notten et al. 2003). Exploratory scenarios are also often participatory and have quantitative and qualitative aspects (van Notten et al. 2003). Exploratory scenarios aim to raise awareness, flexibility, and preparedness, stimulate creative thinking and even change mental models (Hiltunen 2009; Wack 1985), or gain an understanding of how different drivers influence each other (Kok et al. 2011). On the other hand, backcasting scenarios are used to explore paths to futures that vary in their desirability (Kok et al. 2011).

The scenario process itself can also produce deep insights and knowledge, which may not be the main goal but a valuable aspect (Godet 2000; Heijden 2005; Schwartz 2012). Even if the definitions of scenario and scenario techniques have quite long traditions in futures studies, it must be noted that scenarios are used quite flexibly. On one hand, in policy-oriented scenario analysis, a scenario can be considered more like a defined policy option that changes the future development. On the other hand, when anticipating e.g. food system change more broadly, a scenario can be seen as a holistic description or storyline of how the future evolves step by step from the present to the future. Hence, the term scenario remains also contested. In the broadest sense, scenarios can be understood as “qualitative storylines, quantified descriptions of alternative futures, or anything in between” which “can be used to describe, explore and communicate how the future may unfold” (Mitter et al. 2020, 2).

2. Materials and methods

For our analysis, we concentrated on studies that described and evaluated alternative futures for food systems in Finland, Europe, and on the global scale. The studies contain both academic articles and grey literature highlighting food system level futures.

The studies were searched using a variety of resources. Web of Science (WoS) was used as the primary database, where we used keywords *scenario, foresight, "food system", Europe*, Finland* and *global* to search academic literature published between 2014–2021. Additional keywords *future, transition, transformation, food** and *Finnish* were used for a second query targeting articles pertaining Finnish food system. The queries from WoS resulted 221 unique entries in total. Based on the titles, abstracts, and methodology sections, we excluded articles that had wrong spatial scope, generally meaning national case studies outside of Finland or sub-national emphasis or did not include scenario creation within them. Moreover, we excluded studies pertaining primarily to energy, general land use, soil nutrients or single food commodities. For the sake of analysis, we decided to target scenario studies pertaining agricultural food production, thus excluding studies discussing for example aquaculture. The exclusion process resulted in a set of 25 studies, which were considered suitable for further evaluation. The search was supplemented by three papers from Google Search engine to reflect scenario analysis conducted outside of academia. Moreover, we extended the search to Google Scholar and considered few studies based on personal recommendations. The search in Google Scholar was treated as secondary and was conducted for the purpose of enriching the sample, especially on the Finnish and European spatial levels.

Finally, we selected the sample of 19 studies by reviewing the pool of articles we had collected. The studies were reviewed and selected to portray widest methodological range possible. The final set comprises both qualitative and quantitative scenarios with variety of scenario methodologies applied. The main themes include climate change, land use, food security, food trade, dietary change, and structure of agriculture with time dimensions of the scenarios varying between 2030–2050.

The selected studies were analysed using qualitative content analysis (Hsieh and Shannon 2005). Conventional content analysis approach was selected to give primacy to the data, but existing scenario literature and typologies such as Börjeson et al. (2006), Reilly & Willenbockel (2010) and Benton (2019) were reflected during the analysis. Initially, we coded the data for thematic, spatial and temporal focus together with methodological elements used in the scenario building. After the first round of coding, methodological elements appeared the most fruitful point of departure for further analysis. Therefore, a more nuanced coding was conducted to gain more insight in the differences these methodological approaches contained. Altogether, the coding can be described inductive and iterative, where new categories were created throughout the analysis and the coding matrix adjusted accordingly. After the coding process, the categories were reviewed, condensed and combined to form entities that would be best representative of the range of literature we reviewed. The final categories were then assessed to distinguish differences and commonalities within the coded material. We chose to present the results of the coding process as dichotomies, as they allow clear and practical mean to present the extremes in methodological choices and scenario elements encountered. The dichotomies are presented in the results section and summarized in table 1.

[FIGURE 1 PLACEHOLDER]

Figure 1. Framework for the data collection and the analysis.

3. Results

Table 1. Dichotomies of methodological elements in food system scenarios

[TABLE 1 PLACEHOLDER]

3.1. Qualitative and quantitative scenarios

One main way to describe a methodology used in a scenario study (and generally in any research) is the division *between qualitative* and *qualitative approaches* (Amer, Daim, and Jetter 2013; Popper 2008).

Quantitative methods measure variables and apply statistical analyses, employing or generating data using modelling or simulation. *Quantitative scenarios* are therefore often associated with the use of models, which apply numerical values to portray variables within the food system, as well as the interactions and exchanges between them. The term model itself includes a wide variety of applications which vary in their scope and level of complexity. Three main modelling approaches in food system modelling comprise balance models (e.g. Huan-Niemi et al. 2020), economic equilibrium models (e.g. Lehtonen et al. 2020), and integrated assessment models (e.g Van Vuuren et al. 2015). The variables used in a model are economic, demographic, technical, geographical, etc. phenomena deemed important for the system interaction, which can be measured or otherwise reliably portrayed as numerical values to allow the model to function. Quantitative food system scenarios tend to evolve around estimating structural change in agricultural production (Lehtonen et al. 2020), analyse land-use effects (Röös et al. 2017) and assess food security under different product portfolios (Van Vuuren et al. 2015).

Whereas quantitative approaches are powerful when system variables can be measured, *qualitative* methods allow more nuanced interpretations of different events and can build on personal views and knowledge. The scenario process aims to identify, collect, condense, categorise, and restructure the data to make sense of the variables and interactions within the food system against a selected framework. Qualitative scenario building process can take a variety of forms, which vary in their relation to existing knowledge and theory, as well as data collection practices and subsequent results the analysis may yield. Frameworks, such as multilevel perspective on socio-technical transitions (e.g. in Kuhmonen & Kuhmonen 2019), background narratives such as shared socio-economic pathways (e.g. in Mitter et al. 2020, Lehtonen et al. 2021) or morphological tables (e.g. in Rikkonen 2017, Mora et al. 2020) are used to guide the systematic assessment of food system variables and dynamics. In contrast to quantitative scenario approaches, qualitative scenarios are more capable of addressing future developments, which are difficult to accurately quantify, and where interactions of different variables cannot be generalised. Such developments include many socio-political developments: change in consumer values, feasibility of different policies and technical solutions, and cultural aspects related to food. Hence, qualitative scenarios expand the scenario horizon to cover aspects that qualitative model are generally incapable of.

While the differentiation between qualitative and quantitative approaches sits tight in many scientific fields, drawing the line between qualitative and quantitative scenario methods is less definitive. Almost every scenario study involves both qualitative and quantitative aspects: modelling approaches include qualitatively created scenario setups, which are further populated or transformed into numerical equivalents for modelling purposes. Furthermore, every quantitative scenario requires a qualitative analysis to make sense of the numerical results generated by the model in the selected context. When using qualitative scenario methods, quantifying the created scenarios in the foresight process may make them more approachable to larger audiences by aligning them with scenarios created using modelling tools. The literature also recognises semi-quantitative methods, which apply mathematics to quantify subjectivity, i.e. weighting the opinions and probabilities of experts (Popper 2008).

3.2. Type of foresight

Variety exists in the attention and expected outcome of the scenarios. Some scenarios aim to accurately portray interactions within the food system and analyse the effects resulting from these dynamics. Other scenarios are more interested in envisioning and uncovering new possible future scenarios to further expand the horizon of the possible food system futures. *Projection scenarios* are formulated with the aim of anticipating the most prominent developments affecting and altering the food system in the future. Projections pay attention to analysis, especially to the formal logic by which the scenario elements interact with one another, making it very common within quantitative, model-based scenario construction that aims on producing multiple projections based on altering the key assumptions in simulation runs.

In contrast, when the scenarios pay more attention to the end state of the developments, we refer to them as *future images*. Future images (see e.g. Kuhmonen 2017; Rubin 2013) are often more explorative than scenarios presented as projections, and while they pay attention to dynamics that formulate and enable the given future state, they are more interested in exploring the various future states generated.

For example, the interest of Odegard & van der Voet (2014) was in assessing global land, water, and fertiliser use in 2050 for a complete diet in the global population. Their analysis was conducted with the aim of accurately quantifying future resource use and discussing the implications of the results. Hence, the analysis leant towards the projections side of the dichotomy. On the other hand, Mathjis et al. (2018) aimed to "develop medium- to long-term explorative scenarios describing possible futures for the external environment that EU farming systems face" (ibid. p. 3). Their analysis aimed not to specifically quantify or evaluate probabilities, but to explore possible future operating conditions for European agriculture based on the analysis.

3.3. Direction of the analysis

Frontcasting scenarios take the current system as a starting point, without giving the scenarios set end states. The themes and general direction of the scenario exercise may be implied, but the scenarios are generally more interested in the effects the individual developments have on the scenario outcome. Frontcasting scenarios can thus be best used to assess sensitivities between different economic and environmental developments or to uncover the new futures which form through the cross-effects of different developments. Mora et al. (2020) used morphological analysis to create multiple combinations of external and internal drivers in global food systems. According to the authors, their selected approach aimed to improve "understanding of future developments and the forces likely to shape them" rather than "predicting the future" (ibid. p. 4).

The *backcasting* approach is selected to uncover new pathways to system outcomes set prior to the analysis. Hence, backcasting is more interested in the developments, drivers, and measures required to achieve the selected future, and it is often more concerned with accuracy in its analysis. Huan-Niemi et al. (2020) studied the Finnish food system under five different future diets as the starting point, analysing the changes these dietary shifts would imply for the Finnish food production.

Special attention was paid to the developments and interventions that would have to occur in agricultural and food policies to make the transition feasible.

Somewhere between frontcasting and backcasting are scenarios in which the general conditions of alternative futures are defined, but their more accurate end state is left ambiguous. Mitter et al. (2020) and Lehtonen et al. (2021) utilised shared socioeconomic pathways (SSP) as background descriptions to study the futures of the European food system and Finnish agriculture respectively. The role of background descriptions, or storylines, was to deliberatively create different system conditions in which the scenarios would be developed. Hence, the scenarios would mostly be created in a frontcasting manner but still describe the food system's future in conditions set prior to the scenario construction.

3.4. Statistical and participatory data collection

The data for the scenario study can be collected in various ways, in which our dichotomy differentiates between statistical and participatory data collection. The quantitative models often utilise databases or numerical values based on the existing literature. For example, Röös et al. (2017) collected data for their model using primarily publications by the Food and Agriculture Organization of the United Nations, supplemented by the relevant research and grey literature.

Stakeholders can be engaged in participatory data collection both to validate quantitative data sets and to more qualitatively anticipate future trends and their interaction. In Kuhmonen & Kuhmonen (2019)the interviewees described their views on the future of Finnish agriculture, as well as the drivers and outcomes these futures contained. Stakeholders were also involved by Rintamäki et al. (2016), where 29 stakeholders participated in a Delphi panel via a questionnaire and face-to-face interviews to evaluate outcomes and effects of alternative climate change mitigation policy scenarios to Finnish farms.

Multiple data sources can be combined to achieve a more comprehensive set of materials for the scenarios. Mitter et al. (2020) reviewed the existing SSP literature to establish major topics and storyline -elements for their scenarios before engaging with more than 100 European stakeholders to create their EUR-Agri narratives. The stakeholder input data were collected over 50 interviews, refined with a research group and validated with causal loop diagrams by Mathjis et al. (2018). Additionally, they arranged a series of workshops throughout the scenario process, where the stakeholders participated in the scenario creation, evaluation, and validation.

3.5. Locus of food system change

Changes in food systems are often a result of an action taken by an actor that directly or indirectly affects the food system. The main actors capable of initiating the change are actors in food production (farmers, the food industry), consumers through dietary change, or politicians directly or indirectly by affecting the economic, normative, or legislative conditions in which the food system operates.

Production-push occurs when the food system change is mainly initiated through the production side actions. This effect may be a result of either necessity or an opportunity, which causes farmers and the food industry to act in proactively. In Lehtonen (2020), food demand is expected to undergo only minimal change until 2035, and the agency is given to agricultural producers who change their farming techniques and land use patterns. The policy change expected in the scenarios is a combination of carrot and stick, in which the economic conditions for sustainable farming are improved with targeted subsidies, and undesired farming activities result in lower subsidy levels.

Demand-pull occurs when the change is more demand-oriented, usually as result of a policy intervention or a change in consumer dietary preferences due to economic or ideologic reasons. In Westhoek et al. (2014) consumption animal-deprived food is assumed to reduce, which is found to have positive effect on the land use and GHG emissions in European agriculture due to the production response in agricultural production. Similarly, in Huan-Niemi et al. (2021) Finnish food consumption changes towards more plant- and fish-based diets creating a demand-pull effect to the Finnish food system.

3.6. Food production system foci

Food system scenarios seem to generally favor quantitative changes in food production characteristics such as land-use, crop yields and product portfolios, which easily result in *traditional production system scenarios*. Traditional production system scenarios expect farming-based food production and contemporary actors to remain central for food production in the future. Majority of the scenarios we reviewed expected the food system to undergo either intensification or diversification, where food production maintains its contemporary characteristics, yet transforms into different forms. Intensification aims for global and economically efficient food production, which is achieved through more efficient use of production inputs and land use (e.g. Odegard & van der Voet 2014). In contrast, diversification relies on a regionally adjusted and self-sufficient production with agroecological farming practices and nutrient cycles (e.g Mora et al 2020). Especially the demand-pull oriented scenarios often expect rather conservative changes in technological development, focusing mostly on quantitative changes in agricultural production areas and product portfolios under traditional farming techniques.

Novel production system scenarios rely on technological advancements as a key driver in food production transformation. Food system structure undergoes significant changes when new actors enter the system, and the food production systems are significantly altered. In Röös et al. (2017) introduction of artificial meat and other novel protein sources is expected to replace traditional livestock systems completely, thus effectively removing the need for arable land in protein production. Similarly, rapid technical development in Hamilton et al. (2020) results in a significantly decreasing number of food producers and supplier, making farming systems largely reliant on information technology and automation. Novel production system scenarios are often accompanied with a production-push effect, as the scenarios are generally envisioned to be a result of an economic and technological opportunity. Novel production systems scenarios are described to be less probable compared to traditional production systems due to the high requirements in technological development as well as economic feasibility.

4. Discussion

There are multiple scenario typologies, which aim to categorise intent, probability, and logical flow in scenario studies (Amara 1991; Börjesson et al. 2006). We believe our dichotomies of food system scenario elements can support these typologies and allow rather innovative combinations of different scenario elements. However, it is rather safe to say that some scenario elements complement each other better than others. In reflection to the scenario typology proposed by Börjesson et al. (2006), we find similarities when combining different foresight types and different directions of the analysis. Projection foresight type seems to be applicable with both frontcasting and backcasting, resulting in scenario studies that are highly similar to forecasts and normative scenarios respectively. However, scenarios that aim for future images are generally more inclined to be created in a frontcasting manner, resembling explorative scenarios. A combination of future images and backcasting appears an unlikely combination, but could resemble pluralist backcasting approach applied by Järvi et al. (2014).

Moreover, the synergies between quantitative modelling, projections and statistical data collection are apparent in our sample of scenario studies. Computer simulation models have historically held a great foothold on global agrifood foresight, yet they have also encountered increasing critique due to their in-built economic axioms and tendency to standardise food system reality (Dorin & Joly 2020). Recently, more foresight tools, such as Agrimonde-Terra (Mora et al. 2020) have emerged to challenge the purely quantitative models and their epistemological choices on global level. Quantitative scenarios seem to work well with frontcasting practices and participatory data collection. Workshop exercises (Mitter et al. 2020, Hamilton et al. 2020), Delphi method (Rintamäki et al. 2016) and interviews (Kuhmonen & Kuhmonen 2019) all resulted in scenarios that are more detached from one another compared to the scenarios created with modelling tools.

In our analysis, the three spatial scales had surprisingly limited influence in the scenario elements. Both qualitative and quantitative scenarios were found on all spatial levels, as well as future images and projections. We did find a tendency to favour quantitative approaches in global and European level studies compared to the Finnish level, which is in line with Bourgeois' (2017) observation. Similarly, production push-effect was more common in Finnish studies compared to European and global levels, which often held demand-pull from dietary change as the dominant effect shaping food production. Finnish food system scenarios also appear rather agriculture and policy centric, which highlights the prominence EU-level decisions have on the Finnish food system (Rikkonen 2017). Policy targets and nuanced policy effects were arguably better included in Finnish and European studies, whereas global scenarios rely more on general descriptions of global political development.

4.1. Four different types of food system scenarios

To illustrate how different scenario elements can be combined in food system foresight, we propose a set of four different scenario types based on our dichotomies of scenario elements. We emphasise that the scenario types presented here are not an exhaustive list of all the available scenario types, but rather a compilation based on the results of this article (table 2).

Table 2. Dominant elements in different type scenarios

[TABLE 2 PLACEHOLDER]

'Policy scenarios for policy planners and decision-makers' are quantitative and modelled scenarios that are generally constructed in conjunction with policy analysis or other strategic planning activities. They have narrow thematic scope which, in our case, focused mainly on analysing means to reduce the climate effects of food production. Within this thematic scope, *policy* scenarios provide a detailed analysis of different endogenous and exogenous elements affecting the structure of the food system and aim to accurately model and project the effects different policy actions could generate through the food system. As a result, *policy* scenarios can effectively be used to generate quantified targets for policymakers and stakeholders that can be used as a basis for further policy planning.

Similarly, '*Detailed data scenarios for aiming on accuracy'* use quantitative modelling to construct either backcast or frontcast scenarios. The modelling and spatial scales of the analysis may vary depending on the given theme and variables selected. Generally, *data* scenarios are effective in portraying the cross-effects of few selected variables that can be modelled in multiple iterations to generate a large number of scenarios. A major strength of the *data* scenarios is the rather transparent description of the model, as a detailed description of the model and its operating logic is often found in conjunction with the scenarios. However, the tendency to favour only few variables of interest in the analysis may simplify the food system dynamic within the modelling.

'Trends for exploring and constructing macro-level scenarios' are qualitative scenarios which emphasise the identification and exploration of the trajectory changes that affect the food systems. These scenarios take a more holistic approach to the food system dynamics by including social, cultural, and political variables in the scenario construction as more independent variables. This contrasts with the mostly techno-economic variables driving the modelling in previous scenario types. In general, *trends* scenarios utilise a combination of literature reviews and participatory stakeholder methods in their data generation, with the emphasis often on the latter. The scenarios are constructed in either frontcasting or backcasting manner, yet the scenarios are rather independent and thus hard to compare, because of the complex interactions within the holistic and qualitative system portrayal. As a result, the scenarios often pinpoint future states and are presented as narrative descriptions, lacking accurate quantitative estimations or illustration.

Finally, '*visioning scenarios for new futures'* utilise qualitative scenario construction to explore possible future images with a high degree of flexibility in the framework and materials. The thematic and spatial scope of the analysis may vary greatly, but *visioning* scenarios are generally used on the national or subnational level, as the data processing requires rather detailed knowledge of the selected system(s). *Visioning* scenarios can be generated solely based on the literature by collecting and combining identified system developments in different futures, but participatory data collection methods such as interviews and workshops are also common. The scenarios are generally frontcast scenarios, where the interest of the analysis is on the future visions and the combination of developments that enable those futures to occur. The scenarios also pay more attention to the agency of groups and individuals, whereas other scenario types may easily treat them as variables whose action is reactive to other system variables.

Table 3. Common strengths and weaknesses of different scenario types

[TABLE 3 PLACEHOLDER]

4.2. Involving stakeholders with different types of scenarios

In relation to the four proposed scenario types, next we discuss how different scenario types can be effectively used with stakeholders. Stakeholder engagement is often considered beneficial for a scenario process, because it exposes the process to a wider range of practical issues and often introduces larger variety of societal perceptions to the scenario planning process by promoting active discussion between researchers and other actors in the society (Andersen, Hansen, and Selin 2021; Oteros-Rozas et al. 2015). Moreover, stakeholder participation is central when building legitimacy for policy decisions that emerge from a scenario analysis (Wright, Stahl, and Hatzakis 2020). According to Hebinck et al. (2018), stakeholder participation in foresight can serve three purposes when addressing transformative change in food systems: 1) the pre-conceptualisation of change; 2) creating an avenue for new actor networks; 3) creating tangible strategies with a high chance of implementation.

Trends scenarios may be used to form an important starting point to understand the holistic and interconnected nature of the food system by identifying trends, drivers and challenges of food system futures. Therefore, *trends* scenarios may prove useful in engaging stakeholders in an early phase of the process to pitch in and deliberate their views, thus inviting a more explorative discussion of different futures. A larger number of scenarios can thus be established for deliberation on which of them are possible, desired, probable, and undesirable futures. *Visioning* scenarios are also fitting for stakeholder engagement purpose due to their flexible nature. Furthermore, *visioning* scenarios may also be suited for stakeholder engagement for the purpose of transforming identified macro-trends into more detailed drivers in more nuanced spatial and thematic scopes. If the interest of the study is to explore specific stakeholders' perception of different futures, *visioning* scenarios allow nuanced and tailored tools for the analysis. Both *visioning* and *trends* scenarios enable tackling of complex socio-political interactions thus allowing more liberty in the scenario discussion compared to more limited framework of quantitative modelling environments. They are also capable of promoting inclusive discussion from different segments of the society due to the holistic nature of their approach.

Due to the more specific knowledge required to fully engage with quantitative scenario approaches and modelling frameworks, stakeholder engagement in *data* and *policy* scenarios often tend to be more exclusive. However, when it comes to communicating scenario results and using scenarios as tools of strategic planning, quantitative scenario approaches are often considered more robust in their methodology (Tetart 2020). *Data* scenarios can be used effectively to visualise and address sensitivities between selected variables, thus being particularly useful in exploring and validifying prominent macro development identified by stakeholders. Moreover, expert stakeholders may be engaged to construct and validify data sets used for a *data* scenario analysis. Because policy scenarios are generally created in conjunction with a strategic decision-making process where stakeholder interaction is generally expert based, the complexity of quantitative modelling may not be such significant issue compared to more inclusive scenario processes. For communication purposes, *policy* scenarios are strong tools to visualise low number of future pathways for wider audiences due to the low number of scenarios presented. In addition, they allow high usability for the scenarios in a more executive purposes, because the comparison between baseline and alternative scenarios is presented in a straight-forward manner.

5. Conclusion and recommendations

In this paper, we investigated the food system scenario literature and the methodological elements found in contemporary studies. We reviewed scenarios from the global, European, and Finnish national levels to establish dichotomies that portray the variety in the scenario elements present. We found that food system scenarios vary in their choice between quantitative and qualitative approaches, which still appears to be the major dividing point in the scenario field. The direction of a scenario analysis can be either forward-looking in frontcasting (where are we headed?) or back-tracking in backcasting (how do we get there?). The type of foresight contained in the food system scenario literature varies from projections aiming for accuracy to futures images that emphasise envisioning and discovering new futures. Data for the scenario analysis can be collected from literature or pre-existing datasets, which often suit more quantitative scenarios, or through interviews, workshops and surveys, which are more common when constructing qualitative scenarios. Majority of the food system scenarios appear to favour futures with rather conventional agriculture, and express food system transformation through demand-pull effect. Similarly, novel production systems and production-oriented developments were less common in the scenarios we reviewed.

To illustrate different combinations of these scenarios elements, we proposed four types of scenarios to give a more tangible portrayal of the variety of scenarios with different methodological elements. *Policy* scenarios aim for high quantitative projection accuracy with a narrow thematic scope, often in conjunction with strategic planning. *Data* scenarios use large number of scenarios to effectively explore or portray sensitivities between a limited number of variables. *Trends* scenarios explore and identify macro-level trajectories affecting the food system more qualitatively. *Visioning* scenarios use qualitative tools to explore new futures with a higher degree of flexibility in the methodological applications, as well as thematic and spatial framing.

Based on our analysis of the food system scenario reviewed, we propose a check list which should be considered in a scenario process. This list is also a concluding summary of the scenario elements discussed in this paper.

- **What is the goal and purpose of the scenarios?**
  Selection can be based on the four types of scenarios i.e. Policy, Data, Trend or Visioning scenarios.
- **Are scenarios intended to be based on accuracy or of a holistic nature?**
  Quantitative or qualitative?
- **What is the theoretical framework for the scenario analysis?**
- **What are the system boundaries?**
  What are the spatial, temporal and thematic frames of interest?
- **What are the data used in scenarios?**
  E.g. data from workshops, Delphi or statistical data?
- **What is/are the method/s for constructing scenarios?**
  E.g. modelling or participatory or both?
- **How are scenarios discussed or co-designed with key stakeholders?**
  Is the scenario construction based on desk research or is it participatory? If participatory, who will be involved and how? How are the scenarios discussed and distributed after the process.
- **Who is the end user of the scenarios?**
  E.g. political decision makers, food company, researchers or a group of various stakeholders.

Through this kind of a checklist, it is possible to follow and enrich the guidelines that have been defined as a successful scenario planning. Van der Heijden (1996) pinpoints the following criteria for scenario planning and for scenarios itself; 1) each of the scenarios must be plausible, 2) scenarios must grow logically in a cause-effect way from the past and from the present, 3) they must be internally consistent (the events within a scenario must be related through cause-effect lines of argument, which cannot be flawed), 4) scenarios must also be relevant to the issues under scrutiny, 5) provide useful and comprehensive idea generators, and 6) test conditions against which the plans and strategies can be considered. These kinds of checklists help and improve the quality of scenarios and prepares the responsible group to think of critical aspects before initiating and during the actual scenario construction process.

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TABLES AND FIGURES

Figure 1. Framework for the data collection and the analysis. (pg. 3)

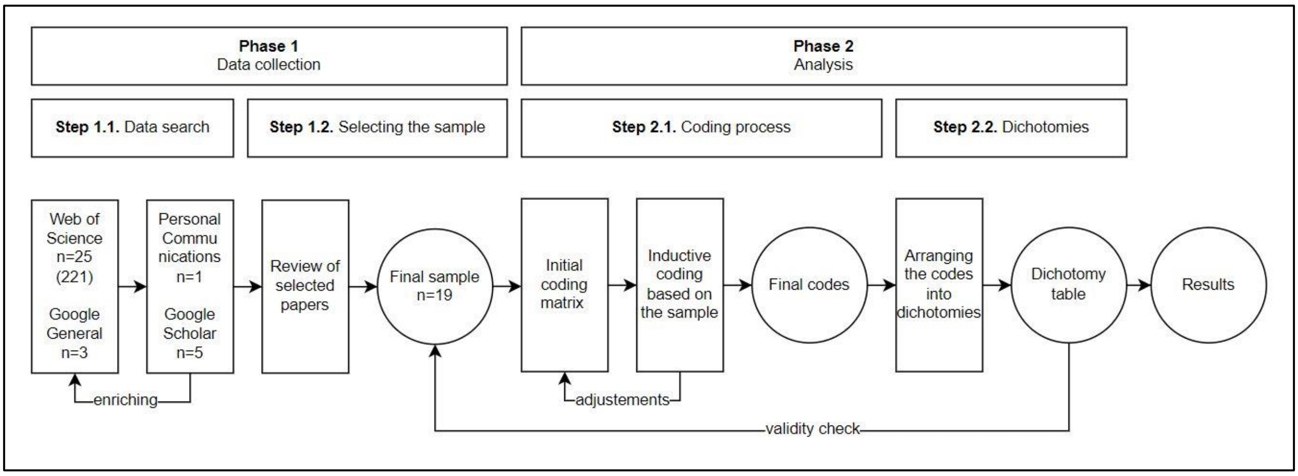

Table 1. Dichotomies of methodological elements in food system scenarios. (pg. 4)

General approach	**Quantitative** Descriptive. Macro-level analysis. Top-down approach. Statistical data and models.	**Qualitative** Explorative. Macro or micro-level analysis. Bottom-up approach. Stakeholder participation.
Foresight type	**Projections** Create projections based on available data. Estimate probabilities of different futures. Focus on measures.	**Future images** Discover and describe new futures and pathways. Focus on possible (probable and preferable) future states.
Direction of analysis	**Backcast** Fixed future states. Portrayal required changes and selection of measures for fixed targets.	**Frontcast** Open-ended. Estimate impact and cross-effects of different measures.
Data collection	**Statistical** Utilise databases and state-of-art estimations on relevant trends. Focus on quantitative accuracy.	**Participatory** Stakeholder engagement at multiple stages of the process. Encourage deliberation on future developments on acute themes.
Locus of change	**Demand-pull** Agency on consumers. Focus on dietary changes. Imply effects on production end.	**Production-push** Agency on farmers and food industry. Focus on new farming methods. Imply preconditions for politicians and society at large.
Food production system foci	**Traditional production systems** Maintain conventional food production practices and general system structure. Transformation towards intensification or diversification.	**Novel production systems** Radical transformation in food production through technological innovation. Change in food system actors and system strucure.

Table 2. Dominant elements in different type scenarios. (pg. 8)

	Policy scenarios for policy planners and decision-makers	**Detailed data scenario s for aiming on accuracy**	**Trends for exploring and constructing macro-level scenarios**	**Visioning scenarios for new futures**
General approach	Quantitative	Quantitative	Qualitative	Qualitative
Foresight type	Projections	Projections	Projections, Future images	Future images
Direction of the an alysis	Frontcast, Backcast	Backcast, Frontcast	Frontcast	Frontcast
Data collection	Statistical	Statistical	Participatory	Participatory, Statistical
Locus of change	Production-push	Demand-pull	Demand-pull	Production-push
Food production system foci	Traditional production s ystems	Traditional production s ystems	Traditional production s ystems	Traditional production s ystems

Table 3. Common strengths and weaknesses of different scenario types. (pg. 9)

	STRENGTHS	**LIMITATIONS**
Policy scenarios for policy planners and decision-makers	• Detailed description of selected pathways • Usable and understandable outside academia	• Narrow scope limits developments in wider society • Resource- and time-intensive
Detailed data scenarios for aiming on accuracy	• Strong in comparing impacts between selected variables • Multiple scenarios allow transparent sensitivity analysis	• May simplify and generalise food system dynamics • Few variables of interest can be selected, which may exaggerate their weight
Trends for exploring and constructing macro-level scenarios	• Comprehensive perspective on different future developments • Important starting points for further research	• Macro-level analysis frame may limit the depth of spatial scale • Limited use outside academia unless quantified
Visioning scenarios for new futures	• Complex non-quantifiable system dynamics can be explored • Flexible in methodological and thematic choices	• Analysis may result in poor comparability between scenarios • Limited transparency concerning choices made