



Sustainable supply chains from farm to table

– case study legumes

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Mistra Food Futures Report #26

Sustainable supply chains from farm to table – Case study legumes

Hållbara leveranskedjor från gård till bord – Fallstudie baljväxter

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The overarching vision of the programme Mistra Food Futures is to create a science-based platform to enable transformation of the Swedish food system into one that is sustainable (in all three dimensions: environmental, economic and social), resilient and delivers healthy diets. By taking a holistic perspective and addressing issues related to agriculture and food production, as well as processing, consumption and retail, Mistra Food Futures aims to play a key role in initiating an evidence based sustainability (including environmental, economic and social dimensions) and resilience transformation of the Swedish food system. This report is a part of Mistra Food Future's work to identify the next generation's food system sustainability indicators, one of the central activities within Mistra Food Futures.

Mistra Food Futures is a transdisciplinary consortium where key scientific perspectives are combined and integrated, and where the scientific process is developed in close collaboration with non-academic partners from all parts of the food system. Core consortium partners are Swedish University of Agricultural Sciences (SLU), Stockholm Resilience Centre at Stockholm University, RISE Research Institutes of Sweden and The Beijer Institute of Ecological Economics.

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Abstract

The food systems need to change to meet the many challenges facing humanity. The food system in the future needs to deliver good performance in a broad spectrum of impacts, such as environment, health, socioeconomics and cultural values. To do this, supply chains need to be rearranged, and efficiency needs to increase without compromising other valuable outputs. Assessing sustainability performance of possible future production systems is inherently difficult and including the broad array of impacts complicates the task even further. In this report we 1) describe an iterative four-step process for designing hypothetical future supply chains for different “product concepts” and 2) evaluate their sustainability performance. The design process included used scenarios developed within MISTRA Food Future and the evaluation of sustainability performance was made by Multi-Criteria Assessment (MCA).

The results showed that the method developed was useful, facilitated close and fruitful collaboration with supply chain stakeholders, and provided new insights and better understanding of the role of industry and retail in development of the future food system. The use of MISTRA Food Future scenarios helped the process by supporting wider perspectives among all participants. The MCA approach for evaluation worked well in capturing the broad sustainability performance, though the result was too aggregated to work as a decision support for decisions on real actions, but acted rather as a clear screening of the relative importance of the different sustainability areas. However, this in turn is valuable for deciding on the next steps in supply chain design.

Keywords: Designing Food Supply Chains, Multi-criteria assessment, MCA

Svensk sammanfattning

Vårt livsmedelssystem måste förändras för att möta de många utmaningar som mänskligheten står inför. I framtiden måste livsmedelssystemet leverera bra prestanda inom ett brett spektrum av effekter, som miljö, hälsa, socioekonomiska och kulturella värden. För att göra detta måste försörjningskedjorna omorganiseras och effektiviteten måste öka utan att kompromissa med andra värdefulla resultat. Att bedöma hållbarhetsprestanda för möjliga framtida produktionssystem är i sig svårt och att inkludera det breda utbudet av effekter komplicerar uppgiften ytterligare. I denna rapport beskriver vi 1) en iterativ process i fyra steg för att utforma hypotetiska framtida leveranskedjor för olika "produktkoncept" och 2) en utvärdering av deras hållbarhetsprestanda. Designprocessen inkluderade användning av scenarier utvecklade inom MISTRA Food Future och utvärderingen av hållbarhetsprestanda gjordes med hjälp av Multikriteria-analys (MCA).

Resultaten visade att metoden var användbar och underlättade nära och fruktbart samarbete mellan leverantörskedjans intressenter, och den gav nya insikter och bättre förståelse för industrins och detaljhandelns roll i utvecklingen av framtidens livsmedelssystem. Användningen av MISTRA Food Futures framtidsscenarier bidrog till processen genom att stödja bredare perspektiv på framtida lösningar bland alla deltagare. MCA-metoden som bas för utvärdering fungerade bra för att fånga den breda hållbarhetsprestationen, men resultaten var för aggregerade för att fungera som ett beslutsstöd för verkliga åtgärder, utan agerade snarare som en tydlig kartläggning av den relativa betydelsen av de olika hållbarhetsområdena. Detta är dock mycket värdefullt för att besluta om nästa steg i design av försörjningskedjan.

Nyckelord: Utformning av livsmedelsvärdekedjor, Multikriteria-analys, MCA

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1. Introduction

The food sector, like society in general, is facing major changes. Several of the major global challenges such as climate change, deteriorating public health and depletion of ecosystems are closely linked to both the consumption and production of food (Poore and Nemecek, 2018, Willett et al., 2019). To meet this, major changes are likely required in how food is produced, but also which food is consumed and produced. The usual approach for companies has so far been to conduct active sustainability work within activities they feel they have control over (production, logistics, purchasing, etc.). This has been successful, but to reach the next level of sustainability, a new form of close cooperation in the supply chain is required (Rota et al., 2013, Leon-Bravo et al., 2017). To begin a change in the system, actors in the supply chain must collaborate in new ways, which in turn requires the development of tools and work processes that create conditions for these relationships (Dania et al. 2018).

Within the MISTRA Food Futures project, a method and work process for designing the future's more sustainable supply chains for food has been developed (Sonesson et al., 2023). In the work to develop the methodology, case studies have been central. These case studies have been carried out in close cooperation with the actors of the supply chains, both the food industry and retail trade.

This report describes the work carried out in one of the case studies and the results generated specifically for the case study, but also insights and conclusions about the relevance and usefulness of the method.

1.1. Purpose and Goals

Overall purpose:

To develop a method that manages to include production-specific aspects within the food value chain and at the same time contributes to an understanding of what future sustainable food systems can look like. The method is intended as a tool to support actors in the food chain in their strategic work.

Case study purpose:

Method development: The purpose was to test and evaluate the method developed; "Metod och arbetsprocess för design av mer hållbara leveranskedjor från gård till butik" (Method and work process for designing more sustainable supply chains from farm to retail, see Sonesson et al., 2023) in collaboration with actors in the product chain. A secondary purpose was to test how MISTRA Food Future's scenarios can contribute to a deepening of understanding and contribute to better decision-making. The scenarios are briefly described in Appendix 1.

Case study results: The purpose was to analyze the sustainability performance of future product chains from farm gate to store (or equivalent), to provide a broad understanding of the totality and to rank different options. The goal is that the analysis of sustainability performance should be able to form the basis for decisions on what in-depth analyzes of the supply chains that should be prioritized to get an accurate and relevant decision support.

Goals:

- To use the " Ramverk för design av mer hållbara leveranskedjor från gård till butik (Framework for the design of more sustainable supply chains from farm to store)" (Sonesson et al., 2023) to carry out a case study of concrete supply chains, in collaboration with companies in the chain.
- Using the case study as a basis to assess how well the use of the method generates new knowledge, what type of knowledge, how the cooperation between the various actors works and how the actual results and experiences are valued by participating parties. (Method development).
- To use the scenarios developed within MISTRA Food Futures to create a transparent process for making assumptions in the work of designing product chains and analyzing results. (Method development).
- Develop and describe possible future concepts within the framework of the case study. Describe different alternative ways to deliver concepts and evaluate the

sustainability performance of the future product chains using methods that cover all three pillars of sustainability. (Case study results).

- Evaluate how the case study results can contribute to decisions or strategies at company or product chain level (Case study results).

2. Method

The method developed and used in the case studies is presented in detail in Sonesson et al. (2023). The method is outlined in Figure 1, and a brief description is given below.

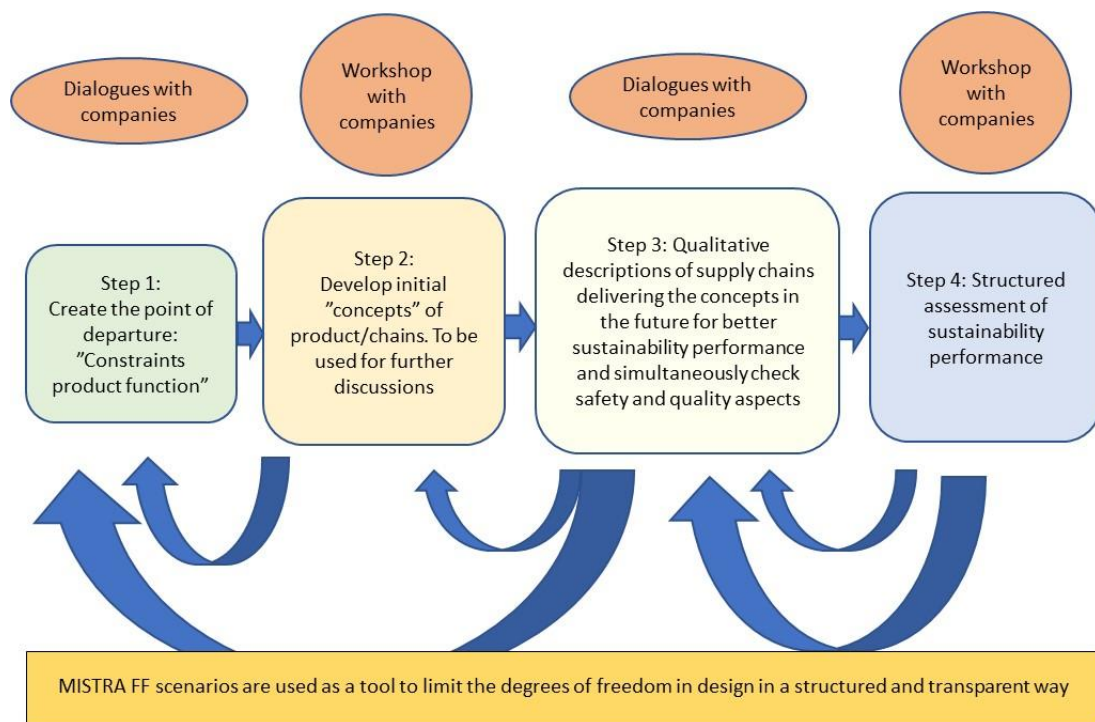


Figure 1. Schematic view of the methodology and work process used in the design and evaluation of the case studies.

2.1. Step 1. Description of boundaries and focus

This step mainly covers the choice of product, product group or product function, which in turn guides the design and implementation of the case study. The choice is largely governed by the type of question to be answered during the work. Table 1 below describes the different types of choices that must be made.

Table 1. Description of choices with bearing on what is to be delivered from the system.

Type of case study	Functionality that the system must deliver
<i>Specific product</i>	<p>The study is limited to analyzing different supply chains that deliver the same or similar well-defined products, where the design of the chain can vary as long as the end product is perceived as interchangeable when consumed and has a similar nutritional composition.</p> <p>Answers the question: "How should a supply chain for product X be designed to best contribute to a sustainable food system?"</p>
<i>Raw material defined products</i>	<p>The study is limited to products that have the same main raw material, but where the final product can vary both in terms of consumer experience, nutritional content and how/in what context it is consumed. This means that a case study of this type will be significantly wider in terms of degrees of freedom to design supply chains.</p> <p>Answers the question: "How should supply chains be best designed to utilize a certain raw material?"</p>
<i>Functionally defined products</i>	<p>The study is limited to products that deliver the same function. What this function consists of can vary, but it must be a strict definition that can, for example, describe the culinary function of a meal, the nutritional content, or the consumption situation.</p> <p>Answers the question: "Which supply chain and raw material selection for a function can best contribute to a sustainable food system?"</p>

In summary, Step 1 must deliver a description of which product, product group or function to be studied, including reasons for the choice. This is supplemented with other relevant information, including whether the choice of product is linked to one or several scenarios.

2.2. Step 2. Choice of concepts to proceed with

To make a design process of this type operational and relevant for participating companies, it is necessary that the solutions are relatively concretely described. This applies to what type of product it is, how it is available on the market, what the production chain looks like and how the surrounding systems are structured. We call this "concept" and is a way of describing the combination of product characteristics (actual and perceived by the consumer), market channel, distribution system and main customers. The definition and description of concepts was a key factor and through these concepts the clearly market-oriented perspective of the companies could be combined with the discussion of future sustainable food systems.

The concepts that are developed should logically fit within one of MISTRA Food Future's scenario skeletons (Gordon et al., 2023). In this way, it is possible to in a structured way develop concepts that are logical and interesting in futures that are very different, thus a

way to develop concepts that are quite different. This creates more value of the study than having concepts that are similar to each other.

In summary, Step 2 must deliver a smaller number of well-described concepts, supplemented with information about which scenario(s) the concepts fit best in, as well as other relevant information. How many concepts should be developed depends on the case study, but 4-8 is reasonable as it is demanding to analyze and draw conclusions if there are too many concepts.

2.3. Step 3. Qualitative description of production chains for each concept

Based on the concepts, descriptions of the actual solutions for each concept must be made, i.e., to describe the supply chains that deliver the concepts from Step 2. Initially, today's supply chain is described, or multiple chains if there are more alternatives. These descriptions function partly as a reference and partly to identify and solve problems that arise, helping to decide on the relevant level of detail. The required descriptions include both technical solutions at all steps and organizational functions.

In Step 3, in addition to production experts, expertise in sustainability evaluation and product safety and quality also participate. This is part of the subsequent evaluation and is valuable in the early design of chains, as it helps identify obviously unsuitable solutions. The procedure is part of the iterations shown in Figure 1. The level of detail is determined pragmatically, ensuring it is detailed enough to provide a basis for evaluating environmental impact, product safety in the chain, product quality, and economics.

In summary, Step 3 must produce a smaller number of well-described solutions for different supply chains that deliver the concepts developed in Step 2. When choosing solutions, those that improve sustainability performance in production and ensure product quality and safety are sought. In cases of conflicts between sustainability goals, Mistra Food Future scenarios are used for selection, focusing on the scenarios where the concept logically fits. Simplified, the scenario context provides a basis for decisions often called "common sense," with a transparent background explaining why the decisions are made.

2.4. Step 4. Structured evaluation of sustainability performance

When the various chains are described in sufficient detail, Step 4, sustainability evaluation, takes place. Additionally, an evaluation of how product safety and product quality could be affected by the proposed solutions is carried out. The methodology used is a developed variant of multicriteria analysis (MCA). MCA is a decision-making method that involves evaluating and comparing alternatives based on several criteria or factors. It is used for

complex decisions that require consideration of different dimensions or goals. For an overview of the methodology, see Lindfors (2021). The detailed methodology and the data used for the sustainability evaluation are presented separately (Naseri Rad & Sonesson, 2024).

For the evaluation of how product safety is affected, a mainly qualitative expert assessment is carried out. This means that the expert "flags" possible new or increased risks with the new solution compared to existing solutions, based partly on experience and partly on literature. The same approach is used for product quality.

The sustainability performance of the various supply chains is assessed with MCA, which includes a wide range of sustainability indicators combined into an overall indicator for sustainability performance (Lindfors, 2021). The ability to include many sustainability aspects equally, or weighted, is the reason for choosing this method. Alternative methods could have been life cycle analysis (LCA) supplemented with various extensions under development. However, this option is not used as it requires detailed data on systems that do not exist. Furthermore, these methods are not "equally comprehensive" and emphasize quantifiable aspects of sustainability, which does not suit the purpose of our study.

MCA requires structured information about the analyzed systems and the establishment of the importance of various sustainability indicators in the overall assessment. The process to develop this and assess sustainability performance is described in Figure 1. An overview of the different steps in the sustainability evaluation with Multicriteria Methodology is visualized in Figure 2.

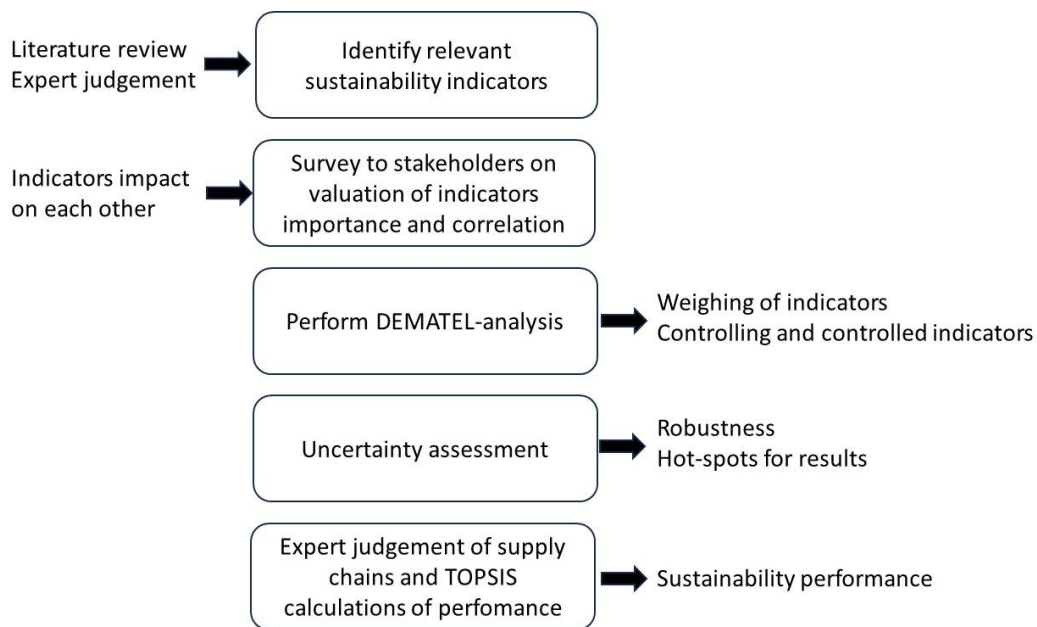


Figure 2. Overview of the various steps in sustainability evaluation with Multicriteria Methodology. DEMATEL (DEcision-MAking Trial and Evaluation Laboratory); see below.

Description of selected indicators

It is important to realize that there is no set of indicators that is "always right". Different types of production systems and products have different effects on the environment and where the production takes place also matters. In addition, selected indicators must be meaningful for the specific questions asked in the study. There are also purely practical limitations on how many indicators it is possible to manage, both mathematically and intellectually. A rule of thumb is that a maximum of 15 indicators should be used.

A series of three workshops was carried out within the research group (RISE, SLU) to map which sustainability aspects could be said to be most relevant for the systems we would study and the Swedish context we chose for the future supply chains to be in. As the research group was composed of senior sustainability expertise as well as senior product and production expertise, we assessed that the breadth of the concept of sustainability was captured as well as what impact the systems can de facto have. The outcome of these workshops was structured and an overview of what was used in previous studies based on different types of literature was made. The indicators we decided to use as well as the short description used when assessing the system are listed below:

- Product affordability
- Cultural values preservation
- Animal welfare
- Fair market functioning
- Capital cost
- Revenue
- GHG emissions
- Biodiversity loss potential
- Land use
- Water use
- Energy use
- Material efficiency
- Use of toxic material

Weighting of indicators

The weighting of the selected sustainability indicators is done using the DEMATEL method (DEcision-MAking Trial and Evaluation Laboratory). The method and the results we used in this case study are presented in detail in Naseri Rad & Sonesson (2024), where the scientific literature that is the basis for the method is also described. In short, DEMATEL works so that a relatively large number of people with experience in the specific sector, from companies, authorities and research, are asked how they view the various sustainability indicators, both how important they are for sustainable development

and how they influence each other. The survey can be found in Appendix 2. The survey responses are then statistically processed, and the results of the analysis are the basis for the weighting of the indicators. By weighing is meant how much relative influence each indicator has on the combined sustainability performance indicator.

Sustainability assessment

The contribution of the included specific indicators to the total value provides good opportunities to create an understanding of what are the critical factors for the overall picture. Information about how the weighing of specific indicators was done adds information that enables discussions and sensitivity analyses. MCA is not a purely objective method as it requires subjective stakeholders' judgements to define the structure of the system it assesses and how the involved factors (indicators) work together in the system.

In this case, the experts are partly knowledgeable about the production itself and the surrounding system, or experts in sustainability in the food sector. The process, which is similar to a Delphi process (Hsu & Sandford, 2007), is carried out in the following steps:

1. Clear description of what the indicators reflect and how different things affect the indicators. This was done by using Chat GPT to generate descriptive texts. The motive for using ChatGPT was that the texts would not be influenced by the author's competence and interests. We know that even Chat GPT can be unbalanced, but our assessment was that that risk was less. The questions we asked, and the full descriptions of the indicators, are presented in Appendix 2.
2. Clear definition of what constitutes a high or low rating for the various indicators. It is central that it is completely clear what the grading scale looks like. This was ensured by the person responsible for the MCA methodology describing this in text, see Appendix 3.
3. A meeting was held with the people who would assess the systems, i.e. the research group from RISE and SLU and persons from participating companies. The aim of the meeting was to discuss the above and thus to reduce the risk that the various people's interpretation of the above affects the grading.
4. A questionnaire is designed, and individual grading of the specific indicators is done by experts (production and sustainability experts).
5. MCA manager compiles the rating and marks the indicators and systems where the rating is widespread.
6. Consensus meeting, at which the above is discussed. Why are the ratings different? Is it a different interpretation? Different level of knowledge about the system? Or

is it genuine ambiguously behind the differences? The goal is to change grading if the reason for differences are differing interpretation of indicators or system description. If the differences in grading is a result of different judgments then they should remain and the spread in grading is indicating uncertainty.

7. MCA manager adjusts the calculations and generates appropriate charts and tables. A joint discussion is the basis for which conclusions can be drawn. This process generates results that provide a coherent description of the sustainability performance of production systems. This is given in form of a value, where the contribution of all sustainability indicators is calculated as a function of the mean given in the expert assessment and the weight of the indicator according to the questionnaire and the DEMATEL methodology.

3. Development of supply chains for the case study

3.1. Step 1. Description of boundaries and focus

At an open workshop arranged within MISTRA Food Futures during October 2021, possible case studies were discussed. Aspects that were highlighted were that the case studies should be in product areas that 1) are important for Swedish food production (volume, value), 2) could reasonably have a place in a future sustainable food system, 3) have a sustainability profile that was interesting (development potential, challenges) and 4) be of interest to MISTRA Food Future's business partners. These too would be willing to invest time in the project. The proposals that were put forward were: Minced meat (animal, vegetable), Bread, Cheese, Salmon, Legumes. The partners who participated in the workshop were Orkla Foods, COOP, Axfood, Lantmännen, Polarbröd, HK Scan, Region Östergötland, Region Västra Götaland, the Swedish Food Agency, the Swedish Agency for Agriculture, Food Companies, LRF and Mathilda Foodtech.

Based on the criteria above, the project group (RISE, SLU) decided to carry out case studies in Legumes, Bread and Animal products (blood-based products and meat from culled ewes.). Only the Legume Case Study is described in this report, separate reports are available for the Bread and Animal products Cases.

After that, the working group (RISE, SLU) began in a series of working meetings to set the framework for the Legumes Case Study. The work was continuously documented in a shared Powerpoint presentation. The result of the framing is summarized in italics below and constitutes the platform for the development of the concepts to study:

The case study must focus on commodity-defined products, i.e. products that have legumes as raw material but where the final product can vary both in terms of consumer experience, nutritional content and how and in what context it is consumed. The case study will thus answer the question "How should supply chains be designed to utilize legumes in the most sustainable way?"

It is important to reflect on which consumer groups eat legumes, and what they demand. Relevant consumer groups for the case study on legumes are considered (by the working group) to be:

- **The conscious consumer** (the flexitarian who wants to cut back on meat but is not a vegetarian). The conscious consumers are primarily driven by two driving forces, health and/or the environment, and can be divided into two subgroups:
 - o The health-conscious flexitarian (knows nutrition).
 - o The environmentally conscious flexitarian (doesn't know much about nutrition, many young people).
- **The vegetarian/vegan**
 - o Often tolerant to pea/bean taste - Getting accustomed to "vegetarian tastes" happens over time.
 - o Among the next generation of elders, there will be more vegetarians/vegans.
- The family with children – **“The comfortable (not lazy) consumer”**
 - o Must be easy, flexible and quick to do the right thing.
 - o Need to take into account different food preferences at the same table, easy to change the meat part to vego in the same dish.
- **The price-conscious consumer**
- **The protein-hunting consumer**
- **Public meal**
 - o The restaurant guest – both fine dining and the lunch restaurant (fast food).
 - o The (multi-)cultural consumer – who are they? What do they eat? Do you come up with the legume-based foods for them?
- **The traditional (Swedish) consumer** (meat eater).

The functions legumes must deliver were selected as:

- **Vegetable.** For example: green peas, sugar snaps etc. Important properties: tasty, fresh, sold both chilled and frozen. Both locally and far-away produced. Organic.
- **Staple food.** For example: chickpeas, white beans etc. Important properties: tasty, sold both frozen, dried, canned (tetra/canned). Both locally and far-away produced. Organic.
- **Substitute meat and dairy consumption for flexitarians.** For example, soy-based mince, bean milk, etc. Important properties: should resemble properties of meat or dairy products, sensory properties important, price (important in comparison with meat and dairy), Clean label. Nutrition. Satiety. Interest in locally produced (Swedish). Divided into:
 - o Vegetarian/vegan products.
 - o Hybrid products (mixture of animal proteins and legume proteins).
- **Protein source for vegans and vegetarians.** For example, falafel, faba steaks, etc. Important features: Can be new products, does not have to resemble existing meat or dairy products. Nutrition important. Sold chilled, frozen, dried. Clean label. Satiety important. There is interest in locally produced (Swedish) products.

- **Snack.** *For example: bars, lentil chips, etc. Important features: The consumer must find it useful, high in protein compared to regular snacks, something that is convenient to carry in the bag and send with the children. Divided into:*
 - *Protein bars*
 - *Snacks (Mellanmål)*
 - *Unhealthy snacks*

The functions the leguminous plants must fulfill were called concepts, and according to the method in "Method and work process for the design of more sustainable supply chains from farm to store" various criteria were specified according to Table 2.

Table 2. Parameters the concepts need to fulfill and relevant clients and distribution aspects.

Concept	Vegetables	Staple food
<i>Must have</i>	flavour, fresh	convenient, low price, long shelf-life, nutritious
<i>Like to have</i>	origin, organic, environmental sustainability, nutritious	flavour, organic, environmental sustainability
<i>Don't care</i>	price, shelf-life	origin
<i>End user</i>	all (also meat eaters)	all, but more often vegetarians/vegans
<i>Clients</i>	households, public sector and restaurants (often traditional products, such as green peas)	households, public sector and restaurants (salad buffets, yellow peas, chickpeas etc)
<i>Distribution</i>	cold storage / frozen, small packages	Ambient storage (dried/canned), frozen

Concept	Substitute meat and dairy consumption for flexitarians	Protein source for vegans and vegetarians	Hybrid products for flexitarians
<i>Must have</i>	similar to the original meat/dairy product, satiety	nutritious – good protein source, flavour, mouth feel, texture, satiety	similar to the original meat/dairy product, satiety, sustainable (good for the environment /health)
<i>Like to have</i>	protein source, low price (lower than meat/dairy)	organic, origin, clean label, low price	low price (lower than meat/dairy)
<i>Don't care</i>	origin, clean label		origin, clean label
<i>End user</i>	conscious consumers – environment conscious consumers - health	vegetarians and vegans	conscious consumers – environment conscious consumers - health
<i>Clients</i>	households, public sector, lunch restaurants	households, public sector, (restaurants)	households, public sector, lunch restaurants
<i>Distribution</i>			

Concept	Protein bars	Snacks (mellanmål)	Unhealthy snacks
<i>Must have</i>	protein content, convenience, flavour, long shelf-life, ambient storage	flavour, nutritious (compared to products in the same category)	better or similar nutrient quality than traditional unhealthy snacks (may still be rich in salt/fat)
<i>Like to have</i>	low price	low price, organic, origin	environmental footprint
<i>Don't care</i>	origin, organic		nutrition, low price
<i>End user</i>	vegetarians/vegans, exercise enthusiasts, young people	all, conscious consumers	conscious consumers
<i>Clients</i>	households	households	households
<i>Distribution</i>	small packages, ambient storage	small/medium packages, ambient storage	small packages, ambient storage

The working group (RISE, SLU) reflected on the importance of changing consumption patterns over time. What will we eat in the future? Which consumer groups and product categories will grow/decrease? Where, how and when will we prepare food and eat it? The group saw a need to put the legume chain in a future perspective. This work took place before the four future scenarios developed in Mistra Food Future were published, and therefore freely reflected on various issues:

Are there hybrid products (meat and legume protein) on the market today? Is the category growing or shrinking over time?

- *They have already been on the market (eg Korvis, Järpis, etc.). In the past, mixed products have been made to "save" on the meat, and they have been "diluted" with, for example, vegetables. They have also made low-fat products with starch. In several cases, this led to consumers feeling cheated (e.g. via the media) and perceived the mixed products as low-quality.*
- *There is now a new incentive for mixed products for flexitarians who want to reduce their meat consumption, both for health and environmental reasons. Can be good for ready-to-eat food that is eaten outside the home (You could, for example, eat half a hot dog and more vegetables at home, but it is more difficult to choose half a hot dog with bread at a hot dog kiosk and be full at the same time).*
- *A positive aspect may be that the consumer is not so concerned about the nutritional content because meat is also included.*
- *May be easier to produce compared to vegan products with respect to appealing sensory properties (meat flavor, reduced off-flavors, increased juiciness, etc.)*

Many are promoting vegetarian eating, how will this affect the consumption of legumes?

- *Influence takes place via influencers, restaurants, celebrity chefs*
- *Public meals. Can have vegetarian Mondays, etc. They are guided by policies and goals, for example must provide a certain nutritional value in their dishes. Can public meals create effects on eating behaviors and public health? Can they set nutritional standards on new vegetarian products?*
- *Enrichment. Will it become more/less accepted and common?*

Residual streams

- *What do you do with the streams that remain after you have purified the protein from legumes (eg starch and fibres)?*
- *When do residual currents occur and what can be done with them?*
- *If we scale up the consumption of vegetable proteins, the residual streams will also scale up. Can they be taken care of?*

Cultivated in Sweden / imported. What should we grow/produce in Sweden?

The next step was to present and discuss the framework and concepts developed by the working group (RISE, SLU) for the companies that participated in the case study (Orkla, Axfood and COOP). A workshop was held on 10 February 2022 with Orkla (Anders Högberg, Helene Thörnlund, Susanna Karlsson), COOP (Anneli Bylund), SLU (Marie Olsson) and RISE (Evelina Höglund) as well as a gathering meeting with Axfood (Åsa Domeij) and RISE (Karin Östergren, Karin Bjerre and Evelina Höglund) on 1 March 2022.

Input from the companies to the framework and concepts was:

It was unclear what was meant by "raw material defined" and "product defined". The working group needs to work further on clarifying the concept of "function". It was also problematic to use the term "concept" because that word is already widely used within companies, but with different meanings. It turned out to be important to define the concepts before proceeding with the work.

*The companies contributed with more aspects of so-called hybrid products. It doesn't have to be a mixture between meat and veg but can also be a mixture between legumes and other vegetarian ingredients such as bulgur, rice, cheese etc. (e.g. Felix veggi pyttipanna). The companies reinforced the image that consumers often perceive mixed products consisting of meat and veg as "cheating", and that they are trying to dilute a meat product. It can be difficult to market a mixed product that is a mix between meat and vegan because you exclude both the vegetarian/vegan target group and the die-hard meat eater. **Hybrid products have not yet caught on but may become an important category in the future. Now there are new incentives for such a category (the conscious consumer). But new recipes and meals are needed, it must not look like diluting an existing meat product. They should also communicate good health or that they are smart dishes for a better climate.** Another solution that was advocated was **to make new dishes where the meat plays a smaller role and legumes a bigger one**, without mixing them together in the same product.*

*Another product category that was widely discussed was the meat analogue. Is it here to stay or is it a steppingstone into plant-based eating? Will it decrease or increase over time? Will we get more conscious consumers over time? For meat analogs, frozen is the largest category, but chilled has exploded. However, chilled products cause a lot of wastage in the store. Dry products are on the way out, even if the products are good, the consumer thinks it is too cumbersome. Perhaps the barrier for dry products is lower in public meals. Discussions around "processed" and Clean label will be important barriers. The role of the meat analogue is associated with our eating behaviors, whether we will eat more or less at home or on-the-go. **Vegans are good at cooking legumes and demand clean ingredients and proteins that they can cook themselves. Meat eaters need more help and more often choose compound products.** The companies see different behaviors for consumers who live in the countryside compared to those who live in the city, and more*

international migration is predicted for various external reasons. **Here, a clear need for future scenarios to adhere to crystallized and became urgent.**

Many consumer groups say they want to increase plant-based in their diets. **There is a clear drive to buy more plant-based with the motives of environment and health. Barriers are "processed", price, taste (clean label may become important later on).** Pricing can be a problem, consumers expect products based on legumes to be cheap and they do not think about the fact that there are development costs, etc. The conscious consumer wants to put themselves in a box and communicate their life choices to others. **Among flexitarians, the younger (<30 years) are most interested in the environment. They are the ones who drive the entire flexitarian category.** 43% of all Millennials want to eat more plant-based. Consumer groups who eat vegetarian food are used to a lot of new products – they are inclined to try new products. **Families with children are also an important driving force.** It should be easy to replace parts of common dishes with plant-based alternatives.

It is difficult and complex to influence consumer behavior. You have to find the right level. **Consumer demand is not keeping up with the transition.** But Orkla has found some successes, such as “vego-pytt”. You must get the consumer on board, and meat analogues can be a step on the way to other vegan alternatives. If you look back 30 years, consumer behavior has changed a lot, and now changes are generally even faster. **Political control can be an important tool, such as the former subsidy on milk.**

It is difficult to say what consumers want and expect in terms of **the origin** of legumes. In the case of many legume products, there is usually only one origin per product, and the consumer cannot make an active choice. Consumers care most about the origin of meat and milk; it is usually not perceived as important for plant-based products. Coop is now seeing more customer questions about “Swedish”, which has increased during the pandemic. But goods that are too expensive cannot be sold and taste is always the most important factor. There is an interest in Swedish meat and dairy analogues, but so far, the products differ greatly from each other in taste, which is always the most important thing when choosing. If the products are equal in quality, Swedish may become more important.

Restaurants/fine dining are generally good at vegetables, but not with legumes. Public meals are very much governed by policies and goals. The climate goals mean that they steer towards a more plant-based approach. Here they have nutritional requirements, which means that they cannot switch to nutrient-poor vegetarian alternatives. **Public meals can be a forerunner and have a high impact.**

The companies thought that the concept of Snacks was interesting but that it can be difficult to find good products in the area. Snack products are often very high in calories, and it's hard to find products that are good nutritionally. It is important to define what role legumes can have in a snack, what do they compete against and what can they substitute? Is it flakes/cereals? Could legumes be included in new product categories such as bread or cakes? Maybe instead of expensive and/or allergenic nuts and seeds?

Some of the discussions concerned the role of soy. Often, a desire to replace soy is communicated because it is grown in an unsustainable way in South America. However, it is important to keep in mind that it is feed soy that is grown in South America, soy for human consumption is to a larger extent produced in EU.

It is important to note that the production of legume protein ingredients involves side streams (starch, fiber, etc.). If the production of protein ingredients increases, so will the side streams, and it is important to find a market for them. We also have other plant-based proteins that we don't use so much today, such as potato protein, and we may be able to use them to a greater extent. The waste debate is very hot, but there is a need for other people with other skills to discuss this issue.

3.2. Step 2. Choice of Concepts to proceed with

Based on input from the companies, some decisions were made by the working group:

It was unclear what was a concept and what was meant by raw material-defined and product-defined, therefore the definitions were refined. Based on these definitions, three concepts were formulated:

Concepts based on the function of legumes

Whole legumes "The green component on the plate" or "A staple in a dish"

Vegetable. Key characteristics: tasty, fresh, sold both fresh, frozen. Both locally and far-away. Organic is available.

Staple food. Important characteristics: tasty, sold both frozen, dried, canned (tetra/can). Both locally and far-away. Organic available

Legume Proteins "The Protein Component of the Platter/Dairy Option"

Reduce meat and dairy consumption for the flexitarian. Key characteristics: want to resemble characteristics of meat and dairy products, sensory properties important, price (important in comparison to meat and dairy), Clean label desirable. Nutrition is important. Saturation. Interest in locally produced (Swedish).

Protein source for vegans and vegetarians. Key features: Can be new products, does not have to resemble existing meat and dairy products. Nutrition is important. Sold chilled, frozen, dried. Clean label. Saturation. Interest in locally produced (Swedish)

Snacks

On-the-go. Key features: Comfortable, long shelf life, healthy and high in protein

Supplement. Key features: High in protein, alternative to milk protein-based products

The main consumer groups for the case study are:

These are the groups we focus on

- **The conscious consumer (the one who wants to cut down on red meat but not be a vegetarian)**
 - The health-conscious consumer (knows nutrition)
 - The environmentally conscious consumer (doesn't know much about nutrition)43% of Millennials want to eat more plant-based. Among flexitarians, the younger (< 30 years) are most interested in the environment. They are the ones who drive the entire flexitarian category.
- **The Vegetarian/Vegan**
 - These consumers often have a long way to get used to "vegetarian flavours"
 - Growing group, even among the next generation of older people – COOP does not see that the proportion of vegetarians is growing now
- **The "comfortable (not lazy) consumer"**
 - Must be easy and convenient to do right.
 - Easy to replace components of the meal with plant-based to be able to cook the same dish for everyone in the family
- **The protein-chasing consumer**
 - There is an overconfidence in how much protein we need, and protein-rich bars/drinks still have a large (growing?) place on store shelves. Many consumers are afraid of getting too little protein
 - Fitness freaks, but also parents who want to send a simple snack for the kids, or for the adult who is traveling
 - Elderly people who need protein-rich supplements
- **Public meal**
 - Governed by policies and goals. The climate goals mean that they steer towards a more plant-based approach. Here there are nutritional requirements, they can't switch to nutrient-poor vegan alternatives. They can be a frontrunner and have a high impact.

Hybrid products are complex, and it is difficult to predict how they will be used in the future, therefore the working group chose to exclude this category from the case study.

As complex meals containing legumes will be difficult to manage in the upcoming sustainability assessment, the working group chose to exclude them and instead focus on products that mainly consist of legumes.

Snacking was considered to be an unclear concept where it is difficult to find good products based on legumes, therefore the working group chose to wait with that concept and focus on moving forward with the other two.

To be able to discuss how different concepts and products may be developed, there is a clear need for well-founded future scenarios to stick to. (Skeletons for future scenarios were developed in MISTRA Food Future after this phase and were addressed later on).

Analysis of the companies' input and the working group's choices was discussed together with the Bread case study at a workshop 2022-05-05 where Lars Hamberg, Sandra Pousette, Kavitha Shanmugan, Ulf Sonesson, Karin Bjerre, Karin Östergren and Evelina Höglund from RISE and Marie Olsson from SLU participated.

A follow-up workshop was then held on 14 June 2022 to anchor the working group's decisions and reformulations of concepts with the companies. The workshop was attended by Orkla, COOP, SLU and RISE. The companies agreed with the choices made. Furthermore, the start of step 3 in the work process: Choice of chains for sustainability analysis was discussed. Since the sustainability analysis is an extensive work, the working group proposed a delimitation to two main sets of production chains to focus on (Snacks will be addressed later if time allows):

Dried vs Frozen vs Canned Peas/Beans

Given that we want to eat peas/beans in the future, should they be provided in a dried, canned or frozen chain? If you do it right in the value chain, the legume can be a clear winner in environmentally smart food.

Meat analogue vs whole-legume product

Given that we eat legume products as the protein component on the plate, should they be in the form of a meat analogue based on a protein concentrate or should it be a product where the whole pea/bean is used, such as falafel? Prerequisite: Same distribution method = frozen products.

Snack

Protein drink/bar based on legume protein isolate vs. milk protein-based products (to be addressed later if time permits).

The companies agreed that the first two concepts were interesting to work on towards a sustainability analysis, and the working group started the work of drawing up production chains for the concepts.

3.2.1. Concept Dried vs Frozen vs Canned Peas/Beans

The working group started by drawing up a rough sketch of the production chains for dried, frozen and canned peas and beans:

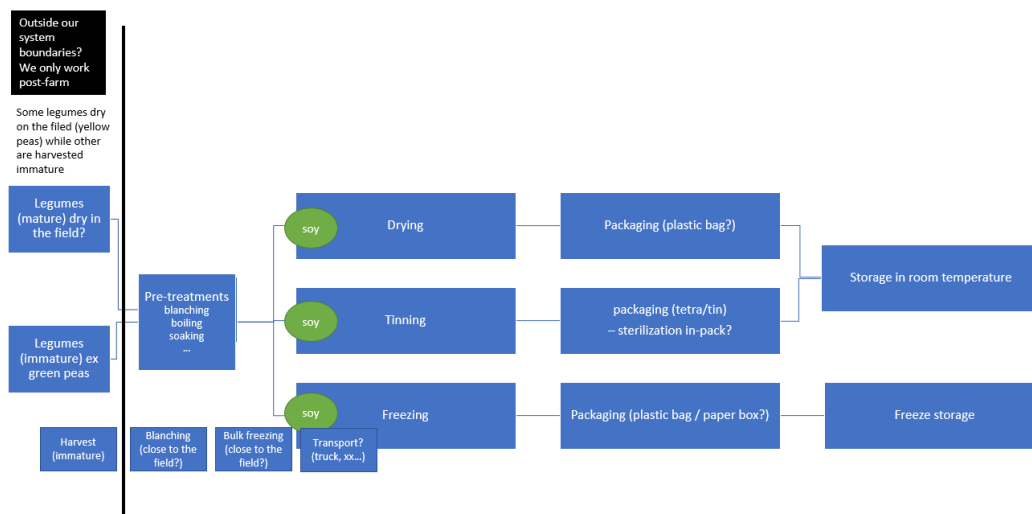


Figure 3. A simplified sketch of the production chain of dried, frozen and canned peas and beans.

Conditions and external factors that affect the production chains were discussed and summarized. This work took place before the group had access to Mistra Food Futures' four future scenarios.

Conditions for production chains

- There seems to be process data for these products.
- It is important to check what happens where, e.g. packaging abroad.
- Should we include residual streams? Can be large volumes. We include them in an initial analysis, and then see if it becomes relevant to look at them in more detail. Need to reconcile with WP5.
- Frozen legumes are harvested on another occasion than dried, which are allowed to dry in the field.

Economy:

- We believe it's a growing market, in absolute numbers.
- Commodity availability and food prices could become an important factor.
- Growers choose crops based on the market.

- Cultivation trials of new crops are now underway in Sweden to see which ones can be competitive.

Future scenarios

- We believe that ready-to-eat products will increase even more, but that legumes as a staple will also increase.
- We live in a changing future – dry/canned good for emergency stocks.
- Consumer habits:
 - o Convenience is important. Dried food requires more preparation on the part of the consumer. Dried and canned are seen as interchangeable for the consumer.
 - o The assortment of veggies in the freezer is increasing (e.g. edamame beans, avocado, herbs)
- Production:
 - o Are there farmers and infrastructure in Sweden to cope with the growth?
 - o Should it be an all-Swedish value chain, or imported?
 - o Food safety at the production stage (what is the difference between dried/canned/frozen?)

Choice of raw material:

- Based on what is available in the store today.
- Suggestion 1: Soybean – it is available both frozen, dry and canned. (not Swedish)
- Suggestion 2: Frozen green peas, dried yellow peas, canned chickpeas (both Swedish and imported).
- Is there room for a new type of product "the instant chickpea"? A dry/frozen product that is already soaked.

Nutrition:

- It is important to get rid of anti-nutrients, but that can occur in different parts of the chain.
- High-quality protein (amino acid composition). Important to compare between different crops, for example when choosing Swedish-produced/imported.

The working group investigated how the production chains for dried, frozen and canned peas/beans look like today in order to have them as a basis; *(i)* what kinds of legumes are sold in Sweden today, *(ii)* where they are grown, *(iii)* how harvesting, cleaning, peeling, storage and transport take place, and *(iv)* what technology development is expected.

3.2.2. Concept Meat analogue vs whole-legume product

Similarly, a rough sketch of the production chains of meat analogues and products made from whole peas/beans was set. Meat analogues are based either on plant-based protein concentrates (produced by dry process, about 30-60% protein content) or protein isolates (produced by wet process, about >75% protein content). These two types of protein-rich ingredients have different production processes, which were also outlined.

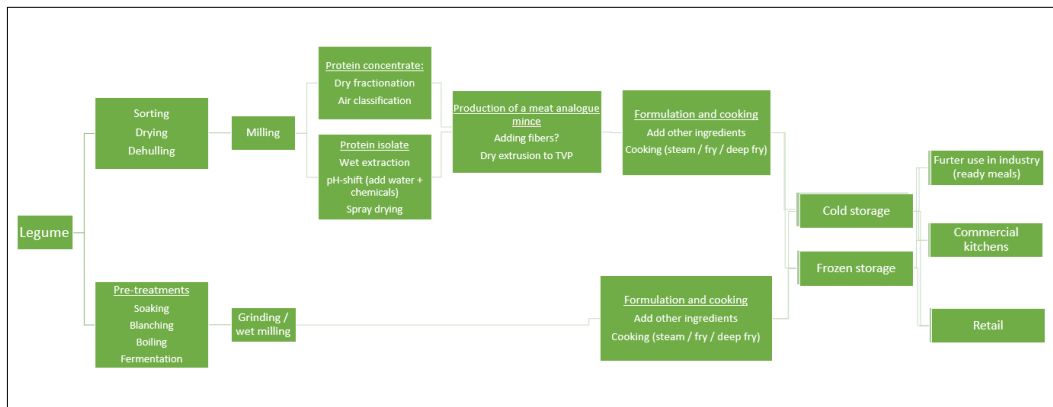


Figure 4. A simplified sketch of the production chain of meat analogues.

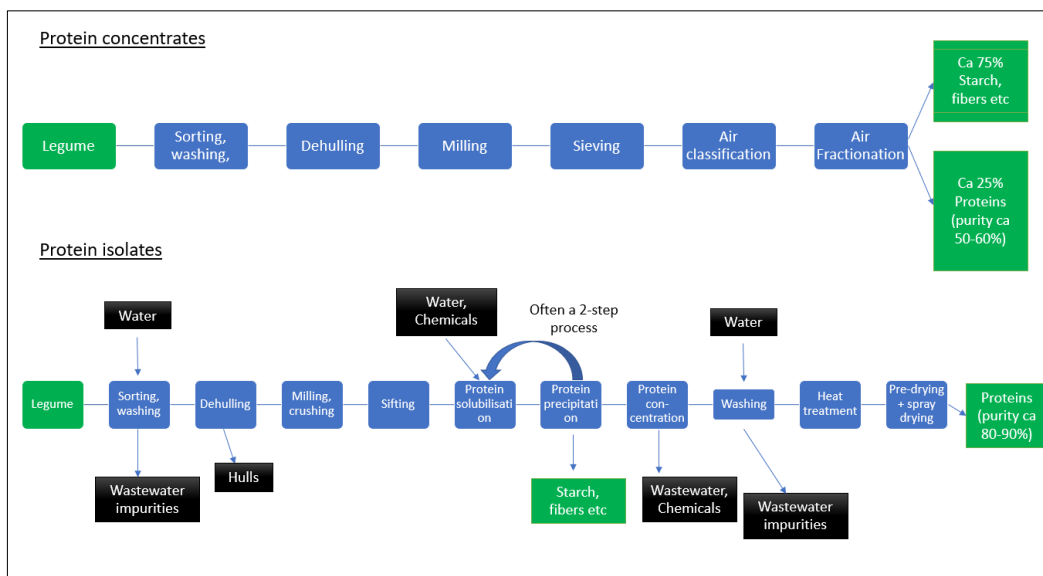


Figure 5. Simplified sketch of the production chains of plant-based protein concentrates and isolates.

Conditions and external factors that affect the production chains were discussed and summarized. This work took place before the group had access to Mistra Food Futures' four future scenarios.

Conditions for production chains:

- The same way of distribution of the products: **we choose frozen.**
- Check if relevant data is available for meat analogues.

Future scenarios:

- We believe that we will increase the consumption of plant-based protein components instead of meat.
- Should the protein component be based on the whole legume (e.g. falafel-like product) or on a protein concentrate/isolate?
- Are meat analogues a transitional product? Or here to stay?
- Origin of raw materials. Swedish-grown vs. imported (Europe vs. China).
- Infrastructure for making protein isolates/concentrates from legumes is under construction in Sweden. Concentrates will soon be on the market, but not isolates so far.

Economy

- We believe that plant-based protein products will increase.
- The meat analogue should be more expensive to produce than the whole legume product.
- The meat analogue is a high-tech product.
- The meat analogue causes large side streams from protein concentration (fibre, husks, starches, etc).

Nutrition

- Is there a big difference between the meat analogue and the whole legume product (protein, fiber, etc.)?
- Is it possible to reduce anti-nutrients in the meat analogue during the protein purification processes? (via extraction, extrusion etc).
- Should we also compare with meat? (iron, fatty acids, B vitamins)

A summary of the concepts and their production chains was sent out to the companies (Orkla, COOP, Axfood) in February 2023 for review.

Now the working group had rough sketches of the various production chains as well as lists of prerequisites. The next step was to adjust and apply a method for sustainability assessment to be able to evaluate and compare the chains. The choice of method determines the level of detail needed for data from the different production chains. Discussions were held with sustainability experts in WP6 (Elin Rööös (SLU), Kavitha Shanmugan, Mehran Rad and Ulf Sonesson (RISE)).

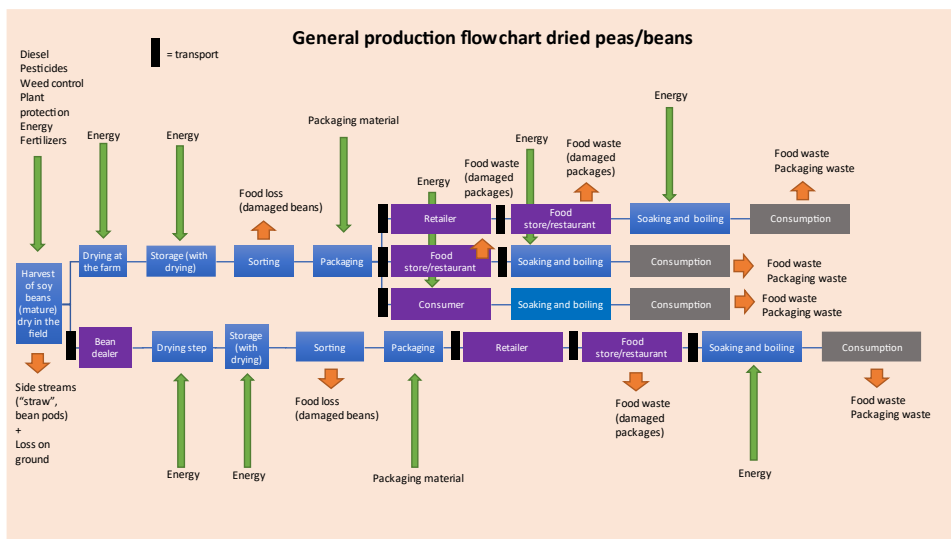
The sustainability analysis requires a lot of work, and the working group (RISE, SLU) chose two production chains to focus on, one from each concept:

- **Dried peas/beans (drying was chosen because it is considered to be a sustainable production chain)**
- **Meat analogues**

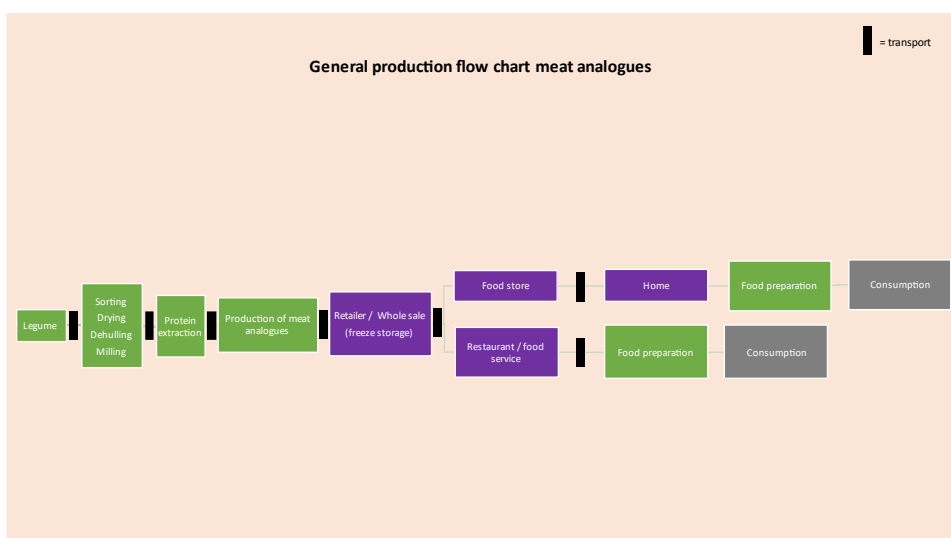
3.3. Step 3. Qualitative description of production chains for each concept

Based on the information that the concepts need to deliver to the sustainability assessment tool, slightly more detailed production chains were drawn (Figure 6). As a basic premise, and to limit the number of elections, the working group made certain assumptions:

- Choice of pea/bean: Soy, as it is a commonly used legume in dried form, both for consumption in whole form and as an ingredient for meat analogues.
- Drying, sorting, packing and storage of peas/beans can take place either on the individual farm, or at a bean dealer, who collects peas/beans from several farms.
- The meat analogues are based on "protein powder" from legumes, we do not distinguish between protein concentrates and protein isolates.



a)



b)

Figure 6. General production chain of (a) dried peas/beans and (b) meat analogues

At this point, the four future scenarios were developed in Mistra Food Future. In order to evaluate the different production chains, it was discussed how each product (dried peas/beans and meat analogues) would be used and produced in each of the four future scenarios.

The working group anticipates that the two products will be used to different extents in the different future scenarios (Figure 7). In Food as Industry and Food Forgotten, we believe that people will eat both dried peas/beans and meat analogues, but to slightly different extent. In Food as Tech, we believe that only a small amount of dried peas/beans will be eaten and that meat analogues will be a larger product, while in Food as Culture, we expect that people will not eat meat analogues at all.

Overview: volumes of dry peas/beans vs. meat analogues we think people eat in the 4 scenarios (in relation to each other)

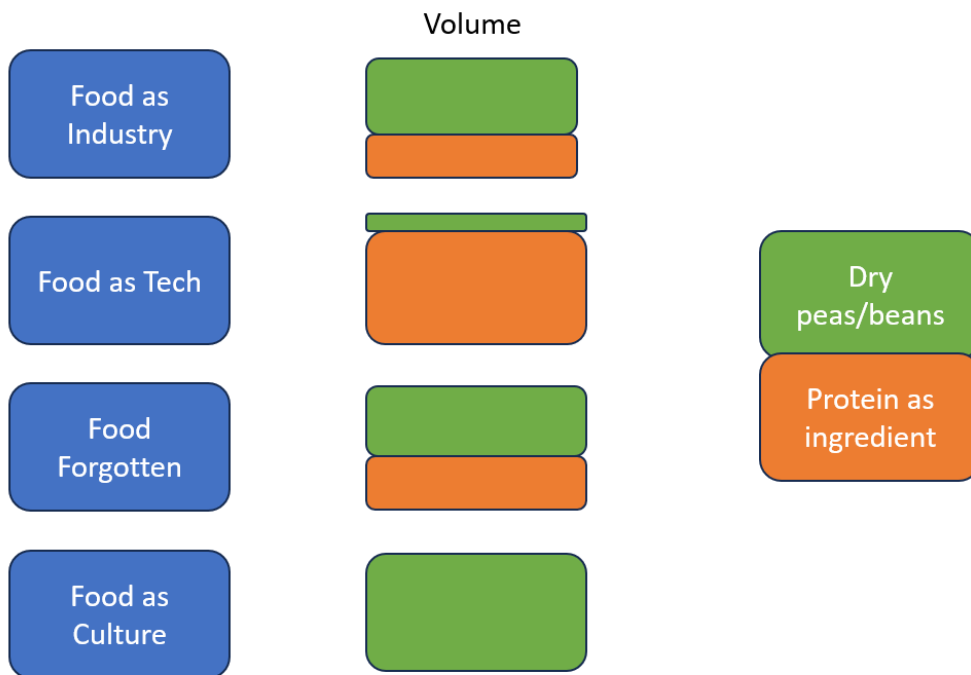


Figure 7. Overview of the proportions of dried peas/beans vs. meat analogues in the four future scenarios.

The working group went on to map the two concepts into Mistra Food Futures' four future scenarios by thinking into each scenario and reflecting on what the production chain from field to fork would look like in such a future. What assumptions do we need to make? What future movements are needed to get it in place? For each scenario, a specific production chain was drawn up for the two concepts. A table was then made with a little more detail for each production chain, as well as a column with "future movement" – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045. Below is a description of the production chains for each scenario.

3.3.1. Food as Industry

Based on the description of the scenario, the working group made some assumptions:

Dried peas/beans

- We believe that we will eat about twice as much legumes in 2045 compared to now.
- We will eat legumes grown in Sweden, and soy will be replaced by pea and faba bean.
- Developments in crop production have meant that we now have faba beans without the anti-nutrients vicine and convicine.
- We will have a larger proportion of organically grown raw materials.
- We will have a more automated and fossil-free agriculture.
- Bean dealers will be cooperatives of farmers.

Meat analogues:

- A significant part of meat consumption will have been replaced by meat analogues, which means that larger amounts of pea/bean protein will be needed and we will need to partially import raw materials.
- We have built up infrastructure to extract plant protein and manufacture meat analogues in Sweden, which meet the Swedish need.

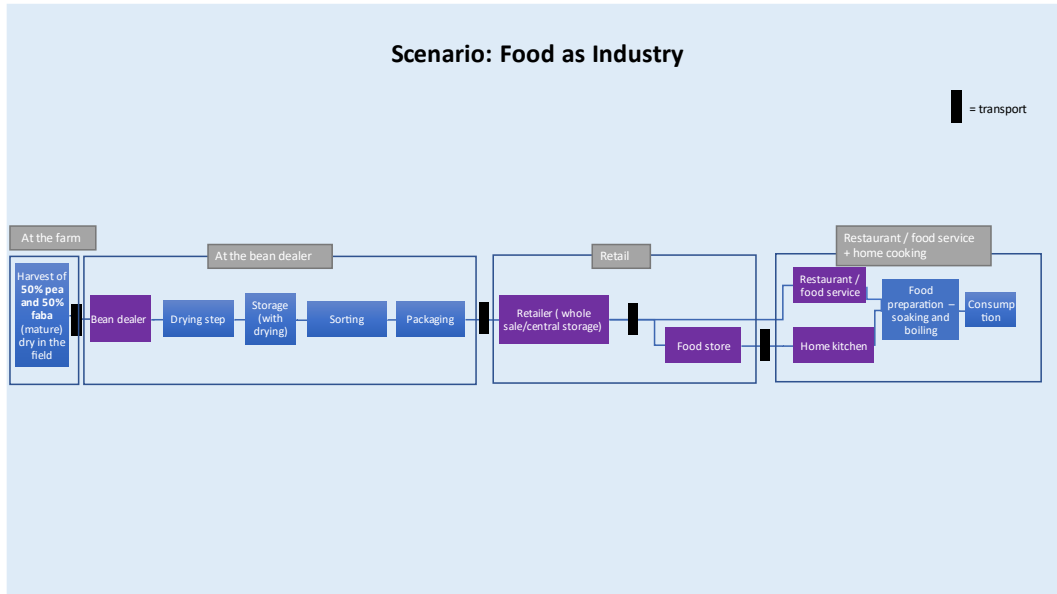


Figure 8. Production chain for dried peas/beans for the scenario Food as Industry.

Table 3. Key Descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for dried peas/beans in the scenario Food as Industry.

Food as Industry	Key Description	Main Shift in the Future
<i>Primary production</i>	Production of Swedish crops (exchange soy for 50% pea and 50% faba) New crops (vicine free faba) Farmers have their own farms, larger than 2020. More organic farms. Automation, high efficiency. Precisions farming First sorting is done on the field (removal of straw etc)	Gene modification is allowed and gives us new crops (with less antinutrients that needs to be soaked away) New EU regulations that allow gene modified crops. Climate adapted crops are grown in Sweden. The side streams (straw, bean pods) are used for food/feed/packaging materials
<i>Transport</i>	Self-driving electric trucks to the bean dealers who are situated close to train nodes	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Drying</i>	Drying to a certain water content (14%) Hot air with fans	Centralized bean dealers Fossil free energy sources (solar, wind, nuclear energy)
<i>Storage (with drying)</i>	The peas/beans need ventilation also during storage (fans)	Fossil free energy sources (solar wind, nuclear energy)
<i>Sorting</i>	Automized sorting of stones etc	Improved automatic sorting systems (mechanical systems, NIR)
<i>Packaging</i>	Packaging in bags (important that the peas/beans don't take up moisture)	New, recyclable packaging materials that has good barriers for moisture
<i>Transport</i>	To retail storage (ex central storage) and to restaurant retailers	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Storage</i>	At retail storage (ventilated, ambient temperature)	
<i>Transport</i>	Self-driving electric trucks to local food store / restaurants 50% of consumers drive electric cars from food store to the home and 50% have home delivery by electric small trucks from food stores	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions More consumers have home delivery of food
<i>Food preparation</i>	In restaurant or home kitchen: Soaking. Boiling. Possibly further used in a dish Need for water and energy	New varieties that have less antinutrients – less water is needed for soaking/boiling. More energy efficient cooking equipment, especially in restaurant / food service, but also at home
<i>Consumption</i>	Dried peas/beans can be further stored in the kitchen/home. Food leftovers are recycled. Packaging material is recycled	Better system to recycle food loss in restaurants / food service. More advanced sorting of food waste in the home, a larger part can be used for feed

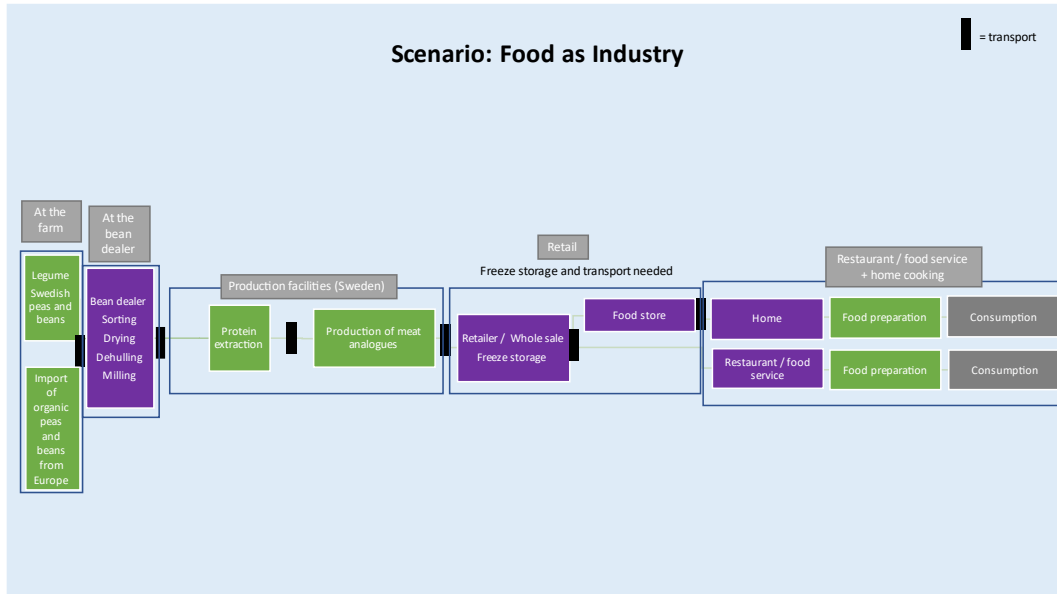


Figure 9. Production chain for meat analogues for the scenario Food as Industry

Table 4. Key Descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for meat analogues in the scenario Food as Industry.

Food as Industry	Key Description	Main Shift in the Future
<i>Primary production Swedish crops + import of European crops</i>	Production of Swedish crops (exchange soy for 50% pea and 50% faba) New crops (vicine free faba) Farmers have their own farms, larger than 2020. More organic farms. Automation, high efficiency. Precisions farming First sorting is done on the field (removal of straw etc)	Gene modification is allowed and gives us new crops (with less antinutrients that needs to be soaked away) New EU regulations that allow gene modified crops. Climate adapted crops are grown in Sweden. The side streams (straw, bean pods) are used for food/feed/packaging materials
<i>Transport</i>	Self-driving electric trucks to the bean dealers who are situated close to train nodes	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Drying</i>	Drying to a certain water content (14%) Hot air with fans	Centralized bean dealers Fossil free energy sources (solar, wind, nuclear energy)
<i>Storage (with drying)</i>	The peas/beans need ventilation also during storage (fans)	Fossil free energy sources (solar wind, nuclear energy)
<i>Sorting</i>	Automized sorting of stones etc	Improved automatic sorting systems (mechanical systems, NIR)
<i>Packaging</i>	Packaging in bags (important that the peas/beans don't take up moisture)	New, recyclable packaging materials that has good barriers for moisture
<i>Transport</i>	To protein extraction facility	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Protein extraction and meat analogue production</i>	Dry or wet fractionation to make protein powders. Production of meat analogues	New infrastructure for production of protein powders (large factories specialized in different crops) New infrastructure for meat analogue production More employees in industry, High level of competence Fossil free energy sources (solar wind, nuclear energy) Side streams are valorised (starch, fibre) circular thinking is mainstream in the production
<i>Transport</i>	To retail storage (ex central-lager) and to restaurant retailers Freeze transport needed. Freeze storage	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Transport</i>	Self-driving electric trucks to local food store / restaurants 50% of consumers drive electric cars from food store to the home and 50% have home delivery by electric small trucks from food stores	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions More consumers have home delivery of food
<i>Food preparation</i>	In restaurant or home kitchen: Boil or fry Need for energy	More energy efficient cooking equipment, especially in restaurant / food service, but also at home
<i>Consumption</i>	Uncooked meat analogues can be kept in the freezer. Food leftovers are recycled. Packaging material is recycled	Better system to recycle food loss in restaurants / food service. More advanced sorting of food waste in the home, a larger part can be used for feed

Food as Food Tech

Based on the description of the scenario, the working group made some assumptions:

Dried peas/beans

- We grow legumes in Sweden (pea and faba bean), but we will also import sustainably cultivated soy from Europe and Canada.
- You eat a lot of processed foods and not so much dried peas/beans.
- People don't eat as much at home together, and they spend less time cooking and eating.

Meat analogues

- Most of the legumes we grow in Sweden will go to the production of meat analogues.
- We will need more protein powder than what we produce in Sweden, and therefore we will also import protein powder.
- We will produce more meat analogues than are consumed in Sweden, and we will export the surplus.
- The production facilities for meat analogues are not owned by Swedish companies but belong to international groups.

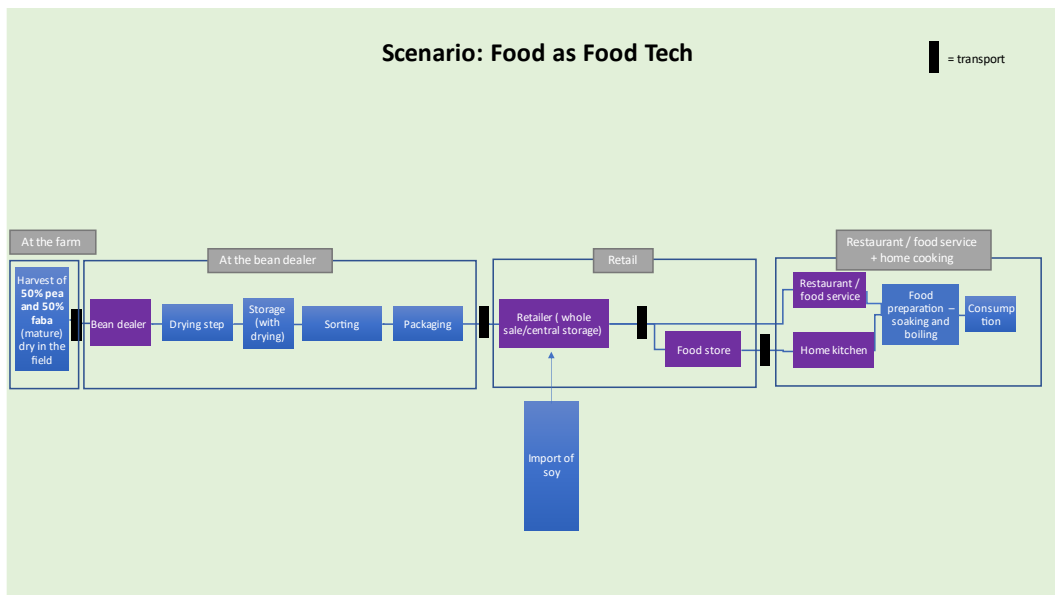


Figure 10. Production chain for dried peas/beans for the scenario Food as Food Tech.

Table 5. Descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for dried peas/beans in the scenario Food as Food Tech.

<i>Food as Food Tech</i>	Key Description	Main Shift in the Future
<i>Primary production</i>	Production of Swedish crops (exchange soy for 50% pea and 50% faba) New crops (vicine free faba) Farmers have their own farms, larger than 2020. More organic farms. Automation, high efficiency. Precisions farming First sorting is done on the field (removal of straw etc)	Gene modification is allowed and gives us new crops (with less antinutrients that needs to be soaked away) New EU regulations that allow gene modified crops. Climate adapted crops are grown in Sweden. The side streams (straw, bean pods) are used for food/feed/packaging materials
<i>Transport</i>	Self-driving electric trucks to the bean dealers who are situated close to train nodes	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Drying</i>	Drying to a certain water content (14%) Hot air with fans	Centralized bean dealers Fossil free energy sources (solar, wind, nuclear energy)
<i>Storage (with drying)</i>	The peas/beans need ventilation also during storage (fans)	Fossil free energy sources (solar wind, nuclear energy)
<i>Sorting</i>	Automized sorting of stones etc	Improved automatic sorting systems (mechanical systems, NIR)
<i>Packaging</i>	Packaging in bags (important that the peas/beans don't take up moisture)	New, recyclable packaging materials that has good barriers for moisture
<i>Transport from other countries</i>	To retail storage and to restaurant retailers Self-driving electric trucks / train / boat (ex from Canada)	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Storage</i>	At retail storage (ventilated, ambient temperature)	
<i>Transport</i>	Self-driving electric trucks 10% of consumers drive electric cars from food store to the home and 90% have home delivery by drones, bikes, from food stores	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Food preparation</i>	In restaurant or home kitchen: Soaking. Boiling. Possibly further used in a dish Need for water and energy	New varieties that have less antinutrients – less water is needed for soaking/boiling. More energy efficient cooking equipment, especially in restaurant / food service
<i>Consumption</i>	Dried peas/beans can be further stored in the kitchen/home. Food leftovers are recycled. Packaging material is recycled	Better system to recycle food loss in restaurants / food service

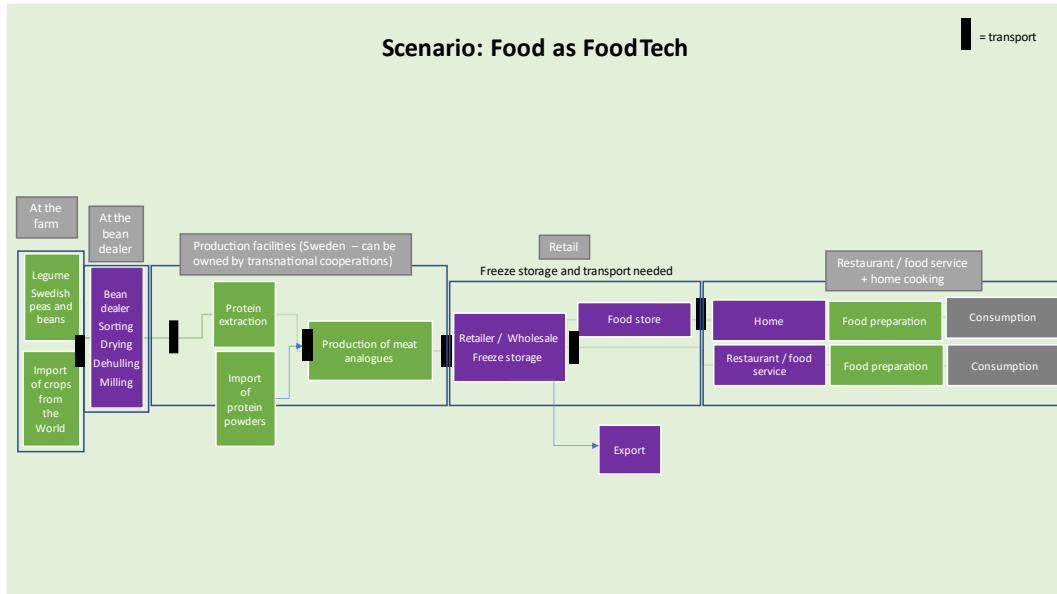


Figure 11. Production chain for dried meat analogues for the scenario Food as Food Tech.

Table 6 Key descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for meat analogues in the scenario Food as Food Tech.

Food as Food Tech	Key Description	Main Shift in the Future
<i>Primary production Swedish crops + import of crops from the world</i>	Production of Swedish crops (exchange soy for 50% pea and 50% faba) New crops (vicine free faba) Farmers have their own, larger farms, More organic farms. Automation, high efficiency. Precisions farming First sorting is done on the field (removal of straw etc)	Gene modification is allowed and gives us new crops (with less antinutrients) New EU regulations that allow gene modified crops. Climate adapted crops are grown in Sweden. The side streams (straw, bean pods) are used for food/feed/packaging materials etc
<i>Transport</i>	Self-driving electric trucks to the bean dealers who are situated close to train nodes	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Drying</i>	Drying to a certain water content (14%) Hot air with fans	Centralized bean dealers Fossil free energy sources (solar, wind, nuclear energy)
<i>Storage (with drying)</i>	The peas/beans need ventilation also during storage (fans)	Fossil free energy sources (solar wind, nuclear energy)
<i>Sorting</i>	Automized sorting of stones etc	Improved automatic sorting systems (mechanical systems, NIR)
<i>Packaging</i>	Packaging in bags (important that the peas/beans don't take up moisture)	New, recyclable packaging materials that has good barriers for moisture
<i>Transport</i>	To protein extraction facility	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Protein extraction</i>	Dry or wet fractionation to make protein powders	New infrastructure for production of protein powders (large factories specialized in different crops) More employees in this industry, High level of competence (antinutrient removal) Fossil free energy sources (solar wind, nuclear energy) Side streams are valorised (starch, fibre) circular thinking is fully applied
<i>Transport</i>	Transport of protein powders from Swedish producers as well as imported from other countries	Electrified trucks, self-driving cars, train/boat from abroad Fossil free fuels and energy New sustainable transport solutions
<i>Meat analogue production</i>	Production of meat analogues	New infrastructure for meat analogue production More employees in this industry, High level of competence Fortified products with micronutrients Fossil free energy sources
<i>Transport</i>	To retail storage (ex central storage) and to restaurant retailers Freeze storage, Freeze transport needed. Export	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Transport</i>	Self-driving electric trucks to local food store / restaurants 10% of consumers drive electric cars from food store to the home and 90% have home delivery by drones, bikes, from food stores	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions More consumers have home delivery of food
<i>Food preparation</i>	In restaurant or home kitchen: Boil or fry Need for energy	More energy efficient cooking equipment, especially in restaurant / food service, but also at home

3.3.2. Food Forgotten

Based on the description of the scenario, the working group made some assumptions:

Dried peas/beans

- In this scenario, we will eat more legumes.
- We will not grow so many legumes in Sweden, but mainly import from countries in Europe.

Meat analogues

- We will eat a greater proportion of plant-based food.
- Since we will not grow so many legumes in Sweden, we will import protein powder from Europe.
- Meat analogues will be manufactured in Sweden, but the manufacturing companies may be owned by large, multinational corporations.

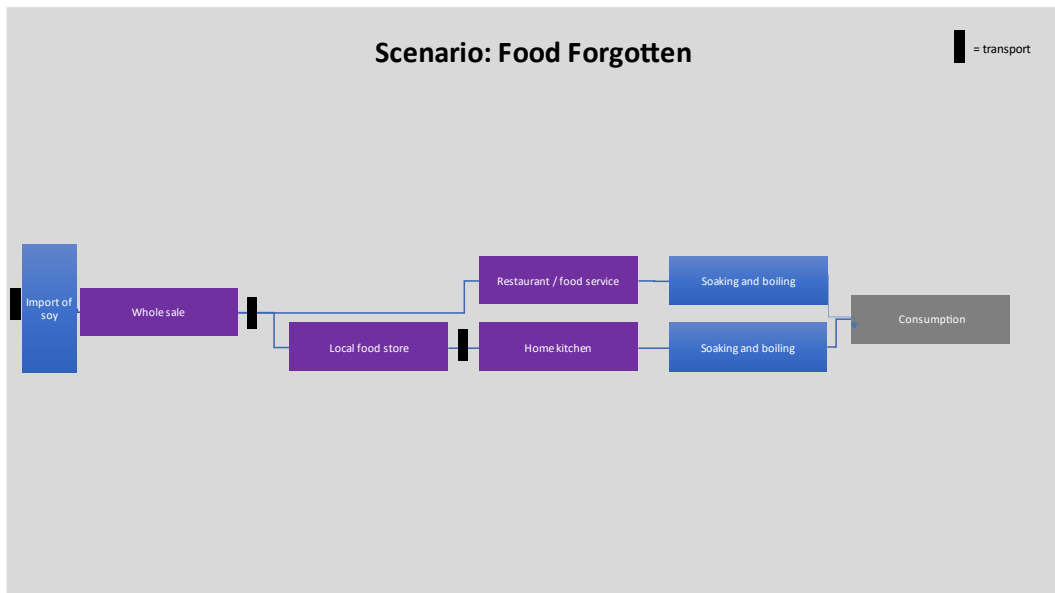


Figure 12. Production chain for dried peas/beans for the scenario Food Forgotten.

Table 7. Key Descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for dried peas/beans in the scenario Food Forgotten.

<i>Food Forgotten</i>	Key Description	Main Shift in the Future
<i>Transport from other countries</i>	To retail storage (ex central storage) and to restaurant retailers Self-driving electric trucks / train	Sustainable soy from Europe Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions Strong pressure for solutions with low climate impact
<i>Storage</i>	At retail storage (ventilated, ambient temperature)	
<i>Transport</i>	Self-driving electric trucks to local food store or restaurant/food service 50% of consumers drive electric cars from food store to the home and 50% have home delivery by electric small trucks from food stores	Strong pressure for solutions with low climate impact We have less items in food store, they are “bulk” ingredients, and we don’t need to go to the food store to see them
<i>Food preparation</i>	In restaurant or home kitchen: Soaking. Boiling. Possibly further used in a dish Need for water and energy	New varieties that have less antinutrients – less water is needed for soaking/boiling. More energy efficient cooking equipment, especially in restaurant / food service, but also in the home Strong pressure for solutions with low climate impact
<i>Consumption</i>	Dried peas/beans can be further stored in the kitchen/home. Food leftovers are recycled. Packaging material is recycled	Sharp regulation/incentives to reduce food waste (consumers pay for their waste) which has reduced food waste a lot

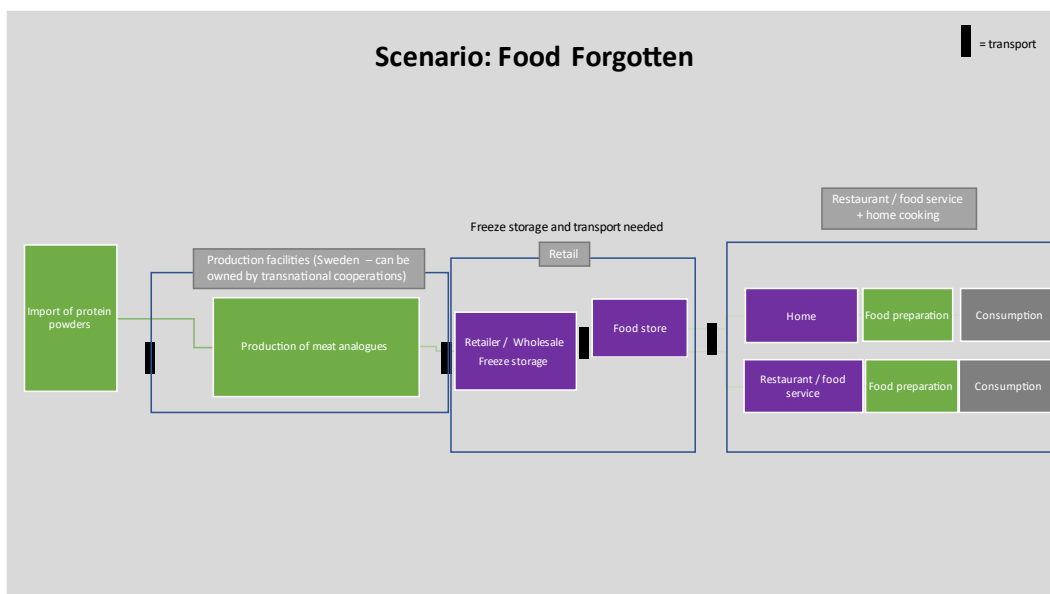


Figure 13. Production chain for meat analogues for the scenario Food Forgotten.

Table 8. Key Descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for meat analogues in the scenario Food Forgotten.

<i>Food Forgotten</i>	Key Description	Main Shift in the Future
<i>Meat analogue production</i>	Import of protein powders from Europe	Electrified trucks, self-driving cars, train/boat from abroad Fossil free fuels and energy New sustainable transport solutions
	Production of meat analogues	New infrastructure for meat analogue production More employees in this industry, High level of competence Fossil free energy sources (solar wind, nuclear energy)
<i>Transport</i>	To retail storage (ex central storage) and to restaurant retailers Freeze storage Freeze transport needed	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions
<i>Transport Transport</i>	Self-driving electric trucks to local food store / restaurants 50% of consumers drive electric cars from food store to the home and 50% have home delivery by electric small trucks from food stores	Electrified trucks, self-driving cars Fossil free fuels and energy New sustainable transport solutions More consumers have home delivery of food
<i>Food preparation</i>	In restaurant or home kitchen: Boil or fry Need for energy	More energy efficient cooking equipment, especially in restaurant / food service, but also at home
<i>Consumption</i>	Uncooked meat analogues can be kept in the freezer Food leftovers are recycled Packaging material is recycled	Better system to recycle food loss in restaurants / food service More advanced sorting of food waste in the home, a larger part can be used for feed

3.3.3. Food as Culture

Based on the description of the scenario, the working group made some assumptions:

Dried peas/beans

- We will eat legumes grown in Sweden, and soy will be replaced with pea, faba bean and other protein-rich legumes we can grow in Sweden.
- We will eat more locally produced food.
- We will shop for food in different ways than we do today. Instead of large grocery stores, we will have several small cooperatives, where the food producers have more influence and get a larger share of the money (similar to “REKO-ringar”, Mylla, etc.). What we call "wholesale hubs" are digital platforms for the distribution of Swedish-produced food across the country.
- Food security in this scenario will require people to spend more time growing, producing, cooking, and dealing with waste. This requires other changes in lifestyle and attitudes, such as a six-hour working day, more household services or the like.

The working group expects that meat analogues will not be produced and eaten in the Food as Culture scenario, because in that scenario traditional food will be eaten, therefore only dried peas/beans will be taken up.

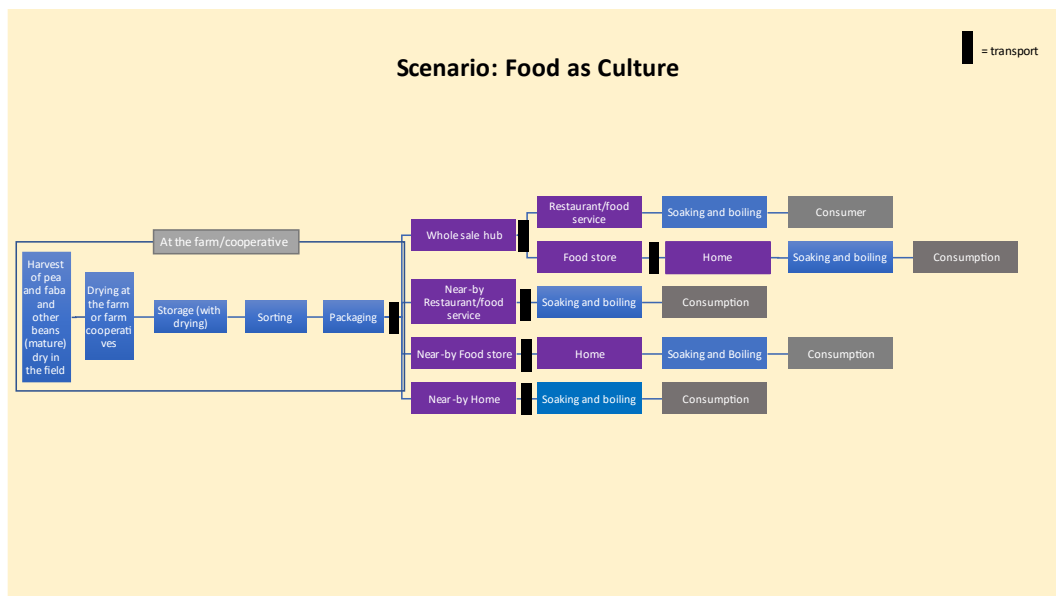


Figure 14. Production chain for dried peas/beans for the scenario Food as Culture.

Table 9. Key Descriptions and “future movement” – i.e. changes that must have been realized for the chain to exist and be sustainable in 2045 for dried peas/beans in the scenario Food as Culture.

Food as Culture	Key Description	Main Shift in the Future
<i>Primary production</i>	Production of Swedish crops (exchange soy for pea, faba and other protein rich crops) Farmers have their own farms, many small farms. Small farms join in cooperatives to dry and sell crops. More organic farms. First sorting is done on the field (removal of straw etc)	New and old varieties of peas and beans (via plant breeding) (with less antinutrients that needs to be soaked away) Climate adapted crops are grown in Sweden. The side streams (straw, bean pods) are used for feed since we have small farms close to production sites – feasible. It is OK that things take longer time
<i>Drying</i>	Drying to a certain water content (14%) Hot air with fans	Cooperative own mobile and small-scale drying equipment Fossil free local energy sources (solar, wind)
<i>Storage (with drying)</i>	The peas/beans need ventilation also during storage (fans)	Fossil free local energy sources (solar wind)
<i>Sorting</i>	Automized sorting of stones etc	Improved automatic sorting systems (mechanical systems, NIR)
<i>Packaging</i>	Packaging in bags (important that the peas/beans don't take up moisture)	New, recyclable packaging materials that has good barriers for moisture
<i>Transport</i>	Transport from pick-up points (cooperatives or farms) to restaurants/food service and food stores across Sweden	Electrified trucks, self-driving cars Fossil free fuels and energy
<i>Transport</i>	Transport to near-by food stores, restaurants/food service and consumers	Electrified cars or bikes Fossil free fuels and energy – local solar wind energy
<i>Food stores</i>	Full traceability back to the producer Focus on local producers, when possible, otherwise small scale produced products in other parts of Sweden	Less packaging materials, buyers come with their own packages
<i>Transport</i>	Transport from food store to consumer	Bicycles, electrified bikes, small, electrified vehicles (mopeds, golf car)
<i>Food preparation</i>	In restaurant or home kitchen: Soaking. Boiling. Possibly further used in a dish Need for water and energy	More work in the home is need (Increased knowledge about handling peas/beans among consumers – we are familiar with soaking and boiling in a good way. New varieties that have less antinutrients – less water is needed for soaking/boiling. More energy efficient cooking equipment, especially in restaurant / food service, but also at home
<i>Consumption</i>	Dried peas/beans can be further stored in the kitchen/home. Food leftovers are recycled. Packaging material is recycled	Better system to recycle food loss in restaurants / food service. More conscious sorting of food waste in the home, a larger part can be used for feed

3.3.4. Discussion of the supply chains with the partner companies

When the working group (SLU, RISE) had mapped the two production chains in each scenario, a workshop was held with the companies. Participants were representatives from Orkla Foods, Axfood, SLU and RISE on 15 September 2023. The working group guided Anders and Åsa through the scenarios, and the working group's assumptions and relevance of the mapping of the production chains were discussed. The outcome of the workshop was:

Convenience is a key trend.

- *Despite poor finances, Axfood's 2022 rocket was fully repaired.*
- *Hot food sales / buffet is going well at Hemköp.*
- *Nowadays, many of the things we had to do ourselves in the past are now hobbies, such as sewing, carpentry and gardening. When we don't want to do it ourselves, we buy ready-made. Cooking will also turn more into a hobby.*
- *The level of knowledge among the public for cooking is low, people do not believe that they can cook good meals themselves, such as baby food – They trust the food industry.*
- *There will be more special food for the elderly in the future.*

The driving license rules currently prevent us from having more electric small trucks that can handle electrified transports. They are heavier than diesel trucks, and then you must have a C driver's license, which there is a shortage of people who have.

How will the general public act in the future?

- *This is often discussed but is very difficult to predict!*
- *You guess and try to follow the trends. After the pandemic, customers have come back to stores, especially those who are 70+.*
- *Shopping is not only a way to make your purchases, but also a desire for service and an experience – you don't always want to do what is easiest and quickest, but you want added value*
 - o *Ex: the border trade with Norway is seen as a recreational excursion.*
 - o *Consumers scout for the right person at the checkout before joining the queue, to have a chat.*
- *Most people who shop online still buy most of their food in stores.*
- *Axfood has stores together with Norges-Gruppen (EuroCash). Norwegians don't want to shop online from EuroCash, they want to go there and walk around and have a look. But Willys has Click-and-collect, which works well. However, they do not want repatriation from Willys.*

Each scenario can be seen as "where do you draw the line of responsibility for livelihood?"

- Food as Food Tech – Global
- Food Forgotten – Europe
- Food as Industry – Sweden
- Food as Culture – Gated community

Food as Industry:

Discussion about increasing the use of organic raw materials: At the moment, there is a clash between organic and GMO. GMOs started with a desire to increase resistance to diseases, but now we want to control more things. Policies and rules need to be updated; they have not kept up with developments. EU rules take a long time to change, but by 2045 it should be possible. We can already see that the view of genetic scissors such as CRISPR/Cas9 and GMOs is changing. We believe that there will be new technologies for plant breeding by 2045. The "organic" of the future should be the "organic production system".

Production of legumes in Sweden: Crop rotation – can you grow legumes more often than every six or seven years? We can probably double the cultivation of legumes in Sweden, it does not need too large areas for that.

Food as Food Tech:

Personalized nutrition doesn't have to affect the supply, but maybe what you choose. It can be a solution with an order assortment in the stores as at the public alcohol monopoly (Systembolaget). Protein powder is a good bulk product – similar to how milk powder is handled today.

Food Forgotten:

Now we have major changes in the world around us (war, shipping crises, pandemic, climate change). These factors make this scenario not very likely anymore due to:

- Vulnerable system.
- Civil preparedness is needed.
- Climate change will not decrease (e.g. drier in southern Europe – it is already noticeable that fresh fruit and vegetables from southern Europe are harder to come by). We need to grow food in Sweden to supply Europe.
- There is a political will to have food production in Sweden.
- This is an extreme scenario. What would tradeoff be for increased preparedness?

Food as Culture

- Protein powder will probably be available in Food as Culture anyway, as a niche, etc. However, they may not be made into meat analogues.
- Near-by food stores become important.
- We want to order more ourselves, even larger quantities.
 - o People need to store larger quantities at home, houses/apartments are not fitted for that now.
- We have allotments and earth cellars that are shared with the neighbours.
- More direct contact with producers (e.g. Nordisk Råvara).
- Biodiversity is important.
- Resilient system – if there is a crisis, you have food at home/nearby.
 - o As during the Second World War, people broke up allotments in the cities.
 - o In times of insecurity, people want to take control of their food supply.
 - o The supply system is not trusted.
 - o However, this presupposes that you live in a peaceful group, the residential areas become a gated community.
- For this system to become a reality, a major crisis is required!

3.4. Step 4. Structured evaluation of sustainability performance

The results are described in different ways to provide a good platform for discussions and conclusions. Absolute numbers are often not very interesting, it is relationships between the sustainability indicators within a system as well as between systems that provide meaningful information. The results will be presented with three different perspectives:

1. The overall weighted sustainability performance of all systems (Figure 15 and 18). Higher values indicate better sustainability performance given the valuation made in the instructions (Table 10, and a detailed description in Appendix 3).

Table 10. The valuation of the sustainability indicators used in the study (Rad & Sonesson, 2024).

Positive indicators (high value leads to better sustainability performance)	Negative indicators (high value leads to poorer sustainability performance)
<ul style="list-style-type: none"> • Product affordability for consumers • Cultural value preservation • Animal welfare • Fair trading • Revenue for commercial actors in the system • Material efficiency 	<ul style="list-style-type: none"> • Capital cost • GHG emissions • Biodiversity loss potential • Land use, area • Water use • Energy use • Use of toxic materials

2. How much the different indicators contribute to the total within each system is visualized in Figure 16 and 17. The positive values are sustainability aspects that we within the project have judged to be desirable to increase, such as economic indicators and resource efficiency (Table 10). The negative values are sustainability indicators where we believe that reduced impact is desirable, typically emissions and resource consumption. The results should be read as the entire bar being 100%. The positive indicators are displayed in colors and the negative in black/white. The relation to the total result is that the sum of the positive values minus the sum of the negative values is the result shown in Figure 15.

3. How the profile of the different systems compares to each other and today's systems is visualized in Figure 17 and 20. These graphs give an indication of how the different systems compare to each other and to today's systems. This can provide a basis for conclusions about choices that are desirable, but also aspects that need to be changed for sustainability performance to be acceptable.

The rating 9 on the scale refers to an almost optimal system (low emissions, low resource consumption and large socio-economic benefits) and 1 refers to the worst imaginable in a Western European context. To make it easier to evaluate the results the positive indicators are shown as they are, while the negative indicators are recalculated as "the distance to the optimal system". (Example: Capital cost is a negative indicator, and if this indicator has a high value, such as 7, the distance to the optimal system is 3, which shows in the spider diagram). This means that for all indicators a higher number is better, and the scenario that has the largest area in the diagram will be the most sustainable.

The three levels of results together provide a good overview and details about the systems performance that can be used to discuss and decide on the next steps. Examples of next steps can be to do a more detailed assessment of some of the indicators that contribute negatively, e.g. a Life Cycle Assessment (LCA) which is quantifying emissions. Other examples are to perform a consumer study to validate the results for the social aspects or a thorough check on investments costs. Results can also be used for training and communication.

3.4.1. Result "Dry peas/beans"

Figure 15 shows the overall sustainability index for the four supply chains and the reference (which is the current system) for "Dry peas/beans". The production system with the best performance seems to be the one developed in the Food as Industry scenario, closely followed by Food as Culture and Food Forgotten. Food as Food Tech has the lowest sustainability performance, but all systems have better outcomes than today's systems. It should be noted that it is not possible to quantify significance, so the results should be looked upon as indications that need to be analyzed in more detail.

In Figure 16 the relative importance of contributions from all the indicators are shown, and in Figure 17 the grading for all indicators for all production systems are presented and comparison between production systems can be done.

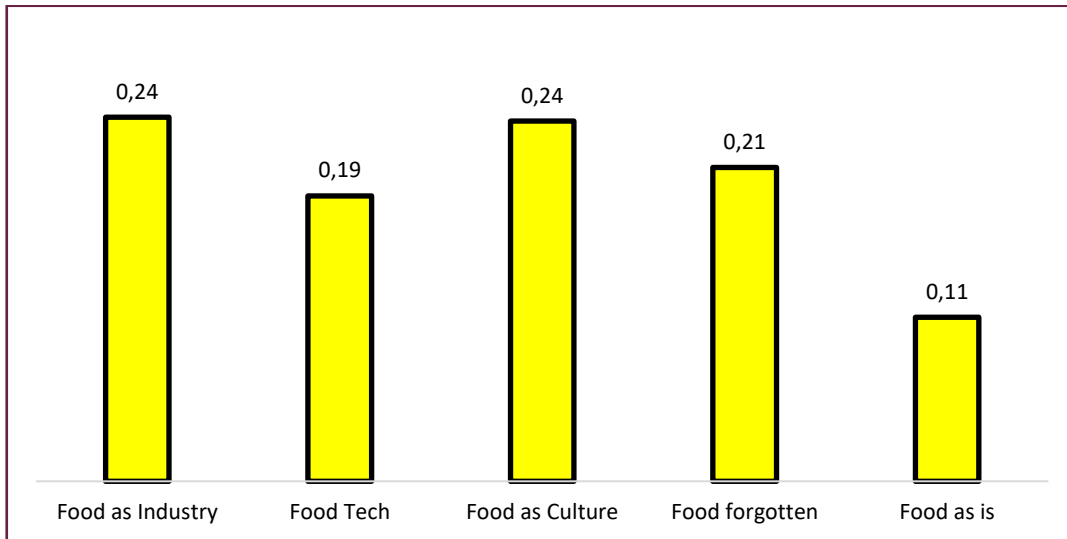


Figure 15. Relative weight of evidence sustainability performance of the four 'Dry peas/beans' schemes. A higher value means better sustainability performance given the valuation made in the instructions, Appendix 3.

Food as Industry:

In the Food as Industry scenario, we will eat more legumes than today, and imported soy will be replaced by peas/beans grown in Sweden. Many of the sustainability indicators was rated higher for the dry peas/beans value chain than Food As Is, such as *GHG emissions*, *Use of Toxic materials*, *Product affordability*, *Cultural values*, *Fair trading*, *Revenue* and *Material efficiency*. Out of these, this scenario scored the highest of the four future scenarios for *GHG emissions* (similar as Food Forgotten). This is in line with the scenario prerequisites that emissions from agriculture remained relatively stable between 2015 and 2045 despite an increase in overall production, leading to decreased GHG emissions per kg of product. Even though overall GHG emissions were not reduced, food production was considered sustainable since GHG emissions in other countries were reduced due to increased sustainable food production in Sweden, i.e. Swedish products replace products with worse environmental performance. The only indicators with a lower rating than Food As Is were *Land use* and *Capital cost*. This is in line with the assumption that food production in Sweden had increased considerably, implying larger land use and investments in food production.

Food as Tech

In the Food Tech future we grow legumes in Sweden, but we also import sustainably cultivated soy. Consumption of dry peas/beans is low, as people eat more ready-to-eat products. In the Food as Food Tech scenario, the main indicators that was regarded as more

sustainable than Food As Is were *GHG emissions*, *Land use*, *Product affordability*, and *Material efficiency*. Out of these, this scenario scored the highest of the four future scenarios for *Land use* (similar as Food Forgotten), and *Water use* (similar as Food as Industry), which is logic since Swedish agricultural production, both in terms of number of farms and farmers, has declined and as many farms closed down the ones that remain grew in size. The indicators with a lower rating than Food As Is were *Cultural values* and *Fair trading*. The food system is dominated by transnational corporations and raw materials are imported from wherever is cheapest, which may add to the perceived decrease in *Fair trading*. As this scenario build on the assumption that a large dietary shift has taken place, from animal-based proteins and dairy fats to plant-based and novel ingredients, people's habits have markedly changed, and preservation of *Cultural values* may be compromised. Also, in the Food Tech scenario food is less of a social phenomenon where less time and effort are spent on preparing and consuming foods and personalized diets are chosen over family meals.

Food Forgotten

In the Food Forgotten scenario foods are produced anywhere in the world where the environmental impact is the lowest. It is more profitable for Swedish farmers to invest in carbon storage than in food production, and most legumes we consume will be imported. Therefore, many of the indicators for the dry peas/beans value chain were regarded as more sustainable than Food As Is, such as *GHG emissions*, *Land use*, *Product affordability*, *Material efficiency* and *Capital cost*. Out of these, this scenario scored the highest of the four future scenarios for *GHG emissions* (same as Food as Industry), *Product affordability* and *Capital cost*. In this scenario we will eat more legumes, but we will import almost all that we need, since legumes can be produced with lower emissions in other countries. Hence, only small amounts of legumes are produced in Sweden and the total *GHG emissions* from legume production will be small. Also, *Product affordability* is considered high due to effective production abroad and not many investments are needed. Two indicators had a lower rating than Food As Is; 1) *Cultural values*, since almost no peas/beans are produced in Sweden and we will consume mainly non-Swedish crops such as soy and 2) *Fair trading* which may be due to that Swedish companies will not be able to influence the production chain much as it is abroad.

Food as Culture

In the scenario Food as Culture many indicators were regarded as more sustainable than for Food As Is, such as *GHG emissions*, *Biodiversity loss potential*, *Use of toxic materials*, *Cultural values*, *Animal welfare*, *Fair trading*, *Revenue* and *Material efficiency*. Out of these, this scenario scored the highest of the four future scenarios for *Biodiversity loss potential*, *Use of toxic material*, *Cultural values* and *Fair trading*. This may be explained by the assumption that we will eat a variety of legumes grown in Sweden, focus on small scale production and locally produced foods and that the food producers can influence the whole production chain and get a large share of the revenue. The only indicators with a

lower rating than Food As Is were *Land use*, *Water use* and *Capital cost*, which may be because it is assumed that the production chains for dried peas/beans will mainly be at small scale, with less efficiency improvement than the large scale production chains in the other scenarios.

General results

The scenario that received the best assessment, Food as Industry, has both the lowest negative impact and the highest positive impact. The scenario, and thus the design of the supply chain, is governed by an industrial logic with a strong focus on reduced emissions and resource efficiency. On the positive side, the Food as Industry solution is characterized by a reasonable balance between players and that the industrial efficiency has an effect for both consumers and producers. The differences are small, but these results can be used to identify aspects where action should be prioritized, ideally those that have a high impact and it can be assumed that there are effective solutions. For example: In Food as industry: “*Land use*” accounts for a relatively large part of the negative impact. Land use can be reduced by using raw materials from higher-yielding crops, or by reducing waste. On the positive side, it may be worth investigating whether it is possible to increase the perceived contribution to cultural values. Something that can possibly be achieved by being more open to dialogue with consumers and taking other considerations into account in communication and product development.

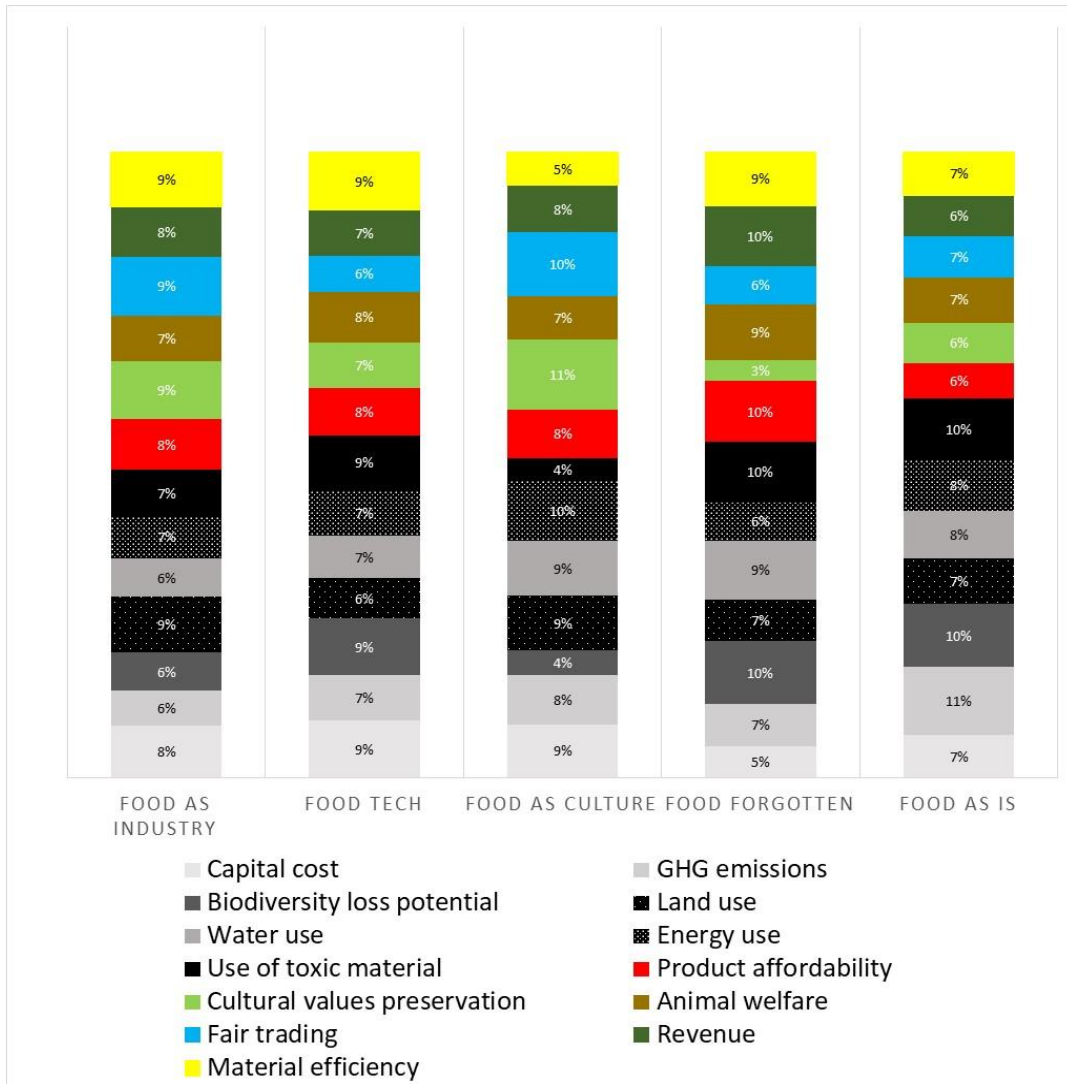


Figure 16. Relative contribution of the indicators to the sustainability performance of the four future systems and the current system for dried peas/beans. Indicators in black and white are "negative", i.e. it is negative if they have high values, colored indicators the opposite.

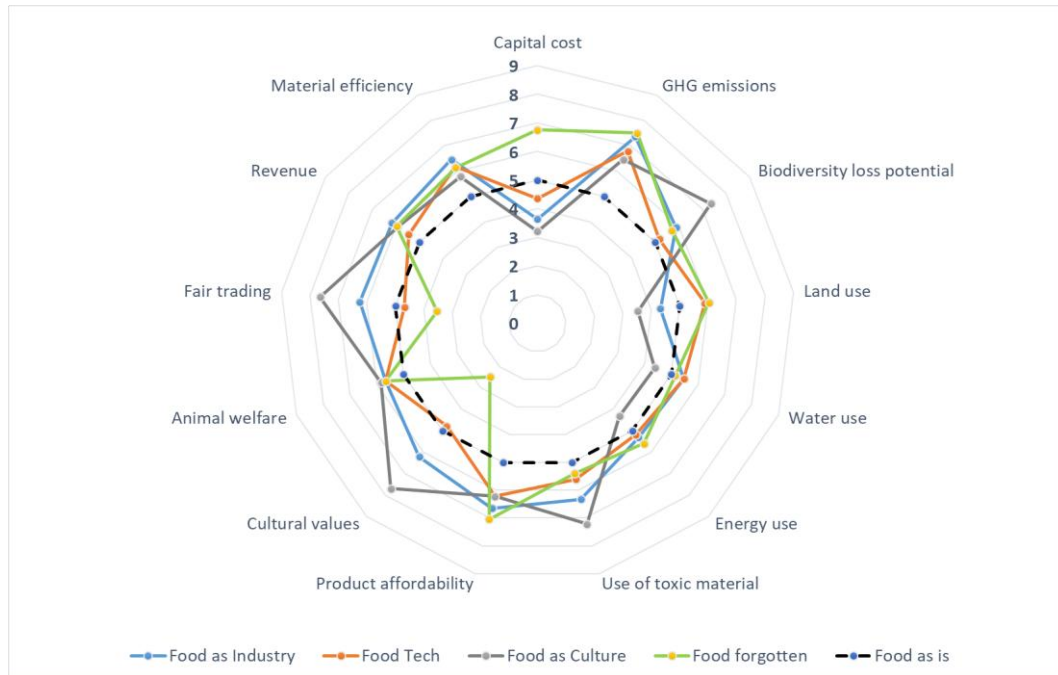


Figure 17. The systems' assessed improvement potential, dry peas/beans. The rating 9 on the scale refers to an almost optimal system (low emissions, low resource consumption and large socio-economic benefits) and rating 1 means that the assessor think the system is the worst imaginable in a Western European context, where in both cases the present system have a grading of 5. The positive indicators are shown as they are, while the negative indicators are recalculated as "the distance to the optimal system". (Example: Capital cost is a negative indicator, and if this indicator has a high value, such as 7, the distance to the optimal system is 3, which shows in the spider diagram). This means that for all indicators a higher number is better, and the scenario that has the largest area in the diagram will be the most sustainable.

3.4.2. Results "Meat analogues"

The overall sustainability performance of the meat analogue production systems is presented in Figure 18. The only supply chain that performs better is "Food as Industry", however, the difference between the best and worst systems is small. It should be noted that it is not possible to quantify significance, so the results should be looked upon as indications that needs to be analyzed in more detail.

In Figure 19 the relative importance of contributions from all the indicators are shown, and in Figure 20 the grading for all indicators for all production systems are presented and comparison between production systems can be done.

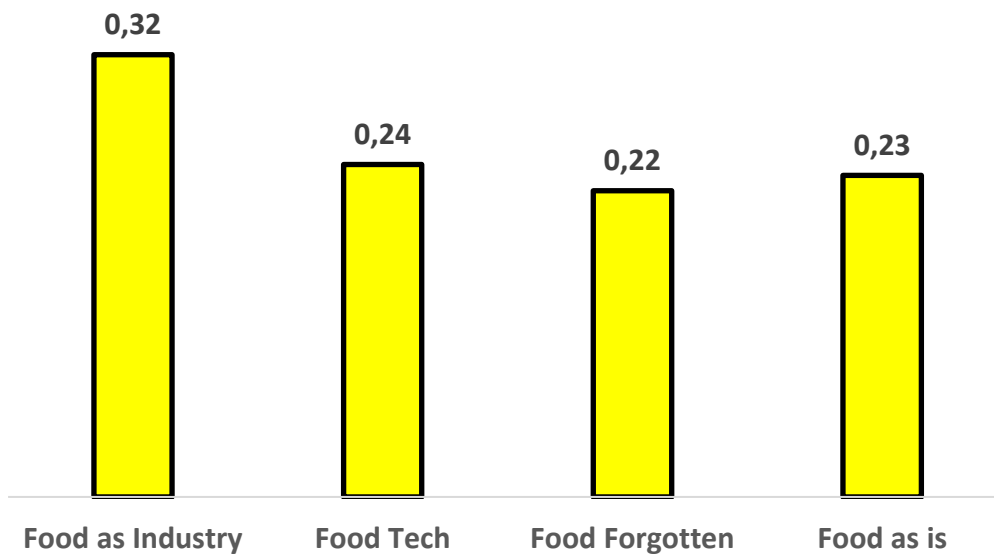


Figure 18. Relative sustainability performance of the four 'Meat analogues' systems. A higher value means better sustainability performance given the valuation made in the instructions, Appendix 3.

Food as Industry:

Regarding the concept meat analogues, the assessment of the different sustainability indicators followed the same trend as for dry peas/beans, which is not surprising as in this scenario we will produce meat analogues in Sweden, and we have built an infrastructure to extract plant proteins. The main difference in the sustainability assessment in relation to dry peas/beans is that *Cultural values* is reduced for meat analogues. This may be because we consider meat analogues to still be a quite new product in 2045, and that it is not perceived as traditional foods by the consumers. *Cultural values* is assessed as low for meat analogues in all future scenarios considered.

Food as Food Tech:

In a Food Tech future, the *Capital Cost* is expected to be higher for the meat analogues than for the dried peas/bean production chain, since we have implemented both protein extraction and meat analogue production at large scale in Sweden. In this scenario, we assume that we import a large part of dried soy that is used, and therefore not many investments are needed in the Swedish production chain of peas/beans. We expect Sweden to be an advanced meat analogue producer and meat analogues will be produced for export, implying high ratings for *Product affordability* and *Revenue*, which are rated highest for the Food Tech scenario out of all future scenarios. *Fair trading* is rated lower for meat analogues than for dry peas/beans which may be due to the assumption that the production facilities will be owned by international groups, reducing transparency and possibility to influence these long production chains.

Food as Forgotten:

Meat analogues will be popular in The Food Forgotten future, and Sweden will have meat analogue production that cover our own needs. The raw material will be imported as protein powders, and production facilities will be owned by large transnational corporations. This may explain why *Fair trading* is rated lowest for Food Forgotten compared to the other future scenarios. *Land use* is rated high on the sustainability scale, since the raw material is imported from elsewhere.

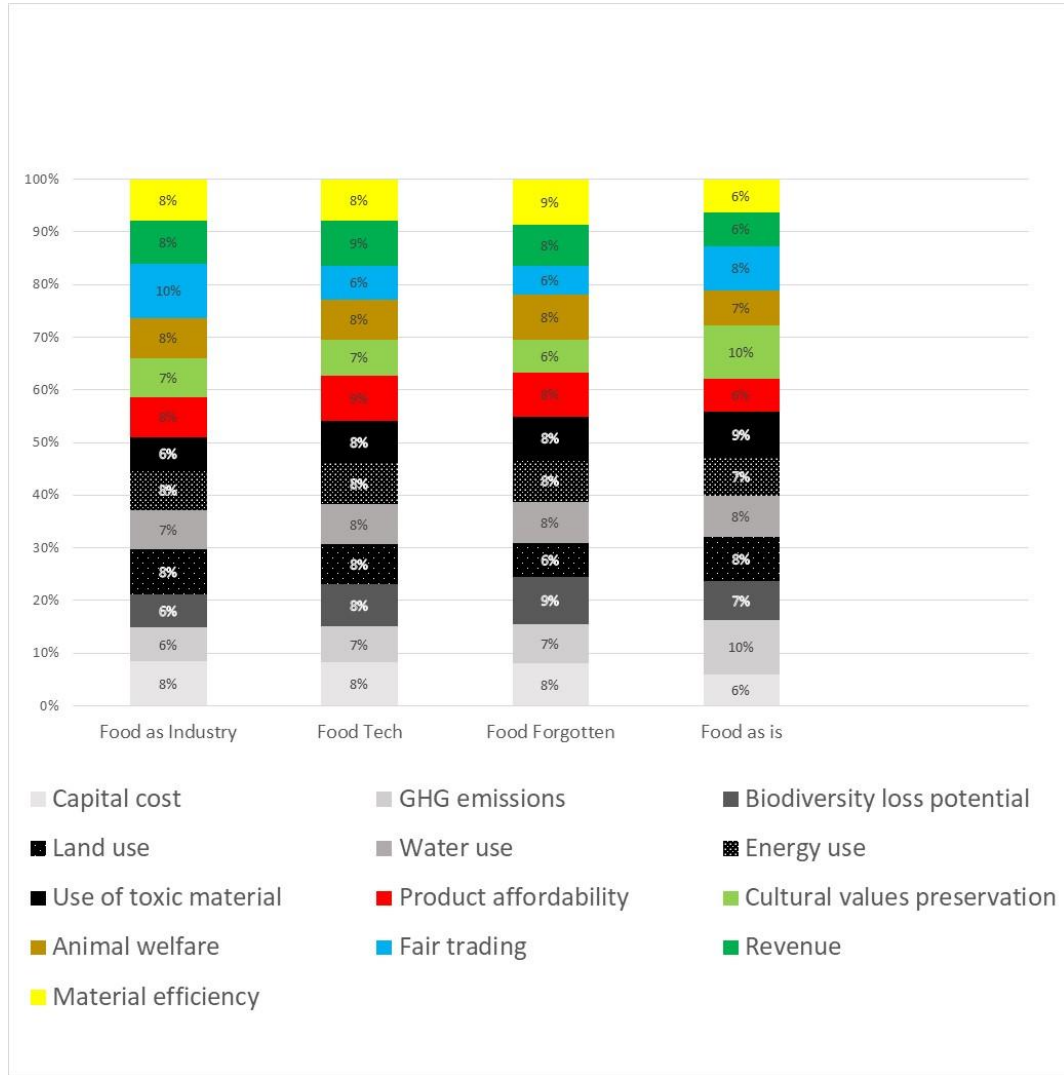


Figure 19. Relative contribution of the indicators to the sustainability performance of the four meat analogues systems and current systems. Indicators in black and white are "negative", i.e. it is negative if they have high values, colored indicators the opposite

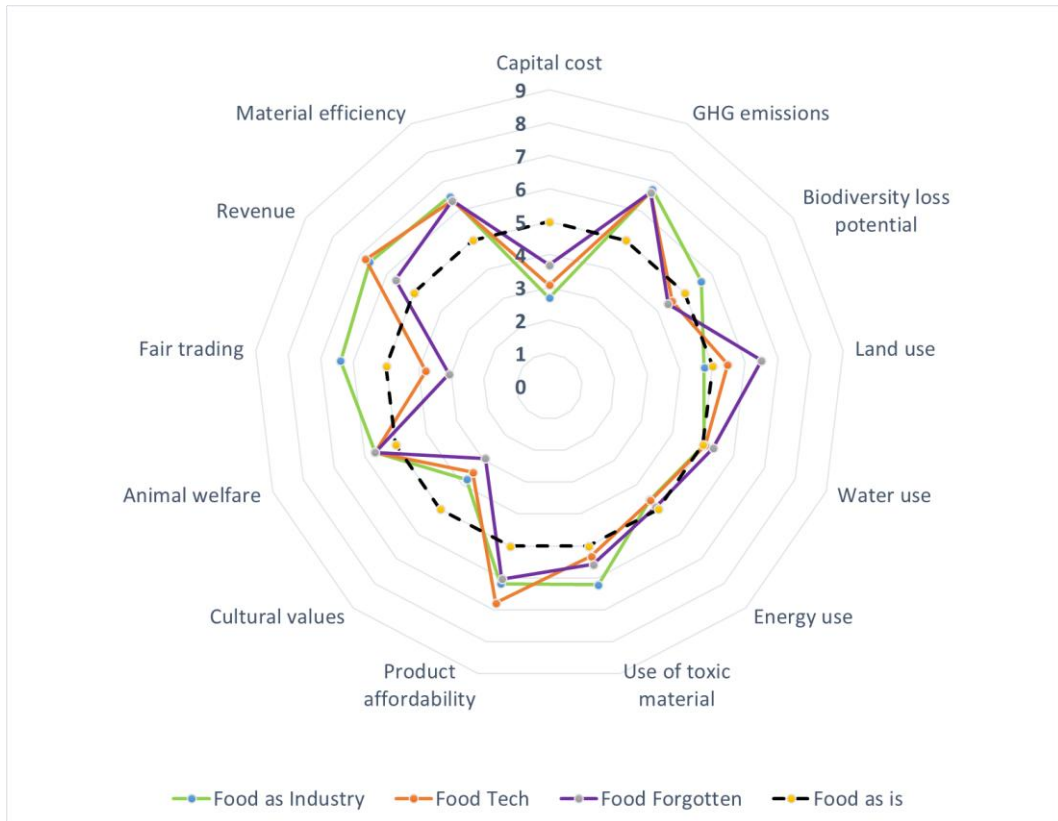


Figure 20. The systems' assessed improvement potential, dry peas/beans. The rating 9 on the scale refers to an almost optimal system (low emissions, low resource consumption and large socio-economic benefits) and rating 1 means that the assessor think the system is the worst imaginable in a Western European context, where in both cases the present system have a grading of 5t. The positive indicators are shown as they are, while the negative indicators are recalculated as "the distance to the optimal system"

4. Discussion and Conclusions

4.1. Method for designing and evaluating future supply chains

A first aim was to test and evaluate the method developed ("Metod och arbetsprocess för design av mer hållbara leveranskedjor från gård till butik", "Method and work process for designing more sustainable supply chains from farm to store"), in collaboration with actors in the product chain. A secondary aim was to test how MISTRA Food Future's scenarios can contribute to a deepening of understanding and contribute to better decision-making. Finally, the third aim was to apply Multi-Criteria-Assessment (MCA) to food systems, which hitherto is rarely done (Naseri Rad & Sonesson, 2024)

The method applied (Sonesson et al., 2023) is based on a combination of approaches and was developed using simplified case studies, and the case study presented here was the first real test of the method. It was evident that the supply chain design process gave valuable insights into challenges and bottlenecks in trying to look into the future. The introduction of MISTRA Food Futures scenarios was a key to open-up the discussion and include more radical solutions since it provided a common rather concrete vision of different futures. A practical, but nonetheless critical problem, was the involvement of several senior persons in different organizations. The design process was often delayed and suffered from that many discussions was repeated due to these delays. The way this was handled was to keep all documentations in a single document and to include also general descriptions of discussions. By that, it was easier for the project leader to make the design process in motion.

The use of product and value chains, i.e. the "concepts", as platforms for addressing larger questions on sustainable food production proved to be useful. The discussions in the group were creative and future-looking and at the same time the focus could be maintained by the clear task in developing hypothetical supply chains that deliver the product concepts developed. The use of well-known structures in product- and process development was key in not losing track in the complex and multi-dimensional area of sustainable future food production we approached.

In this research project, partly the same persons took part in several steps in the process, i.e. development of concepts, designing the system and evaluating sustainability performance. This is clearly not ideal; it is very difficult to avoid being affected by previous

discussions in later steps in the process. Nevertheless, it did not affect the overall aim; to develop and apply a method to identify what needs to be done further on.

4.2. MCA as a tool for assessing sustainability

The main value in using MCA was that it provided a systematic way of incorporating a broad consideration of sustainability that few other methods did, and the top-down approach reduced the risk of important sustainability aspects being missed. The identification of weak and strong aspects in sustainability performance is also valuable since it indicates where improvements in the supply chains should be sought. Hence the method tested in this report, where MCA is the assessment, is suitable in early design phases since it helps identifying technological and organizational as well as sustainability improvement areas. However, due to the semi-quantitative approach it is probably not useful for direct decision-making.

A second benefit with MCA was that all indicators were equally treated, which is rarely the case when assessments of both quantitative and qualitative indicators are done; the quantitative ones will get more attention.

Defining and choosing what sustainability indicators to use in case studies was a complex task. It is not efficient to include too many indicators since the complexity in the result will increase rapidly, and at the same time it is key to capture the broad sustainability impacts. In this study we chose to omit some indicators that was deemed to complex, as “nutritional quality” or “health”. In retrospect it would probably have increased our understanding to include it. In future studies we would give more attention to the choice of indicators and invest time to assess consequences of indicator choices. Moreover, different assessors may interpret indicators differently when they rate the production chains in the four different scenarios, even if a clear definition was provided to assessors before the rating (See Appendix 3). If all sustainability assessors had written comments of how they reasoned for each indicator in the Excel sheet, it would have been easier to reach consensus in the assessment group and reflect on the results.

The results show where the hotspots are in the different scenarios and where attention should be paid to improve sustainability performance. However, the interpretation of results was more difficult than anticipated. There are many aspects to consider and the fact that the values are based on judgements, rather than quantification, made it difficult to describe connections between system design and assessment.

Since we in this study did not have the possibility to engage separate groups of people for the design phase and the evaluation phase the MCA results as such probably became less valuable. The reason being that it is inherently difficult to separate one’s perceptions of a system when evaluating it and designing it. Hence, the actual results are of less importance

as such, but it was valuable to test whether the approach could deliver the “screening to avoid missing important things”.

The composition of the expert group doing the assessments most probably explains that the results for the technical/scientific indicators varied less between scenarios than did the social and economic ones. The experts were absolutely dominated by engineers and scientists etc.

The weighing of the various sustainability indicators has been made based on a survey of many people working in the food system. The survey has not attempted to identify any differences in how the different sustainability indicators are valued in the different future scenarios that have guided the design of the production systems. This can lead to results that are not entirely logical, as it is reasonable to assume that the valuation of various sustainability aspects is also affected by how society changes.

4.3. Case study results

The sustainability performance for the dry peas/beans value chain in all four scenarios was expected to be better than what we have today (Food As Is). This is in line with the prerequisites that the future scenarios are supposed to be four sustainable systems. Indeed, the relative weight of evidence sustainability performance was higher for all four future scenarios than Food As Is.

For meat analogues, on the other hand, the future scenarios Food Tech and Food Forgotten had a relative sustainability performance in the similar range as Food As Is, and only Food as Industry had increased rating (In Food as Culture meat analogues were not included since meat analogues was judged to be illogical in that scenario, and therefore was not considered here). A reason for this result may have been that it was difficult for the assessors to really imagine the future scenarios for this new type of product, to grasp the differences in how they can be produced and how it affects the food system.

4.4. Conclusions

The method (design process and MCA) is a promising attempt to develop a method that supports decisions in early design phases of food supply chains.

The method should be useful as a tool for companies to engage more people in long-term sustainability planning. The process with iterations and sustainability assessment could be introduced in product development as an option to “think further”.

Comparisons between systems are dependent on the valuation by experts, which needs to be managed with care. It is important to engage experts with broad understanding of the whole spectrum of indicators as well as experts on the actual production systems. Ideally,

experts from different knowledge areas as well as with different background professionally and personally is to prefer.

The choice of indicators is critical for the value of a study, hence indicators should be chosen with great care and involvement of an expert group covering a broad range of sustainability areas is recommended.

It is very important to describe the indicators in a way that is understandable for all evaluators. Considering the wide scope, no one can be expected to master all indicators. Moreover, the grading needs to be clearly explained, and a common understanding of the scale is needed.

To enhance the relevance of results, weighing factors between indicators depending on the scenario context should be developed, i.e. that there will be different weights in different futures. This would require additional surveys, but the outcome can be used for many studies, as a data base on weighing factors connected to the scenario descriptions.

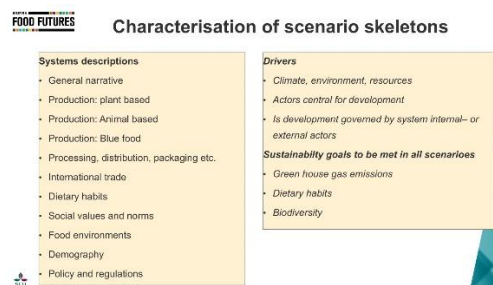
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6. Appendices

6.1. Appendix 1. Brief description of MISTRA Food Future's scenarios.

Below are the images that were used during the work, both workshops and work meetings. For complete descriptions see Gordon et al. (2023).



FOOD FUTURES **Food as Tech - Narrative**

Overview of the system of year 2045:

- The average Swedish consumer follows personal dietary advice. These are managed by new technologies, such as nutrient density trackers and microbiome mapping, which are connected to smart kitchens and apps that develop sustainable and healthy menus.
- Healthy and sustainable diets are the norm, aided by increased availability of new food products that are considered practical to prepare. These include artificial meat from cell cultures, bacterial and fungal-produced proteins and new plant-based products.
- Shopping for food and ready meals is convenient thanks to the growth and integration of the e-grocery sector and low-carbon delivery systems.
- Although diets are more individualized, this does not mean consumer control, but rather that the food environment is enabled and shaped by transnational companies that produce, process and sell food.
- Swedish food processing has increased significantly since 2015, while the size of the agricultural sector has decreased.

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FOOD FUTURES **Food as Tech - Narrative**

Logics behind the development:

- The changes to the Swedish food system outlined in this scenario were largely a result of the success of new innovations.
- Investment companies programs determined to disrupt the food sector, invested heavily in innovations that reduced climate emissions and developed health friendly food processing.
- Investments and innovations took place in a society that towards the end of the 2020s started to enforce substantial regulations focused on ensuring healthy and sustainable food processing.
- Many of the companies that did really well were new to the food sector. They built new business models based on expertise and experience from outside the food sector.
- Consumer demand for both personalised diets and convenient novel foods developed with stronger sustainability values, was also a driver of these changes.
- The personalised nutrition trends started in the 2010s, with a great increase in sales of gluten- and lactose-free products and dietary supplements. Sales of sports nutrition related products went up and there was increased shelf space of protein bars and drinks.
- The demand for more convenient food continued to grow in the 2020s with new food products on the market that reduced food preparation times.

Umeå University | SLU | Swedish University of Agricultural Sciences

FOOD FUTURES **Food as Culture - Narrative**

Overview of the system of year 2045:

- Increased focus on rural development and close relationships between consumers and food producers.
- Local food cultures, multifunctional small-scale production and "local food nodes" important.
- Social equality, climate, animal welfare and environmental concerns rather than economic growth.
- High national self-sufficiency rate.
- More grazing cattle mainly on natural pasture and a focus on nature conservation in general. This results in a reduced technical production efficiency.
- Slow introduction of precision agriculture and other new technologies.

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FOOD FUTURES **Food as Culture - Narrative**

Logics behind the development:

- The changes in the Swedish food system are a result of growing social movements, which were reinforced by the fact that Europe was hit by severe climate-related disasters.
- Great public awareness that consumption patterns must change dramatically.
- The policy has had a major focus on regenerative agriculture, agroecology, sequestration and storage of carbon dioxide, biological diversity and increased animal protection. This has led to more diversified cropping and farming systems and an emphasis on food security and healthy foods.

Umeå University | SLU | Swedish University of Agricultural Sciences

FOOD FUTURES **Food Forgotten - Narrative**

Overview of the system of year 2045:

- Increased measures to both reduce climate emissions and adapt to the consequences of climate change have shaped the food system with both food production and consumption.
- The countryside produces different products and services than before, such as bioenergy and ecosystem services.
- Due to the strong focus on and support for climate change mitigation, farmers have converted land previously used for food and feed into bioenergy production, infrastructure for climate change mitigation and adaptation.
- Lower consumption of animal foods than 2022.
- Swedish food producers have become even more deeply integrated into the European food system.

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FOOD FUTURES **Food Forgotten - Narrative**

Logics behind the development:

- The changes to the Swedish food system was largely a result of two separate developments.
 - an increased emphasis of climate and biodiversity concerns (internationally and nationally)
 - a loss of influence of food and agricultural actors
- The EU Green Deal accelerated the transformation of social and economic activity across the EU to reduce greenhouse gas emissions by 55% by 2030. This influenced changes in land use.
- The strong focus on climate and biodiversity targets within the green deal has led to less focus on social sustainability and economic development in rural areas.
- Nationally, the GHG reduction targets for agricultural emissions was strengthened as compared to previous plans as a result of strong pressure from society and other sectors.
- Consumption targets for climate impact was introduced, driving diets into less animal products.

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6.2. Appendix 2. Survey of stakeholders to create weighting between sustainability indicators

Hello and welcome!

We are grateful that you have taken the time to participate in this survey questionnaire. Your valuable insights will help us in our endeavor to understand how different stakeholders in the Swedish food production and consumption sector perceive a sustainable food system for the future.

Your responds are important to us! Based on these we assess the interdependencies among involved factors in shaping a sustainable food system, identify their significance, and use this knowledge to provide a picture of how sustainable different scenarios of tomorrows food systems in Sweden are.

This questionnaire is part of the research program MISTRA Food Futures, and specifically the workpackage dedicated to “Sustainable post-farm supply chains” lead by RISE Agriculture and Food.

Thank you for your participation!

Mehran Naseri Rad and Ulf Sonesson

Part 1: General Information

1. What is your gender? Choose an item.
2. What is your age? Click or tap here to enter text.
3. What is your highest level of education? Choose an item.
4. In which stage of the food value chain, you have been working?
 - Primary production (farming, aquaculture, fishing, etc)
 - Food producing companies
 - Retail
 - Ingredients providers and equipment supplier (including food packaging)
 - Food research
 - Waste and by products management
 - Food service
 - Public meals (offentlig måltider)
 - I only enjoy the end product as an individual consumer

Part 2: Sustainable food production and consumption

1. Which of the following best describes your knowledge of sustainable food systems?
 - a. Little or no knowledge
 - b. Basic knowledge [less than 5 years of work/study experience in food]
 - c. Moderate knowledge [5 to 10 years of experience]
 - d. Extensive knowledge [over 10 years of experience]

2. How important do you think sustainable food production and consumption are for our society?
 - a. Not so important
 - b. Somewhat important
 - c. Important
 - d. Very important

3. What are the main benefits of sustainable food production and consumption? (Multiple answer)
 - a. Environmental benefits
 - b. Economic benefits
 - c. Social benefits
 - d. Other [Please specify] [Click or tap here to enter text.](#)

4. In your opinion, what are the main challenges of implementing sustainable food systems? (Multiple answer)
 - a. Lack of government policies and support
 - b. Resistance from conventional food production and consumption trends
 - c. Consumer preferences
 - d. Other [Please specify] [Click or tap here to enter text.](#)

5. In your opinion, what are the potential solutions to address the challenges of implementing sustainable food systems? (Multiple answer)
 - a. Encouraging government policies and support.
 - b. Supporting local and regional food systems.
 - c. Increasing public awareness and education.
 - d. Other [Please specify] [Click or tap here to enter text.](#)

Part 3: DEMATEL Analysis

We understand that food value chains are intricate, extensive, and interdependent, making it difficult to isolate specific factors that can accurately determine the overall sustainability of the food value chain. However, drawing on expert knowledge and relevant literature, we have identified 13 indicators, listed below, that are likely to provide a comprehensive assessment of the sustainability of food systems.

- *Product affordability*: the extent to which a food item can be purchased by consumers at a reasonable cost.
- *Cultural values preservation*: the act of safeguarding and maintaining the traditional beliefs, customs, practices, and artifacts of a particular culture.
- *Animal welfare*: the physical and psychological well-being of animals, particularly those that are used for food.
- *Market concentration*: the degree to which a few large companies dominate the food industry and control a significant share of the market.
- *Capital cost*: the total amount of money required to start, operate, or expand a business or a project, including expenses such as equipment, infrastructure, and labor.
- *Revenue*: the total amount of money earned by a company or an individual from the sale of goods or services, minus any discounts or returns.
- *GHG emissions*: the release of gases such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) into the atmosphere, which contribute to global warming and climate change.
- *Biodiversity loss potential*: the potential impact that a human activity may have on the diversity and abundance of plant and animal species in an ecosystem.
- *Land use*: the way that land is utilized by humans for various purposes, including agriculture, urban development, forestry, and mining.
- *Water use*: the amount of water consumed or withdrawn by humans for various purposes, including domestic, industrial, and agricultural use.
- *Energy use*: the consumption of energy resources such as fossil fuels, renewable sources, and nuclear energy to power human activities.
- *Material efficiency*: the ability to use resources efficiently and reduce waste in production processes.
- *Use of toxic material*: the use of toxic materials, such as chemicals, heavy metals, and pesticides, that can have a significant impact on the environment and human health.

Importance

Picture your ideal sustainable food value chain as vividly as possible and envision it as a goal to be attained. How do you evaluate level of importance for each of the following indicators in achieving that more sustainable food system that aligns with your ideal?

	Very low	Low	Medium	High	Very high
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Interaction

Here we want to know what you think about how these different sustainability indicators are connected. In the following comparisons, please tell us how much you think each indicator affects the others. It doesn't matter if it's a good or bad effect, we just want to know how much influence they have on each other in your opinion.

An example!

In the first question you are asked about how much *Product affordability* affects *Cultural values preservation*.

Jens cannot think of any connection between these two and checks the box under “Hardly any” alternative. This reflects Jens’ idea that if *Product affordability* increases, *Cultural values preservation* will only slightly change (if any)!

Sarah however has a different opinion. She thinks “Mmmm, if *Product affordability* increases for processed food as an example, the concept of preparing food as we think of will be changed. We will probably be cooking less and less and might even eat it more frequently; we won’t even need to sit together for eating when we can do that on the go and save some time!” So, higher *Product affordability* in Sarah’s mind might lead to poorer *Cultural values preservation* and this will be a significant effect she believes. However, she doesn’t think this is so extreme effect either, as humans will try to keep their values alive anyway. So, she makes up her mind and checks the box under “Significantly” alternative.

Neither Jens nor Sarah is wrong though. Actually, nobody is wrong! Here and we only seek your opinion, the way it is!

Now it is your turn. We are curious to know what you think!

1. How much do you think *Product affordability* affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. How much do you think *Cultural values preservation* affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. How much do you think *Animal welfare* affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

4. How much do you think *Market concentration* affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. How much do you think **Capital cost** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. How much do you think **Revenue** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. How much do you think **GHG emissions** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

8. How much do you think **Biodiversity loss potential** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9. How much do you think **Land use** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

10. How much do you think **Water use** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11. How much do you think **Energy use** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

12. How much do you think **Material efficiency** affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of toxic material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13. How much do you think *Use of toxic material* affects the indicators below in a food system?

	Hardly any	A little	Moderately	Significantly	Tremendously
Product affordability	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cultural values preservation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal welfare	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Market concentration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Capital cost	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Revenue	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GHG emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Biodiversity loss potential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Land use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Energy use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Material efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6.3. Appendix 3. Brief descriptions of the Indicators used in case studies within MISTRA Food Futures WP6

Product affordability

ChatGPT Question: Describe value-for-money in foods

Value-for-money in foods refers to the concept of getting the best quality food products at an affordable price. It involves finding a balance between price and quality, where the consumer can feel that they are getting a fair deal for the products they purchase. The value of the food in terms of its nutritional content, taste, and the overall satisfaction it provides needs to match the price paid for it. For example, a value-for-money meal might include healthy ingredients cooked in a tasty manner, substantial servings with good portion sizes, and budget-friendly prices. It also means that the price should not be excessively high compared to other similar products in the market. The combination of quality and affordability creates value-for-money in foods, allowing consumers to make informed decisions and feel confident about their purchases.

Cultural values preservation

ChatGPT question: How does food products contribute to the cultural value of foods?

Traditional Preparation Methods: Different cultures around the world have their own unique ways of preparing and cooking food. For example, making sushi is an important part of Japanese culture, while barbecue is a significant part of American culture.

Historical Significance: Some foods are closely tied to the history and heritage of a particular culture. For example, pasta is a traditional Italian food that has been passed down through generations, and the cultural significance of this dish cannot be underestimated.

Symbolism: Certain foods can be symbolic of cultural traditions or beliefs. For example, the Passover Seder meal is symbolic of the Jewish people's escape from slavery in Egypt, and every item on the Seder plate has a specific meaning.

Festivals and Celebrations: Food is often an integral part of festivals and celebrations around the world, and the dishes served can be representative of cultural traditions and customs.

Ultimately, food products are a vital part of cultural identity, providing a link to history, tradition, and values.

Animal welfare

This indicator was not relevant for the case study on legume based products.

Fair market functioning

ChatGPT question: Describe the concept of fair market functioning of European food supply chains

The concept of fair market functioning of European food supply chains refers to the idea that the production, processing, and distribution of food should be conducted in a transparent and competitive manner, without undue concentration of power in the hands of a few large companies.

The European Union has implemented various policies and regulations to promote fair market functioning within the food supply chain, including measures to prevent unfair trading practices, increase price transparency, and support the development of producer organizations. These policies aim to ensure that all actors in the food supply chain, from farmers to retailers, have a fair chance to participate in the market and receive a fair share of the value generated by their activities.

Additionally, the European Union promotes sustainable food production and consumption practices that take into account social, economic, and environmental considerations. This includes measures to reduce food waste, promote organic farming, and support the development of short supply chains that connect consumers directly with producers.

Overall, the concept of fair market functioning of European food supply chains is based on the principles of competition, transparency, and sustainability, and aims to promote a more equitable and resilient food system for all stakeholders.

Capital cost

ChatGPT question: What are the main contributors to capital costs in food industry in high income countries?

The capital costs in the food industry in high-income countries can be significant due to the high level of technology, automation, and specialization required in modern food production facilities. The main contributors to capital costs in the food industry can vary depending on the specific type of food production, but some common factors include:

Equipment and machinery: The cost of specialized equipment and machinery such as food processing machines, packaging machines, conveyors, and refrigeration systems can be a significant contributor to capital costs in the food industry.

Facility construction: The cost of constructing and outfitting a food production facility, including building materials, electrical systems, plumbing, and ventilation, can be a major expense for food companies.

Utilities: Energy costs, including electricity, water, and gas, are a significant contributor to capital costs in the food industry. Food production requires a significant amount of energy for processes such as cooking, refrigeration, and packaging.

Regulatory compliance: Food production is subject to a variety of regulations and requirements, including food safety, hygiene, and environmental regulations. Compliance with these regulations can be expensive due to the need for specialized equipment, training, and certification.

Research and development: The food industry is constantly evolving, and companies must invest in research and development to stay competitive. R&D costs can be significant, particularly in areas such as product innovation, process optimization, and sustainability.

Overall, the main contributors to capital costs in the food industry are related to the high level of technology, automation, and specialization required in modern food production facilities, as well as the need to comply with a wide range of regulatory requirements.

Revenue

ChatGPT question: What determines the revenue for food processing industry in high income countries

The revenue of the food processing industry in high-income countries is determined by a variety of factors, including:

Market demand: The demand for food products is a key driver of revenue for the food processing industry. This demand is influenced by factors such as population growth, changes in consumer preferences and dietary habits, and trends in the retail and foodservice sectors.

Pricing: The pricing of food products is a key determinant of revenue for food processing companies. Pricing decisions are influenced by factors such as production costs, competition, and market demand.

Efficiency and productivity: The efficiency and productivity of food processing operations can have a significant impact on revenue. Companies that can produce high-quality food products at a low cost are likely to be more profitable.

Innovation and product development: The ability to innovate and develop new products can also drive revenue growth in the food processing industry. Companies that can anticipate and respond to changing consumer demands and trends are more likely to succeed.

Regulatory environment: The regulatory environment can also impact revenue for food processing companies. Regulations related to food safety, labeling, and other issues can increase costs and affect market demand for certain products.

Supply chain management: Effective supply chain management can also be a key determinant of revenue for food processing companies. Companies that can efficiently source raw materials, manage inventory, and optimize logistics are more likely to be successful.

Overall, the revenue of the food processing industry in high-income countries is influenced by a wide range of factors related to market demand, pricing, efficiency and productivity, innovation and product development, the regulatory environment, and supply chain management.

GHG emissions

ChatGPT question: What are the main sources of GHG emissions from processing, packaging and distribution of **legume-based food products** in high income countries?

The main sources of greenhouse gas (GHG) emissions from processing, packaging, and distribution of legume-based food products in high-income countries include:

Energy use: The processing, packaging, and distribution of legume-based food products requires a significant amount of energy, which is often generated from fossil fuels. This can include energy used for heating, cooling, lighting, and machinery operations.

Transportation: The transportation of raw materials and finished products can also generate GHG emissions, particularly if long distances are involved. This can include emissions from vehicles used for shipping, as well as emissions associated with the production of fuel.

Packaging materials: The production and disposal of packaging materials can also generate GHG emissions. This can include emissions associated with the production of plastic, paper, and other packaging materials, as well as emissions from the disposal of these materials in landfills.

Waste: The disposal of waste generated during the processing and packaging of legume-based food products can also generate GHG emissions. This can include emissions from landfills, as well as emissions from the breakdown of organic materials.

Water use: The production and processing of legume-based food products can also generate GHG emissions through the use of water. This can include emissions associated with the energy used to pump and treat water, as well as emissions from the release of methane during the breakdown of organic matter in wastewater treatment systems.

To reduce GHG emissions associated with the processing, packaging, and distribution of legume-based food products, companies can implement a range of strategies, including increasing energy efficiency, using renewable energy sources, optimizing transportation routes, reducing packaging waste, and implementing recycling and composting programs. Additionally, consumers can also play a role by choosing products with lower environmental footprints and minimizing food waste.

Biodiversity loss potential

Chat GPT Question: How does different farming practice affect biodiversity?

Farming practices can have varying impacts on biodiversity, depending on factors such as crop types, use of pesticides, and land management techniques. Here's a brief overview:

- **Monoculture vs. Polyculture:**
 - **Monoculture:** Planting a single crop over large areas can reduce biodiversity by providing a limited range of habitats and food sources.
 - **Polyculture:** Growing multiple crops in the same area can support a more diverse range of species, enhancing biodiversity.
- **Pesticide Use:**

- Intensive pesticide use: Excessive application of pesticides can harm non-target species, including beneficial insects, birds, and soil organisms, leading to a decline in biodiversity.
- Integrated pest management (IPM): Using environmentally friendly pest control methods can minimize the negative impact on biodiversity.
- Crop Rotation and Diversification:
 - Crop rotation: Alternating the types of crops grown in a field over time can help break pest cycles and maintain soil health, promoting biodiversity.
 - Agroforestry: Integrating trees and shrubs with crops can create diverse habitats, supporting a variety of plant and animal species.
- Organic Farming:
 - Reduced chemical inputs: Organic farming practices typically involve fewer synthetic chemicals, which can benefit biodiversity by preserving the health of soil organisms, insects, and other wildlife.
- Habitat Management:
 - Field margins and buffer zones: Leaving uncultivated areas around fields can provide habitats for plants, insects, and birds, contributing to overall biodiversity.
- Genetically Modified Organisms (GMOs):
 - Opinions on GMOs vary, but some argue that certain genetically modified crops may have unintended ecological consequences, affecting non-target species and potentially reducing biodiversity.
- Water and Soil Management:
 - Sustainable water use: Efficient irrigation practices can help conserve water resources and maintain wetland ecosystems that contribute to biodiversity.
 - Soil conservation: Preventing soil erosion and maintaining healthy soils can support diverse microbial communities and plant life.

In summary, sustainable and biodiversity-friendly farming practices involve a holistic approach that considers the ecological impact of crop choices, pest management strategies, and overall land management.

Land use

ChatGPT question: What is the most important factor that determines land use for food products?

Determining the most important factor influencing land use for food products is complex, as it often involves an interplay of various factors. However, if I were to highlight a crucial factor, it would likely be crop yield efficiency.

- Crop Yield Efficiency:
 - The amount of food produced per unit of land is a critical factor in determining land use. High-yield crops allow for more efficient use of land resources, as they produce larger quantities of food per acre or hectare. This efficiency is crucial for meeting the growing global demand for food while minimizing the expansion of agricultural land into natural ecosystems.

While other factors such as water availability, climate, and agricultural practices also play significant roles, the efficiency of crop yield is often a key determinant in balancing the need for increased food production with sustainable land use practices. Advanced agricultural technologies, improved crop varieties, and effective farming practices contribute to enhancing crop yield efficiency and, consequently, influencing land use for food production.

Water use

ChatGPT question: What are the main sources of water use in processing, packaging and distribution of **legume based food products** in high income countries?

The main sources of water use in processing, packaging, and distribution of legume-based food products in high-income countries include:

Cleaning and sanitation: Water is used extensively in food processing facilities for cleaning and sanitation purposes to maintain hygiene and prevent contamination.

Ingredient preparation: Water is used for soaking, boiling, blanching, and other preparation methods for legumes before processing.

Processing and cooling: Water is used in processing and cooling of legumes, such as for cooking, steaming, and cooling the legumes after processing.

Packaging: Water is also used for packaging legumes, including washing and rinsing the packaging materials.

Irrigation: In some cases, water is used for irrigating the crops before harvesting.

To reduce water use in processing, packaging, and distribution of legume-based food products, companies can implement a range of strategies, including increasing water efficiency through the use of water-saving technologies and practices, recycling and reusing water, optimizing cleaning and sanitation practices, and using more sustainable irrigation practices. Additionally, consumers can also play a role by reducing their water consumption and choosing products with lower environmental footprints.

Energy use

ChatGPT question: What are the main sources of energy use in processing, packaging and distribution of **legume based food products** in high income countries?

The main sources of energy use in processing, packaging, and distribution of legume-based food products in high-income countries include:

Processing equipment: Energy is required to operate the processing equipment, such as boilers, cookers, and dryers, that are used to transform raw legumes into finished products.

Packaging equipment: Energy is also required to operate the packaging equipment, such as filling machines, labeling machines, and shrink-wrapping machines, that are used to package the finished products.

Refrigeration and cooling: Energy is required to operate refrigeration and cooling systems that are used to keep the legume-based products fresh during storage and transportation.

Transportation: Energy is required to power the vehicles used to transport the legume-based products from the processing facilities to the distribution centers and retail locations.

To reduce energy use in processing, packaging, and distribution of legume-based food products, companies can implement a range of strategies, including increasing energy efficiency through the use of energy-saving technologies and practices, switching to renewable energy sources such as solar or wind, optimizing transportation routes to reduce fuel consumption, and using more sustainable packaging materials. Additionally, consumers can also play a role by choosing products with lower environmental footprints and reducing food waste.

Material efficiency

ChatGPT question: What are the critical aspects of material use efficiency in food supply chains in high income countries?

Material use efficiency in food supply chains in high-income countries is critical to reducing the environmental impact of the food industry. Some critical aspects of material use efficiency in food supply chains include:

Packaging materials: Packaging is a significant source of waste in the food industry, and reducing the amount of packaging used can improve material use efficiency. Companies can optimize their packaging designs to reduce the amount of material needed while still protecting the food products during transportation and storage.

Food waste reduction: Reducing food waste throughout the supply chain can improve material use efficiency by ensuring that fewer resources are used to produce food that is ultimately wasted. Companies can implement strategies such as improved storage and transportation practices, better forecasting and inventory management, and donation programs to reduce food waste.

Efficient use of resources: Efficient use of resources such as water, energy, and raw materials is essential to improving material use efficiency in food supply chains. Companies can implement technologies and practices that reduce the amount of resources used in food production, such as water-saving irrigation systems, energy-efficient processing equipment, and waste reduction programs.

Circular economy practices: Implementing circular economy practices, such as recycling and upcycling, can help to reduce waste and improve material use efficiency. For example, waste materials from food production processes can be used as inputs for other products, such as animal feed or biofuels.

Overall, improving material use efficiency in food supply chains requires a holistic approach that considers the entire lifecycle of the food products, from production to consumption and disposal. By optimizing resource use and reducing waste, the food industry can become more sustainable and reduce its environmental impact.

Use of toxic material

ChatGPT question: What are critical aspects of use of toxic materials in food supply chains in high income countries?

The use of toxic materials in food supply chains in high-income countries can have negative environmental and human health impacts. Some critical aspects of the use of toxic materials in food supply chains include:

Pesticides: Pesticides are used to control pests and diseases in agriculture, but they can also have harmful impacts on the environment and human health. Overuse or misuse of pesticides can lead to water contamination, harm to beneficial insects and animals, and long-term health effects in workers and consumers.

Antibiotics and hormones: Antibiotics and hormones are commonly used in animal agriculture to promote growth and prevent disease, but their overuse can lead to antibiotic-resistant bacteria and environmental pollution. The use of hormones in animal agriculture can also lead to negative health effects in humans who consume meat or dairy products.

Food additives: Food additives such as preservatives, colorants, and flavorings are commonly used in processed foods, but some can have harmful effects on human health. For example, some food colorants have been linked to hyperactivity in children, and some preservatives have been linked to cancer and other health problems.

Packaging materials: Some packaging materials, such as plastics, can contain toxic chemicals that can leach into food and harm human health. Additionally, the disposal of packaging materials can lead to environmental pollution and harm to wildlife.

To address the use of toxic materials in food supply chains, companies can implement strategies such as reducing the use of pesticides and antibiotics, using safer food additives and packaging materials, and implementing more sustainable agricultural practices. Governments can also regulate the use of toxic materials and promote the development and adoption of safer alternatives. Consumers can also play a role by choosing foods that are produced with safer and more sustainable practices.

Beskrivning av betygsskalan för hållbarhetsbedömningar

Indikator	Vi jämför med dagens system, som alltså har ett betyg 4 på alla indikatorer Höga poäng ska ges om:
Product affordability	produkten är mer prisvärd, alltså "värde för pengarna"
Cultural values preservation	produkten bidrar mer till kulturella värden
Animal welfare	djurvälfärden är bättre
Fair market functioning	marknaden är mer rättvis
Capital cost	kapitalkostnaderna är höga
Revenue	vinsten för producenten är hög
GHG emissions	växthusgasutsläppen per kg produkt är högre
Biodiversity loss potential	förlusten av biodiversitet/negativ påverkan på biodiversitet är stor
Land use	markanvändningen är hög per kg produkt
Water use	vattenanvändningen är hög per kg produkt
Energy use	energianvändningen är hög per kg produkt
Material efficiency	materialeffektiviteten är hög (litet svinn i kedjan)
Use of toxic material	användningen av toxiska ämnen är hög

