

D 1.2 Interim Report

# **New Topics in Food Systems - Horizon Scanning Long List**

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# Glossary

Abbreviation	Full form
CDI	Change-Driven Initiative
K&I	Knowledge and Innovation
IoT	Internet of Things
RFID	Radio Frequency Identification technology

## Executive Summary

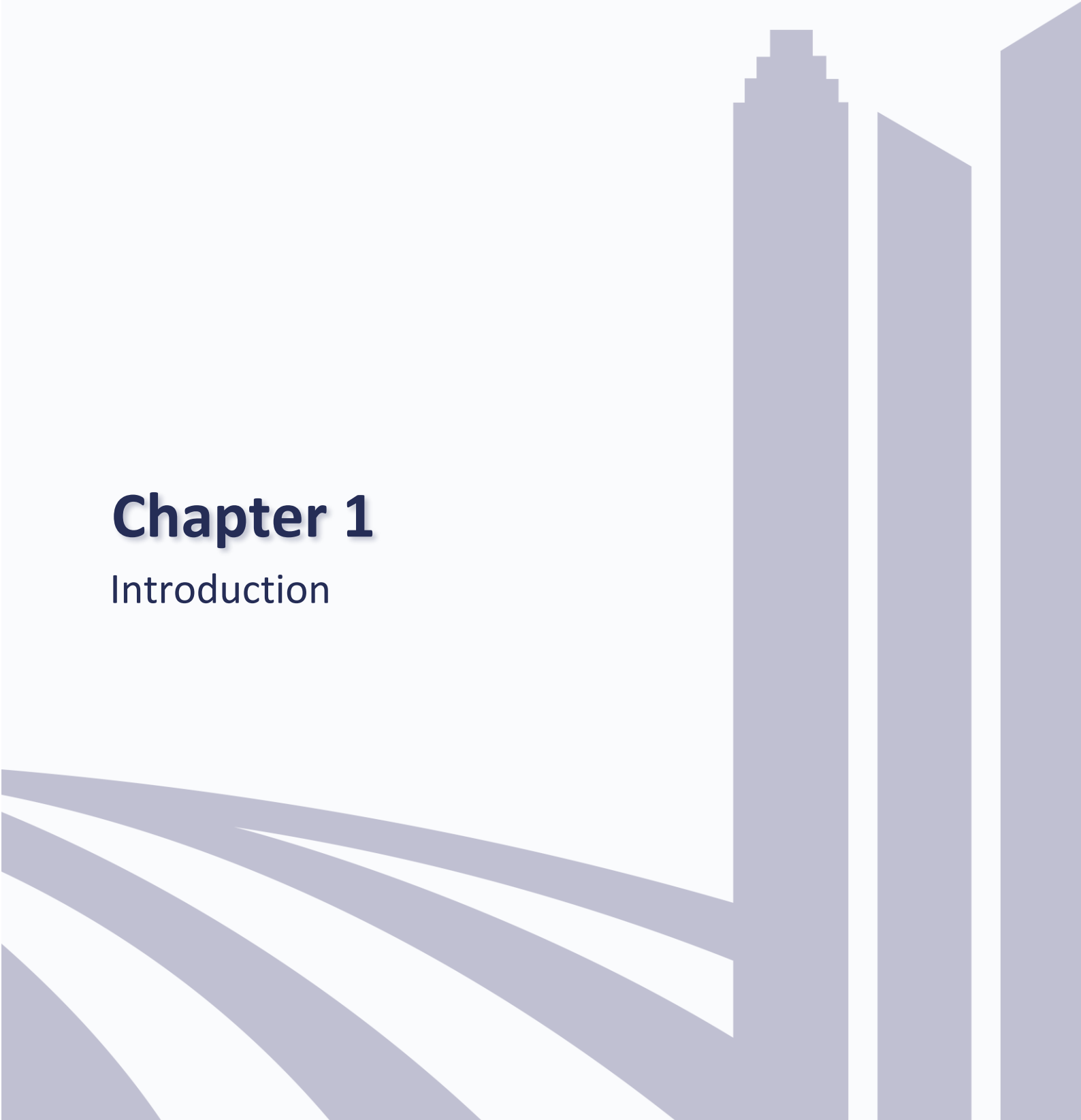
FOSTER is a European Horizon Europe project called "Fostering food system transformation by integrating heterogeneous perspectives in knowledge and innovation within the ERA". The FOSTER project was set up to "build a foundation from which a Knowledge and Innovation (K&I) governance structure for Europe's food system can emerge" (FOSTER, 2023). In FOSTER, we work on how to change, improve, and broaden the scientific knowledge base and the associated knowledge and innovation system (in and for the food system). The food system in the EU is facing many challenges within new geopolitical contexts but also changes within the system and its environment that have to be taken into account when thriving for transformation.

This report contains a preliminary, once updated list of new topics in the food system, drivers for the food system and new framework topics for food systems, which were found during a broad and participatory Horizon Scanning process in the project. The conceptual background of the project FOSTER is described elsewhere. In this Deliverable 1.2, you can find the conceptual frame and the methodology of the Horizon Scanning as well as a first selection of topics that may be relevant in the future and are requiring new knowledge. The changes in food systems in general and further challenges are summarised at the beginning. Drivers for changing the EU food system and topics that are expected to undergo changes within the food system are shortly outlined as signals and developments. They are displayed on the digital FOSTER Knowledge Platform (via website <https://fosterfoodsystem.eu/>).

The identification process of signals and developments within the food system and those driving the food system had several steps. This Horizon Scanning long list (interim findings) will be used for further discussions and roadmapping exercises of the CDIs. It was consulted for the description of context scenarios (separate deliverable D 1.5) and it is the basis for the identification of a potential new theme for another Change-Driven Initiative (CDI) in addition to the already existing ones within the FOSTER project. This new CDI is supposed to remain when the FOSTER project as such has already ended.

# Chapter 1

Introduction





## Chapter 1 - Introduction

### 1. Interim Report of the Horizon Scanning Phase

#### 1.1 FOSTER Narrative

FOSTER is a European Horizon Europe project called "Fostering food system transformation by integrating heterogeneous perspectives in knowledge and innovation within the ERA". The FOSTER project was set up to "build a foundation from which a Knowledge and Innovation (K&I) governance structure for Europe's food system can emerge" (FOSTER 2023). In FOSTER, we work on how to change, improve, and broaden the scientific knowledge base and the associated knowledge and innovation system (in and for the food system). The food system in the EU is facing many challenges within new geopolitical contexts but also changes within the system and its environment that have to be taken into account when thriving for transformation.

More explanation on the approach of FOSTER and the conceptual background can be read in the White Paper of FOSTER<sup>1</sup>. In this Deliverable 1.2, you can find the conceptual frame and the methodology of the **Horizon Scanning** as well as a first selection of topics that may be relevant in the future and are requiring new knowledge. The food system concept framework in FOSTER is based on the system visualization from the Foresight4Food Initiative, but extended with added drivers, e.g., Resources and Energy, Societal patterns or Mobility.

In FOSTER, we assume that adequately **changing how knowledge is produced** (by scientists, people engaged across the food sector, etc.) **and used** (by policy makers, scientists, farmers and other food system actors, etc.) **will serve as a lever** towards a more sustainable, resilient and just system, **change how our food is produced, processed, distributed, consumed and its waste is discarded or re-used**.

For this reason, the following report provides an input of future topics across the agri-food system with a **focus on the perspective of six change-driven initiatives (CDIs)**. The CDIs are collaborators and partners of the FOSTER project and present diverse contributions in knowledge production in the food system from a very practical side. This report only describes intermediate findings, drivers and signals that were found in connection to the EU food system. The findings are not assessed but selected by our CDIs as being useful knowledge for them. The findings are new for some, for others they are well known. We share the findings from this deliverable on the digital FOSTER Platform (<https://fosterfoodsystem.eu/future-food-systems-knowledge/>). During the project until 2026, the digital platform will be regularly updated.

#### 1.2 Background

This is the interim report of the first Horizon Scanning phase. It informs about the conceptual frame we used for the scanning activities, the methods and procedures applied. The general frame, the motivations behind the project FOSTER and the description of the general purposes of the project are described in a separate White paper of FOSTER. **The purpose of this deliverable is to provide an overview of the current and thus intermediate findings.** The aim of this

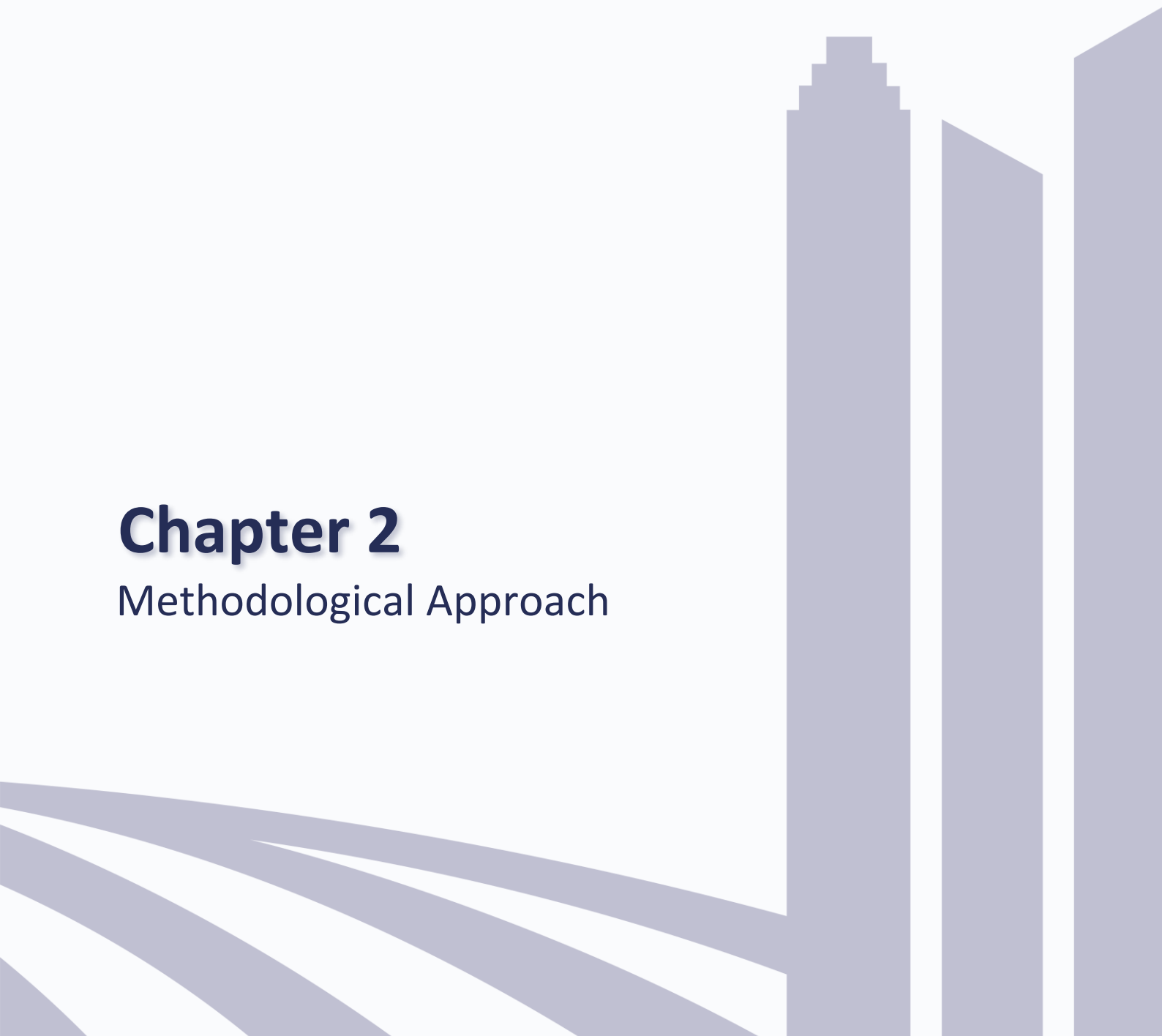
<sup>1</sup> The FOSTER White Paper will be published as a deliverable, soon.

deliverable is to **introduce the framework concept** used (and modified during the course of the process) for the futures work within FOSTER only (not for the later Theory of Change approaches), the **methods applied for searching** new and existing topics, and a **documentation of the first long list of findings**, from which a later identification and priority-setting process takes place that paves the way for a potential new CDI or similar activity. The objective of later phases of FOSTER will be the identification of single issues, signals (strong and weak), drivers and framework conditions that are currently observable and may be framing future food systems, too. The current search is driven by the needs of the CDIs and consortium members in this project, which means we are very selective and do not intend to give a full overview of things to come in and around food systems. The results are displayed during the course of the project on the digital website of the FOSTER Knowledge Platform (<https://fosterfoodsystem.eu/future-food-systems-knowledge/>), so that other actors of the system can make use of our findings, too. On this website, one will also find links to other EU projects. This will serve as an entrance point for further searches and thus gaining different knowledge.

**We thank all members of the consortium and especially the CDIs for their contributions and vivid discussions as this is a participative and co-creative process. We also thank the two interim reviewers for their recommendations that led to an additional chapter 3 in this version of the Deliverable 1.2 and a re-arrangement of the findings.** In the following chapters, we start with a very short introduction into the Foresight methodology and Horizon Scanning used here. Our starting view on the EU food system is briefly explained including the challenges the food system is facing. External drivers that force the system to change, and the changes within the system are shortly described, structured according to our food systems framework concept. Some sources for each finding are given to illustrate that there is already some evidence for these developments. Nevertheless, the future developments remain uncertain.

# Chapter 2

## Methodological Approach



## Chapter 2 – Methodological Approach

### 2. Methodological Approach

#### 2.1 The Framework Concept

Foresight is integral part of the project FOSTER. Foresight is defined as the "systematic debate of complex futures" (Cuhls 2003, 2019) opening up contexts like open and exploratory possible futures, realistic/ probable futures, and desirable/ preferred futures (sometimes represented by "visions"). **Foresight** is thus

- **structured:** it is a systematic approach by applying methods of futures research, science-based, and based on new theories of futures research
- **a debate or dialogue:** it includes interaction of relevant actors, active preparation for the future or different futures, and orientation towards shaping the future
- **complex:** it includes the consideration of systemic interdependencies, takes a holistic view
- **"futures" is plural:** it is an open view on different paths into the future with thinking in alternatives.

We also envisage **different types of futures** and differentiate between **possible, probable and desirable** futures. Voros even adds potential and plausible futures (Voros 2003, p. 16-17) to the classification. In this report, we concentrate on **possible futures** only. Desirable futures will be framed and selected during the course of FOSTER. Foresight takes the **long- and medium-term view**, and encourages us to learn about the impacts of our actions in the present. It is not prediction (Cuhls 2003, 2019), but rather a "set of approaches to bringing longer-term considerations into decision-making, with the process of engaging informed stakeholders in analysis and dialogue being important alongside the formal products that can be codified and disseminated" (Miles 2008, p. 37).

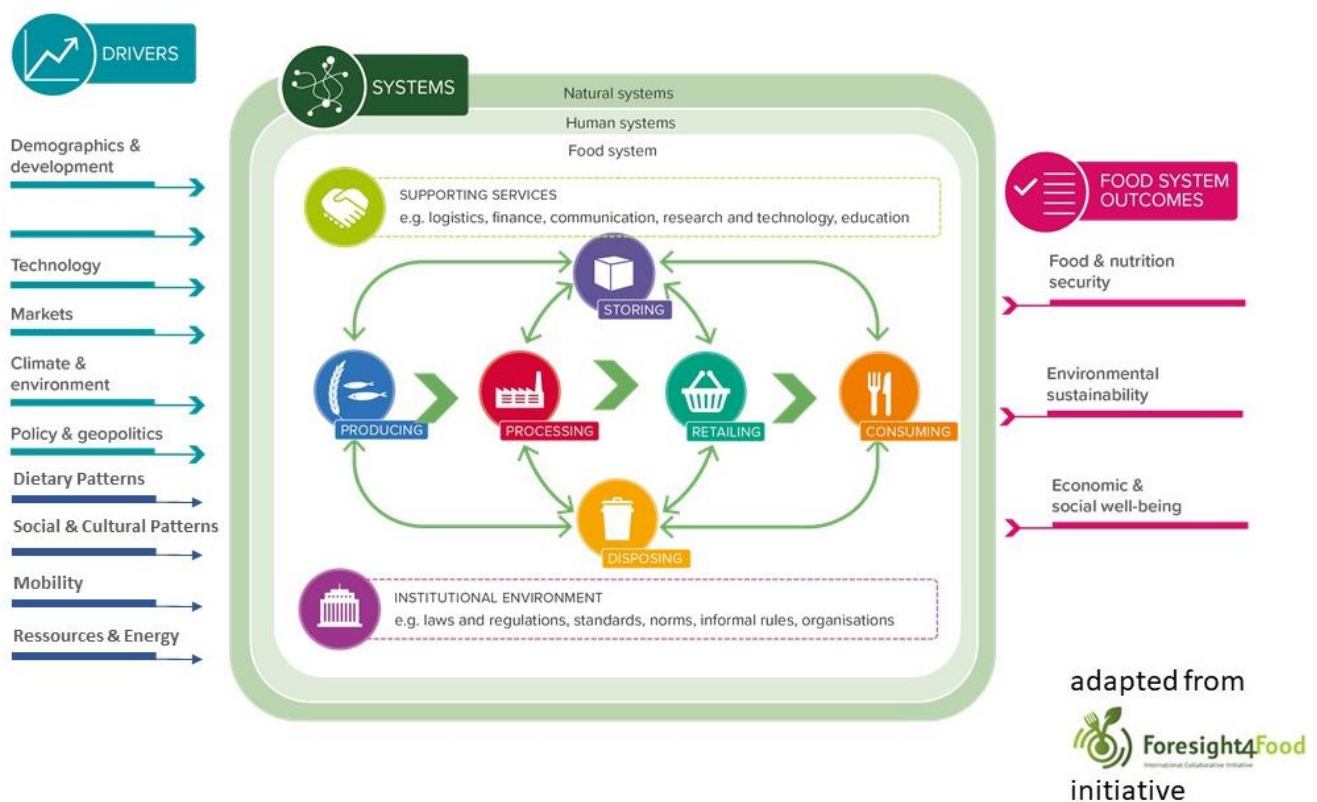
Methodologically, in this Deliverable 1.2, we are still in the exploratory phase of the project, searching for **possible futures** and not yet judging on futures or applying a theory of change (Balman et al. 2016; Daria Cantù et al.; Simeone et al. 2023). We are not selecting in favour of certain topics –that kind of sense-making is part of the following task 1.4 of the FOSTER project. The possible futures we describe may be different and sometimes contradicting futures. **They are not necessarily desirable futures and not all of them are new.** In Deliverable 1.5, we outline potential worlds in different scenarios that may frame food systems of 2040 and beyond.

Therefore, we started with a literature analysis of different food systems frameworks, as the first step of any Horizon Scanning is to define the boundaries of the system we are searching in and to define a search strategy. We considered food systems frameworks from the scientific literature like Bukeviciute et al. 2009, Eigenraam et al. 2020, Ericksen 2008, Hilmi 2019, Ingram 2011, Ingram et al. 2012; Ingram et al. 2018, Vallejo-Rojas et al. 2016, Voglhuber-Slavinsky et al. 2021, Westhoek et al. 2016, Zurek et al. 2022b and others, and of relevant organisations as in FAO 2014ff<sup>2</sup>, the FAO High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security 2017, FAO 2018, different

<sup>2</sup> <https://www.fao.org/climate-smart-agriculture-sourcebook/production-resources/module-b10-value-chains/chapter-b10-2/en/>

visualisations of IFST<sup>3</sup>, Bizikova et al. 2021<sup>4</sup>, Lomax 2018<sup>5</sup>. But most of them were too complex or too strongly aligned to the classical value chain in food production, which may change.

Therefore, and to be in line with other EU projects, we decided to start with the framework concept adapted from Foresight4Food. This does not only use the food production value chain but includes framework conditions, drivers and outcomes in a very straightforward way. Therefore, it is a first entrance point to a Horizon Scanning strategy. During the process of scanning, we already adapted the frame according to our findings, especially for the driving forces. For example, we added Mobility as well as Resources & Energy as drivers. Moreover, we re-included Dietary Patterns and Societal & Cultural Patterns as they were originally subsumed under different headlines but our research suggested they need specific attention. **Figure 1** is the **concept frame used for this stage of the scanning** and sets the frame as well as titles for the following chapters. On the left, you can see some changes from the original (dark blue arrows).



**Figure 1 - The FOSTER concept frame**  
(adapted from Foresight4Food, see also Zurek et al. 2022b)

In Chapter 3, we start with a look back and give a brief description of the food system. We then look forward from recent changes to further developments of and within this system. We collected some challenges our food system is facing. For the Horizon Scanning, we then began with the inner circle of the image – that is, the food system itself – with six categories or phases of the food supply chain: 1. Producing, 2. Processing, 3. Retailing, 4. Consuming, 5. Storing and 6. Disposing. The results are selectively described in Chapter 6.

<sup>3</sup> [http://www.3keel.com/wp-content/uploads/reports/IFST%20Sustainable%20Food%20System%20Framework\\_0.pdf](http://www.3keel.com/wp-content/uploads/reports/IFST%20Sustainable%20Food%20System%20Framework_0.pdf)

<sup>4</sup> <https://www.iisd.org/articles/visual-representations-food-systems>, visualisations based on scientific literature

<sup>5</sup> [https://resilientcities2018.iclei.org/wp-content/uploads/D4\\_Presentation\\_Lomax.pdf](https://resilientcities2018.iclei.org/wp-content/uploads/D4_Presentation_Lomax.pdf)

On the left-hand side of the framework, some current drivers of the food system are characterised. The approach is thus similar to the "7 Drivers Model" applied by NATO (NATO Allied Command Transformation 2023) and in many other Foresight and Horizon Scanning processes. Drivers are assumed to shape the food system of the future and are described in Chapter 4. The original list of drivers was based on the Foresight4Food initiative but modified according to our findings.

The last identified results can be found in Chapter 5, discussing the frame of: 1. Supporting services and 2. Institutional environment (within the green circle of the image in Figure 1). The right-hand side of the figure, the outcomes, are not part of the Horizon scanning and will be described as "objectives" or goals of the system in later phases of the FOSTER project. As indicated by several arrows, there are many feedback loops within the food system and the context of the food system. The context of the food system is described in a separate report, D 1.5, with various context scenarios.

## 2.2 Methods of the Horizon Scanning Process

The process started methodologically with the definition of the scanning strategy based on the framework. The first step was a semi-automated Horizon Scanning approach using the database Dimensions.ai. This database contains scientific journals (like the Web of Science journals) and more recent publications that are trusted but not fully reviewed as well as some grey literature like reports. We started with the second category Processing (see Figure 1 above) as the number of hits to be checked was much lower compared to Production. For Processing, we defined key words for searches (e.g. health food, functional food, personalised nutrition, bioactive compound, cellular agriculture, insect, algae, plant-based milk, cultured meat –just to mention a few of them, there were up to 100 key words), which we then combined for the search. With these search terms, a first selection of abstracts from the last 10 years in the database Dimensions.ai was automatically run and ranked according to some key indicators (e.g. frequency) in Excel files. In processing, we thus identified more than 674,000 papers. We started to cluster the first ones and build categories like "starch-based products and processes", "emulsions" or "pigments, colours", but noticed soon, that this is much too detailed for our further work in FOSTER, especially in the work of the CDIs, and that we have too many hits to cluster them. We tried another approach with topic modelling using the same abstracts, and created some word clouds (as one example see Figure 2). Despite this, in the discussion with our CDIs we came to the conclusion that we need a higher granularity level.

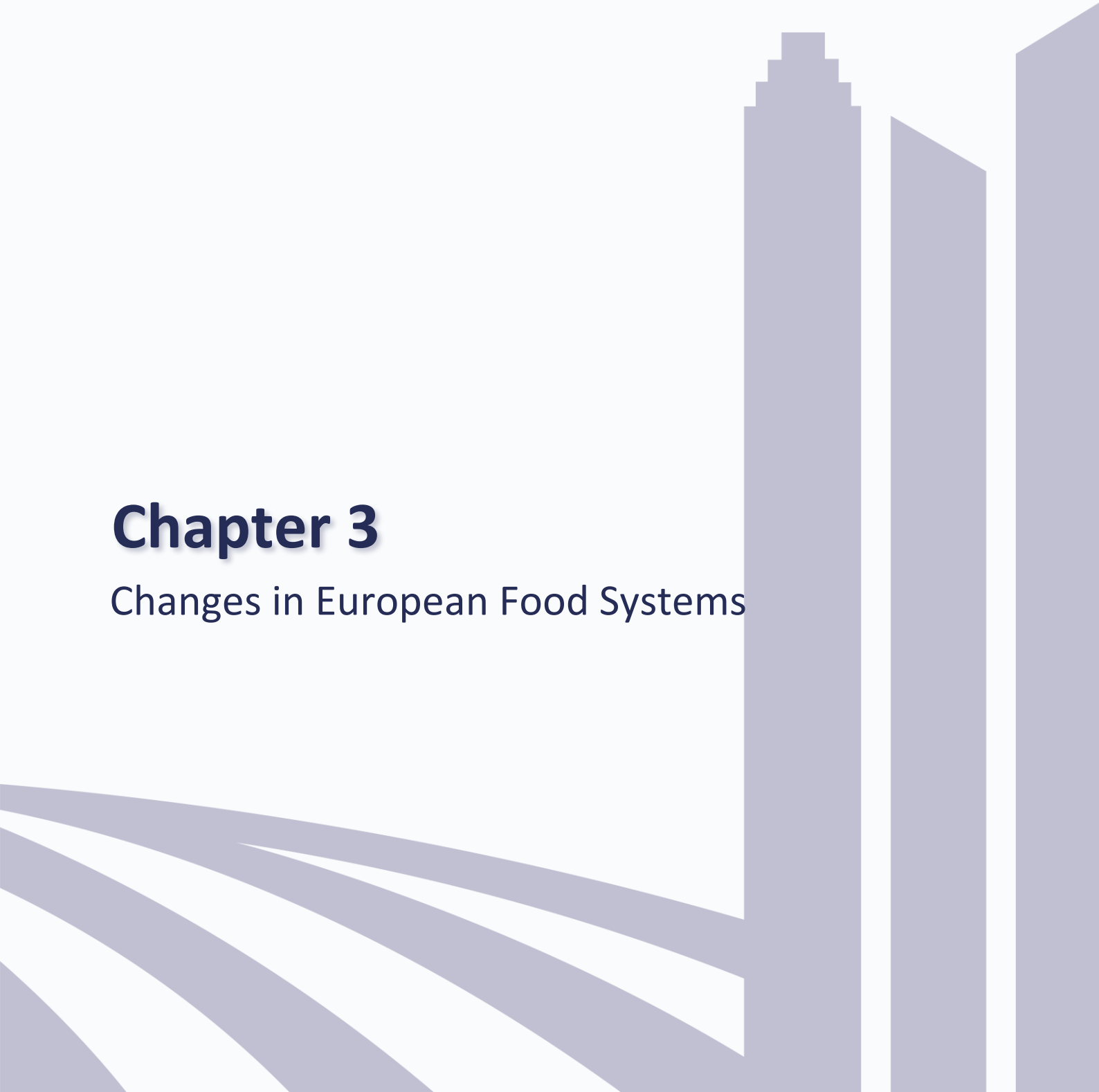
That meant, **we went on with manual searches**, which were anyway planned for later insights. We started to scan some of the consortium's own food-related projects and databases of other European food systems projects manually, for example: Fit4Food, Foresight4Food, FoodNavigator, Futures4Europe, DAKIS etc. We are aware that there are many more – and some databases will be linked to the digital FOSTER Knowledge Platform.

These findings served as a starter and we then **screened through, overviewed and reviewed papers and databases** with statistics to deepen some of the findings or underline them with current data. We also read **single papers, attended webinars** and the **Conference** of Food Systems 2030 in December 2023 in Brussels to take other issues into consideration. And we **re-clustered** some of the findings from the automated clusters mentioned above. But we did intentionally not evaluate the findings according to pre-described criteria as we did not want to impose our search biases or the biases of "experts" into this search. We hosted all the findings in Excel files and provided them for the CDIs on our FOSTER SharePoint. The task of the CDI members was then to add to the findings, reformulate them, and assess if they were **interesting knowledge** (new or existing) to them at all. Each file contained between 17 and 67 findings.



# Chapter 3

Changes in European Food Systems





## Chapter 3 – Changes in European Food Systems

### 3. European Food Systems changed and are challenged

#### 3.1 Importance of Food Systems

Food is essential for human beings; we cannot survive without food or water. This is often forgotten as we nowadays have enough food in the European Union. In most of the EU countries, food is available everywhere and always. In addition, "food waste is estimated to cost the EU economy some €143 billion per year, and is responsible for 15 per cent of all greenhouse gas emissions associated with the food supply chain" (Grant 2022). The Covid-19 pandemic and the war in Ukraine have thus shocked Europeans and demonstrated that nothing can be taken for granted - and that food can become scarce, even here in Europe (Lang 2021). Food system stability may not last forever. In other countries, we do not see such relatively stable food systems as we have in the EU. Worldwide, the absolute number of people who do not have access to enough or high quality food is increasing again (FAO 2023; Ingram et al. 2020). Some even warn that feeding all people of a still increasing world population (United Nations World Population Data 2024<sup>6</sup>) is impossible. Others are more optimistic and argue that "feeding ten billion people is possible within four terrestrial planetary boundaries" (Gerten et al. 2020, see also Steffen et al. 2015a) or propose how it can be possible (Ranganathan et al. 2018).

As we are facing challenges like climate change – and thus new conditions for producing, processing, transporting or storing food – scientists warn that we will face many changes in the future (Cuhls et al. 2022; IPCC 2024; Kemp et al. 2022; Ripple et al. 2021), some of them in a cascading way by one influencing the other, and a transformation of our food system is needed (FAO 2020, 2022, 2023).<sup>7</sup>

In this deliverable, we do not discuss the directionality of the transformation, but describe the observations of what seems to be changing – in a selective way from our Horizon Scanning. This does not mean that scientists fully understand the upcoming changes or their directions nor that the directions are fixed or we already know how to handle the challenges ahead. There are many possibilities and scenarios. But as we have to face these changes, it is important to describe at least the known ones that are important for the work in food systems – here **selected under the perspective of the CDIs' work**.

But **what is a food system?** A food system is the full system that provides us with food and spans the full range of activities that are related to producing, processing, distributing, retailing, preparing, and consuming food (Zurek et al. 2022a; Zurek et al. 2023), and in the last years, storing and waste management are also added to the food system functions. Many actors are involved in these activities, which are influenced by a range of policies, politics, governance, social developments, new technologies and single technical developments, markets, environmental or economic drivers as well as stress caused by single events or shocks (Braun et al. 2023; Ericksen et al. 2012; Grillitsch et al. 2019; Hansen et al. 2020; Hasnain et al. 2020; Hebinck et al. 2021; Ingram 2011; Ingram et al. 2018; Westhoek et al. 2016; Wiebe et al. 2018;

<sup>6</sup> see <https://population.un.org/wpp/>; <https://www.un.org/development/desa/pd/>

<sup>7</sup> See Hölscher et al. (2018) for a deeper understanding of the terms transition and transformation and "how the respective approaches and perspectives on understanding and interpreting system change can enrich each other."

Zurek et al. 2022a; Zurek et al. 2023). Figure 1 visualizes this framing of a food system, its drivers and its outcomes. Feedback loops in the figure show that the system permanently develops, changes, adapts, and that it is embedded in the human system and the natural system with economic developments at its core.

The food system concept is not new: driven by social and political concerns, rural sociologists had promoted this approach for some years (McMichael 1994; Tovey 1997). Several authors have since put forward frameworks for analysing food systems, but Sobal et al. (1998) noted that few existing models broadly described the system and most focused on one disciplinary perspective or one segment of the system. They identified four major types of models: food chains, food cycles, food webs and food contexts, and developed a more integrated approach including nutrition (Ingram et al. 2023; Zurek et al. 2022b; Zurek et al. 2023).

In this framework system (we here refer to Figure 1), there are **food system activities** (the inner circle in Figure 1) and **food system outcomes** (the right hand side in Figure 1) **that relate to food security** (derived from Ericksen 2008; Ingram 2011; Ericksen et al. 2012; Ingram et al. 2018). Food security does not only relate to the amount and quality of food available for people (Grant 2022; Lang 2021), but also to outcomes in and for the physical environment and the socio-economic sphere. It is important to note in our activities in FOSTER "that 'transform' relates to the food system outcomes, 'adapt' relates to the food system activities and 'reassess' relates to the policies that sends signals to food system actors can help clarify policy and practice discussions about what, precisely, 'transforming the food system' actually means" (Ingram et al. 2022). Policy and practice discussions are part of work packages 3 and 4 of FOSTER.

In this Horizon Scanning exercise, we concentrate on the food system activities to identify signals for change and possibilities for transformation activities in the sense of Hölscher et al. (2018), for details in the system see also Chapters 4, 5 and 6. To clarify what we mean with the inner circle, we refer again to Zurek et al. 2022b, p. 420, with the arrows in the figure representing the relationships, knowledge flows and food transport within the system<sup>8</sup>:

- **Producing** food includes all activities involved in the production of the raw food materials. Key factors include farmers, hunters, fishermen, the multiple suppliers of production inputs including agrichemicals, agricultural labourers, and land owners.
- **Processing** and packaging food includes the various transformations that the raw food material (e.g. grain, vegetable, fruit, animal) undergoes before it is sent to the retail market for sale. Key factors include the middlemen who buy from producers and sell to processors; the managers and workers in processing and packaging plants; and trade organisations that set standards.
- **Retailing** and distributing includes a range of middlemen who go between the producers, processors, packers and the final markets, and the many actors involved in e.g. transport, delivery and warehousing operations, advertising, trading and supermarkets.
- **Consuming** includes all consumers themselves, and the varied actors that control what they consume, e.g., market regulators, advertisers, consumer groups.

<sup>8</sup> Storing and Disposing were added into this figure later by the Foresight4Food network and is already integrated in Figure 1 of Ingram et al. 2022.

- **Storing** in connection to food and food systems refers to the methods and practices used to keep food in conditions that maintain its quality, safety, and nutritional value over time. This can include refrigeration, freezing, canning, drying, using preservatives or changing already the resources for better storing. Effective food storage helps prevent spoilage, contamination, and waste, ensuring a stable food supply.
- **Disposing** in the context of food and food systems refers to the methods and processes used to manage and eliminate food waste and by-products. This can include practices such as composting, recycling, incineration, and sending waste to landfills. Proper disposal is crucial to minimize environmental impact, reduce waste, and promote sustainability within food systems. In this context, no or low waste is intended and circular approaches are more and more in the forefront so that the remainders are limited (European Commission 2020; Fassio et al. 2019).

Therefore, the signals found in Chapter 6 resulted partly from our general literature analysis, from the automated search and additional clustering as described above, from manual searches in other Foresight exercises, or in findings from scientific papers or overviews. The descriptions contain several single sources.

### 3.2 From a more agriculture-based to an industrialised Food System

The food system of former times was mainly an agricultural system with farmers and fishers as the providers of food with short supply chains and minimal processing. Resources were scarce and dependent on weather, luck and know-how for good harvests. International trade routes developed and thus connected different food systems, different food providers and consumers as well as different local food systems (Barisitz 2017; Gurukkal 2016). But this changed over time and the food system is more and more similar to an industrial system with economic criteria of **efficiency and effectivity in the forefront**. Small-scale farming is belittled, and more and more people left the sector, many farmers had to give up, so that in 2019, only 4.37% of the population in the EU worked in farming (Popescu et al. 2021a). With decreasing and volatile incomes, during the last 15 years, Germany has lost close to 40% of its farmers (BMEL 2020), mainly small and medium farms had to give up. The figures for the EU are similar (Balmann et al. 2016; Lowder et al. 2021; Popescu et al. 2021b)<sup>9</sup>. "The number of farms declined between the early 2000s and mid-2010s across all Member States [...], apart from Ireland which saw a 4% increase in its number of farms. In all other member states the number of farms has decreased between 2005 and 2016 by at least 9% reaching 62% in Bulgari and Slovakia" (Maucorps et al. 2019).

Agriculture thus became more and more intensified (Kelly et al. 2019) so that many researchers demand a much more "sustainable intensification of agriculture for human purposes" (Rockström et al. 2017). But humans are still in the forefront of thinking (anthropocentric thinking), their economy comes first, then the environment and animal welfare. Worldwide, more and more people are living in urban areas (Ritchie et al. 2024; United Nations 2018), and also in the European Union (Giannakis et al. 2020), de-ruralisation is progressing leading to less attention to the rural areas, their infrastructures, culture or ways of living. With the focus on urbanisation comes the hegemony of urban narratives about

<sup>9</sup> see also <https://www.fao.org/faostat/en/#data>

food, transport and political decisions<sup>10</sup>. There are small attempts in new European calls for proposals to work on this<sup>11</sup>, but there are no signals that this situation is changing. During pandemic times, many people moved to the countryside (see the scenarios in Cuhls et al. 2022), but not all stayed there. We have no recent figures here, but the development does not seem to be a permanent one as commuting to the cities is expensive and energy-intensive, and many employers do only allow part-time home office or call their staff permanently back to office after pandemic times.

Europe is not independent from food imports. This lack of food sovereignty<sup>12</sup> is triggered by the demand for food that is not grown in Europe at all, by the demand for any food at any time, but also due to the high demand for meat –which is often produced with imported feed from other regions of the world (EU countries imported about 23% of total feed proteins in 2022 (FEFAC 2024), which made the EU even more dependent on global value chains). Moreover, agribusinesses import food commodities used for producing processed food exports – i.e. the EU food system heavily depends on imports for its operations in the system and in processing food. This caused massive disturbances in internal operations of the food system due to globalization, especially in a situation when geopolitical changes are driving the EU into new orders, relations and disruptions (see Deliverable 1.5, and the drivers in Chapter 4).

With more and more aging societies (Gu et al. 2021)<sup>13</sup> in the EU, the average age of farmers in the EU has risen to nearly 60 years nowadays<sup>14</sup>. As hard work in this sector is required, not only the elderly, but also young people leave the sector for more comfortable and less dirty jobs, even though automation and digital helpers make parts of the work better, easier and doable for people. There is enough to work in other sectors and, in average, unemployment in the EU is decreasing for years now<sup>15</sup>. The progressive aging of EU societies implies a significant reduction of the economically active population and only few young farmers<sup>16</sup> remain: only 11.9 % of EU farm managers were under the age of 40 years old in 2020. At the same time, there is a continuous increase in the fraction of the workforce that is leaving for other sectors, changing jobs within the food sector into industry or shifting to the service sector. As a consequence, there is less labour available for the food system, especially for the agricultural part, and there is loss in knowledge when people are leaving. Food distribution has already and is still changing combined with a trend towards food convenience and even more the expectations from the consumers to have food available everywhere and at any time.

On the other hand, more new skills from the IT sector are needed in agriculture (Kepkiewicz et al. 2015; Klerkx et al. 2020) as more and more processes are digitalised (Macpherson et al. 2022), connected and depending on networks. The agricultural sector is quite advanced in using new technology, from precision farming (Kanter et al. 2019) to Agriculture 4.0 (Klerkx et al. 2020), from new biotechnology made possible with the means of new data use to precision fermentation, just to mention a few (see also Chapter 6 of this Deliverable 1.2).

But the industrialisation of farming went along with another trend: pure, unprocessed resources like natural resources are not the only basis of our nutrition, anymore, but the food system changed towards more and more processed, ready-

<sup>10</sup> We thank our interim report reviewers for hinting at this point.

<sup>11</sup> e.g. call HORIZON-CL6-2024-COMMUNITIES-01-2: Rural Life, see also [https://ec.europa.eu/commission/presscorner/detail/en/IP\\_21\\_3162](https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3162)

<sup>12</sup> We thank our interim report reviewers for stressing this point.

<sup>13</sup> see also <https://ourworldindata.org/population-growth>; <https://population.un.org/wpp/>; <https://www.populationpyramid.net/>

<sup>14</sup> There are countries, for example Japan, where the average age is even higher.

<sup>15</sup> [https://epthinktank.eu/2024/07/08/economic-outlook-quarterly-a-soft-landing-within-reach/eu-economy-and-recovery\\_sn\\_fig-5/](https://epthinktank.eu/2024/07/08/economic-outlook-quarterly-a-soft-landing-within-reach/eu-economy-and-recovery_sn_fig-5/)

<sup>16</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farmers\\_and\\_the\\_agricultural\\_labour\\_force\\_-\\_statistics](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farmers_and_the_agricultural_labour_force_-_statistics)

made food, longer transport chains, different storing techniques and production, processing and logistic systems that are similar to industry, like in manufacturing, as many food is now dependent on being manufactured. "Thus a significantly greater percentage of the final price paid by consumers is now garnered down chain rather than up chain over the last 20 years" (Cucagna et al. 2018). These "industries" are the parts of the value chain that make the money (Afshin et al. 2019; Cucagna et al. 2018) but are not necessarily creating other values (Sadovska et al. 2020), and the generation of benefits for the environment and consequently also for society is not valorised sufficiently (Ariane Voglhuber-Slavinsky et al. 2023).

### 3.3 Ongoing transformation within and challenges for the EU Food System

**Food security for all as an outcome of the food system** (Ingram 2011) is one of the major aims to be achieved or secured, also in the future. It is regarded as one of the four highly valued features in a society (Walker 2020). Food security has many dimensions that will be further discussed in FOSTER Foresight activities, especially with the CDIs, but not in this Deliverable 1.2. From literature analysis, we took over some frames and challenges for this, especially from Hansen et al. 2020; Hasnain et al. 2020; Ingram et al.; Ingram 2011; Ingram et al. 2018; Ingram 2020; Zurek et al. 2022b; Zurek et al. 2022a. Environmental or Earth science studies provide new and more knowledge for food systems and their change, sometimes linked to the framework of Planetary Boundaries (Folke et al. 2021; Rockström et al. 2009; Rockström et al. 2023a; Rockström et al. 2023b; Steffen et al. 2015a; Steffen et al. 2015b; Willett et al. 2019). This demonstrates that there are external and internal factors having an impact on the food system itself as it is embedded in many different systems. These factors are often intertwined, as the Doughnut economy concept of Raworth (2016) demonstrates, which was brought to food system transformation discussions in several studies, e.g. in European Commission 2020.

Changes of the climate induce changes in the Earth system and the human system. Major challenges are the ecological limits to food production. When the famous "Limits to Growth" report was published (Meadows et al. 1972), many thought of industry and the resources mentioned in this report. The Forrester model was the basis of the findings. But food systems have the same limits as industrial systems, and more and more, they become evident. The situation in food production is at a serious tipping point now, and the future of human beings depends on the actions taken now when addressing the following major challenges:

1. Water (drinking water and aquifers) are under stress by droughts and changes in snow melting seasons (Nistor 2020; Peña-Angulo et al. 2022; Toreti et al. 2023), but also by poor water management and conflicts
2. Soil health needs to be kept (see European Mission<sup>17</sup>) and we still face soil loss (Halleux 2024; Panagos et al. 2024)
3. Pollution (NP) and pesticides residues, especially the everlasting chemicals are part of our food (Carrasco Cabrera et al. 2024; European Commission 2024))
4. Loss of biodiversity (Crenna et al. 2019; European Commission 2020) and loss of habitat for many species is further increasing (IPBES 2019, 2022, 2023).

<sup>17</sup> [https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-deal-europe\\_en](https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-deal-europe_en)

Often sustainability is demanded for, "sustainable intensification of agriculture for human purposes" (Rockström et al. 2017), but this concept is very broad and needs clear and concrete targets to be reached. The anthropocentric view herein is challenged and collides with many targets of biodiversity protection (Frison et al. 2011), but it is an essential notion for feeding more human beings in a sustainable and just way and for protecting our spheres. The 5<sup>th</sup> SCAR Foresight Expert Group of the European Commission described three major challenges in a narrative (European Commission 2020). It is expected that the 6<sup>th</sup> SCAR Foresight will take over these findings and put them more into context. They are:

1. Healthy, sustainable diets for all,
2. Towards a 'circular' food supply, and
3. Towards greater diversity.

The question thus is to figure out how the food system can adapt to the challenges and where there is room for manoeuvring. Demand for water, for resources and land is still increasing (also in the EU). Is feeding even more people on the planet a question of food distribution, of collaboration or are there physical limits? What are the transformations needed to address these challenges? Are small measures enough? What does it mean for the EU and the food system, if we do not address these questions and do not manage our ecological systems?

These questions are the starting point of the CDIs activities in addressing small parts of the food system (knowledge) and in transforming food systems to be more sustainable and more resilient in the sense of transformative resilience (European Environment Agency 2019, 2024). The questions will not be answered here in this Deliverable 1.2 as this is just opening up thinking about and describing possible future developments. Ranganathan et al. (2018) offer first starting points illustrated by figures, see also Searchinger et al. (2019), but they argue from the resources supply point of view:

Reduce growth in demand for food and other agricultural products

1. Reduce food loss and waste<sup>18</sup>
2. Shift to healthier, more sustainable diets<sup>19</sup>
3. Avoid competition from bioenergy for crops and land
4. Achieve replacement-level fertility rates

Increase food production without expanding agricultural land

5. Increase livestock and pasture productivity
6. Improve crop breeding
7. Improve soil and water management
8. Plant existing cropland more frequently

<sup>18</sup> see also the 5th SCAR Foresight Group (European Commission 2020). Both, pre-harvest and postharvest losses (especially in transport and storing) are still increasing (European Commission 2020; Kovacs 2015).

<sup>19</sup> This includes the fight against the "triple malnutrition", see also the 5th SCAR Foresight Group (European Commission 2020) or the recommendations of the EAT Lancet Expert Group (2023). Health/ malnutrition of people (Gillespie et al. 2017) is often coupled with income, knowledge and inclusion issues (Kepkiewicz et al. 2015), see also Chapter 4 Drivers.

## 9. Adapt to climate change

Protect and restore natural ecosystems and limit agricultural land-shifting

10. Link productivity gains with protection of natural ecosystems
11. Limit inevitable cropland expansion to lands with low environmental opportunity costs
12. Reforest agricultural lands with little intensification potential
13. Conserve and restore peatlands

Increase fish supply

14. Improve wild fisheries management
15. Improve productivity and environmental performance of aquaculture

Reduce greenhouse gas emissions from agricultural production

16. Reduce enteric fermentation through new technologies
17. Reduce emissions through improved manure management
18. Reduce emissions from manure left on pasture
19. Reduce emissions from fertilizers by increasing nitrogen use efficiency
20. Adopt emissions-reducing rice management and varieties
21. Increase agricultural energy efficiency and shift to non-fossil energy sources<sup>20</sup>
22. Implement realistic options to sequester carbon in soils

But this is only the agricultural, the resource-providing view. Some argue that a soilless agriculture and urban farming are solutions (see also Chapter 6), but both require energy and other resources, both are a small brick in the supply of food but cannot feed the whole population of the EU with its high demand. We thus have to analyse much more: What is going on in the industrialized part of the EU food system? What is the knowledge base here? We know about the Agricultural Knowledge System (AKIS), actors therein and how some parts of the system are governed. Much less knowledge exists about the part of the food system where the processing, retail, storing and waste processing take place, which means, we need more knowledge on the food system knowledge system (FOKIS) and its governance. That is part of FOSTER in WP 4.

Many projects of Horizon Europe try to address these issues and provide a huge amount of information - but not always transferred into usable knowledge or action. As a starting point, interdisciplinary research, knowledge and convincing concepts for citizens are necessary. But there is also a shift to the industrial side of the food system (not only the resource

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<sup>20</sup> In the USA, more than 7 Joules of fossil energy were needed per joule of food consumed, and 80% of this fossil energy consumption was in the post-harvest sector. With more processing, automation and transport, these numbers are still on the rise and cannot always be replaced by with regenerative energies (especially in the transport sector or where high energy input or stable conditions for cooling are needed. Thus, the energy consumption within the food system needs more attention (Grossmann et al. 2024), see also Chapter 4 and 6.

providing side) that make sustainable food production even more difficult as people and their consumption are very distant from nature and some people even do not know, anymore, what they eat or how a cow really looks like. For hygienic reasons, pigs and other animals are separated on farms, which makes visits on farms and thus learning for pupils on the spot nearly impossible. These are only a few visible examples. And there is a last challenge for food systems often neglected: **changing values or lifestyle trends of societies and individuals**. Citizens have their values and those often change slowly, but some can be observed, one being **growing concerns for animals**, e.g. the growing importance of animal welfare in a food system when it comes to animal products. Consumers are more and more concerned about what they eat, how the animals were fed, what kind of life they had, and if they lived under adequate conditions. As many regard these conditions as bad, this forced supermarkets already to introduce labels or only sell meat with certificates. But it also brought consumers to decisions for veganism or at least reducing their meat consumption with many follow-up consequences for and within the food system.

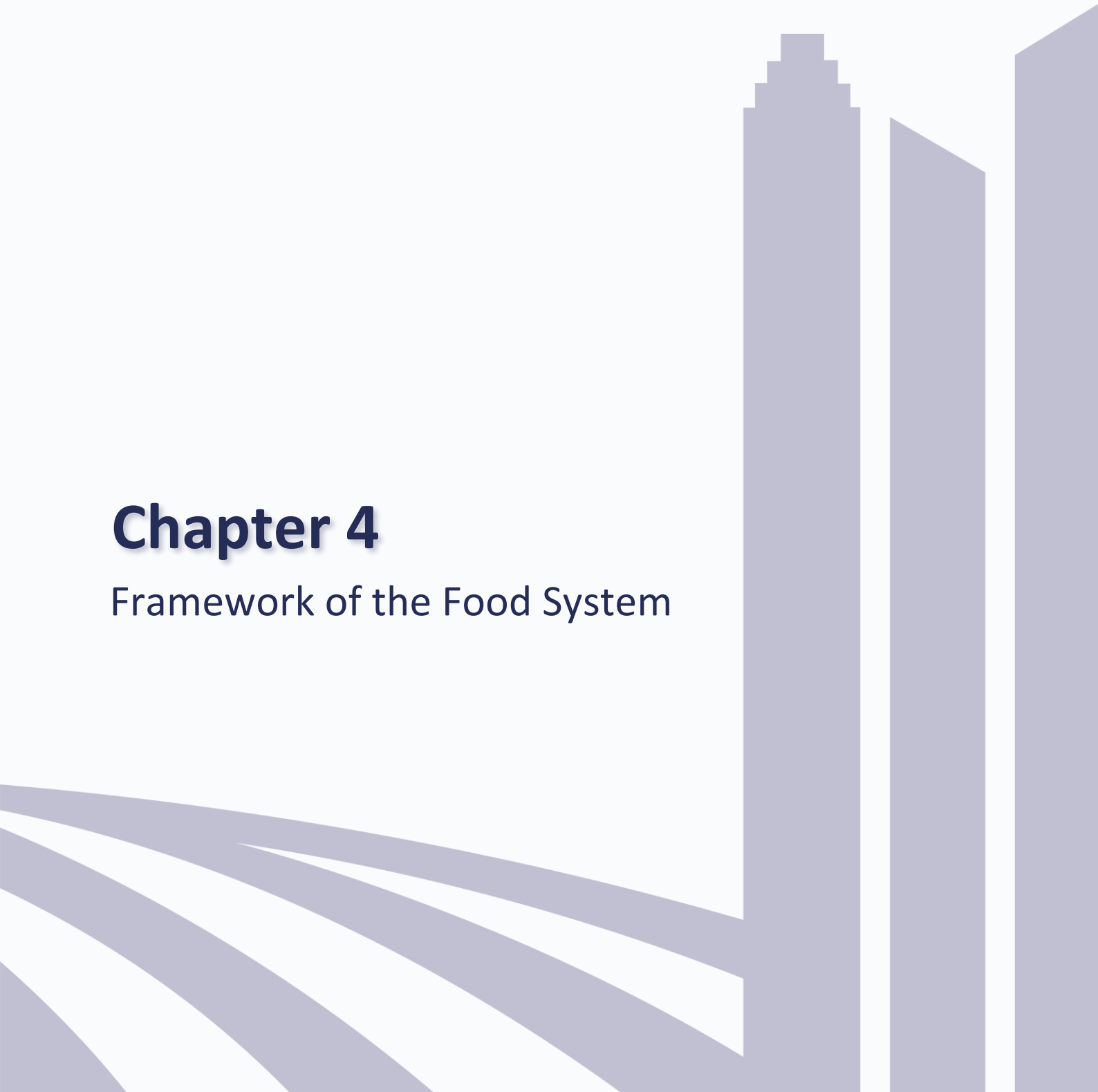
This new industry-based food system with very limited links to nature and also without connections to the urban living places of people brings with it many trade-offs (FAO 2020, 2022, 2023), for example hygienic goals conflicting with plastic reduction (many foods are packed into plastic for hygienic reasons) or higher incomes for farmers that are directly translated into higher prices in the supermarket so that people on low incomes can hardly afford good food whereas at the same time, retail still profits. In the future, we will see many of these tensions and to find a balance will be part of the transformation towards a more sustainable food system. We need much more knowledge on all levels to handle trade-offs, conflicts and limited resources. Transformations within the food system and of the food system are thus requested (Duncan et al. 2022; Jehlička et al. 2020). Listening to the dominating "academic concepts and theories in alternative agro-food scholarship" (Jehlička et al. 2020) is thus not enough, knowledge systems need to be connected (Tengö et al. 2014), and reality checks are necessary. That also means that solutions cannot be only technical or innovations, but have to take consumers and their lifestyles as well as farmers, retailers and food industry with their specific interests and knowledge into account. The idea of FOSTER is that some of the solutions can start by work on the ground –where our CDIs journeys start.

Further, more focussed drivers of the system are listed in Chapter 4, changes in the environment of food system in Chapter 5 and single signals for change or ongoing developments within the system in Chapter 6.



# Chapter 4

## Framework of the Food System



## Chapter 4 – Framework of the Food System

### 4. Framing the system

This chapter is about the environment of food systems (the green ring around the system in Figure 1) with the examples of "supporting services" and "institution and environment". During the course of discussions at a workshop, it was decided that the "bioeconomy" can be included in the considerations. The next steps in the project will thus be used to add information on the bioeconomy.

**Attention: Not all of the sources** we provide in Chapters 4, 5 and 6 **are links**. There are some sources that are not available, anymore (example: Fit4Food2030.eu, therefore we have linked the last version of the web saved in the [wayback machine](#)), but were on the internet at the point of time when we were searching and scanning (mainly in spring 2023). "FOSTER automated search – topic modelling" means a direct cluster result from the automated search as described above and contains several single sources.

In Chapter 4 to 6, the sources are listed directly and not in the Bibliography, see also <https://fosterfoodsystem.eu/>.

#### 4.1 Supporting Services

All services are meant here, including knowledge and research as services, all supporting services, and possibly also financial services. A general definition is: "Ecosystem services are the many and varied benefits to humans provided by the natural environment and healthy ecosystems." (Jeffers et al. 2015). Such ecosystems include, for example, agroecosystems, forest ecosystems, grassland ecosystems, and aquatic ecosystems. These ecosystems, functioning in healthy relationships, offer such things as natural pollination of crops, clean air, extreme weather mitigation, and human mental and physical well-being. Collectively, these benefits are becoming known as ecosystem services, and are often integral to the provision of food, the provisioning of clean drinking water, the decomposition of wastes, and the resilience and productivity of food ecosystems.

While scientists and environmentalists have discussed ecosystem services implicitly for decades, the Millennium Ecosystem Assessment (MEA) in the early 2000s popularised this concept. There, ecosystem services are grouped into four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits. To help inform decision-makers, many ecosystem services are being evaluated to draw equivalent comparisons to human-engineered infrastructure and services.

Estuarine and coastal ecosystems are both marine ecosystems. Together, these ecosystems perform the four categories of ecosystem services in a variety of ways: "Regulating services" include climate regulation as well as waste treatment and disease regulation and buffer zones. The "provisioning services" include forest products such as timbers, marine products, fresh water, raw materials, and biochemical and genetic resources. "Cultural services" of coastal ecosystems include inspirational aspects, recreation and tourism, science and education. "Supporting services" of coastal ecosystems include nutrient cycling, biologically mediated habitats, and primary production. Others focus more on the reciprocal connection between humans and ecosystems, or introduce a concept of "Services to Ecosystems" (Comberti et al. 2015).

The following signals were selected as relevant for the CDIs:

### **Food safety and traceability systems**

Ensuring the safety and traceability of food products throughout the supply chain.

Sources:

- <https://link.springer.com/article/10.1007/s00003-020-01277-y>
- <https://link.springer.com/article/10.1007/s11042-022-14006-4>
- <https://www.tandfonline.com/doi/abs/10.1080/10408398.2020.1830262>

### **Quality assurance and certification programs**

Implementing systems to maintain consistent quality and obtain certifications for food products.

Source:

- <https://doi.org/10.1016/j.jclepro.2020.124344>

### **Supply chain optimisation and logistics management**

Optimizing the movement of food products from production to consumption for efficiency.

Sources:

- <https://www.mdpi.com/2305-6290/5/1/2>; <https://doi.org/10.1016/j.spc.2021.11.019>

### **Training and education in the food industry**

Providing educational programs and training to improve skills and knowledge in the food industry. This includes training about systemic connections within the food system, sustainability and circular thinking.

Sources:

- <https://www.mdpi.com/2304-8158/9/4/492>
- <http://www.converter-magazine.info/index.php/converter/article/view/307/300>
- <https://doi.org/10.57674/vzz6-sw54>

### **Consulting and advisory services for sustainable food practices a new systems leadership**

Offering expert advice and support for businesses adopting sustainable food practices. Providing educational programs and training can improve skills and knowledge in the food industry in general and add knowledge to services. This can be provided by agriculture parties, change agents, people who enter the farm, food advisors, EU projects. It can be much more focused on the farm that is necessary for the whole food system. We also need to learn how systems work and we need a new way of leadership that deals with systems in a holistic way. Food systems need to be transformed from ego to eco. This new way of leadership is based on systems thinking as developed by Donella Meadows – in which trust, system balances, commons and the way to work are interpreted in a different way, e.g. what is waste for one is a resource for others. See also the activities of the Earth4All initiative.

Sources:

- <https://www.tandfonline.com/doi/full/10.1080/1389224X.2020.1738046>
- <https://www.sciencedirect.com/science/article/pii/S0308521X19310522>
- <https://www.mdpi.com/2304-8158/9/4/492>

- <http://www.converter-magazine.info/index.php/converter/article/view/307/300>
- [https://www.clubofrome.org/wp-content/uploads/2022/10/Earth4All\\_Deep\\_Dive\\_Scharmer.pdf](https://www.clubofrome.org/wp-content/uploads/2022/10/Earth4All_Deep_Dive_Scharmer.pdf)
- Earth4All: <https://earth4all.life/>

### **Increased support for ecosystem services**

Agricultural practices with more focus on protecting and aiding ecosystem services. Ecosystem services are the many and varied benefits to humans provided by the natural environment and healthy ecosystems. These ecosystems, functioning in healthy relationships, offer such things as natural pollination of crops, clean air, extreme weather mitigation, and human mental and physical well-being. Collectively, these benefits are becoming known as ecosystem services.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-Sources> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **A new (re-newed) appreciation of agricultural production**

The increase in urban gardening and urban farming practices along with the demand for sustainable agricultural production leads to a new found appreciation of food and the farming methods, which are used for its production. The image of farmers and the general work in gardens and farms gets or has a highly positive image.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Biodiversity services**

Human activity has a negative impact on the world's biodiversity, as it increases the extinction rate of species. A continuation of current policies will further increase the problem. Possible solutions range from a minimisation of local environmental impact, an expansion of protection areas to achieving sustainability. Some solutions are mimicking biology to overcome biodiversity problems already visible in food systems (e.g. pollination with drone swarms)

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Eatable landscapes - including co-villages**

Park-like landscapes with trees for fruits and other eatable plants are established as parts of cities. In some cities, co-villages directly in these areas with agriculture and full infrastructure are integrated. They are single and cooperative entities fostering the quality of life for people as well as direct food access.

Source:

- Stella Schaller; Lino Zeddies; Ute Scheub; Sebastian Vollmar (2022): Zukunftsbilder 2045. München: oekom verlag

### Peer-to-peer-based consumption decisions

Networks of people around the world advising each other are the dominant factor in democratized consumption and purchasing decisions for products and services. Competing and complementary digital platforms provide access to detailed product information provided in a transparent manner.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### Co-Creation and user input

Currently users are mostly integrated through observational studies and data collection. Integration of customers in innovation processes happens rarely. Challenges of user integration include scepticism towards companies, loss of control through big data and shit storms online. Also: consumer engagement.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>;
- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

### Smart products as enablers

Intelligent and/or ubiquitous systems in the field of smart home/smart building enhance functionalities to meet the needs of the users. For example, smart products deliver information about current stock quantities of the usually purchased products. Handling and using big data is necessary. Seamless connection has to be enabled. The kitchen is connected with the rest of the house and the outside. Information about food and cooking recipes is delivered.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### Ease of use

The "ease of use" is strongly related to the concept of usability. An understanding of the five characteristics of usability – effective, efficient, engaging, error tolerant, easy to learn – helps guide the user-centred design tasks to the goal of usable products (Ulwick 2003). There are three key requirements: (i) Usability means thinking about how and why people use a product: The first step in creating a usable product is understanding those goals in the context of the user's environment, task, or work flow and letting these needs inform the design. (ii) Usability means evaluation: The usability relies on user-feedback through evaluation rather than simply trusting the experience and expertise of the designer. (iii) Usability means user-centred design: Users are satisfied when an interface is user-centred, when their goals, mental models, tasks, and requirements are all met.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- Ulwick 2003: <https://jobs-to-be-done.com/the-history-of-jobs-to-be-done-and-outcome-driven-innovation-a2fd0c7a9a>

### **Simplified solution**

High Tech has become Shy Tech, which works quietly in the background. Complicated devices with switches, cables, and buttons are being replaced by intuitive interaction interfaces. The only thing that remains visible is the immediately accessible feature. This technology is integrating itself into our everyday objects. Surfaces are becoming user interfaces that enter into our surroundings.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Dissemination and usage of shopping apps**

Apps offer support for the customer for private purchases. However, sustainability apps fail in displaying carbon and material footprints. The purchaser of the future will influence the production and design of products through digital interaction.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- <https://www.thefloopapp.com/carbon-footprint-of-food/>

### **Sales increase through Big Data**

Retail companies start to collect data about their customers to generate customer profiles in combination with other available data. The data can be used for dynamic pricing and individual marketing to maximise profit.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Online Shopping E-Commerce**

E-Commerce describes commercial activities via the internet. It includes purchase and selling as well as customer service and online banking. E-commerce does not have any technical or temporal boundaries and it offers a wide range of information on potential products. The importance of e-commerce in B2C and B2B sectors has risen exponentially over the last decade. The IoT could automate many sales processes. Online Food retailing is currently only available in select cities. One obstacle in this area is, that the recipient has to be at home especially for refrigeration-mandatory products. Currently online food retailing is mostly used for non-perishable and special food products.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### New curricula and teaching

Many curricula are currently under examination and revised, and the ways of teaching are also changing. One example from India for example newly included the following: "In Agricultural Extension Education, new doctoral-level courses, such as Policy Engagement and Extension, Technology Commercialisation and Incubation, Risk Management and Climate Change Adaptation, Livelihood Development, and Facilitation for People-centric Development, have been introduced. At the Master's level, outdated courses have been replaced with fresh ones like Extension Landscape, Capacity Development, ICTs for Agricultural Extension and Advisory Services, and Enabling Innovation & Gender Mainstreaming." In Europe, we also see some changes.

Source:

<https://blog.gfar.net/2023/11/24/a-hopeful-contribution-to-transforming-agri-food-systems/>

## 4.2 Institutions and Environment

### Food Policy Councils in the world

Food policy councils are collaboratives that strive to improve food system outcomes. They have different aims and focal points. They have different cultural backgrounds and identified different impact areas for themselves.

Sources:

- <https://www.foodsystemsjournal.org/index.php/fsj/article/view/623/608>
- <https://foodsystemsjournal.org/index.php/fsj/article/view/626/611>
- <https://ep.liu.se/ecp/067/007/ecp1267007.pdf>

### Carbon footprint reduction and greenhouse gas emissions in the food industry

Implementing measures to reduce carbon emissions and environmental impact in food production.

Sources:

- <https://www.mdpi.com/2071-1050/12/16/6463>
- <https://ourworldindata.org/food-choice-vs-eating-local?ref=planksip-r>
- <https://pdfs.semanticscholar.org/63f6/fa99b92c6f6ddb2d0e1acb912a2848d31616.pdf>
- <https://www.frontiersin.org/articles/10.3389/fsufs.2020.00069/full>

### Agroecology as new paradigm

Agroecology is an academic discipline that studies ecological processes applied to agricultural production systems. Bringing ecological principles to bear can suggest new management approaches in agroecosystems. The term can refer to a science, a movement, or an agricultural practice. Agroecologists study a variety of agroecosystems. The field of agroecology is not associated with any one particular method of farming, whether it be organic, regenerative, integrated, industrial, intensive or extensive, although some use the name specifically for alternative agriculture.

Sources:

- [https://knowledge4policy.ec.europa.eu/publication/agroecological-transformation-sustainable-food-systems\\_en](https://knowledge4policy.ec.europa.eu/publication/agroecological-transformation-sustainable-food-systems_en)
- <https://www.fao.org/agroecology/database/detail/en/c/1492650/>
- <https://reliefweb.int/report/world/food-security-commission-steps-support-global-action-transform-food-systems-eight>

- <https://www.thehindu.com/business/fertilizer-subsidy-bill-in-fy23-seen-at-23-25-lakh-cr-may-drop-25-in-fy24-fai/article66230904.ece>
- Kumar, R., Agrawal, N. K., Vijayshankar, P. S., & Vasavi, A. R. (2020). State of Rural and Agrarian India Report 2020: Rethinking Productivity and Populism Through Alternative Approaches. Notion Press.
- Kumar, R. (2023). Degrowth, Diversity and Decentralisation: Building Sustainable Food Systems for Food and Nutrition Security. In Reimagining Prosperity: Social and Economic Development in Post-COVID India (pp. 171-187). Singapore: Springer Nature Singapore.
- <https://www.soilassociation.org/causes-campaigns/a-ten-year-transition-to-agroecology/what-is-agroecology>

### **Innovation policy mixes to support food system innovation**

Although the availability of food is not perceived as an immediate, major concern in Europe, the need to ensure a secure, safe, nutritious and affordable supply of food, from both land and the oceans, remains. Despite the overall level of economic prosperity in Europe, access to safe and nutritious food is still problematic for parts of the population, and food poverty is a concern in many European countries. Furthermore, obesity and diabetes, often related to poor dietary choices have become a major public health issue in the EU, with additional negative effects on economic productivity. Moreover, the global food system on which Europe relies faces a number of challenges concerning ecological sustainability, and robustness in the face of shocks and global change. There has been an increasing interest in science, technology and innovation policy studies in the topic of policy mixes. While earlier studies conceptualised policy mixes mainly in terms of combinations of instruments to support innovation, more recent literature extends the focus to **how policy mixes can foster sustainability transitions**. For this, broader policy mix conceptualisations have emerged which also include considerations of policy goals and policy strategies; policy mix characteristics such as consistency, coherence, credibility and comprehensiveness; as well as policy making and implementation processes interdisciplinary social science research on policy mixes which combines approaches, methods and insights from innovation and policy studies to further such broader policy mix research with a specific focus on fostering sustainability transitions.

Sources:

- Kern et al. 2019: <https://doi.org/10.1016/j.eist.2017.11.001>
- Kivima and Kern 2016: <https://doi.org/10.1016/j.respol.2015.09.008>
- Köhler et al. 2019: <https://doi.org/10.1016/j.eist.2019.01.004>
- Geels 2011: <https://doi.org/10.1016/j.eist.2011.02.002>
- Turnheim et al. 2020: <https://doi.org/10.1016/j.eist.2019.12.009>

### **New Agribusinesses**

Farmers of the future are confronted with new environments and have to develop new ways of doing their business.

Source:

- <https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccv/2020/Agribusiness%20in%202035%20-%20Farmers%20of%20the%20Future.pdf>

### **Biodiversity preservation and conservation farming with data and digitalisation**

The goal of the "Digital Agricultural Knowledge and Information System (DAKIS)" project is to develop a new decision support system, which enables the management of the non-commodity products of today, such as ESS and biodiversity, as "products" of agricultural activities with an economic value. DAKIS will introduce a flexible work organisation, and



enable resource efficient sustainable production controlled by market, societal demand and cooperation among farms. This will be achieved via the use of real-time digital information systems, and autonomous, interlinked, small-scale robots.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Investments and developing finance**

Investment in food and agriculture is one of the most effective means of stimulating economic growth and reducing poverty, especially in countries at a low level of economic development. It is also essential for ending hunger and malnutrition in all their dimensions – by increasing food production to meet growing demand, improving the access of vulnerable people to food, and stabilising markets so that prices are affordable for consumers and remunerative for producers. Food and agricultural investments are also necessary to improve the resilience of rural incomes and livelihoods by addressing climate change, conserving natural resources and facilitating the transition to sustainable agriculture.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Stability of political environment**

In a globalised world, agricultural politics is more determined through supranational or intergovernmental bodies. These institutions do not possess the same dependency on public support as local and national politicians, which leads to a decreasing importance of politics. Still these institutions decide the agricultural framework and decide on, whether sustainable agriculture will be promoted and non-sustainable agricultural practices will become more expensive

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Nudging as small-scale self-regulation of sustainable consumption**

Nudges are an umbrella term for soft paternalistic measures to regulate and change automatic and reflective behaviour. Although nudging offers a wide range of tools (social norms, warning signs, reminders, simplification, Defaults), it is rarely used in sustainable consumption.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Transforming the food system into a regenerative, sustainable food system that works for all within planetary boundaries.**

Transforming the food system into a regenerative, sustainable food system that works for all within planetary boundaries.  
Call to action: Transforming the food system into a regenerative, sustainable food system and providing healthy diets for

people without destroying the planet – halting biodiversity loss and protecting the global commons to ensure food for all without destroying nature and health. Goal and a kind of vision = Turnaround 4 of Earth4All.

Source:

- [https://earth4all.life/wp-content/uploads/2023/03/Earth4All\\_Exec\\_Summary\\_EN.pdf](https://earth4all.life/wp-content/uploads/2023/03/Earth4All_Exec_Summary_EN.pdf)

### **Considering time in agriculture, production, land use**

Time is a major factor in many parts of the food system. Consumers expect immediate responses, products on their table all around the year whereas the time spans in agriculture are much longer: seasonal, yearly or even decades when planning for land use.

Sources:

- FOSTER search
- <https://doi.org/10.1016/j.landusepol.2019.104036>
- <https://doi.org/10.1016/j.landusepol.2019.104024>
- <https://doi.org/10.1016/j.landusepol.2019.05.005>

### **Land use and land use policies**

Increasing food production without further harming biodiversity is a key challenge of contemporary societies. That also means a differentiation in land use and the policies thereof. Land is a finite, non-renewable and irreplaceable resource underpinning many ecological processes that sustain human life and well-being (Millennium Ecosystem Assessment, 2005). Questions from owning land to political decisions for keeping land in farmers' hands arise and are discussed as pressure on land increases. Some scenarios represent different storylines encompassing assumptions on macro-economic drivers (e.g. population and GDP growth rate), demand for food and livestock products as well as policy choices on trade liberalisation/protectionism, biodiversity conservation, regulations on land-use planning and subsidies to farmers through the European Union (EU) Common Agricultural Policy (CAP). Projections for the year 2040: i) the total energy content of agricultural output; ii) the total nitrogen surplus, a proxy of the overall impact of agriculture on the environment; and iii) an index measuring the capacity of agricultural systems to support biodiversity. A study presents aggregate results (EU level) and spatially explicit assessments at a fine resolution (1 km<sup>2</sup>). Results indicate that a strong neo-liberal approach to agriculture (full liberalisation, abolition of subsidies) will lead to increased use-input efficiency and decrease of impact from Nitrogen input; however, a large amount of agricultural area in Europe will be abandoned, which will lead to an absolute decrease in production and increased land homogenisation and polarisation, with negative effects on the capacity of agricultural areas to support biodiversity. Protectionist and sovereigntist policies will keep absolute production and cultivated area high, but at the cost of less efficiency in the use of inputs and higher impacts on the environment and biodiversity. Under a scenario characterised by environmental-friendly practices, multifunctional landscapes and localism, significant decreases in the environmental pressure of agriculture (compared to other scenarios) can be achieved with a minimum decrease in agricultural output. Study results indicate that agricultural and land-use policies aiming at preserving production over large rural areas, multi-functionality and diversification of agricultural landscapes can contribute to the joint achievement of biodiversity protection and high food production.

Sources:

- <https://doi.org/10.1016/j.landusepol.2019.104036>
- <https://doi.org/10.1016/j.landusepol.2019.05.005>
- <https://www.eea.europa.eu/publications/soer-2020>
- <https://www.thuenen.de/de/newsroom/detail/landwirtschaftliche-boeden-sorgsam-mit-der-wertvollen-ressource-umgehen>
- [www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper\\_224.pdf](http://www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper_224.pdf)

### Hygienic regulations and their impacts

Hygiene is an important issue in the whole food system, from production to transport. Therefore, packaging plays a role but also new processes and ideas to keep food fresh longer and healthy. This does not mean to eradicate all bacteria, viruses or other organisms, but maybe there are also new ways of thinking when avoiding harm or updating human beings' immune system, e.g. in yoghurt, you intentionally use organisms, in fermentation they are essential etc. But there are also new regulations on EU level on the way that may have long-term impacts on the way we produce and transport food or even the way collaborations have to be organised.

Sources:

- <https://eur-lex.europa.eu/eli/reg/2004/852/oj> on the hygiene of foodstuffs
- <https://eur-lex.europa.eu/eli/reg/2004/853/oj> laying down specific hygiene rules for on the hygiene of foodstuffs, in EUR-Lex - 32004R0853 - EN - EUR-Lex (europa.eu)
- <https://eur-lex.europa.eu/eli/reg/2004/854/oj> laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption in EUR-Lex - 32004R0854 - EN - EUR-Lex (europa.eu)

### Food policy and regulation

Examining government policies and regulations related to food safety, labelling, and sustainability. There are examples in the world the EU might learn from – as positive or negative example.

This will be part of the work in work package 4.

Source:

- USA: <https://foodprint.org/issues/food-policy-101>

### Land use and power

Land grabbing is a power issue and widens the markets. Especially in forestry, there are many attempts for different land use or to use power to distribute land in a different way.

Source:

- <https://doi.org/10.1111/conl.12950>

### Multiplier effects in local food system

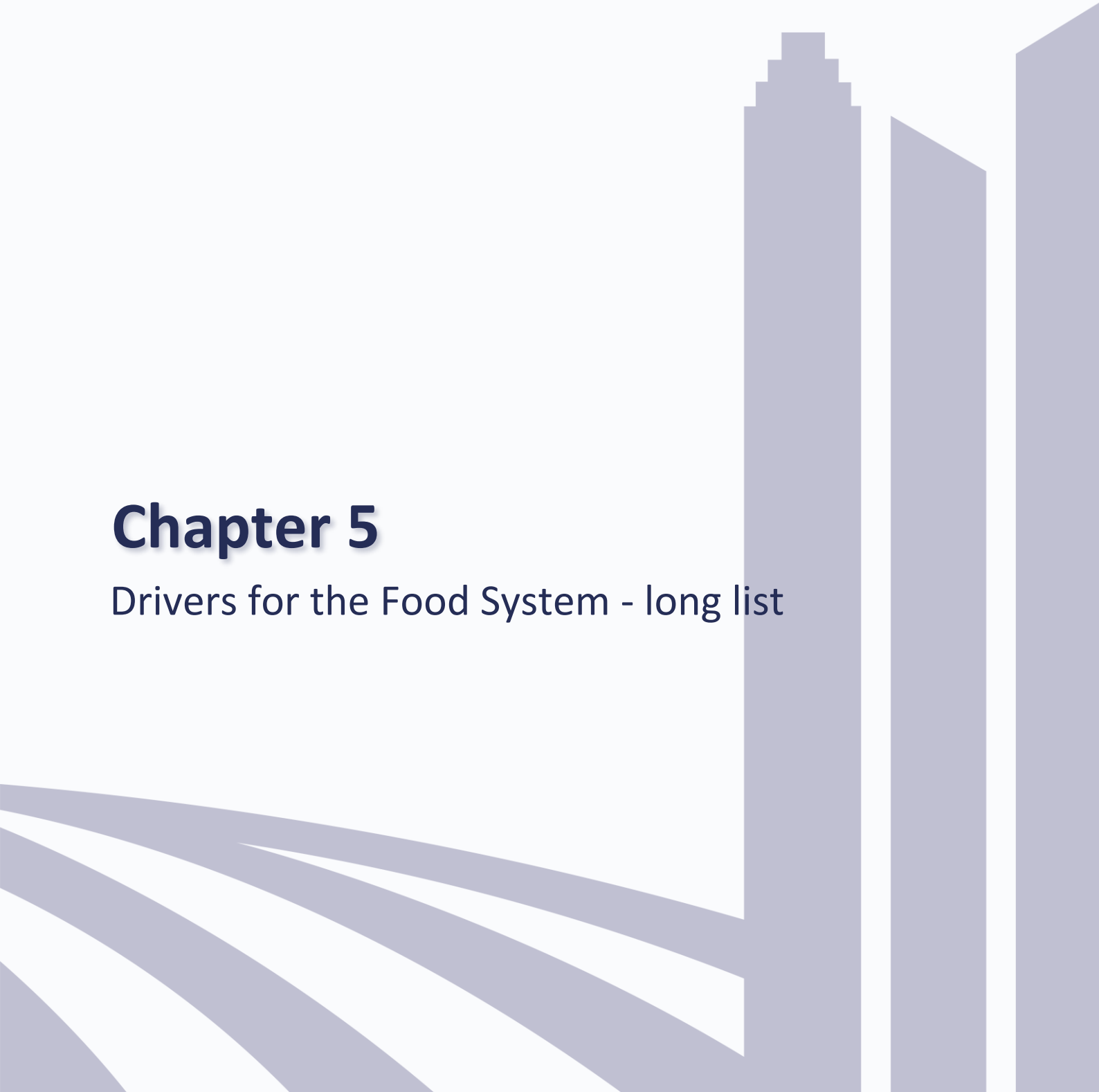
Re-localisation: The purchase of local food is often argued to stimulate local economies through multiplier effects. But there are doubts that this argument is correct. It is questioned.

Source:

- <https://www.mdpi.com/2071-1050/12/9/3524>

# Chapter 5

Drivers for the Food System - long list



## Chapter 5 – Drivers for the Food System

### 5. Drivers that shape the future of food systems

Drivers are developments, strong or weak signals, or existing and observable trends that have an influence on the food system. Drivers can come from within the system but are most often external.

#### 5.1 Demographic Change

##### Ageing Society in Europe - differing in the Member States

Ageing Society in Europe differs in the Member States.

Sources:

- [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing\\_Europe\\_-\\_statistics\\_on\\_population\\_developments](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_population_developments)
- UN World Population data: <https://www.un.org/development/desa/pd/>
- <https://ourworldindata.org/population-growth>
- <https://population.un.org/wpp/>
- <https://www.populationpyramid.net/>

##### Changing food preferences and cultural influences

Analysing shifts in consumer food preferences and the impact of diverse cultural influences.

Source:

- <https://www.sciencedirect.com/science/article/pii/S2214799321001119>

##### Ageing population and specialized dietary needs

Addressing the dietary requirements and health needs of an ageing population.

Source:

- <https://www.ncbi.nlm.nih.gov/books/NBK51837/>

##### Rise of urbanisation and its impact on food consumption

More people, also in the EU, live in urban areas. With more urbanisation the pattern of eating and food consumption change. It is still unclear, how urban living affects food choices, convenience, and access.

Source:

- <https://link.springer.com/article/10.1007/s12571-021-01182-8>

##### Changing family structures and meal patterns

Family structures are changing. There are more single households, different family patterns and thus different ways of having food together or alone. Understanding how evolving family dynamics impact meal planning and consumption habits is thus changing. Gendered divisions of foodwork plays a role here. There are question if there is an influence of public policies such as work-family or parental leave policies.

Source:

- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4942858/>; <https://ourworldindata.org/marriages-and-divorces>

### **Migration to Europe and integration**

Migration to Europe is changing steadily. Most migration takes place within the EU, but there is now a tendency that immigration to the EU is increasing because of war, climate change and many other reasons. Integration (bringing someone into an existing group or system) or inclusion (creating an environment that values and respects all individuals) approaches are existent, but not in all EU regions, and societies are struggling with integration and inclusion. The search for new ideas and the permanent application of existing approaches is driving the food system. Migration has an influence on food – migrants bring their own food cultures. Exploring the influence of migration on food cultures and the emergence of multicultural food trends.

Sources:

- <https://cordis.europa.eu/article/id/444854-migration-new-tools-and-perspectives-to-understand-movement-in-europe>
- <https://agrumig.iwmi.org/country-team-pages/>
- <https://cordis.europa.eu/article/id/444854-migration-new-tools-and-perspectives-to-understand-movement-in-europe>

### **Impact of nutrition on healthy ageing**

Healthy nutrition is more important for healthy ageing than generally recognised. Improved public health messaging about nutrition and ageing, combined with routine screening and medical referrals for age-related conditions that can be treated with a nutrition prescription, should form core components of a national nutrition roadmap to reduce the epidemic of unhealthy ageing. Healthy ageing starts with very young people and their behaviour.

Sources:

- <https://pubmed.ncbi.nlm.nih.gov/33838032/>
- EU Healthy Aging project: [https://ec.europa.eu/health/ph\\_projects/2003/action1/docs/2003\\_1\\_26\\_frep\\_en.pdf](https://ec.europa.eu/health/ph_projects/2003/action1/docs/2003_1_26_frep_en.pdf)

### **Sustainable food for all**

With the rising global population, food availability is an important need and an important challenge. Sustainable food systems are fundamental in solving many of the global issues, such as mass migration or the double burden of famine and obesity. The spreading of different lifestyles across the planet and the associated food intake, together with the development of sustainable and healthy food habits and associated public health advice shape the Global Value Network.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Global demographic transition leads to structural changes in nutrition paradigm**

The demographic transition is leading to changes in dietary behaviour in many countries. Many people are shifting their work from the farm to the factory. This also results in changed social structures. Among other things, families live separately when people in urban regions work in factories while part of the family remains in the countryside.

Accordingly, people are adjusting their eating habits. For example: Food delivery services for the elderly increase. Many elderly people live alone at home and do not cook for themselves. There are food suppliers who provide them with a hot meal every day. This can have a positive effect on the well-being of the persons if through this a healthy and balanced nutrition takes place rather than if the people prepare their food themselves. The social context of eating is not met, anymore, and there are effects of eating alone. Institutionalised food services for ageing populations can be an option.

Sources:

- <https://www.kansascityfed.org/documents/7023/umberger-paper.pdf>
- <https://europepmc.org/article/med/15481550>

### **New prospects for infant nutrition in emerging markets and developing countries**

In many emerging countries, the nutrition situation for young children is improving. Better availability and higher incomes are enabling a major shift in nutrition paradigms. In addition, there is a transfer of knowledge through the Internet that provides education about healthy and good nutrition for babies. New market potentials arise for the food industry and the problems of malnutrition among children can be reduced. But the breastfeeding rate is getting lower even though it is well known that this is an important part of infant nutrition: About 44% of infants 0–6 months old are exclusively breastfed (WHO). Globally in 2022, 149 million children under 5 were estimated to be stunted (too short for age), 45 million were estimated to be wasted (too thin for height), and 37 million were overweight or obese (WHO).

Sources:

- <https://www.unicef.org/reports/fed-to-fail-child-nutrition>
- <https://www.who.int/health-topics/infant-nutrition>

### **Old-age poverty leads to malnutrition in older population**

Poverty in old age is a major problem in many European societies. Women are particularly affected by it. As a result of insufficient financial resources, there is food poverty, which can lead to a deterioration in health. Poverty as an issue in other population groups remains, too, and is also increasing among young people.

Source:

- <https://www.boell.de/de/2021/09/15/ernaehrungsarmut-wer-schlecht-isst-ist-nicht-selber-schuld>

### **Changing household structures and food**

The number of single-person households is rising worldwide – and in European countries, too. The same is true for people with different lifestyles. This is also associated with distinctive food-related consumption behaviour.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>;
- Statista, e.g. <https://www.statista.com/statistics/582621/single-women-households-in-denmark/>
- <https://www.statista.com/statistics/582600/single-men-households-in-denmark/>
- <https://www.statista.com/statistics/522000/netherlands-total-number-of-single-person-households-by-gender/>
- <https://www.statista.com/statistics/526013/sweden-number-of-households-by-type/>
- <https://www.statista.com/statistics/1289826/fashion-and-lifestyle-purchase-aspects-italy/>

### Skilled personnel missing

In Germany and many other European countries, competent personnel are missing. From March 2019 to February 2020, around 938,000 workers were employed in agriculture in Germany, according to the representative results of the 2020 agricultural census. As the Federal Statistical Office further reports, this represents a decline of 15% compared with the last agricultural census in 2010. During the same period, the number of agricultural holdings fell by around 13%. As a result, the average number of workers per farm remained almost stable at 3.6 compared to 2010. In contrast, the number of workers per 100 hectares of agricultural land decreased from 6.6 workers in 2010 to 5.6 workers in 2020. This development can be attributed in particular to the growing farm sizes and the further advancing mechanization and digitalization in agriculture.

46 % of the labour force is family labour: Nearly half of the agricultural workforce, 434,400 people, were family workers in sole proprietorships. Furthermore, 228,900 permanently employed workers and 274,700 seasonal workers worked on farms.

Sources:

- [https://www.destatis.de/DE/Presse/Pressemitteilungen/2021/09/PD21\\_N053\\_13.html](https://www.destatis.de/DE/Presse/Pressemitteilungen/2021/09/PD21_N053_13.html)
- <https://www.populationpyramid.net/>

## 5.2 Dietary Patterns

### Divided Societies

Societies are more and more divided into Haves and Have nots. In Europe, this can be overserved in the health system but also in nutrition: those without adequate income cannot afford quality food, sometimes even not a sufficient quantity of food. These people are often qualitatively undernourished.

Sources:

- <https://jfsdigital.org/articles-and-essays/2023-2/vol-28-no-2-december-2023/foresight-to-develop-and-support-a-mission-the-case-of-the-european-mission-on-conquering-cancer-mission-possible/>
- <https://www.doi.org/10.1038/s43016-022-00479-x>
- [https://www3.weforum.org/docs/WEF\\_The\\_Global\\_Risks\\_Report\\_2024.pdf](https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf)

### Nutrition for better health and curing

Nutrition for better health and curing get more and more attention. Even though there are many myths around food and health and the recommendations for healthy food are changing frequently, people who can afford it and have the knowledge of what is good quality nutrition, pay more and more attention to healthy food. Food additives and functional foods also play a role in innovation here.

Sources:

- <https://doi.org/10.3390/foods10112746>
- <https://doi.org/10.3390/ijerph182212107>
- <https://doi.org/10.1111/bjhp.12665>
- Buxton, Jane (2022): The Great Plant-based Con. Why eating a plants-only diet won't improve your health or save the planet. London, UK: Piatkus; Reference list on [www.thegreatplantbasedcon.com](http://www.thegreatplantbasedcon.com)
- <https://www.fao.org/3/cc9394en/cc9394en.pdf>



### Nutritional guidelines and dietary recommendations

Developing evidence-based guidelines and recommendations for healthy and balanced diets.

Sources:

- <https://www.who.int/news-room/fact-sheets/detail/healthy-diet>
- <https://eatforum.org/eat-lancet-commission/the-planetary-health-diet-and-you/>
- <https://www.fao.org/3/cc9394en/cc9394en.pdf>
- Abstracts processing functional food from the automated FOSTER long list
- <https://doi.org/10.3390/foods10112746>
- <https://doi.org/10.3390/ijerph182212107>
- <https://doi.org/10.1111/bjhp.12665>
- Buxton, Jane (2022): The Great Plant-based Con. Why eating a plants-only diet won't improve your health or save the planet. London, UK: Piatkus; Reference list on [www.thegreatplantbasedcon.com](http://www.thegreatplantbasedcon.com)
- <https://www.fao.org/3/cc9394en/cc9394en.pdf>

### Food allergies and intolerances

Addressing the growing prevalence of food allergies and intolerances and providing suitable food options.

Source:

- [http://cifs.agriculturejournals.cz/artkey/cjf-202105-0001\\_food-allergies-and-intolerances-a-review.php](http://cifs.agriculturejournals.cz/artkey/cjf-202105-0001_food-allergies-and-intolerances-a-review.php)

### Nutrition labelling and transparency

Ensuring clear and accurate nutrition information on food labels to empower consumers to make informed choices.

Source:

- <https://pubmed.ncbi.nlm.nih.gov/26591821/>

### Food safety and hygiene practices

Promoting food safety measures and hygiene practices to prevent foodborne illnesses and ensure consumer health.

Source:

- [https://food.ec.europa.eu/safety/biological-safety/food-hygiene/guidance-platform\\_en](https://food.ec.europa.eu/safety/biological-safety/food-hygiene/guidance-platform_en)

### Eating plastics

Plastics are everywhere and we are meanwhile eating plastics in large amounts. There is also first knowledge about the influence of BSPs (plasticisers) on the development of fat cells, which leads to the fact that people gain weight without eating more.

Sources:

- <https://www.sciencealert.com/microplastics-may-pose-a-serious-danger-to-the-intestine>
- Plasticosis: <https://medium.com/predict/plasticosis-the-new-disease-you-should-know-about-8fc310e85eb3>

### Nutrition myths: obesity

Obesity is not simply developed by eating more calories – there are different processes involved. Plant-based nutrition often contains too many carbohydrates and direct sugars – they even create a kind of addiction if not well balanced.

Many diet myths are not yet critically examined and need to be better funded empirically. They tell us that we do not know very much about the molecular level.

Sources:

- <https://doi.org/10.3390/ijerph182212107>
- <https://doi.org/10.1111/bjhp.12665>
- <https://doi.org/10.3390/foods10112746>
- challenged by several scientists and medical doctors, also by Buxton, Jane (2022): The Great Plant-based Con. Why eating a plants-only diet won't improve your health or save the planet. London, UK: Piatkus and References under [www.thegreatplantbasedcon.com](http://www.thegreatplantbasedcon.com).

### **Nutrition myths: plant-based**

Plant-based nutrition is not necessarily healthy. Often it can be, but it needs a lot of knowledge and a balanced diet. Vegetarian and vegan nutrition often lack many vitamins and minerals, which cannot be overcome by eating tons of plants or intake via pills (they often cannot be incorporated and exploited). Plant-based is also not necessarily better for climate etc, the narratives have to be differentiated. Many myths were never examined or just taken as given. When looking at facts, many myths can be detected and better nutrition would contribute to a more balanced food system.

Sources:

- <https://doi.org/10.3390/ijerph182212107>; <https://doi.org/10.1111/bjhp.12665>
- <https://doi.org/10.3390/foods10112746>
- <https://ourworldindata.org/less-meat-or-sustainable-meat>
- challenged by several scientists and medical doctors, also by Buxton, Jane (2022): The Great Plant-based Con. Why eating a plants-only diet won't improve your health or save the planet. London, UK: Piatkus; Reference list on [www.thegreatplantbasedcon.com](http://www.thegreatplantbasedcon.com)
- <https://www.cerealkillersmovie.com>

### **Dependencies on Big Food (big companies, sugar, carbohydrates)**

International food corporations ("Big Food") are increasingly conquering markets in emerging and developing countries. As partners of globally organised aid organisations, this opens up markets for industrially manufactured products, which primarily provide profit for the companies. Unhealthy food dominates markets and suppresses the production of smaller scale and healthier food approaches. Sugar and carbohydrate addiction add to these tendencies.

Source:

- <http://www.transcript-verlag.de/978-3-8376-3965-0>.

### **Planetary Health Diet**

The planetary health diet is flexible by providing guidelines to a range of different food groups that together constitute an optimal diet for human health and environmental sustainability. It emphasises a plant-forward diet where whole grains, fruits, vegetables, nuts and legumes comprise a greater proportion of foods consumed. Meat and dairy constitute important parts of the diet but in significantly smaller proportions than whole grains, fruits, vegetables, nuts and legumes. In addition to the targets set within each section, the dietary targets also suggest that the average adult requires 2500 kcal per day. While this amount will vary based on age, gender, activity levels and health profiles, overconsumption is a waste of food with both health and environmental costs.

Science-Based: The EAT-Lancet Commission's scientific targets for healthy diets allow individuals to prepare and consume meals in the total amount, composition and proportions that fit within the ranges of different food groups. The dietary pattern allows for flexible application of these criteria with room to tailor foods and amounts to different preferences and contexts to reduce the risk of poor diets and environmental degradation. The diet is criticised to be too expensive and not adequate for the lower income parts of the population. The WHO Council assumes that prevention for all is less costly than curing or risking diseases.

Sources:

- <https://eatforum.org/eat-lancet-commission/the-planetary-health-diet-and-you/>
- [https://doi.org/10.1016/S0140-6736\(15\)60901-1](https://doi.org/10.1016/S0140-6736(15)60901-1)
- [earth4all.life](http://earth4all.life)
- [https://cdn.who.int/media/docs/default-source/council-on-the-economics-of-health-for-all/council-eh4a\\_finalreport\\_web.pdf](https://cdn.who.int/media/docs/default-source/council-on-the-economics-of-health-for-all/council-eh4a_finalreport_web.pdf).

### **Regulation of food ingredients, especially fat and sugar**

Various countries levy a tax on ingredients in foods that are harmful to health, such as fat and sugar, in order to control consumer behaviour. Companies then adjust the recipes of their food and beverages in these markets. As some of the assumptions behind (e.g. to see fat as "evil" in general) are criticised, there are also counter-voices on this who are rather promoting a well-balanced diet and/ or a diet based on more fat (but a good one).

Sources:

- <https://onlinelibrary.wiley.com/doi/full/10.1111/nbu.12460>
- <https://jech.bmj.com/content/early/2024/06/11/jech-2023-221051>

### **Highly Processed Foods Increase Dehydration Risk**

The typical Western-style diet leads us to consume less fluid overall at a time when adequate hydration is key to surviving the heat waves striking multiple countries. Sweltering temperatures have led to much more focus on staying hydrated with liquids, but disappointingly few headlines focus on the role diets play in hydration. Highly processed foods with a low water content are rapidly replacing more traditional, water-rich foods. Bottled water purchases have increased by 40% over the past decade as more people focus on drinking enough fluids, but at least 20% of total daily water intake typically comes from water-rich foods like fruits and vegetables.

That 20% can be vitally important to prevent dehydration when temperatures soar. However, over half of the daily calories consumed in Western-style diets now come from a type of highly processed food classified as "ultra-processed" that has most of the water removed during processing to extend shelf life at the store. A food is said to be ultra-processed if it has gone through several extra processing steps adding more fats, sugar, salt, and preservatives that change the final form of the food. This includes foods like breakfast cereals, potato chips, fast food burgers and chicken nuggets, and many frozen meals. This junk food often masquerades as healthy with labels like "gluten free" or "sugar free," but if you look at the nutrition label, most of these foods contain a lot more sodium, fat, and simple sugars than you need in a healthy diet. They also have a lot less water compared to the original food.

Not all processed foods are categorized as ultra-processed, so it helps to understand the spectrum of processing.

One-ingredient foods – the least processed – are ideal. For example, a strawberry can be eaten in its natural form. That strawberry can also be blended into a smoothie or mixed into plain yoghurt – processed but still water-rich and healthy.

Sources:

- <https://medium.com/wise-well/highly-processed-foods-increase-dehydration-risk-e55ae38022ec>
- <https://www.economist.com/the-economist-explains/2023/08/07/what-makes-ultra-processed-foods-so-bad-for-your-health>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10561017/>

### **Packaging and health**

Advances in processing techniques, preservation, and packaging have enabled the food industry to consistently supply consumers with a wide array of healthy and fresh products all year round. Food packaging can improve food safety by reducing bacterial contamination, prolonging shelf life, ensuring convenience in distribution and handling. On the other hand, food contact materials can transfer chemicals to food with partly unknown effects.

Source:

- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

### **Triple burden of malnutrition**

Triple or multiple burden of malnutrition is hunger, obesity and other malnutrition –all at the same time, in the same region or country. Around 700 to 830 million people worldwide suffer from hunger, and around 3 billion people cannot afford a healthy diet. Particularly in young children malnutrition can lead to disturbances in the mental and physical development of young and physical development, which are usually irreversible. Thus 150 million children under the age of five are affected by growth retardation due to insufficient nutrition, and another 45 million children in this age group suffer from emaciation. At the same time, more than two billion people worldwide are overweight or obese – and the trend is rising. Research describes the global constellation of undernutrition, malnutrition and overnutrition as the triple burden of malnutrition. In Germany for example, all three forms of malnutrition can be observed. Diabetes and cardiovascular diseases are widespread as a result of unhealthy nutrition. Other diseases, such as AIDS, malaria or measles, can have malaria or measles can be exacerbated by poor nutrition. The financial burden on the health care system malnutrition is serious: In 2013, the Food and Agriculture Organization of the United Nations (FAO) put the social and economic costs of malnutrition worldwide at up to approx. 3.5 trillion US dollars annually. Childhood malnutrition has a staggering impact on our world. Almost 40 million children worldwide are classified as overweight or obese, and undernutrition is linked to an estimated 45% of deaths among children under five. Fortunately, there are many identified solutions for reducing the risks for present and future generations.

What is childhood malnutrition? Childhood malnutrition generally occurs when a child does not receive the necessary nutrients needed for healthy growth and development, whether it be via undernutrition, an unbalanced diet, or overconsumption. The impacts of malnutrition can be long lasting, with negative effects on physical and cognitive development and increased risks for chronic diseases. These effects can lead to significant costs for health and social care systems in the long term, making it even more crucial to address the problem so that all children have the opportunity to reach their full potential and lead healthier lives. What's more, the level of childhood malnutrition is not evenly

distributed across Europe, meaning there is no one-size-fits-all solution, and EU initiatives should reflect this regional variation. Countries in Eastern and Southern Europe, for example, generally have higher rates of malnutrition compared to the rest of Europe. There is also variation at country level, with four Southern European countries on course to meet targets to reduce childhood stunting (children being too short for their age), one experiencing some progress, two showing no progress or worsening, and seven with no data at all. This is exacerbated further by inequalities such as poverty, access to nutritious food and healthcare, as well as cultural factors and dietary needs.

Sources:

- <https://doi.org/10.57674/vzz6-sw54>; <https://www.fao.org/3/ca9692en/CA9692EN.pdf>
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/>, <https://cordis.europa.eu/project/id/774088>
- <https://www.fao.org/4/i3300e/i3300e.pdf>
- [https://doi.org/10.1016/S0140-6736\(19\)30041-8](https://doi.org/10.1016/S0140-6736(19)30041-8)
- <https://www.eitfood.eu/blog/nourishing-the-next-generation-the-role-of-the-food-system-in-tackling-childhood-malnutrition>
- <https://bonndoc.ulb.uni-bonn.de/xmlui/handle/20.500.11811/9164>

### Food shortage

As a result of crises such as the global Corona pandemic or the Ukraine war, and in the future increasingly due to climate change, there will be selective shortages of individual food groups. These are strongly dependent on the supply chains. Hoarding and panic buying may occur.

Source:

- <https://www.consilium.europa.eu/en/policies/food-security-and-affordability/>

### Medication like Ozempic (against obesity) makes food restrictions unnecessary

Some new medical treatments like Ozempic or Majoun can help people to lose weight because of manipulation with GPT1 – but they have to be taken for the whole life. That already threatens fast food providers or soft drink producers, and it may lead to a society where a differentiation can be seen between those who can afford the expensive treatment and those who cannot. This kind of medication can be a current hype, but there is a connection to many research fields (especially medicine, pharma, chronobiology) and consumer behaviour. It is critically observed that a "problem" in the background exists: obesity of people lead to business opportunities for companies, which means conflicting targets: obese people are created in order for these companies to exist. This leads to perverse incentives. This topic is chosen by the CDIs.

Sources:

- <https://www.handelsblatt.com/unternehmen/handel-konsumgueter/ozempic-und-co-so-bedrohen-abnehmspritzen-die-umsaetze-der-foodbranche-01/100037617.html>
- <https://www.pbs.org/newshour/health/patients-say-drugs-like-ozempic-help-with-food-noise-heres-what-that-means>
- <https://www.fda.gov/drugs/postmarket-drug-safety-information-patients-and-providers/medications-containing-semaglutide-marketed-type-2-diabetes-or-weight-loss>
- <https://www.bloomberg.com/news/articles/2023-10-04/walmart-says-ozempic-weight-loss-drugs-causing-slight-pullback-by-shoppers>
- CDIs discussions

## 5.3 Science and Technology

### Genetic Engineering (CRISPR & Co, gene editing)

Genetic engineering allows scientists to move desired genes from one plant or animal into another. The process of creating GE foods is different from selective breeding. This involves selecting plants or animals with desired traits and breeding them. Not all procedures are allowed in the EU and there is a lot of criticism and fear by consumers. But there are also many technical problems that might lead to the conclusion that gene editing is not the solution for the food system (see example apples).

Sources:

- [https://www.oekom.de/files\\_media/zeitschriften/artikel/OEL\\_2023\\_02\\_38.pdf](https://www.oekom.de/files_media/zeitschriften/artikel/OEL_2023_02_38.pdf)
- <https://medlineplus.gov/ency/article/002432.htm>
- <https://doi.org/10.1038/s44222-023-00115-8>
- <https://doi.org/10.1038/s44222-023-00136-3>

### Artificial intelligence (AI) and machine learning in food industry applications

Applying AI and machine learning algorithms to improve various aspects of the food industry. There are many ideas, but not much experience of how efficient AI really is and what really works. Many applications are not yet AI even though called AI. But the potential of machine learning is very high. (Strong) artificial intelligence generally refers to the computer-aided reproduction of human intelligence. The goal is an autonomous computer system that can work independently on abstract, non-trivial problems under changing boundary conditions. Artificial intelligence has (self-) learning abilities. However, the term is not clearly defined, so the imitation of intelligent behaviour by programmed algorithms is also referred to as (weak) artificial intelligence. With this weak AI, however, the function of machine learning is clearly limited. Artificial intelligence has an impact on products, production environments and socio-economic systems.

Sources:

- <https://www.hindawi.com/journals/jfq/2022/8521236/>
- <https://data.europa.eu/doi/10.2826/403075>
- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- 50 trends influencing Europes food sector: <https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccv/2019/50-trends-influencing-Europes-food-sector.pdf>

### Blockchain and decentralised food supply chain management

Utilising blockchain technology for secure, transparent, and decentralised management of the food supply chain is an expectation. There are critical views, questioning if blockchain is well-suited to solve these problems.

Sources:

- <https://thecorrespondent.com/655/blockchain-the-amazing-solution-for-almost-nothing/86649455475-f933fe63>
- <https://www.scnsoft.com/blockchain/food-supply-chain>
- <https://data.europa.eu/doi/10.2826/403075>
- <https://www.mdpi.com/2305-6290/4/4/27>

### Robotics and automation in food production and processing

Robots and automation streamline and enhance food production and processing. This is a large field of applied sciences and many countries have action plans and strategies for robotics in agriculture and industrial food production.

Sources:

- <https://www.anugafoodtec.de/magazin/roboter-treiben-die-digitale-transformation-in-der-lebensmittelindustrie-voran.php>
- <https://doi.org/10.1038/s44222-023-00126-5>
- <https://www.extrica.com/article/23209>
- <https://www.anugafoodtec.de/magazin/zukunft-der-digitalisierung-und-automatisierung.php>

### Sensory technology and flavour profiling

Using advanced sensory technology to analyse and enhance flavour profiles in food products.

Source:

- <https://www.frontiersin.org/articles/10.3389/fpsyg.2018.00026/full>

### Predictive analytics and data-driven decision making

Leveraging data analytics and predictive modelling for informed decision making in the food industry.

Source:

- <https://www.dataversity.net/the-impact-of-predictive-analytics-on-the-global-food-system>

### Beyond Meat and other synthetic foods incl. large-scale lab-grown meat

There is already a wide range of meat substitutes and synthetically produced foods. In the future, alternatively produced foods may be used to feed humans, like cultured meat and fish, vertical farming, insects, micro-algae, etc. If it is possible to produce meat without killing animals, this is often seen as a huge advantage. However, there still needs to be a lot of research to do this on a large scale. Lab-grown meat in masses will have a huge impact on animal production and agriculture in general – if successful. But it does not only have advantages, there are many different points to consider.

Sources:

- FOSTER topic modelling: many sources from the automatic scanning with details in new foods
- <https://www.efsa.europa.eu/en/events/efsas-scientific-colloquium-27-cell-culture-derived-foods-and-food-ingredients>
- <https://doi.org/10.1038/s44222-023-00137-2>; <https://doi.org/10.1038/s44222-023-00075-z>
- <https://jk-lund.medium.com/the-promise-and-peril-of-artificial-meat-f07096686c64>
- <https://www.ox.ac.uk/news/2011-06-21-lab-grown-meat-would-cut-emissions-and-save-energy>
- <https://doi.org/10.1038/s44222-023-00076-y>
- <https://doi.org/10.1038/s44222-023-00115-8>
- <https://doi.org/10.1038/s44222-023-00112-x>
- <https://doi.org/10.1038/s44222-023-00077-x>

### Development of sustainable soil-friendly fertilisers

Intensive agriculture, which makes extensive use of agrochemicals, has undoubtedly increased farm commodity output, but the negative impact of these chemicals on soil structure, soil microbiology, water quality, food, fodder and food

materials is abundantly obvious. Pesticides and fertiliser nitrates have been identified in ground water in numerous agricultural areas due to chemical leaching. [This type of agriculture also usually increases topsoil erosion.]

Source:

- <http://large.stanford.edu/courses/2015/ph240/verso2/>; <https://www.degruyter.com/document/doi/10.1515/psr-2022-0174/html>

### **Vertical farming enables better land use and local production**

Vertical farming is an agricultural concept in which production takes place in high-rise buildings (vertically) in order to use urban space for sustainable agriculture. The cultivation of plant and animal products can thus take place directly in cities and saves transport time and costs due to the proximity to the consumer. Critical: beware high energy needs.

Sources:

- <https://www.greenforges.com/blog/energy-and-underground-farming>
- <https://www.pflanzenforschung.de/de/pflanzenwissen/lexikon-a-z/vertical-farming-10036>

### **Precision agriculture and Smart farming increase agriculture productivity**

Smart farming makes it possible to make agriculture more sustainable, efficient and resilient at the same time – so the expectations. Lower costs for sensor technology make investments in smart farming technologies attractive. Using technology to optimise crop production and reduce resource waste increases productivity and reduces manual work. AI enables precision farming techniques that utilise real-time data, satellite imagery, and sensors to optimise crop management. Machine learning algorithms analyse data from weather patterns, soil conditions, and crop health to provide insights on optimal planting times, fertiliser application, irrigation schedules, and pest control. Precision farming minimises resource waste, enhances crop productivity, and reduces environmental impact.

Sources:

- <https://www.iks.fraunhofer.de/en/topics/smart-farming.html>
- <https://www.mdpi.com/2077-0472/13/8/1593>
- <https://link.springer.com/article/10.1007/s10462-022-10266-6>
- <https://books.google.de/books?id=hEv9DwAAQBAJ&lpg=PA157&dq=Vertical%20farming%20and%20urban%20agriculture&lr&hl=de&pg=PA157#v=onepage&q=Vertical%20farming%20and%20urban%20agriculture&f=false>
- <https://www.tandfonline.com/doi/full/10.1080/14620316.2022.2141666>
- <https://www.researchgate.net/publication/349623902>

### **Integrating blockchain and the internet of things in precision agriculture**

In precision farming, the combination of the Internet of Things and the blockchain can move us from smart farms only to the internet of smart farms and add more control in supply-chains networks. The result of this combination can lead to more autonomy and intelligence in managing precision agriculture in more efficient and optimised ways.

Sources:

- <https://www.sciencedirect.com/science/article/abs/pii/S0168169919324329>
- <https://www.sciencedirect.com/science/article/pii/S0959652621009823>



### Renewable Energy generation for food production

Agri-food systems consume about 30% of the world's energy, and a third of agri-food systems' emissions of greenhouse gases stem from energy use. The energy transition to renewable generation will directly affect the food system, and vice versa. The structure of energy consumption in food systems varies significantly between developing and developed countries. Worldwide, energy consumption in agri-food systems increased by more than 20% between 2000 and 2018.

Sources:

- International Renewable Energy Agency and the Food and Agriculture Organization of the United Nations: [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Nov/IRENA\\_FAO\\_Renewables\\_Agrifood\\_2021.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Nov/IRENA_FAO_Renewables_Agrifood_2021.pdf)
- <https://link.springer.com/article/10.1007/s43154-022-00080-x>

### Patents on seeds - seed monopolies

In the present and future times, when climate extremes are increasing, site-adapted varieties and a wide variety of seeds would be important. Many of the varieties that were common in the past were well suited to the local soil and climate because that is exactly where they developed. To meet the challenge of finding suitable plants for new climatic conditions, mankind needs a rich gene pool of varieties. One danger and constraint for breeders is the increasing patenting of seeds and plants. This has created monopolies for seeds in the past. Although since 2017 the European Patent Office is no longer allowed to grant patents on plants and animals of conventional breeding, this does not apply to breeding based on genetic engineering methods, e.g. CRISPR/CAS. In some cases, attempts are also made to create the impression of a technical and thus patentable invention. The boundaries are fluid.

Sources:

- <https://www.no-patents-on-seeds.org/>
- [www.opensourceseeds.org](http://www.opensourceseeds.org)

### Genebanks and seed vaults to provide cheap access to a range of seeds

Related to previous: Genebanks and seed vaults like the Svalbard Global Seed Vault and the Indian Seed Vault provide a safe, cheap access to diversified seed varieties. This offers the possibility to find seeds that adapt to the changing local climates or to develop new improved varieties that do.

Sources:

- [https://www.croptrust.org/fileadmin/uploads/croptrust/Documents/Technical\\_reports/Other/Impact-Paper\\_16Dec2015\\_ks.pdf](https://www.croptrust.org/fileadmin/uploads/croptrust/Documents/Technical_reports/Other/Impact-Paper_16Dec2015_ks.pdf)

### Antimicrobial use in food-producing animals projected to increase

Even though "the widespread use of veterinary antimicrobials drives antimicrobial resistance, with important consequences for animal health, and potentially human health", antimicrobial use (AMU) in food-producing animals is projected to increase at least until 2030. Although the number of countries reporting national AMU data is increasing, the majority still do not do it. Such data would enable effective antibiotic stewardship policies.

Source:

- <https://journals.plos.org/globalpublichealth/article?id=10.1371/journal.pgph.0001305>

### Advanced Manufacturing and Robotics

Advanced manufacturing and industrial robotics for food processing and preparation may help tackle challenges within the natural or socio-economic environment, as they enable the flexibilisation and automation of food production processes. These are industrial tools which are used for food processing activities, like sorting, handling and packing. They may either work without immediate human presence or alongside human workers with varying degrees of human-robot cooperation. The convergence of technologies is visible here (SFA 2023).

Sources:

- SFA 2023: <https://www.act.nato.int/activities/allied-command-transformation-strategic-foresight-work/>
- AGRI-FOOD. Analytical Report: <https://data.europa.eu/doi/10.2826/403075>

### Big Data and Cloud Computing

Organizations that are unable to afford high upfront investment and maintenance on physical servers can access enormous amounts of data processing and storage space through cloud computing. The cloud infrastructure serves as the foundation for data collection and analysis for the food supply chain from collections of crops from farms to warehouses where it is stored to the shipping containers to final delivery to the consumer.

Sources:

- <https://ieeexplore.ieee.org/abstract/document/9103523>
- Van de Velde et al. (2023)/ EISMEA Report: Monitoring the twin transition of industrial ecosystems. AGRI-FOOD. Analytical Report, <https://data.europa.eu/doi/10.2826/403075>

### Digital security and networks/ cybersecurity

Increased use of technology in the food industry and its supply chains puts this sector more at risk of cyberattacks and breaches than ever. Cyberattacks are starting to impact the operations and distribution of foodstuff, which is a concerning trend for society.

Sources:

- <https://doi.org/10.1016/j.compind.2022.103702>
- Van de Velde et al. (2023)/ EISMEA Report: Monitoring the twin transition of industrial ecosystems. AGRI-FOOD. Analytical Report, <https://data.europa.eu/doi/10.2826/403075>

### New digital technology for food transport

Transporting food from farm to fork is a critical element of any supply chain distributed across global markets connected via internet using e-business solutions. The technologies implemented impact the food transportation and the transportation needs (from short distances from retailers to end consumers to long distances between farmers in one country to processors or distributors in another country) impact the technologies needed.

Sources:

- <https://data.europa.eu/doi/10.2826/403075>; <https://doi.org/10.1016/j.rtbm.2017.10.002>

## Internet of Things

The Internet of Things (IoT) enables the visualisation of supply chain operational processes, information gathering, and control of business development in real time. In particular, in the food industry it enables to maintain safety standards, limit food waste, manage unpredictable variations, track and monitor the quality of foodstuffs, reduce energy consumption and smart control of refrigerators and ovens.

Sources:

- <https://doi.org/10.1016/j.tifs.2023.07.006>
- <https://data.europa.eu/doi/10.2826/403075>;

## Chronobiology - Light at the right time important for plants and animals (and humans)

Plants, animals and humans have circadian rhythms (circa - about/ dian - one day), their phases of activity and inactivity, sleep and wake etc. differ individually but are influenced by light. This also means variations from day to day, during the seasons and in lifetime. Light at the right time of the day is important for well-being, but also for food intake. When the "inner clock" gets de-synchronised (e.g. by insufficient sleep, bad sleep quality or sleep/ light at the wrong time), plants, animals and humans become severely ill and their organs are de-synchronized and not "working together" properly.

Sources:

- Project CIRCADIA: <https://www.isi.fraunhofer.de/en/competence-center/foresight/projekte/circadia.html>

## 5.4 Markets

### Global food trade and emerging markets

Examining the dynamics of international food trade and the emergence of new markets.

Sources:

- <https://blogs.worldbank.org/developmenttalk/risks-global-food-markets>
- [https://www.oecd-ilibrary.org/agriculture-and-food/oecd-fao-agricultural-outlook-2022-2031\\_f1b0b29c-en](https://www.oecd-ilibrary.org/agriculture-and-food/oecd-fao-agricultural-outlook-2022-2031_f1b0b29c-en)

### Local and regional food systems

Focusing on local and regional food production, distribution, and consumption networks.

Source:

- <https://foodprint.org/issues/local-regional-food-systems/>

### Direct-to-consumer sales and farmer's markets

Exploring direct sales models and the growing popularity of farmer's markets.

Source:

- <https://foodprint.org/blog/direct-to-consumer-farms/>

### Food start-ups and entrepreneurship in the food industry

Analysing the rise of innovative food start-ups and entrepreneurship in the industry.

Source:

- <https://eatsmarter.de/ernaehrung/news/diese-16-food-start-ups-sollte-man-kennen>

### **Plant-based and alternative protein markets**

There is already a wide range of meat substitutes and synthetically produced foods. In the future, alternatively produced foods will be used to feed humanity.

Sources:

- <https://www.zukunftsinstitut.de/artikel/food/food-trends-hanni-ruetzler/>
- <https://www.biofach.de/en/knowledge-inspiration/2024/article/biofach-from-omnivores-to-meat-lovers>

### **Discounter versus Delicatessen and specialised trade**

In many European countries, discounters have displaced classic specialty retailers such as bakeries, butchers and greengrocers. Discounters offer all product categories under one roof and enable a speedy and inexpensive shopping experience.

Source:

- <https://de.statista.com/themen/1291/lebensmittel-discounter/#topicOverview>

### **Regulation of food ingredients, especially fat and sugar**

Various countries levy a tax on ingredients in foods that are harmful to health, such as fat and sugar, in order to control consumer behaviour. Companies then adjust the recipes of their food and beverages in these markets. There are no evaluations if these effects are always helpful, because in some cases, companies just rebrand their products and find other ways out.

Source:

- <https://www.mdpi.com/2072-6643/12/11/3401>

### **Use of food traffic lights as consumer information**

The use of food traffic lights is intended to educate citizens and influence their purchasing decisions. It is a means of consumer protection to point out unhealthy food. Due to the regulatory measure, manufacturers adjust their recipes.

Source:

- <https://www.sciencedirect.com/science/article/pii/S0950329319307827>

### **Increasing demand for package-free foodstuff**

The increasing demand for package-free foodstuffs and the proliferation of package-free stores create a positive feedback loop that drives the rise in demand and availability. This is starting to be leveraged by conventional supermarkets as well, some of which are starting to encourage shoppers to bring their own containers and to trial refill stations. The transition is, however, complex, involving changes in the supply chain, the stores and buyers' behaviours and skills. Despite the obvious environmental benefits of not producing packaging, the package-free movement must pay attention to the undesired increase in food-waste due to the shorter shelf lives of some foodstuffs.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0969698918310476>
- <https://lup.lub.lu.se/luur/download?func=downloadFile&recordId=8903648&fileId=8903649>

### **Increase in direct-to-consumer (DTC) online-ordering**

Due to the COVID-19 pandemic, many consumers started ordering food online. However, this trend started even before the pandemic stroke and is continuing nowadays. In the US, food and beverage is now the fastest-growing category in online retail. DTC brands cut out intermediary retailers, which lets them capture more profit margin and/or offer lower prices than traditional players. A notable example is farmers selling subscriptions for boxes of fresh products grown locally.

Sources:

- <https://www.foodsystemsjournal.org/index.php/fsj/article/view/865>
- [https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Expanding%20Grocery%20E-Retail%20Market%20in%20Germany\\_Berlin\\_Germany\\_8-8-2019.pdf](https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Expanding%20Grocery%20E-Retail%20Market%20in%20Germany_Berlin_Germany_8-8-2019.pdf)

### **Strict diets and food preferences**

Strict diets and food preferences (vegan, vegetarian, foodie, food as wellness, healthy eating, mindful eating, fermented foods and drinks, pro-/pre-biotics, food allergies, home cooking, organic, etc.) are shifting demand for particular foodstuffs. Strict diets like vegan and vegetarian or those that people with food allergies must follow are on the rise. In addition, more and more people pay more attention to their nutrition, changing the diets. These changes in people's nutrition shift the demand for particular foods and additives.

Sources:

- <https://foodinsight.org/wp-content/uploads/2020/06/2020-Food-and-Health-Survey-.pdf>
- <https://www.forbes.com/sites/janetforgrieve/2018/11/02/picturing-a-kindler-gentler-world-vegan-month/>
- <https://foodinsight.org/2022-food-and-health-survey-results-a-focus-on-eating-patterns>

### **Food waste awareness**

The awareness of the huge amounts of food wasted (it could reach a 17% of total global food production) could motivate producers, retailers and consumers to be more effective using their food. But there is still too much food waste and with an increasing world population food waste has to be stopped wherever possible.

Sources:

- UNEP Food Waste Index Report 2021: <https://www.unep.org/resources/report/unep-food-waste-index-report-2021>

### **Increased demand for food supplements and superfoods**

The rising interest in leading a healthy lifestyle is driving the globally increasing demand for food supplements and superfoods. This growing demand is still low, which makes it particularly suitable for the direct to consumer (DTC) model.

Sources:

- <https://www.futuremarketinsights.com/reports/superfood-powders-market#>
- <https://www.gtai.de/resource/blob/653250/4bbc772420abb16ffc47f5de372a463a/Food%20Supplements%20Markt%20in%20Germany.pdf>
- <https://www.fortunebusinessinsights.com/super-foods-market-102484>

### **Insects - farming and eating as a new market**

The interest in insects as food and feed has been growing exponentially in the last years. The farming of insects has an environmental impact which is lower than that of livestock species (they can be fed with biomass left from other processes, need a much lower income of food per kilogram of bodyweight, need less space area per kilogram of protein produced, see [https://www.3keel.com/wp-content/uploads/2018/02/Food\\_Futures\\_-report\\_0.pdf](https://www.3keel.com/wp-content/uploads/2018/02/Food_Futures_-report_0.pdf)) and are easy to breed. However, eating insects could bring a rise in allergies and legislation is lagging behind.

Sources:

- <https://www.frontiersin.org/articles/10.3389/fnut.2021.759885/full>
- [https://www.3keel.com/wp-content/uploads/2018/02/Food\\_Futures\\_-report\\_0.pdf](https://www.3keel.com/wp-content/uploads/2018/02/Food_Futures_-report_0.pdf)
- <https://www.tandfonline.com/doi/abs/10.1080/10408398.2023.2223644>
- <https://ift.onlinelibrary.wiley.com/doi/10.1111/1541-4337.13243>

## **5.5 Climate Change and Environment**

### **Temperature increase in Europe higher than in other countries of the world**

Different from average calculations, the temperature increase in Europe is higher than in other countries of the world. It is also an uneven distribution and hot spots occur. This does not only lead to extreme events but also to different timely and space patterns of weather, e.g. more rain in certain periods, more drought in others. In 2023, the Earth has set back-to-back records, some signs are convincing.

Sources:

- <https://foresight4food.net/>;
- Europe is world's fastest warming continent, climate report: <https://www.rawstory.com/europe-is-world-s-fastest-warming-continent-climate-report/>
- <https://www.euronews.com/green/2023/08/09/volcanoes-shipping-and-dust-what-else-could-be-fuelling-this-summer-heatwaves>
- <https://www.smithsonianmag.com/smart-news/earth-faces-hottest-day-ever-recorded-three-days-in-a-row-180982493/>
- IPCC: <https://www.doi.org/10.59327/IPCC/AR6-9789291691647.001> / <https://www.ipcc.ch/report/sixth-assessment-report-cycle/> / [https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC\\_AR6\\_SYR\\_SPM.pdf](https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf)

### **Climate-resilient crops and agriculture practices**

Developing crops and agricultural practices that are resilient to the impacts of climate change, such as drought, heatwaves, and extreme weather events but also to new weather phases and a change in patterns, e.g. more rain in certain periods, more drought in others.

Sources:

- <https://doi.org/10.1016/j.foodpol.2010.10.010>
- <https://onlinelibrary.wiley.com/doi/epdf/10.1111/tpj.15483>

**Mitigation strategies for greenhouse gas emissions in the food industry**

Implementing measures to reduce carbon emissions and greenhouse gas emissions in food production, processing, and transportation.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0306919210001132>
- <https://www.sciencedirect.com/science/article/pii/S0959652617303980>

**Adaptation to changing weather patterns and extreme events**

Adapting farming practices and infrastructure to cope with the changing climate and increasing frequency of extreme weather events.

Sources:

- <https://doi.org/10.1016/j.pbi.2019.12.006>
- <https://www.mdpi.com/2076-3417/10/9/3092>

**Sustainable land management and soil conservation**

Promoting practices that protect and enhance soil health, prevent erosion, and preserve agricultural land.

Sources:

- <https://www.mdpi.com/2071-1050/11/23/6792>
- <https://books.google.de/books?hl=de&lr=&id=Vr4sEAAAQBAJ&oi=fnd&pg=PT6&dq=Sustainable+land+management+and+soil+conservation&ots=fT6hLY3d4Z&sig=CcyGF8xif7tL0cpRargxiR6kjEc#v=onepage&q=Sustainable%20land%20management%20and%20soil%20conservation&f=false>

**Climate-smart agriculture and sustainable resource use**

Integrating climate considerations into agricultural practices to minimize environmental impact and resource use raises high expectations.

Sources:

- <https://link.springer.com/article/10.1007/s13762-018-1827-3>
- <https://www.mdpi.com/2071-1050/14/14/8410>
- <https://doi.org/10.1016/j.jclepro.2021.128602>

**Weather extremes driven by a meandering jet stream cause multi-regional harvest failure at the same time**

The ability of state-of-the-art crop and climate models to adequately reproduce such high impact events is a crucial component for estimating risks to global food security.

Source:

- <https://doi.org/10.1038/s41467-023-38906-7>

**Future flooding and erosion as a consequence and further driver**

Coastal flooding and erosion caused by extreme events are the main factors responsible for beach hazards. This effect will be exacerbated by the sea level rise induced by climate change. The present work determines the vulnerability to erosion and flooding along 55 beaches grouped in different coastal archetypes, representative of the Catalan coast. The

vulnerability assessment has been done through the numerical simulation of different combinations for projected waves and mean water levels under present conditions and the climate change scenarios RCP4.5 and RCP8.5 for the year 2100. A storm event approach has been used to determine coastal flooding and erosion with return periods of 50, 100, and 500 years using the XBeach numerical model. Results show that shoreline retreat is not the best proxy to characterise the erosion. The low-lying nature of the coast, the non-presence of well-developed berms, and the existence of river mouth and torrents govern the coastal flooding. The sea level rise appears to be a dominant variable in coastal hazards.

Source:

- <https://www.frontiersin.org/articles/10.3389/fmars.2023.1125138/full>

#### **4 degrees increase of temperature until 2100**

4 degrees increase of temperature until 2100 is one of the negative scenarios in climate change calculations. In each of the scenarios, the poorer part of the world will suffer more than the rich industrialised countries. There will be more hunger, less arable land, heat, drought and fires will destroy many harvests.

Sources:

- <https://www.ipcc.ch/report/sixth-assessment-report-cycle/>
- Mahlke 2022 Atlas der Globalisierung: 5-13: [https://monde-diplomatique.de/product\\_info.php?products\\_id=245213](https://monde-diplomatique.de/product_info.php?products_id=245213)

#### **Forest and wildfires can destroy agricultural goods**

Forest fires can destroy farmland and are frequently caused by arson or human interference with nature. As a result of climate change, forest fires are expected to increase. In the recent past, numerous forest fires have gotten out of control. As a result, the availability of agricultural commodities is greatly affected and food security is limited. Extreme price fluctuations can occur on the world market.

Source:

- <https://link.springer.com/article/10.1007/s40808-021-01306-1>

#### **Heavy rain and flooding can directly destroy agricultural goods**

Flooding can cause a significant impact on agriculture. On the one hand, harvests can fail. On the other hand, farmland in particularly endangered areas may become permanently unavailable. Floods are also partly the result of urban expansion due to the detour of rivers. This has a major impact on the availability of agricultural goods and limits food security. Extreme price fluctuations can occur on the world market.

Sources:

- <https://link.springer.com/article/10.1007/s41885-018-0033-6>
- <https://www.euronews.com/green/2023/08/09/volcanoes-shipping-and-dust-what-else-could-be-fuelling-this-summer-heatwaves>

#### **Heat protection measures for the population**

Due to extreme heat, the central and northern European countries are also obliged to pay attention to heat protection. In terms of nutrition, it is a matter of sufficient intake of fluids and a diet adapted to the temperatures (light food). Governments provide low-threshold educational information on public access to free water.



Source:

- [https://www.thelancet.com/journals/lanet/article/PIIS0140-6736\(15\)60854-6/fulltext](https://www.thelancet.com/journals/lanet/article/PIIS0140-6736(15)60854-6/fulltext)

### **Disruptive weather events related to climate change, and animal disease outbreaks**

Weather disasters and animal diseases have a profound impact on agriculture trade. Severe weather events like droughts, floods, and hurricanes can devastate crops, reduce livestock populations, and disrupt supply chains. These disruptions lead to decreased availability of agricultural products, higher prices, and increased competition for limited resources. Similarly, outbreaks of animal diseases, such as avian influenza and foot-and-mouth disease, can result in trade restrictions and loss of livestock. Importing countries face challenges in securing adequate food supplies, while exporting nations experience reduced export volumes and revenue. The vulnerability of global food systems necessitates collaborative efforts and investment in resilience to minimise these impacts and ensure a stable food supply.

Source:

- [https://agriculture.ec.europa.eu/data-and-analysis/markets/outlook/medium-term\\_en](https://agriculture.ec.europa.eu/data-and-analysis/markets/outlook/medium-term_en)

### **Wheat harvest: El Niño could trigger a new food crisis**

The war in Ukraine is not the only threat to global food security. In many countries, the wheat harvests are worse than expected. This could drive up prices and trigger political unrest. Until a few months ago, the global wheat supply for the 2023/24 marketing year seemed secure. Despite the war in Ukraine, exports from Russia and Ukraine ran largely smoothly. Prices on the stock exchanges were on a downward spiral for months until they fell to their lowest level since summer 2021 at the end of May. The situation has since changed. Civilian shipping on the Black Sea is increasingly threatened by acts of war, which could prompt shipping companies to stop transporting grain from Russia. But even beyond the war in Ukraine, the warning signals on the wheat market are increasing.

Sources:

- <https://table.media/agrifood/analyse/weizenernte-el-nino-kann-neue-ernaehrungskrise-ausloesen/>
- <https://www.euronews.com/green/2023/08/09/volcanoes-shipping-and-dust-what-else-could-be-fuelling-this-summer-heatwaves>

### **AMOC collapse could happen any time between 2025 and 2095 with a 95% confidence interval.**

What would happen if the AMOC (Atlantic Meridional Overturning Circulation = Gulf Stream) failed and stopped? "Is The Gulf Stream Really About To Collapse & Cause Climate Mayhem?" A new contribution in Science leads to controversial discussions (<https://www.science.org/doi/10.1126/sciadv.adk1189>), claiming that it is clear to say that this will happen, but it is unclear to say when. Background: The algae and carbon dioxide-rich top water can be pushed down into the depths, where the carbon can settle before it can find its way back into the atmosphere. So if the AMOC stopped, the net impact of each kg of carbon emissions we emit would be more significant, and climate change would speed up. This would stop nutrients from being replenished within the Atlantic, which would significantly reduce biomass and biodiversity being devastating for marine ecosystems and the millions of people who depend on the Atlantic fish stocks for sustenance. It would also wreak havoc with weather patterns across the US and Europe. Rain patterns will drastically change, and seriously extreme winter weather will hit much of Europe and America with far more ferocity and frequency than it does today; hurricanes could become more powerful and more frequent, and heat builds up in the Caribbean

seas. This will cost billions of Euros of damage annually and directly threaten millions of lives and significantly reduces the food supply of many developed Western countries as their crops can fail year after year. This reduced food supply has the potential to threaten our economies and cause recessions at a level we have never seen before. Climate scientists were mostly sceptical, and some were even annoyed at this media frenzy because accurate forecasts are impossible.

Sources:

- <https://www.science.org/doi/10.1126/sciadv.adk1189>
- <https://medium.com/predict/is-the-gulf-stream-really-about-to-collapse-cause-climate-mayhem-a9aa2b8d0b03>
- <https://www.sciencemediacentre.org/expert-reaction-to-modelling-study-suggesting-atlantic-ocean-circulation-amoc-could-be-on-course-to-collapse>

### **Extreme weather increase**

Extreme weather hit Europe/ the world at several locations and with more and more intensity: from heavy rain to thunderstorms, from long time heat and drought to floods – food production is suffering. But there are also other reasons for the weather caprioles, among which one is El Niño. Some theorise that our Jet Stream is also slowing down so that weather becomes more stable.

Sources:

- <https://www.euronews.com/green/2023/08/09/volcanoes-shipping-and-dust-what-else-could-be-fuelling-this-summer-heatwaves>
- <https://www.euronews.com/green/2023/08/08/torrential-rain-flash-floods-and-raging-wildfires-europes-extreme-summer>
- <https://www.euronews.com/green/2023/08/08/the-worlds-biggest-heatwave-happened-in-antarctica-last-year-what-does-this-mean-for-our-p>

### **Is a volcanic eruption fuelling global warming?**

Is a volcanic eruption fuelling global warming? There is a clear yes, the question is how much.

Source:

- <https://www.euronews.com/green/2023/08/09/volcanoes-shipping-and-dust-what-else-could-be-fuelling-this-summer-heatwaves>

### **Green Grabbing**

Across the world, ecosystems are for sale. The commodification of nature, and its appropriation by a wide group of players, for a range of uses – current, future and speculative – in the name of "sustainability", "conservation" or "green" values is accelerating.

Sources:

- James Fairhead, Melissa Leach & Ian Scoones (2012) Green Grabbing: a new appropriation of nature? The Journal of Peasant Studies
- <https://medium.com/thewildones/green-grabbing-06da49f7568b>

### **Climate change will impact everything everywhere all at once**

If climate change hits, it will have an effect on everything everywhere and all at once, is a remark from the US that needs reflection. In this case, there is no help from other countries or regions as they are hit themselves. Here is a

recommendation to make use of different standards, esp. for investments: "We will keep fighting until we put a stop to ESG once and for all!" ESG stands for Environmental, Social, and Governance and is a set of investment standards for a company's behaviours. In other words, it's a set of standards that takes more than profit into account. It was coined by the United Nations in 2005. Originally, the acronym was GES because they believed Governance was the most important of the three. They weren't wrong then. They aren't wrong now. They just didn't know at the time the dire state of our environment in 2023. The quote above is so incredibly dangerous because if the United States completely gives up on the environment now, catastrophe is certain. Even if we went to net zero today, there's still no way to keep global warming below 2 degrees Celsius. Above 2 degrees, we will see more intensified storms, extreme heatwaves, dangerous flooding, drought, and fire conditions, crop failures, sea level rise, deadly disease increases, and massive loss of biodiversity in flora and fauna.

Sources:

- <https://christaavampato.medium.com/climate-change-will-impact-everything-everywhere-all-at-once-943aeec66cf7>
- <https://www.euractiv.com/section/energy-environment/news/for-climate-action-look-to-brussels-not-dubai/>
- <https://www.euronews.com/green/2023/12/13/cop28-strikes-historic-deal-to-transition-away-from-fossil-fuels-what-are-the-key-takeaway>

### Planetary Boundaries

Humans respect planetary boundaries when thinking about food systems; or 2. "Humans do not care about planetary boundaries and endanger their food systems", "Human activities increasingly influence the Earth's climate (as readable in the International Panel on Climate Change reports since the start of reporting by the Intergovernmental Panel of Climate Change 2007, see <https://www.ipcc.ch/reports/>) and ecosystems (e.g. Millennium Ecosystem Assessment (MEA) Reports). Crutzen 2002 even saw the Earth entering a new epoch, the Anthropocene, where humans constitute the dominant driver of change to the Earth System (Steffen et al. 2015). The exponential growth of human activities is raising concern that "further pressure on the Earth System could destabilize critical biophysical systems and trigger abrupt or irreversible environmental changes that would be deleterious or even catastrophic for human well-being. This is a profound dilemma because the predominant paradigm of social and economic development remains largely oblivious to the risk of human-induced environmental disasters at continental to planetary scales (Stern Review 2007).

Planetary boundaries is a concept for estimating a safe operating space for humanity with respect to the functioning of the Earth System (<https://www.ecologyandsociety.org/vol14/iss2/art32/main.html>, 07.02.2019), which is also touching upon good systems. There are now different ways of dealing with this knowledge: 1. taking it into account (1. Humans respect planetary boundaries when thinking about food systems); or ignoring it (2. Humans do not care about planetary boundaries and endanger their food systems). As we are already overshooting many of our resources and boundaries, it is unclear, how the food system will be impacted.

Sources:

- <https://www.ecologyandsociety.org/vol14/iss2/art32/main.html>
- <https://www.science.org/doi/10.1126/science.1259855>
- <https://link.springer.com/article/10.1007/s13280-021-01544-8>
- <https://www.ipcc.ch/reports/>
- <https://www.science.org/doi/10.1126/science.1259855>
- <https://doi.org/10.1038/415023a>

- <https://www.millenniumassessment.org/en/index.html>
- <https://www.lse.ac.uk/granthaminstitute/publication/the-economics-of-climate-change-the-stern-review/>

### Water as the next frontier - water security

"Water seems to be the next frontier for comprehensive accounting and adaptation strategies – for food systems too, in industry, municipalities, governments, and individuals, all of which have made impressive commitments and progress to track carbon pollution. "However, our increasingly threatened global water security demands that accounting for water use and risk rapidly acquire the same urgency with which we address carbon." (citation from <https://climate-diplomacy.org/magazine/environment/water-new-carbon>). Some even fear wars over water – already in the US.

Sources:

- <https://climate-diplomacy.org/magazine/environment/water-new-carbon>
- <https://reliefweb.int/report/world/editor-s-pick-10-violent-water-conflicts>

### Consumer behaviour in face of climate change

It remains a question if and how consumers change their behaviour in face of climate change and seeing first symptoms of it.

Source:

- <https://publica.fraunhofer.de/entities/publication/2b3559e7-e3e6-4578-ba57-746dfc863ad9/details>

## 5.6 Politics and Geopolitics

### New world order

There are different scenarios of how a new world order may look like. Many see the USA and China as rivals in science and technology, but also in international food markets. The war in Ukraine plays a big role in the relation of both and with Russia. Many other players are rising powers, also in food markets and within global food chains.

Sources:

- [https://www.consilium.europa.eu/media/69285/forward-look-2024\\_10-january-2024\\_web.pdf](https://www.consilium.europa.eu/media/69285/forward-look-2024_10-january-2024_web.pdf)
- <https://op.europa.eu/s/y6lw>
- <https://doi.org/10.2760/145751>

### Hunger as a weapon - Ukraine war goes on

Russia uses the trade agreement with Ukraine as a threat to African and other countries where hunger is increasing and the prices for food, too. He forces these countries into agreements on grain. Nevertheless, Ukraine is already exporting 40% of the grain (in 2023) via Europe and less by ship as the bombing of Ukraine's harbours goes on.

Sources:

- <https://www.zdf.de/nachrichten/politik/getreideabkommen-putin-afrika-ukraine-krieg-russland-100.html>
- <https://www.handelsblatt.com/politik/international/getreide-aus-der-ukraine-eu-bremst-plaene-russlands-/29269650.html>

**War on resources**

With the world's population on the rise, a struggle for resources is inevitable. Basic food supply is the first step. Hunger can also be used as a weapon. As a result of a shortage of food, wars can arise.

Sources:

- <https://www.un.org/en/land-natural-resources-conflict/pdfs/Resource%20Rich%20Economies.pdf>
- World population: UN World Population data, <https://www.un.org/development/desa/pd/>
- <https://population.un.org/wpp/>
- <https://www.populationpyramid.net/>

**Trade agreements and international food governance**

Analysing the impact of trade agreements and international governance on the global food industry.

Sources:

- <https://www.worldscientific.com/doi/10.1142/10606-vol3#t=aboutBook>
- <https://doi.org/10.24406/publica-2992>

**Food security and access** (to outcomes of the food system)

Addressing issues related to food security, equitable access to food, and reducing food disparities is a geopolitical theme and power play.

Source:

- <https://www.nature.com/articles/s41893-021-00784-6>

**Food sovereignty and local food movements**

Supporting local food systems and the rights of farmers to have control over their food production and distribution.

Source:

- <https://www.frontiersin.org/articles/10.3389/fsufs.2021.686492/full>

**Public-private partnerships in food industry initiatives**

Exploring collaborations between public and private sectors to address food-related challenges and promote sustainability

Source:

- <https://www.sciencedirect.com/science/article/pii/S2211912421000961>

**Policy support to food and agriculture**

(Global) Policy support to food and agriculture for improving affordability of a healthy diet. Repurposing existing fiscal subsidies is found to provide the largest improvement in the affordability of a healthy diet, particularly if they are shifted from producers to consumers. In this case, agriculture's GHG emissions are found to fall, but there are potential trade-offs in poverty reduction, farm incomes, total agricultural output and economic recovery.

Source:

- <https://www.fao.org/documents/card/en/c/cc3017en>: p. 87 ff.

### **Regulation of food ingredients, especially fat and sugar**

Various countries levy a tax on ingredients in foods that are harmful to health, such as fat and sugar, in order to control consumer behaviour. Companies then adjust the recipes of their food and beverages in these markets. In some countries, there is already a tax on sugar, in other countries, this is discussed.

Sources:

- <https://onlinelibrary.wiley.com/doi/full/10.1111/nbu.12460>
- <https://doi.org/10.1016/j.healthpol.2022.06.002>
- <https://doi.org/10.1371/journal.pmed.1003412>

### **The future of the Common Agricultural Policy (CAP)**

The Common Agricultural Policy (CAP) remains a cornerstone of European integration. Like any venerable entity, the CAP has undergone multiple changes during its existence. In each version, the CAP focused on a set of objectives, mobilised a series of policy instruments, and allocated budget. There are different paths into the future of the CAP imaginable.

Sources:

- [https://www.researchgate.net/publication/357826445\\_Modelling\\_environmental\\_and\\_climate\\_ambition\\_in\\_the\\_agricultural\\_sector\\_with\\_the\\_CAPRI\\_model](https://www.researchgate.net/publication/357826445_Modelling_environmental_and_climate_ambition_in_the_agricultural_sector_with_the_CAPRI_model)
- [https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance\\_en](https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en)
- [https://agriculture.ec.europa.eu/common-agricultural-policy\\_en](https://agriculture.ec.europa.eu/common-agricultural-policy_en)
- [https://multimedia.europarl.europa.eu/en/video/timeline-the-common-agricultural-policy\\_N01-AFPS-210920-TCAP](https://multimedia.europarl.europa.eu/en/video/timeline-the-common-agricultural-policy_N01-AFPS-210920-TCAP)

### **Conflict China versus US concerning Taiwan is threatening food chains**

The conflict between China and the USA over the island republic of Taiwan continues to heat up. China wants to "re-unify" with Taiwan, but this is an important ally for the US. On the other hand, China is more and more a rival on international markets. The major threat concerns the global food chains that may be disrupted in such a conflict. China is dependent on imports, but the same for Taiwan. And for many foods and resources, African countries and even Europe are dependent on China. The interwoven situation of global trade will be challenged by this potential conflict and is already by the threat with this conflict on a potential horizon. Most countries react with general strategies or in a military way. The U.S. military is apparently working to increase the range of its missiles, the Reuters news agency reports, citing two congressional staffers and two U.S. officials. According to the report, the U.S. government is considering upgrading its weapons to give the U.S. military an advantage in the Pacific and to be able to operate farther away from China.

Sources:

- [https://www.t-online.de/nachrichten/ausland/internationale-politik/id\\_100218228/china-und-die-usa-im-taiwan-konflikt-ringgen-zwischen-den-supermaechten.html](https://www.t-online.de/nachrichten/ausland/internationale-politik/id_100218228/china-und-die-usa-im-taiwan-konflikt-ringgen-zwischen-den-supermaechten.html)
- <https://www.auswaertiges-amt.de/blob/2608578/810fdade376b1467f20bdb697b2acd58/china-strategie-data.pdf>
- <https://www.foreignaffairs.com/china/xis-plan-chinas-economy-doomed-fail>
- <https://www.foreignaffairs.com/china/end-china-economic-miracle-beijing-washingtonhttps://www.foreignaffairs.com/india/can-india-bring-russia-and-ukraine-table>

### India's rice ban could trigger a global food crisis

On 20 July, India banned exports of non-basmati white rice in an attempt to calm rising domestic prices at home. This was followed by reports and videos of panic buying and empty rice shelves at Indian grocery stores in the US and Canada, driving up prices in the process. There are thousands of varieties of rice that are grown and consumed but four main groups are traded globally. The slender long grain Indica rice comprises the bulk of the global trade, while the rest is made up of fragrant or aromatic rice like basmati; the short-grained Japonica, used for sushi and risottos; and glutinous or sticky rice, used for sweets. But can India feed the world during Ukraine war? India is the world's top rice exporter, accounting for some 40% of the global trade in cereal. (Thailand, Vietnam, Pakistan and the US are the other top exporters).

Source:

- <https://www.bbc.com/news/world-asia-india-66360064>

### Germany's Lieferkettengesetz (Supply Chain Act) with effects on Food Systems

If Germany is only trading with democracies, the supply chains will be shorter or shrink – the world will get smaller. A similar EU law is under discussion.

Sources:

- <https://link.springer.com/content/pdf/10.1007/s10273-022-3225-1.pdf>
- <https://doi.org/10.1515/ngs-2022-0005>

## 5.7 Resources and Energy

### Competition for naturals

Projections for 2050 suggest the emergence of growing scarcities of natural resources for agriculture (Alexandratos and Bruinsma 2012). Intensified competition for these resources could lead to their overexploitation and unsustainable use, degrading the environment and creating a destructive loop whereby resource degradation leads to ever increasing competition for the remaining available resources, triggering further degradation. For millions of farmers, foresters, pastoralists and fisher folk, this could create insurmountable barriers to improving their livelihoods and escaping poverty.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- <https://www.fao.org/3/ap106e/ap106e.pdf>

### Sustainable seafood sourcing and fisheries management

Supporting sustainable fishing practices and responsible management of marine resources.

Source:

- <https://onlinelibrary.wiley.com/doi/full/10.1111/faf.12159>

### Sustainable use of water systems and resources

A territorial governance of water that ensures sustainability of clean water supplies and sufficiency of water resources emerges under the pressure from climate change and environmental degradation. The threat of a severe conflict resulting

from shrinking water resources has brought about a GVN, where global, national and regional public and private actors rise to ensure adequate water supply for all. Water scarcity and efficient water management is needed everywhere, especially developing water-efficient irrigation techniques and sustainable water management practices in agriculture.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- <https://www.mdpi.com/2073-4441/7/3/975>

### **Origin of the bio-based raw material and resources matter**

As companies replace fossil with bio-based resources, the demand for bio-based resources increases. Europe does not have the area or the capacity to satisfy its complete demand through self-sufficiency. Imports of bio-based foods will be necessary, even if the EU and its member states increase their effort to grow renewable resources.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Relationship between energy price, automation and manual labour**

The energy/labour relationship was the foundation of the Industrial Revolution. Most technological processes use "industrial energy" to replace the "human energy" previously used to do the same tasks manually. This has been possible due to the availability of cheap energy. Even though such processes usually increase their energy efficiency over time, were the energy prices to sustainably increase, many energy-intensive processes would become unprofitable. For necessity goods like foodstuff, this means that an increased share of manual labour would be necessary to produce enough of them to meet their demand.

Source:

- <https://www.sciencedirect.com/science/article/pii/S0921800919310067>

### **Energy production in competition with food production**

Biogas production is in direct competition for resources that can also be used in food production. But also photovoltaics are in competition with spaces that can be or are used for agricultural production. On the other hand, there are many improvements in combining both food and energy production. As the share of regenerative energy is supposed and politically wanted to rise, this competition may come up in new forms.

Sources:

- EurObserv'ER: The State of Renewable Energies in Europe 2022, Paris 2023
- <https://www.eurobserv-er.org/online-database/>
- ÖKOLOGIE & LANDBAU 02, 2023, <https://www.oekom.de/zeitschrift/archiv/oekologie-und-landbau-5>



**No land and competition for land**

Competition for land: energy crops and photovoltaics versus land-use for agriculture versus investment in land (+unuse).

Source:

- <https://onlinelibrary.wiley.com/doi/full/10.1111/agec.12057>

**Energy shortage**

Energy supply failures have far-reaching consequences for the nutrition of the population along the entire value chain. In the primary sector, problems can arise with harvesting. In the secondary sector, cold chains or food processing can be interrupted. In the wholesale and retail sectors, cold chains may also be disrupted or stores may close, putting supplies at risk. Restaurants and special facilities, such as nursing homes, could be temporarily unable to supply food or would have to cease operations. For private households, food could spoil if there is no refrigeration or supplies are not prepared due to lack of energy.

Source:

- <https://www.wri.org/insights/triple-threat-water-energy-and-food-insecurity>

**Resource utilisation increase**

Global consumption of energy, water, and other strategic resources is drastically increasing. This relates to fossil energies, fresh water, minerals, and metals. Rising energy and resource consumption is being driven by population growth and economic development, particularly in developing countries and emerging economies. Even though fossil resources will continue to play a major role in future energy supply in terms of managing and mitigating the impacts of climate change, other natural resources to realise and facilitate progress in the creation of renewable energy will be needed. Improved energy efficiencies and decentralised power supplies will become more important.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

**Rise in Energy Consumption**

The global primary energy demand is expected to increase by 37% between 2012 and 2040. In 2040, the largest consumers will be industry (rise in energy demand by 40%), transportation and commercial and residential buildings.

Sources:

- FOSTER topic modeling
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

**Energy efficiency and renewable energy in the food industry**

Implementing energy-saving technologies and utilizing renewable energy sources in food production and processing.

Source:

- <https://www.mdpi.com/1996-1073/13/17/4285>

### Sustainable sourcing of ingredients and raw materials

Promoting responsible sourcing practices to minimise environmental impact and ensure sustainability of resources.

Source:

- <https://direct.mit.edu/glep/article-abstract/18/2/93/14916/Sustainably-Sourced-Junk-Food-Big-Food-and-the>

### Synergies between food and bioenergy industries

From the use of foodwaste and industrial residues from the food industry to produce biofuels, to the co-location of food manufacturing and biorefining. The fact that the bioenergy industry and the food industry work with overlapping raw materials not only introduces competition between them, it can also enable the articulation of a number of synergies.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S096085241731012X>
- <https://www.sciencedirect.com/science/article/pii/S0960308519304717>
- <https://onlinelibrary.wiley.com/doi/10.1002/jsfa.7596>
- [https://www.nordicenergy.org/wordpress/wp-content/uploads/2019/04/Food-Waste-to-Biofuels\\_FINAL.pdf](https://www.nordicenergy.org/wordpress/wp-content/uploads/2019/04/Food-Waste-to-Biofuels_FINAL.pdf)
- <https://www.sciencedirect.com/science/article/pii/S2772416623000372>

### Food shortage

In principle, food scarcity is not a problem in richer countries, at least in the short and middle term. Although some goods are becoming significantly more expensive as a result of inflation, a long-lasting shortage of food cannot be recorded. In the Corona pandemic, specific features emerged in individual areas that can be analysed in more detail on the basis of broad evidence. In rich countries, economic inequality is the biggest problem when food is scarce and prices rise. There may be individual cases of malnutrition or nutritional poverty.

Sources:

- <https://www.mdpi.com/1660-4601/16/10/1804>
- <https://medium.com/@martinknapp/why-there-is-a-growing-global-food-shortage-what-it-will-look-like-daca19b6ec73>
- <https://medium.com/illumination/how-to-prepare-for-a-food-shortage-while-the-shelves-are-still-full-4c1b8f662251>
- <https://medium.com/tea-with-mother-nature/food-shortage-they-werent-kidding-4903d3013ede>
- <https://medium.com/@adebayoadeniran/are-britain-and-america-at-risk-of-a-chronic-food-shortage-65b51f118b5>

### Fertiliser shortage

It is necessary to observe whether shortages of fertilisers occur and how they can be compensated. Certain raw materials could be subject to shortages in the coming years, such as phosphates, among others. The competition of biomass energy generation and manure availability plays into this question.

Sources:

- <https://www.nature.com/articles/493163b>

### Specific resources missing or lagging for the energy transition

Despite the continued technological advancements and the possibility to replace materials, there may not be enough resources, or they may not be available fast enough, to make the energy transition, which would affect food industry. If

this is the case, mine construction and geopolitical risks are more likely to be the reason than the actual lack of minerals available, although there is no consensus.

Sources:

- [https://www.cell.com/joule/fulltext/S2542-4351\(23\)00001-6](https://www.cell.com/joule/fulltext/S2542-4351(23)00001-6)
- <https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary>
- [https://tupa.gtk.fi/raportti/arkisto/42\\_2021.pdf](https://tupa.gtk.fi/raportti/arkisto/42_2021.pdf)

### **Competition between food and bioenergy industries**

The higher methane yield and convenience could incentivize some biogas plants to source feedstock that could be used by the feed industry. Therefore, nations should implement legislation to ensure that feedstock available for feed does not get diverted to the biogas industry. Furthermore, due to the limited availability of raw materials, many countries in Europe are suffering from an increase in the prices of feed materials.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S2211912418301366>
- [https://fefac.eu/wp-content/uploads/2022/07/22\\_DOC\\_106.pdf](https://fefac.eu/wp-content/uploads/2022/07/22_DOC_106.pdf)
- <https://www.sciencedirect.com/science/article/pii/S0959652613002060>

## **5.8 Mobility**

### **New Food logistics and transportation of food products on a small scale**

Improving the efficiency and sustainability of food transportation and distribution networks. Good solutions on how to solve the transport and logistics of small-scale food products in the most efficient and innovative way. Good examples of food hubs. Innovative solutions to organise transport.

Sources:

- <https://doi.org/10.1016/j.spc.2020.10.002>
- <https://doi.org/10.1016/j.ijpe.2020.107746>

### **Last-mile delivery and urban mobility solutions**

Addressing the challenges of delivering food to urban areas and exploring sustainable mobility options. Delivery Drones are one example. The drone market is expected to grow from USD 360.83 million by 2022 to USD 1.13 billion by 2030 at a CAGR of 53.94% during the period 2023-2030. A large share will be delivery drones for everything from medicine to food.

Sources:

- <https://doi.org/10.1016/j.retrec.2019.100805>
- <https://doi.org/10.1007/s11116-020-10134-8>
- <https://doi.org/10.3390/su13115894>
- <https://onlinelibrary.wiley.com/doi/full/10.1111/poms.13289>
- <https://www.snsinsider.com/sample-request/1123>

### **Food delivery platforms and gig economy**

Examining the impact of food delivery platforms and the gig economy on the food industry and employment. There is a huge influence assumed, but the data about the real impact are unclear.

Sources:

- <https://journals.sagepub.com/doi/full/10.1177/0896920520949631>
- <https://onlinelibrary.wiley.com/doi/full/10.1111/ntwe.12183>

### **Mobile food solutions and food trucks**

Exploring mobile food concepts and food trucks as flexible and innovative food service options.

Sources:

- [https://link.springer.com/chapter/10.1007/978-3-030-34492-4\\_17](https://link.springer.com/chapter/10.1007/978-3-030-34492-4_17)
- <https://link.springer.com/article/10.1007/s11042-022-13758-3>
- <https://www.sciencedirect.com/science/article/pii/S0040162522002992>

### **Mobile slaughterhouses and direct food commerce via alternative channels**

Animal producers face specific difficulties in commercializing their product through alternative channels. In this regard, arising small and mobile slaughterhouses, as well as local/shared processing plants can provide great solutions. An EU regulatory framework is necessary, which describes the requirements for the Member States to create a regulation on mobile or community used slaughterhouses. The aim is greater autonomy and the opportunity for those in the food supply chain operating small livestock breeding farms and have the willingness to improve animal welfare by reducing the transportation time of the animals and the sustainability of animal processing with high-quality meat products.

Sources:

- <https://www.foodsystemchange.org/networking/niche-innovations/mobile-slaughterhouses>
- <https://cantekgroup.com/Mobile-Container-Cattle-Slaughterhouse>

### **Pick-Up Points in E-Commerce**

Pick-up points are positioned at diverse locations throughout major city centres and provide an alternative to delivering to individual places.

Source:

- <https://www.mdpi.com/2071-1050/14/14/8521>

### **Drone food delivery service**

The possibility of drone usage (air as well as ground drones) for food delivery is met with enthusiasm by businesses as it promises instantaneous benefits such as reduced costs, improved customer satisfaction, and reduced environmental imprint.

Sources:

- <https://doi.org/10.1080/10548408.2020.1862023>
- [https://fhg-primo.hosted.exlibrisgroup.com/permalink/f/1dgd1pa/TN\\_cdi\\_crossref\\_primary\\_10\\_3390\\_joitmc7020144](https://fhg-primo.hosted.exlibrisgroup.com/permalink/f/1dgd1pa/TN_cdi_crossref_primary_10_3390_joitmc7020144)

**E-Hailing**

E-Hailing services are considered as on-demand vehicles that affect the efficiency of food delivery. They are used for the direct transport from producer to customer. This system improves the process of collecting and sending orders from customers in a short period of time.

Sources:

- <https://doi.org/10.30880/ijscet.2023.14.02.003>
- <https://publisher.uthm.edu.my/ojs/index.php/IJSCET/article/view/13457>

**Automated micro-vehicles**

The current discussion of automated vehicles mainly focuses on road-based passenger cars. However, automated micro-vehicles for delivery purposes might be more lucrative and even earlier available on the market. (delivery robots) They are supposed to deliver on the last mile.

Source:

- <https://doi.org/10.1016/j.ifacol.2019.11.575>

**Electric and autonomous vehicles in food transportation**

Incorporating electric and autonomous vehicles to reduce emissions and enhance efficiency in food transportation.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0198971521000934>
- <https://www.sciencedirect.com/science/article/pii/S0739885919302690>
- <https://www.mdpi.com/2199-8531/7/2/144>
- <https://www.mdpi.com/2071-1050/14/5/2922>

**Pipeline for food production and delivery**

The invention discloses an environmentally intelligent pipeline type device for food production and delivery in a building and an installation way and using the method of a navigation system of the same. Included are a direct-to-home (DTH) pipeline network, a pipeline electric vehicle, an intelligent navigation system and a production and processing line area. The DTH pipeline network is installed on an outer wall of a building or adjacent to a smoke vent, extends into every kitchen in the building, and then communicates with the production and processing line area adjacent to the building to adjust the intelligent navigation system. In use, a user orders a meal through the system at home, then a cook places a processed dish into a delivery container which goes in the DTH pipeline network to the kitchen of the user on its own via the pipeline electric vehicle according to a command of the system, and thus, by means of the device for production and delivery and the installation way thereof, the user can have freshly cooked food at home. Meanwhile, the invention can be used for delivery of fresh fruits and vegetables, and small household items.

Source:

- [https://fhg-primo.hosted.exlibrisgroup.com/permalink/f/1dgd1pa/TN\\_cdi\\_epo\\_espacenet\\_CN104156839A](https://fhg-primo.hosted.exlibrisgroup.com/permalink/f/1dgd1pa/TN_cdi_epo_espacenet_CN104156839A)

### **Coupling photovoltaics with transport refrigerated units**

Numbers of refrigerated transports are recording an impressive growth due to increased demand for chilled and frozen food. They require fuel consumption for traction, but also for feeding the diesel-driven refrigeration unit, which maintains the desired internal vehicle temperature. A photovoltaic integrated delivery process is investigated, in order to foster renewable energy penetration into the cold chain, thus improving its sustainability. It involves photovoltaic panels installed on the rooftop of semitrailers, a battery bank and a power conversion system to cover refrigeration requirements, removing the diesel engine from the refrigeration unit.

Source:

- <https://www.sciencedirect.com/science/article/pii/S0360544221012421>

### **Cars as policy issue**

Cars/vehicles driven with fossil fuels are a policy issue, but they are needed for transport in agriculture – electric cars are no real solution in many cases.

Source:

- <https://doi.org/10.1016/j.landusepol.2019.05.033>

### **Reusable food containers**

Delivery food packaging has a high environmental impact, which can be addressed by re-useable food containers.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S095965262202604X>

### **New Food Delivery and Waste Collection System Onboard Commercial Transport Aircraft**

The objective of this paper is to identify the driving needs for an improved food delivery and waste collection system to be implemented onboard of the commercial passenger transport aircraft. Quality Function Deployment (QFD) method has been applied to establish the design requirements from the point of view of the passengers and airlines. The collected data from conducted public survey and also interview sessions with the experts from the airlines are utilised to construct the House of Quality (HOQ). In short, it has been found that safety and cleanliness are the two top prioritised design requirements for a new food delivery and waste collection system. On the other hand, the type of carriage, the overall profile of the system and also the operating mechanism used for the system are top technical design parameters that can influence the successful achievement of the design requirements. Findings from this study will be further utilized to generate design options for the improved food delivery and waste collection system.

Source:

- <https://www.ijitee.org/portfolio-item/C8966019320/>

## 5.9 Societal and Cultural Patterns

This driver of societal patterns includes culture, values, religious practices etc. as drivers.

### Divided Societies

Societies are more and more divided in Haves and Have nots. In Europe, this can be observed in the health system (European Commission 2020) but also in nutrition: those without adequate income cannot afford quality food, sometimes even not a sufficient quantity of food.

Sources:

- <https://doi.org/10.2777/045403>
- <https://doi.org/10.2777/025150>
- <https://doi.org/10.1038/s43016-022-00479-x>

### Inflation drives micro farming cultures

Inflation causing a shift towards micro/macro farming adapted to own cultures as a solution because it becomes cheaper to produce yourself.

Source:

- <https://www.theguardian.com/global-development/2020/sep/25/money-is-worth-nothing-now-how-lebanon-is-finding-a-future-in-farming>

### Sustainable lifestyle

The advancing climate change and numerous ecological problems move a group of the population to a sustainable way of life. This manifests itself in the way of mobility, nutrition, housing or travel.

Source:

- <https://www.unep.org/explore-topics/resource-efficiency/what-we-do/sustainable-lifestyles>

### Society 5.0

Society in the 21st century is characterised by a high degree of digitalization, which is greatly changing the way people work and live. This creates new social challenges and new opportunities to use the possibilities of digital transformation for a better life together. People are part of a system, that communicates on all levels (IoT, human-centric system...) and where everything is connected.

Sources:

- [https://books.google.de/books?id=b1G\\_EAAAQBAJ&lpg=PA2002&dq=Sharma%20and%20Garg%202024&lr&hl=ca&pg=PA2002#v=onepage&q=Sharma%20and%20Garg%202024&f=false](https://books.google.de/books?id=b1G_EAAAQBAJ&lpg=PA2002&dq=Sharma%20and%20Garg%202024&lr&hl=ca&pg=PA2002#v=onepage&q=Sharma%20and%20Garg%202024&f=false)
- <https://www.overdrive.com/media/9342517/society-5-0-digital-transformation-and-disasters>
- <https://doi.org/10.1007/978-3-030-95112-2>
- [https://www8.cao.go.jp/cstp/english/society5\\_0/index.html](https://www8.cao.go.jp/cstp/english/society5_0/index.html)

### Social innovation in the food system

Social innovation plays a pivotal role in transforming today's food systems into ones that are economically and socially feasible, and sustainable within planetary boundaries.

Source:

- <https://www.eea.europa.eu/publications/reimagining-the-food-system-the>

### **Agribusiness in the future - future farmers**

Future farmers are different – well educated and equipped with technology. They make use of technological potential on the one hand, and soil protection on the other (less heavy machinery). There are different scenarios about how they are seen and what kind of farmers we may see. Their image changed. And there is enormous potential to use crop protection products more and more precisely thanks to technical progress. On the other hand, there must be a return to less heavy machinery in order to prevent further soil compaction. Compacted soils are finding it increasingly difficult to absorb rain, which increases the risk of flooding during heavy rainfall.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Growing importance of animal welfare in the food system**

The importance of animal welfare in food systems is growing. More and more consumers are aware of animal situations in food production and are either going vegetarian or insisting on better living conditions for cattle and other animals. Labels in supermarkets already take up this change and in some EU countries, there is a labelling system on animal products informing about where the meat stems from and under which conditions, the animal lived.

Source:

- [https://www.europarl.europa.eu/RegData/etudes/STUD/2017/583114/IPOL\\_STU\(2017\)583114\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2017/583114/IPOL_STU(2017)583114_EN.pdf)
- <https://www.fondation-droit-animal.org/proceedings-aw/the-european-union-legislation-on-animal-welfare/>
- <https://www.coe.int/en/web/cdci/protection-of-animals>

### **Spoiled consumers in some European countries**

In many European Union countries, consumers did not suffer from hunger during the last 30 years so the consumers are spoiled and expect every kind of food available anytime, anywhere etc. These people do not understand if something is not available – now, when they demand it. They throw away what they do not eat, anymore, still good or not. This is also linked to the fact that often, these consumers consider food extension dates (Mindesthaltbarkeitsdatum in German language) printed on food as expiration date. They often throw away food just because the extension date is over – and create a lot of food waste. This is contrary to "food is never waste".

Source:

- <https://reliefweb.int/report/world/food-security-commission-steps-support-global-action-transform-food-systems-eight>

### **Discounter versus Delicatessen and specialised trade**

In many European countries, discounters have displaced classic specialty retailers such as bakeries, butchers and greengrocers. Discounters offer all product categories under one roof and enable a speedy and inexpensive shopping experience.



Source:

- <https://de.statista.com/themen/1291/lebensmittel-discounter/>

### **Rise of alternative food channels (food trucks, pop-up restaurants)**

Exploring the growing popularity of unconventional food outlets like food trucks and pop-up restaurants, which are temporary restaurants. These restaurants often operate from a private home, former factory, existing restaurants or similar space, and during festivals.

Sources:

- [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2560695;](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2560695;)  
<https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1051&context=dgs>

### **On-demand and personalized food delivery services**

Meeting consumer demand for fast, customized, and convenient food delivery services.

Source:

- <https://de.statista.com/themen/3440/food-delivery-lieferdienste-lieferservice-portale/>

### **Rise of food experiences and food tourism**

Observing the increasing interest in immersive food experiences and culinary tourism.

Source:

- <http://kulinarischer-tourismus.de/forschungsergebnisse/>

### **Convenience-driven food products and snacking culture**

Examining the demand for convenient and snackable food options.

Source:

- <https://de.statista.com/outlook/cmo/lebensmittel/convenience-food/deutschland>

### **Ethical and sustainable consumer choices**

Analysing the influence of ethical and sustainable factors on consumer food purchasing decisions.

Sources:

- <https://www.nachhaltigeernaehrung.de/Grundsaeetze.40.0.html>
- [www.ethicalbutcher.co.uk](http://www.ethicalbutcher.co.uk)
- [www.pastureforlife.org/trace-your-meat/](http://www.pastureforlife.org/trace-your-meat/)

### **School Meals Coalition**

School Meals Coalition is a European Union project focussing on improving the quality and expanding the scale of school meals programmes globally as a platform to reach communities. The global coalition will back investments from the European side that has proven positive effects on small farm livelihoods, such as participation in farmer's organisations, extension services for women farmers, vocational programmes for rural youths, storage and cold chains.

Source:

- <https://reliefweb.int/report/world/food-security-commission-steps-support-global-action-transform-food-systems-eight>

### **Price sensitive consumers**

Price-sensitive consumers – good examples to increase consumer engagement with local products. There are countries where price is the decisive criterion, even though this should not be the case from an economic point of view. For many people and some cultures, however, food and high-quality food are less important than holidays, cars, etc. Food is instead relegated to a mere source of energy. Hungarian or German consumers for example are very price sensitive. How do you get consumers in these countries to consume more local, regional products and potentially pay a "real price"? What marketing and sociological methods are available to do this?

Source:

- proposed by CDIs

### **Origin of the bio-based raw material and resources matter**

As companies replace fossil with bio-based resources, the demand for bio-based resources increases. Europe does not have the area or the capacity to satisfy its complete demand through self-sufficiency. Imports of bio-based foods will be necessary, even if the EU and its member states increase their effort to grow renewable resources.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Greenhushing**

Greenhushing means that everything for consumers is "greened" – especially in advertising. Claiming environmentally friendly products, climate-friendly products or notions with "sustainable" in them are more and more prominent. There is resistance from the food industry to the EU Commission's plans to regulate environment-related advertising more strictly. "Greenhushing" is the bogeyman being used to stir up opposition to the planned directive, writes Jochen Geilenkirchen of the Federation of German Consumer Organizations. But there is no threat of "green silence" about environmental properties, he says. Rather, consumers would be given better guidance when buying sustainable food.

Source:

- <https://background.tagesspiegel.de/energie-und-klima/briefing/greenhushing-ist-nichts-als-ein-schreckgespenst>

### **Cultural food habits**

Human food consumption habits globally pose a significant threat to public health and ecological sustainability. But changing our food habits is not easy due to the deep core physiological mechanisms of the human body that determine our food preferences. In effect, we cannot resist the influence of some flavours and smells. The EU-funded OLFINK project aims at research that will explain how new flavour preferences are formed. In this context, it will study the processes that drive the acquisition of flavour preferences and their regulation through signals from the digestive tract. The project will enable new methods to facilitate changing dietary habits for the better. Awareness of the urgency for

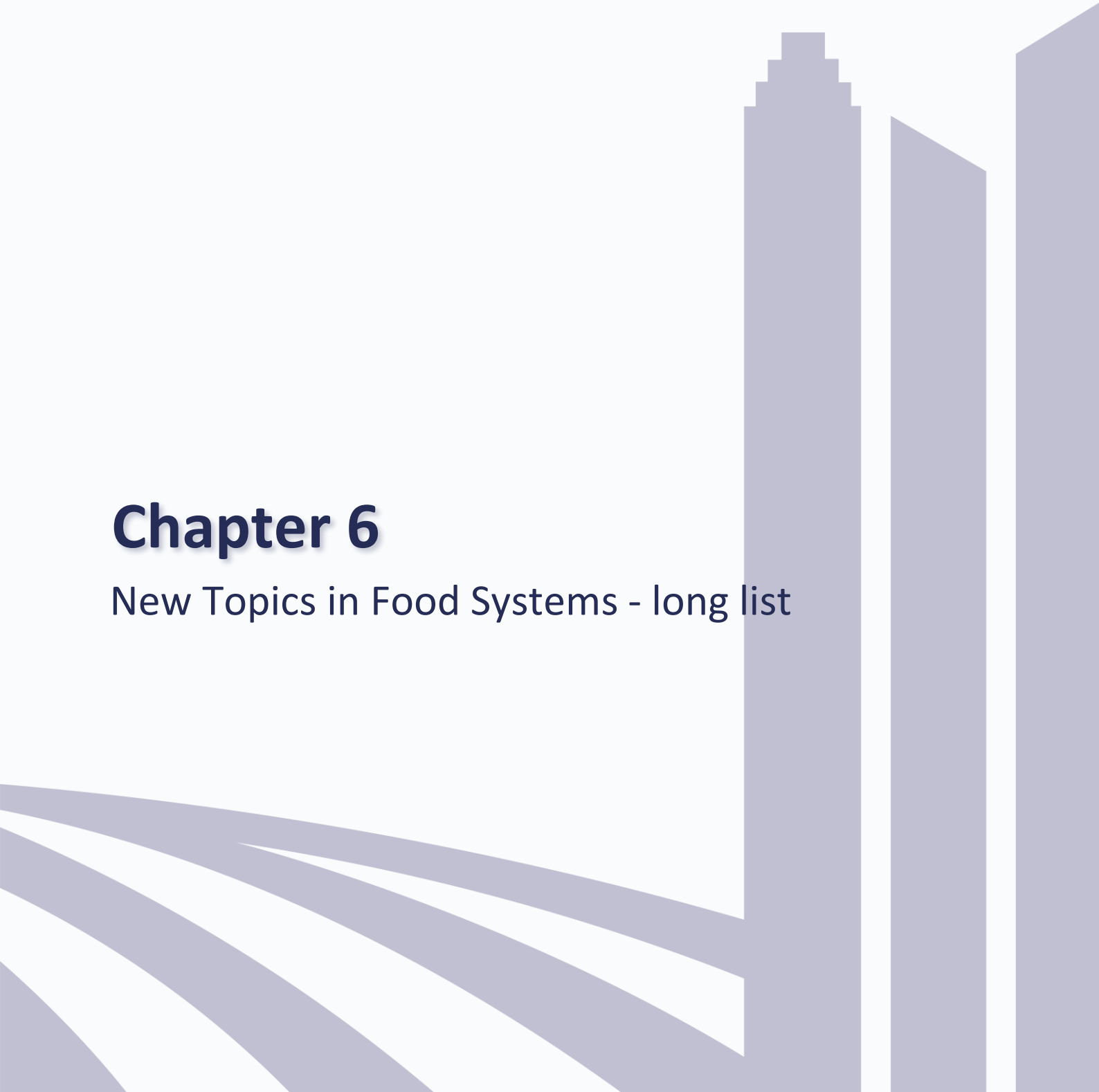
large-scale global changes has recently been growing substantially; yet, overcoming preferences for familiar food flavours in favour of healthier or more sustainable options remains a major challenge. The OLFLINK project helps addressing this challenge by uncovering processes that link olfactory perception inside and outside the mouth across three levels of investigation thereby discovering key factors that facilitate or hinder the acquisition of new flavour preferences. Olfaction as the link between flavour preference formation and retrieval during food consumption.

Sources:

- [https://erc.europa.eu/sites/default/files/2023-06/H2020\\_factsheet-Food.pdf](https://erc.europa.eu/sites/default/files/2023-06/H2020_factsheet-Food.pdf)
- <https://cordis.europa.eu/project/id/947886>

# Chapter 6

New Topics in Food Systems - long list



## Chapter 6 – New Topics in Food Systems

### 6. New themes, newly framed topics and issues in the Food System

The following topics and themes in food systems were identified as new and relevant for the CDIs of the project FOSTER. They are presented and structured along the lines of the food system framework in Figure 1. They are very selective and serve for further work with the CDIs and in the consortium. The sources mentioned are not exhaustive but the ones where we first detected the issue. They are exemplified, and there are definitely many others, which can be found under this headline in the Web of Science or Dimensions.ai. **Focussing on the aim of the FOSTER project, these are the most relevant ones for the CDIs at the current stage of the project.**

#### 6.1 Producing

##### Biodiversity loss

The biodiversity of natural eco-systems provides important, although largely unvalued services (e.g. food provisioning, water purification, flood and drought control, nutrient cycling, and climate regulation) to both human populations and the environment. At a global level, as well as in most regions, biodiversity has been declining for decades. Human intervention in the biosphere is leading to a loss of biological diversity. If the destruction of ecosystems and related services will not be addressed sustainably, losses will be irreversible. Moreover, certain benefits from ecosystems might be lost completely.

Sources:

- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

##### Agriculture (re-)territorialisation

With the COVID-19 crisis, the possibility of having a disruption in the supply chain has emerged as a major concern (UN 2020). In 2021, the obstruction of the Suez Canal by the Evergreen gave international trade a cold sweat. In 2022, the war in Ukraine has been causing dangerous tensions in food markets and food insecurity.

Source:

- <https://link.springer.com/article/10.1007/s11625-022-01211-1>

##### Sustainable aquaculture and seafood farming

Implementing environmentally friendly practices in fish and seafood production.

Sources:

- [https://link.springer.com/chapter/10.1007/978-3-031-10812-9\\_8](https://link.springer.com/chapter/10.1007/978-3-031-10812-9_8)
- <http://sifisheriessciences.com/journal/index.php/journal/article/view/1677>

### Smart Irrigation

AI algorithms optimize irrigation practices by analysing data on soil moisture levels, weather forecasts, and plant water requirements. This data-driven approach ensures efficient water usage, reducing water waste and improving crop health. AI can also adjust water delivery based on real-time conditions, and reduce manual labour requirements.

Source:

- <https://www.sciencedirect.com/science/article/pii/S2772427122000791>

### Climate Smart Agriculture (CSA)

CSA is designed to increase agricultural productivity while reducing greenhouse gas emissions sustainably by Carbon sequestration. It can be both a natural or an artificial process that removes carbon dioxide (CO<sub>2</sub>) from the atmosphere, mitigating its warming effect. CSA practices for example in India range from conservation agriculture and agroforestry to efficient water management and crop diversification.

Source:

- <https://www.mdpi.com/2071-1050/10/6/1990>

### Ammonia

Ammonia Market Size is estimated to USD 126.48 Billion by 2030. Around 70% of the ammonia produced industrially is used to make fertilisers in various forms and composition, such as urea and diammonium phosphate. Ammonia in pure form is also applied directly into the soil.

Source:

- <https://www.reportsanddata.com/report-detail/ammonia-market>

### Agroecology Transitioning toward sustainable, climate and ecosystem-friendly farming and food systems

Farming in Europe has been transformed over the last 70 years by policies, technologies and practices that sought to guarantee a stable supply of affordable food. But success has come at the cost of mounting environmental degradation. The EU CORDIS Results Pack highlights 11 EU-funded research projects that demonstrate the potential of more sustainable alternatives. A holistic approach that supports sustainable agricultural production while maintaining robust stewardship of the environment, agroecology works with nature and ecosystem services, increasing the resilience and diversity of farms, and that holds the potential to drive a full transformation of farming and food systems. Agroecology has implications for a span of agricultural practices, from breeds and varieties used, to soil management practices and crop diversification strategies, integration in value chains, and business models that can sustain locally adapted practices and provide greater market opportunities for farmers and consumers. Examples of farming practices implementing agroecological principles are organic farming, agroforestry and mixed farming.

Agroecology has the potential to become a fundamental tool for the EU in its effort to promote a sustainable farming sector that respects planetary boundaries and is able to respond to the changing needs of society both in terms of sustainable and healthy diets and with regard to the environmental and climate issues related to primary production. Research and innovation in this area is opening up new opportunities in farming systems, making it possible to use

ecosystem services to benefit sustainable and resilient land use systems without jeopardising profitability of the farming activity. Agroecology has been identified as a practice that can be supported through the eco-schemes under the first pillar of the Common Agricultural Policy (CAP). It has also been singled out as one of the sustainable farming practices that can help achieve the targets of the EU Green Deal and its related Farm to Fork and Biodiversity strategies. Under Horizon 2020, the EU has funded several research projects dedicated to advancing agroecological research. These projects are contributing to an increased understanding of the practical implementation of ecological and low-input farming practices, along with their environmental, climate and social benefits.

Source:

- <https://cordis.europa.eu/article/id/430692-agroecology-transitioning-toward-sustainable-climate-and-ecosystem-friendly-farming-and-food>

### **Sustainable fertiliser production and nutrient management**

Fertilisers play a fundamental role in food security. Their production and cost are largely dependent on the availability of natural gas, and following Russia's invasion of Ukraine, the world faces a fertiliser crisis that is driving up food prices. This Results Pack on Fertilisers highlights 13 EU-funded research projects that can help alleviate the pressures placed on farmers and consumers, through the innovative synthesis, use and recapture of fertilisers and improved nutrient management. While humans have been practising agriculture for more than 10,000 years, it was revolutionised a century ago by the innovation of synthetic chemical fertilisers.

Today, those transformative inputs are under threat, demanding a new agricultural revolution. By creating healthy soils rich in organic matter and biodiversity, optimising the efficiency of fertiliser use and enhancing the recovery of nutrients from nutrient-rich side streams such as from manure, food waste or sewage sludge, European farmers can produce healthier crops and higher yields while reducing impact and increasing resilience to climate change.

In addition, crop-livestock integration, more environmentally friendly methods of fertiliser production (including the use of green hydrogen), crop diversification and agroecological plant breeds are helping to reduce the EU's dependency on mineral and fossil fertilisers. Market-based solutions are also crucial to a more sustainable agricultural system.

Source:

- <https://cordis.europa.eu/article/id/443142-innovative-research-for-sustainable-fertiliser-production-and-nutrient-management>

### **Multiple land use**

This theme refers to the use of land for more than one purpose, for example, grazing of livestock, recreation and timber production. The term may also apply to the use of associated bodies of water for recreational purposes, fishing and water supply. Land is also more an investment object, less for farming. Land is more and more a construction site. We see a shift in ownership of agricultural land in favour of large corporations, too.

Source:

- <https://www.publish.csiro.au/aj/AJ84027>; [https://www.istage.jst.go.jp/article/irspsd/11/3/11\\_1/article](https://www.istage.jst.go.jp/article/irspsd/11/3/11_1/article)
- <https://www.sciencedirect.com/science/article/pii/S0264837718303971>
- [https://www.unccd.int/sites/default/files/2018-06/6.%20Land%2BUse%2BPlanning%2B\\_G\\_Metternicht.pdf](https://www.unccd.int/sites/default/files/2018-06/6.%20Land%2BUse%2BPlanning%2B_G_Metternicht.pdf)

### Water justice - RIVERHOOD

The world's rivers are fundamental to social and natural well-being but profoundly affected by mega-damming and pollution. In response, diverse new water justice movements (NWJMs) have emerged worldwide. These transdisciplinary coalitions creatively transform local ideas for 'enlivening rivers' into global action and vice versa, with enormous potential for shaping equitable and nature-based water governance. However, their ideas are under-theorised, largely unnoticed by natural and social sciences, and excluded from policymaking. The EU-funded RIVERHOOD project will study and support evolving NWJMs fighting to revitalise rivers in all senses. The project's partners will investigate eight case studies in Europe and South America to develop a new analytical framework to study NWJMs and 'riverhoods' and foster knowledge co-creation and democratisation from the bottom up.

Source:

- [https://erc.europa.eu/sites/default/files/2023-06/H2020\\_factsheet-Food.pdf](https://erc.europa.eu/sites/default/files/2023-06/H2020_factsheet-Food.pdf)

### Alternative proteins and dietary shift

Changing and diversifying our diets can be a way to reduce anthropogenic greenhouse gas emissions from food production, address the challenges of changes in land use and biodiversity loss while providing sufficient, nutritious, safe and affordable food to a fast-growing population. Excess red and processed meat consumption has significant negative effects on human health, especially in Western diets. Many sources of proteins other than meat or milk (e.g. alternative proteins) exist within the current assortment of food products (e.g. edible insects, cultured meat, fungi and microalgae). First countries (e.g. UAE) demonstrate agreement of the population to increase the consumption of alternative proteins. Mushroom threads can be used as a resource for many products and dishes. These dietary shifts and new demand for alternative proteins affect what is and should be produced on a farm level.

Sources:

- Stella Schaller; Lino Zeddies; Ute Scheub; Sebastian Vollmar (2022): Zukunftsbilder 2045. München: oekom verlag.
- <https://www.universityworldnews.com/post.php?story=20230623105222891>
- [https://erc.europa.eu/sites/default/files/2023-06/H2020\\_factsheet-Food.pdf](https://erc.europa.eu/sites/default/files/2023-06/H2020_factsheet-Food.pdf)
- <https://doi.org/10.1016/j.fufo.2021.100086>
- [https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/751426/EPRS\\_BRI\(2023\)751426\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/751426/EPRS_BRI(2023)751426_EN.pdf)
- <https://doi.org/10.1016/j.animal.2021.100287>; <https://doi.org/10.1016/j.foodres.2019.01.041>
- <https://doi.org/10.1016/j.tifs.2020.11.012>

### Closing the Loop in Aquaculture

The challenges that (finfish) aquaculture faces spark interest in a transition from open to (semi-) closed aquaculture facilities. Most of these challenges can be addressed by fully-closed systems as there is a barrier between the cultivated organisms and the natural environment. These systems can either be land- or marine-based, as long as there is no continuous water exchange between the cultivation system and the natural environment. Although requiring significant investments, the transition from open to closed aquaculture has been demonstrated to be economically viable.

Sources:

- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>



## Permaculture

Permaculture strives to design sustainable agricultural systems and human habitats that mimic the patterns and relationships found in natural ecosystems.

Source:;

- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

## Indoor Cultivation Systems

Indoor (urban) farming technologies involve agricultural production in (multi-storey) buildings. Systems such as hydroponics or aquaponics grow plants in soilless nutrient solutions. New technologies such as LED lights make production all year round possible and environmentally friendly. A further advantage of these growing systems is the controlled conditions or the independence of access to soil.

Source:

- [http://www.pertanika.upm.edu.my/resources/files/Pertanika%20PAPERS/JST%20Vol.%2031%20\(4\)%20Jul.%202023/08%20JST-3789-2022.pdf](http://www.pertanika.upm.edu.my/resources/files/Pertanika%20PAPERS/JST%20Vol.%2031%20(4)%20Jul.%202023/08%20JST-3789-2022.pdf)

## Diversified food systems

The food system is considered from field to fork promoting diversified crop varieties, animal breeds and end products, considering a diversity of consumers, diets and needs according to diverse environmental, socioeconomic and cultural contexts in Europe. Diversified food systems show different models, but all focus on sharing added value among stakeholders within networks and regional organizations. They offer conditions to consumers to choose and enjoy a broad range of locally adapted, tasteful, nutritional and healthy, as well as sustainably produced food. The EU Project DIVERSIFOOD offers reflections for embedding crop diversity and networking for high quality food systems.

Source:

- <https://www.sciencedirect.com/science/article/pii/S030691922030035X>

## Impact Assessment

The assessment of the impacts of food production is gaining more and more attention. Especially, the legal frameworks, e.g. in gene editing etc., underly strict regulation. Some tools are available and assessment approaches are under examination.

Sources:

- [www.nagoyaprotocol-hub.de](http://www.nagoyaprotocol-hub.de)
- <https://www.mdpi.com/2225-1154/9/11/164>
- <https://doi.org/10.1016/j.eiar.2023.107175>
- <https://www.fao.org/sustainable-food-value-chains/library/details/en/c/261333/>

## Competition for water - AI/ IT services and industry compete with agriculture

There is competition for water, between industry and agriculture, but also between citizens as water users for their gardens when water is scarce in some regions in summer. What is new is the competition of agriculture with AI and

information technologies as well as all their digital services for water. We do not have them on the agenda as we think that electromobility or any other technical facilities use many resources, especially energy, but not water. Or we hear about the expectations how AI may help to reduce the use of water, but we often forget that AI and IT services or electromobility and their facilities need a lot of water. A study (Li et al. 2023) is examining this. We also know the discussions about the permission of Tesla in Brandenburg to build a huge production facility for e-cars in a region that is scarce of water and expected to compete harshly with agriculture but also with citizens in the regions to get access to water.

Sources:

- Li et al. 2023: <https://arxiv.org/pdf/2304.03271.pdf>
- <https://www.tesla.com/giga-berlin>
- <https://doi.org/10.1016/j.jclepro.2022.133629>

### **Pest control, pesticides, insecticides, fertilisers, and their remainders in food**

Asymmetry: often too many chemicals are used and we find pesticides, remainders of insecticides etc. in all food and the environment. "Over the 40 years span from the early 1960s to the 2000s, global food production has doubled and land use in agriculture has increased by around 10%. However, pesticide use in the same span has increased by more than 15-fold. This means that on roughly the same size of land, we applied at least 15 times more pesticide to secure a 2-fold increase in food production made possible also by other factors such as the much higher use of nitrogen fertiliser (almost 7-fold increase), increased irrigation (1.7-fold) and improved crop genetics. In fact, a number of experts have already voiced against the myth that pesticides are necessary to feed the world. Another shocking fact is that crop damage attributable to pests has slightly increased compared to 50 years ago despite pesticide use has skyrocketed. This suggests that our crops are increasingly susceptible to pest attack and require more pesticide input per unit of crop production due to our poor agroecosystem resilience management.

There is no feasible way to measure the precise damage pesticides have inflicted on human beings and the environment, let alone make a fair comparison to the benefit (crop protection) they have given us. However, while one can argue that saving even just one starving human life could be worth all the damage, it is important to realise that people at present and people in the future are at odds to some extent, mediated by slow ecological processes. Therefore, it is important not to allow the act of saving one life today to become nothing more than an excuse to maintain a status quo that has no future. ..." (citation: <https://medium.com/@marmotian/out-of-sight-a-nerve-wrecking-war-on-eyesores-0fa1f9b75596>).

Sources:

- <https://www.umweltbundesamt.de/en/topics/agriculture/ecological-impact-of-farming/pesticides>
- <https://medium.com/@marmotian/out-of-sight-a-nerve-wrecking-war-on-eyesores-0fa1f9b75596>
- [https://ec.europa.eu/commission/presscorner/detail/en/QANDA\\_22\\_3694](https://ec.europa.eu/commission/presscorner/detail/en/QANDA_22_3694)
- <https://www.conservationevidence.com/actions/139>
- [https://www.foodwatch.org/fileadmin/-INT/pesticides/2022-06-30\\_Pesticides\\_Report\\_foodwatch.pdf](https://www.foodwatch.org/fileadmin/-INT/pesticides/2022-06-30_Pesticides_Report_foodwatch.pdf)
- <https://www.eea.europa.eu/publications/how-pesticides-impact-human-health>

### **Insects - farming and eating**

The interest in insects as food and feed has been growing exponentially in the last years. The farming of insects has an environmental impact which is lower than that of livestock species (they can be fed with biomass left from other

processes, need a much lower income of food per kilogram of bodyweight, need less space area per kilogram of protein produced, see [https://www.3keel.com/wp-content/uploads/2018/02/Food\\_Futures\\_-report\\_0.pdf](https://www.3keel.com/wp-content/uploads/2018/02/Food_Futures_-report_0.pdf)) and are easy to breed. However, eating insects could bring a rise in allergies and legislation is lagging behind.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0924224419302511>
- <https://doi.org/10.1016/j.foodres.2019.01.041>

### **Aquatic and blue foods**

Aquatic and blue foods aim to realise the full potential of sustainable aquatic foods – such as fish, shellfish, aquatic plants and especially algae, captured or cultivated in freshwater or marine ecosystems– to help end malnutrition and build nature-positive, equitable and resilient food systems. This is also an EU project with the same name, and in the future, there will be more and new blue foods.

Source:

- <https://reliefweb.int/report/world/food-security-commission-steps-support-global-action-transform-food-systems-eight>

### **Vertical farming and urban agriculture**

Growing crops in vertically stacked layers or urban settings for efficient land use.

Sources:

- <https://books.google.de/books?id=hEv9DwAAQBAJ&lpg=PA157&dq=Vertical%20farming%20and%20urban%20agriculture&lr&hl=de&pg=PA157#v=onepage&q=Vertical%20farming%20and%20urban%20agriculture&f=false>
- <https://www.tandfonline.com/doi/full/10.1080/14620316.2022.2141666>
- <https://www.freshplaza.de/article/9589346/im-zuge-der-ernahrungswende-konnten-die-stadtischen-grossmarkte-in-den-kommenden-jahren-wieder-an-bedeutung-gewinnen/>

### **Replacing Fish in food**

Overfishing needs to be tackled. One example is by fish replacing products, for example cultivated fish (similar to cultivated meat) or plant-based fish-like products.

Sources:

- <https://www.nytimes.com/2021/09/08/business/alternative-fish-cultivated-seafood.html>

## **6.2 Processing**

In Processing, there were more very detailed new processing methods in our original long list – but they are too detailed for our purposes. Because of the amount of findings and the first assessment stage by the CDIs, we thus limit to the following selection:

### **Nutrient recovery**

An ideal would be that within the framework of food value creation, reusable by-products are generated, whose potential for nutrient recovery is exploited in accordance with the circular economy. Agricultural products not only contribute to nutrition, but also to the production of energy and materials in a sustainable in the sense of a sustainable bioeconomy,

which leads to a change in the way farmers see themselves. The material and energetic use of agricultural raw materials, including residual materials, is an option for substitutes for fossil raw materials, but without having a significant impact on food prices to a significant extent. Biological resources and residual materials are used efficiently and consistently, and the producing economy is converted to a renewable raw material base.

Source:

- [https://www.wissenschaftsrat.de/download/2023/1189-23\\_en.html](https://www.wissenschaftsrat.de/download/2023/1189-23_en.html)
- <https://op.europa.eu/en/publication-detail/-/publication/d1ea6c83-e538-11e7-9749-01aa75ed71a1/language-en>

### Food hygiene

The so-called "food hygiene package", regulating food safety, has a significant influence on SFSCs development. Composed of the Reg. 852/2004 (on the hygiene of all foodstuffs), Reg. 853/2004 (specific hygiene requirements on food of animal origin), and Reg. 854/2004 as amended, it aims at ensuring the safety of the food from farm to fork, in an integrated approach. According to the principle of flexibility, food hygiene rules are to be applied in a way that is proportionate to the risk posed by particular food operations, methods of production or establishments, through two levels of flexibility. Direct supply to final consumers, small quantities and private domestic use may be excluded from the scope of the regulation, while derogation can be applied in specific circumstances from the technical requirements laid down in Annex I and Annex II of Reg. 854/2005 for the benefit of small businesses to facilitate the implementation of HACCP principles. The rules also permit the adoption of national measures adapting the technical requirements in case of small businesses using traditional methods or belonging to regions that are subject to special geographical constraints.

Sources:

- [https://www.isah-soc.org/userfiles/downloads/proceedings/Proc\\_ISAH\\_2007\\_Volume\\_1/04\\_Dwinger.pdf](https://www.isah-soc.org/userfiles/downloads/proceedings/Proc_ISAH_2007_Volume_1/04_Dwinger.pdf)
- <https://www.fsai.ie/enforcement-and-legislation/legislation/food-legislation/game/general-provisions-of-the-hygiene-package>
- Conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain (FAO): <https://www.fao.org/3/y1579e/y1579e02.htm>

### High-pressure processing and selected non-thermal food preservation methods

Preserving food using high pressure instead of heat to retain nutrients and freshness. High-intensity ultrasound processing is one among the several non-thermal processing methods, which is used alone or in combination with other methods. It improves food quality significantly and is thus considered beneficial. It seems to have much potential. Another potential is dedicated to minimal processing with technologies conserving food without using significant heat.

Sources:

- <https://www.scielo.br/j/rpp/a/NtBmHjmqrtqFbxQWFvtwgtb/?lang=en>
- <https://books.google.de/books?id=PyxfEAAAQBAJ&lpg=PP1&dq=food%20processing%20trends&lr&hl=de&pg=PP1#v=onepage&q=food%20processing%20trends&f=false>
- <https://www.mdpi.com/2304-8158/11/1/122>
- <https://www.mdpi.com/2071-1050/13/24/13908>
- <https://www.sciencedirect.com/science/article/pii/S1466856418308841>

### Advanced food packaging and intelligent labels

Introducing innovative packaging solutions and labels with improved functionality and information (see also Storing).

Sources:

- <https://onlinelibrary.wiley.com/doi/epdf/10.1002/adma.202300875>
- <https://link.springer.com/article/10.1007/s00289-023-04734-4>
- <https://onlinelibrary.wiley.com/doi/full/10.1002/pts.2731>

### **Cultured/ In-Vitro Meat**

Cultured, lab-grown or in vitro meat utilizes technology to produce meat from animal (stem) cells without killing the animal. As stem cells can be the source for pretty much every type of cell it might be possible to change the biochemical composition of meat to make it a healthier or specialized dietary product while also reducing concerns around animal welfare. Worldwide start-ups have already been formed to cultivate meat from different animal (stem) cells since 2016.

Sources:

- FOSTER automated search - topic modelling
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>
- <https://gfi.org/science/the-science-of-cultivated-meat/>

### **Tomato paste is the most widespread industrial product worldwide**

Tomato paste is the most widespread industrial product worldwide. Few large companies distribute it and most of it comes from China, California and Europe.

Sources:

- Mahlke, Stefan (2019): Atlas der Globalisierung. Welt in Bewegung. Berlin: Le monde diplomatique, p. 30-31;
- FutuResilience project application: <https://futuresilience.eu/>, <https://cordis.europa.eu/project/id/101094455>, <https://www.isi.fraunhofer.de/en/competence-center/foresight/projekte/futuresilience.html>

### **Natural Preservatives and Milder Processing Methods**

Preservation of food is essential for prolonging shelf-life and ensuring food safety. Modern processing techs aim at gentle preservation, a combination of preservative factors and their interaction and the use of natural rather than chemically synthesised preservatives. Reason behind it is the retention of food quality with high nutritional values for health.

Sources:

- Project Fit4FOOD2030: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

### **High-level machinery in small-scale food chains**

High-level aseptic filling machine in small-scale food processing for improved food safety in short food supply chains.

Source:

- Project FAIRCHAIN: <https://www.fairchain-h2020.eu/>
- <https://ifst.onlinelibrary.wiley.com/doi/full/10.1111/ijfs.16551>

### **Alternative protein sources**

Consumption of sufficient dietary protein is fundamental to muscle mass maintenance and overall health. However, the production of sufficient amounts of conventional animal-based protein to meet future global food demands represents

a challenge. Edible insects, plant-based, fermented, cultured meat and micro-algae have recently been proposed as alternative protein sources that may be produced in a more sustainable way and may contribute to ensuring global food security.

Sources:

- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>
- <https://gfi.org/science/>
- <https://giantleaps.eu/>
- <https://www.locality-algae.eu/>

### **Short Food Supply chains in production/ Local or regional food cycles**

With increasing globalisation, the food system is also changing. As a result of these developments, more and more people are attaching increasing importance to sustainable nutrition and local food cycles. Regional products are particularly popular with the urban population. This development has led to a wide range of social innovations related to local food production and consumption. "Do-it-together" approaches, such as urban gardening, can promote the sustainable use and design of public space in communities and the cultivation of food in cities. Short food supply chains involve as few intermediaries as possible, connecting local suppliers with local consumers more directly compared to conventional (longer) supply chains.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **The transparent product**

The rise of Industry 4.0 and IOT application produces an enormous amount of data, which allows to re-trace of the entire production process, the logistics and the subsequent processing of the products. The information can be stored in a digital product memory. This product memory gives the customer greater access to information at purchase and it opens up greater repair and reuse possibilities, as repair and service workers can gain a better understanding of the production process and the use of a product, which will allow for a better repair service and longer use. In the food sector, customers are gaining greater access to information through voluntary labels about livestock farming and government recommended labels about a products health impact.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### **Increased requirement for transparency and monitoring of supply chain**

Many consumers demand more transparency and monitoring of complex supply chains, which have become non-transparent due to increased specialization and international division of labour.

Sources:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### 3D printing of food

Creating edible and customized food items using 3D printing technology.

Sources:

- <https://link.springer.com/article/10.1007/s12393-019-09199-8>
- <https://www.sciencedirect.com/science/article/pii/S2214785320307318>
- <https://www.tandfonline.com/doi/abs/10.1080/13675567.2022.2037125>

### 4D/5D/6D printing of food

4D food printing applications have mainly focused on achieving desirable colour, shape, flavour, and nutritional properties of 3D printed materials. 5D and 6D printing can print very complex structures with improved strength and less material than do 3D and 4D printing.

Source:

- <https://www.tandfonline.com/doi/abs/10.1080/10408398.2022.2045896>

### High/ Ultra-Processed Food

A classification for food categorizes food according to the extent of food processing rather than in terms of nutrient content. Ultra-processed food and drink products are regarded as convenient, safe, affordable and highly palatable. However, studies have linked a higher intake of ultra-processed foods with higher risks of cancer, obesity, hypertension or dyslipidaemia.

Sources:

- FOSTER automated search - topic modelling
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>
- <https://gfi.org/science/the-science-of-cultivated-meat/>

### Functional foods incl. pre- and probiotics

Functional foods (incl. pro- and prebiotics) affect beneficially physiological target functions in the human body, beyond adequate nutritional effects, in a way relevant to an improved state of health and well-being and/or reduction of risk of disease. These health claims influence purchase decisions among consumers and drive the demand for functional foods as they promote better health, increase longevity and prevent the onset of chronic diseases.

Sources:

- FOSTER automated search – topic modelling
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

### Novel Food

Novel food has entered the food market in the last two decades. It is based on different innovations like new isolated food ingredients, micro-organisms or novel animal ingredients like insects or new production processes. Despite much interest in Western population due to their nutritional and environmental advantages, novel food products also have very high product failure rates.

Sources:

- FOSTER automated search - topic modelling
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

### Use of Aquafaba

The recovery of legume cooking water (Aquafaba) to be used as food raw materials in various processes means reducing food waste.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- <https://www.tandfonline.com/doi/abs/10.1080/10408398.2021.2002259>
- <https://www.webmd.com/food-recipes/what-is-aquafaba>

### Edible packaging

Edible films and coatings formulations based on biopolymers and active compounds extracted from biowastes offer great opportunities to decrease the devastating overuse of plastic-based packaging.

Source:

- <https://ift.onlinelibrary.wiley.com/doi/full/10.1111/1541-4337.12870>

### New fermentation techniques and biotechnology in food production

Using new microbial fermentation and biotech methods to create novel food products. There are different new and old approaches: 1) Fermentation, now often precision fermentation 2) Biotechnology Fermentation: Food fermentation is the process of creating food or changing the properties of food using microbes. Many cultures started fermenting foods to preserve them. For example, fermenting vegetables allowed people living in places with harsh winters to eat them year-round. Cheese is another fermented food that lasts much longer than its previous form, milk. For some foods, like olives, fermentation makes an inedible or bad-tasting food edible or more palatable.

Sources:

- <https://pubs.aip.org/aip/acp/article/2526/1/040006/2901023>
- <https://www.eufic.org/en/food-production/article/modern-biotechnology-in-food-what-is-food-biotechnology>
- <https://gfi.org/science/the-science-of-fermentation/>
- <https://doi.org/10.1146/annurev-food-072023-034256>
- <https://doi.org/10.1016/j.copbio.2024.103084>
- <https://doi.org/10.1080/10408398.2023.2166014>
- <https://doi.org/10.3390/ijms241210156>

### Coffee innovation

Coffee is causing deforestation at an 'alarming rate' – could a beanless brew be the solution? The caffeinated brew uses superfoods and plant-based waste ingredients like date seeds to mimic the molecular structure of coffee. As the world's climate heats up, coffee farms – specifically those growing the more delicate arabica variety favoured by baristas – are moving uphill, destroying forests along the way in the search for cooler climes. Deforestation is the second leading cause



of climate change after the burning of fossil fuels. Studies have shown that by 2050 roughly half the land currently used to grow coffee could be unproductive thanks to climate change.

Source:

- <https://www.euronews.com/green/2023/10/04/superfood-based-beanless-coffee-could-slash-emissions-and-water-use-by-94>

### **Nanotechnology in food processing**

Applying nanoscale materials and processes for enhanced food quality and safety.

Sources:

- <https://onlinelibrary.wiley.com/doi/full/10.1002/gch2.202200209>
- <https://www.iasj.net/iasj/download/247422d05eae7d06>
- <https://www.ingentaconnect.com/content/ben/nanoasi/2023/00000013/00000001/art00006>

### **Processed food sector**

The term "processed food" is defined (OECD p. 224ff.) as any food that has been altered in some way from its raw state. The processed food sector accounts for a significant share of income generation and employment and is essential to maintaining a steady global supply of safe, affordable, and nutritious foods and is thus key to supporting food security and nutrition.

Source:

- [https://www.oecd-ilibrary.org/agriculture-and-food/making-better-policies-for-food-systems\\_ddfba4de-en](https://www.oecd-ilibrary.org/agriculture-and-food/making-better-policies-for-food-systems_ddfba4de-en)

### **Monopolies and dependencies on providers**

Monopolies and dependencies on providers are increasing and are intended by some large companies, e.g. for seeds or the combination of some crops and fertilisers or pesticides.

Sources:

- EN: [https://www.wissenschaftsrat.de/download/2023/1189-23\\_en.html](https://www.wissenschaftsrat.de/download/2023/1189-23_en.html); DE: <https://doi.org/10.57674/vzz6-sw54>

## **6.3 Retailing**

### **E-commerce and online food retailing**

Selling food products and groceries through online platforms for convenient shopping.

Source:

- <https://www.mdpi.com/2673-7116/1/2/6>

### **Fair distribution of food**

Fair prices and fair distribution of food are no normality, neither in Europe nor in many countries of the world. There are several attempts to improve the situation.

Source:

- <https://www.smallfarmincomes.in/>

### True pricing for food

In many European countries, consumers do not pay the full prices for food products, especially in the agricultural sector. True costs are often not calculated. There are experiments with true pricing figuring out what a true price for a product could be and how much consumers would be ready to pay.

Source:

- <https://www.fao.org/agroecology/database/detail/en/c/443760/>
- <https://www.bzfe.de/nachhaltiger-konsum/grundlagen/true-cost-wahre-kosten/>
- <https://www.truepricefoundation.org/>
- <https://trueprice.org/wp-content/uploads/2022/09/2019-06-True-Price-A-roadmap-for-true-pricing-v1.0.pdf>
- <https://www.wur.nl/en/research-results/research-institutes/economic-research/research-topics-1/improving-sustainability/true-and-fair-pricing.htm>
- [https://knowledge4policy.ec.europa.eu/publication/true-cost-true-price-food\\_en](https://knowledge4policy.ec.europa.eu/publication/true-cost-true-price-food_en).

### Local high quality food system networks

Food Circles shift food production from centralized structures towards decentralised, partially autonomous nutrition systems. This paves the way for bottom-up innovations and can decrease the market share of big players. Local niches for the delivery of distinct food services can lead to innovations and an efficient customer response.

Source:

- 50 trends influencing Europe's food sector by 2035: <https://publica.fraunhofer.de/entities/publication/3aa6aedb-ed7f-4273-9ad2-c1dd13474bd5/details>

### From ego systems economics to ecosystems economics

Food systems need to be transformed from ego to eco in retail. This means a different economic thinking – in which trust, system balances, commons and the way to work are interpreted in a different way, e.g. what is waste for one is a resource for others. Earth4All initiative.

Source:

- [https://www.clubofrome.org/wp-content/uploads/2022/10/Earth4All\\_Deep\\_Dive\\_Scharmer.pdf](https://www.clubofrome.org/wp-content/uploads/2022/10/Earth4All_Deep_Dive_Scharmer.pdf)

### Short Food Supply chains in production/ Local or regional food cycles

With increasing globalisation, the food system is changing. As a result of these developments, more and more people are attaching increasing importance to sustainable nutrition and local food cycles. "Regional" products are particularly popular with the urban population. This development has led to a wide range of social innovations related to local food production and consumption. "Do-it-together" approaches, such as urban gardening, can promote the sustainable use and design of public space in communities and the cultivation of food in cities. Short food supply chains involve as few intermediaries as possible, connecting local suppliers with local consumers more directly compared to conventional (longer) supply chains. Vending machines are a good example for this, selling the products of several producers at place or close to the place of production. But there are many practical questions, e.g. how can we choose the best location for such a vending machine to optimise its utilisation? How can we reach our consumers?

Sources:

- Project DAKIS: <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- <https://iseki-food-ejournal.com/ojs/index.php/e-journal/article/view/975>
- <https://www.smartchain-h2020.eu/>
- <https://onlinelibrary.wiley.com/doi/10.1111/soru.12358>
- <https://www.sciencedirect.com/science/article/pii/S2352550921001883>

### **Direct marketing of foods without retailers**

Direct marketing in cooperative shops, farm shops and at farmers' markets avoids any retailers and is thus less expensive and more independent in prices and earnings for the producers. Retailers cannot dictate the prices or other conditions – and in most cases, the ways to the consumers are shorter. They buy local or regional. But it is difficult to convince them they need different stops to buy their food – and do not just go to one supermarket to have everything on one spot and at each time of the year. This is an issue proposed by the FOSTER CDIs and will be examined further in their own work.

Sources:

- proposed by CDIs
- Stella Schaller; Lino Zeddies; Ute Scheub; Sebastian Vollmar (2022): Zukunftsbilder 2045. München: oekom verlag
- <https://medium.com/@benjaminmckean/why-food-brands-dont-sell-direct-to-consumer-and-what-that-means-for-you-36bf73a26084>
- <https://www.forbes.com/sites/forbesagencycouncil/2023/02/01/weighing-the-benefits-of-a-direct-to-consumer-model-for-food-brands/>

### **Logistics for short food supply chains**

To improve the logistics for locally produced food, and its integration with large-scale distribution systems. The integration of logistics management along with clustering, coordination, and optimisation techniques, could reduce the transport distance, time, trips, and emission, and improve the vehicle capacity utilisation in the local food supply chains.

Source:

- <https://www.scirp.org/html/5232.html>
- [https://www.scirp.org/html/4-9201465\\_22448.htm](https://www.scirp.org/html/4-9201465_22448.htm)
- [https://pub.epsilon.slu.se/10870/1/Bosona\\_T\\_131028.pdf](https://pub.epsilon.slu.se/10870/1/Bosona_T_131028.pdf)
- <https://www.sciencedirect.com/science/article/pii/S2352550920302876>

### **Blockchain and traceability in the food supply chain**

Employing blockchain technology for transparent and traceable food supply chains.

Source:

- <https://ieeexplore.ieee.org/abstract/document/8373021>
- [https://research-and-innovation.ec.europa.eu/document/download/e8cbdd60-670b-47b4-872f-b55ab406c352\\_en?filename=ec\\_rtd\\_radical-innovation-breakthrough\\_052019.pdf](https://research-and-innovation.ec.europa.eu/document/download/e8cbdd60-670b-47b4-872f-b55ab406c352_en?filename=ec_rtd_radical-innovation-breakthrough_052019.pdf)
- <https://op.europa.eu/en/publication-detail/-/publication/d1ea6c83-e538-11e7-9749-01aa75ed71a1/language-en>

### **International standardization of labels for food/ in food systems**

There is a lack of understanding and confusion about on-pack claims and labels (The World Business Council for Sustainable Development (WBCSD 2008, pp. 19–20). The products available in today's supermarkets carry a wide range of labels, on-pack claims, and elements of design that are meant to inform and reassure consumers on health, safety,

environmental, or social concerns. Several brands, including grocery retailers, have developed their own labels; other brands use endorsements from non-certifying (but trusted) third parties or on-pack claims (such as "natural") to convey sustainability attributes. Some products are certified by an internationally recognized and respected body, such as a local, national, or regional authority. Consumers International and the UK's National Consumer Council report that many consumers remain confused about which products are better for society and the environment, in particular about the differences between fair-trade, ethical, organic, and other types of products (The World Business Council for Sustainable Development (WBCSD 2008, pp. 19–20). With "Clean Eating" and other transparent labels, the food industry is communicating to the consumers that a product contains a certain ingredient or additive, or whether a product has been produced using "natural" production methods (e.g. organic agriculture or minimally processed food). It is a consumer-driven movement, demanding a return to "real food" and transparency through authenticity (Fit4FOOD2023 project).

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- <https://www.wbcSD.org/Programs/Food-and-Nature/Food-Land-Use/FReSH/Resources/Understanding-the-shift-required-towards-healthy-sustainable-and-enjoyable-diets>
- <https://www.statista.com/study/102352/gen-z-and-millennials-the-generational-gap-in-sustainable-consumption/>

### Label accuracy and transparency

Certification helps consumers to make informed choices. Many of the early products designed to be environmentally responsible, such as electric cars and recycled paper, did not meet the basic expectations of consumers. Rightly or wrongly, these early disappointments have made it tougher to convince today's consumers that green products work as well as those that they are intended to replace or are worth higher prices (The World Business Council for Sustainable Development (WBCSD 2008, p. 11). In their search for guidance on consumption choices, people trust each other more than any other source of information (The World Business Council for Sustainable Development (WBCSD 2008, p. 20). At the same time, studies are showing that consumers are less trusting in brands than in the past. Consumers are increasingly turning to the Internet as a trusted source of peer-generated in-formation (The World Business Council for Sustainable Development (WBCSD 2008, p. 21).

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>
- WBCSD 2008: <https://www.wbcSD.org/Programs/Food-and-Nature/Food-Land-Use/FReSH/Resources/Understanding-the-shift-required-towards-healthy-sustainable-and-enjoyable-diets>
- <https://www.statista.com/study/102352/gen-z-and-millennials-the-generational-gap-in-sustainable-consumption/>

## 6.4 Consuming

### Our consumed foods are becoming less nutritious

Fruits and vegetables are less nutritious than they used to be. Mounting evidence shows that many of today's whole foods aren't as packed with vitamins and nutrients as they were 70 years ago, potentially putting people's health at risk.

Source:

- <https://www.nationalgeographic.com/magazine/article/fruits-and-vegetables-are-less-nutritious-than-they-used-to-be>

### **Sustainable food for all**

With the rising global population, food availability is an important need and an important challenge. A sustainable food system is fundamental in solving many of the global issues, such as mass migration or the double burden of famine of obesity. The spreading of different lifestyles across the planet and the associated food intake, together with the development of sustainable and healthy food habits and associated public health advice shape the Global Value Network.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis>.

### **Plant-based and alternative protein diets**

Embracing diets that focus on plant-based protein sources and other alternative sources to traditional products.

Sources:

- <https://pubmed.ncbi.nlm.nih.gov/37580584/>
- <https://www.sciencedirect.com/science/article/pii/S096399692301027X>

### **Understanding and feeding the microbiome**

A microbiome is a community of microorganisms that live in a confined environment. Soils, oceans and food host microbiomes, as do plants, animals and the human body. Microbiomes have an impact on our health and on the food we produce, as well as on ecosystems in general. These are researched in a wide variety of disciplines. Knowing how to positively influence our microbiome could have an extraordinary impact on human health.

Source:

- [https://erc.europa.eu/sites/default/files/2023-06/H2020\\_factsheet-Food.pdf](https://erc.europa.eu/sites/default/files/2023-06/H2020_factsheet-Food.pdf)

### **How to feed the world? Hunger and food scarcity**

Food scarcity in more and more regions of the world and less nutrition in the food that exists raises questions about feeding the world – especially as the world population is still increasing. The consequences of this problem are particularly serious and do not stop at national borders. Wars, emigration and their consequences.

Sources:

- <https://www.wfpusa.org/articles/is-there-global-food-shortage-whats-causing-hunger-famine-rising-food-costs-around-world/>
- <https://www.worldbank.org/en/topic/agriculture/brief/food-security-update>
- <https://www.un.org/en/global-issues/food>
- <https://www.heifer.org/blog/understanding-global-hunger-and-food-insecurity.html>

### Consumption of the future includes more than just food

Consumption of the future includes more than just food – often narratives are told, the whole delivery chain has to be considered when consuming and marketing is also driving consumption. There are only few attempts to reducing consumption or sufficiency debates.

Source:

- <https://publica.fraunhofer.de/entities/publication/2b3559e7-e3e6-4578-ba57-746dfc863ad9/details>, [https://commission.europa.eu/document/download/b1125134-b733-45b3-8af2-263442af3f18\\_en](https://commission.europa.eu/document/download/b1125134-b733-45b3-8af2-263442af3f18_en)
- <https://scar-europe.org/images/FORESIGHT/FINAL-REPORT-5th-SCAR-Foresight-Exercise.pdf>

### Avoidance Strategies: How to consume less microplastics

Food and drink sealed in plastic has long been associated with cleanliness, purity and protection from contamination, but we now know that some of the highest exposures to microplastics.

Source:

- <https://www.theguardian.com/lifeandstyle/2023/jul/10/air-drinking-water-dust-food-how-to-reduce-exposure-microplastics>
- <https://www.nytimes.com/2024/06/07/well/microplastics-health.html>

### Eating Healthy might have negative side-effects on the environment

Contrary the climate-friendly dieting, "healthy" diets can also cause negative effects, when only reduced to a nutrition factor, as imports from wealthier communities affect the food distribution worldwide. Wageningen University and Research has modelled multi-modal impacts.

Source:

- <https://www.wur.nl/en/themes/nutrition-health/show/how-changing-our-diet-can-have-unexpected-negative-economic-social-and-environmental-impacts.htm>

### Dependencies on Big Food (big companies, sugar, carbohydrates)

International food corporations ("Big Food") are increasingly conquering markets in emerging and developing countries and influencing consumption towards a standard global food. As partners of globally organised aid organisations, this opens up markets for industrially manufactured products, which primarily provide profit for the companies. Unhealthy food dominates markets and suppresses the production of smaller scale and healthier food approaches. Sugar and carbohydrate addiction add to these tendencies.

Source:

- Kruchem 2017: <http://www.transcript-verlag.de/978-3-8376-3965-0>

### Lab-grown flavours

Lab-grown flavours from fungus instead of natural flavours will dominate flavours, and smells added to most foods and drinks could be created in yeast-brewing tanks rather than extracted from plants or synthesized in labs, some researchers predict. Around two decades ago, scientists found that tweaking the genes in yeast – a single-cell fungus – could cause it

to produce a variety of compounds. Today yeasts are being genetically engineered to produce flavour molecules in research that could eventually lead to entirely new and unfamiliar tastes.

Source:

- <https://www.wsj.com/articles/food-drink-flavoring-fungus-bf45fc96>

### Highly Processed Foods Increase Dehydration Risk

The typical Western-style diet leads us to consume less fluid overall at a time when adequate hydration is key to surviving the heat waves striking multiple countries. Sweltering temperatures have led to much more focus on staying hydrated with liquids, but disappointingly few headlines focus on the role diets play in hydration. Highly processed foods with a low water content are rapidly replacing more traditional, water-rich foods. Bottled water purchases have increased by 40% over the past decade as more people focus on drinking enough fluids, but at least 20% of total daily water intake typically comes from water-rich foods like fruits and vegetables.

That 20% can be vitally important to prevent dehydration when temperatures soar. However, over half of daily calories consumed in Western-style diets now come from a type of highly processed food classified as "ultra-processed" that has most of the water removed during processing to extend shelf life at the store. A food is said to be ultra-processed if it has gone through several extra processing steps adding more fats, sugar, salt, and preservatives that change the final form of the food. This includes foods like breakfast cereals, potato chips, fast food burgers and chicken nuggets, and many frozen meals.

This junk food often masquerades as healthy with labels like "gluten free" or "sugar free," but if you look at the nutrition label, most of these foods contain a lot more sodium, fat, and simple sugars than you need in a healthy diet. They also have a lot less water compared to the original food. Not all processed foods are categorized as ultra-processed, so it helps to understand the spectrum of processing. One-ingredient foods – the least processed– are ideal. For example, a strawberry can be eaten in its natural form. That strawberry can also be blended into a smoothie or mixed into plain yoghurt – processed but still water-rich and healthy.

Source:

- <https://medium.com/wise-well/highly-processed-foods-increase-dehydration-risk-e55ae38022ec>

### Food consumption behaviours in Europe and generation gap

Food consumption behaviours result from a combination of drivers, but it is possible to identify the drivers that seem to influence consumers the most. Some state that there is a generation gap in sustainable food consumption and behaviour. It is noticed that in the last years, the younger generation starts to be more conscious about their consumption, which seems to be different in the differing age cohorts, anyway.

Sources:

- <https://researchportal.hw.ac.uk/en/publications/food-consumption-behaviours-in-europe-mapping-drivers-trends-and->
- <https://www.statista.com/study/125082/consumer-trends-2023-sustainability-edition/>
- <https://www.wbcsd.org/Programs/Food-and-Nature/Food-Land-Use/FReSH/Resources/Understanding-the-shift-required-towards-healthy-sustainable-and-enjoyable-diets>
- <https://www.statista.com/study/102352/gen-z-and-millennials-the-generational-gap-in-sustainable-consumption/>

### Origin of the bio-based raw material and resources matter to consumers

As companies replace fossil with bio-based resources, the demand for bio-based resources increases. Europe does not have the area or the capacity to satisfy its complete demand through self-sufficiency. Imports of bio-based foods will be necessary, even if the EU and its member states increase their effort to grow renewable resources.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### Land use

The increased demand for bio-based resources by consumers has implications for agricultural land use. While the agricultural area in many developed countries is decreasing, the increase in demand for bio-based resources could reverse this trend and lead to more agricultural practices in the developing world. Additionally, the production practices of agricultural goods could change. The debate between the expansion of ecological agricultural and an intensification of industrial agriculture will continue. Other pressure on land use comes from investors (raising the price of land), the need for housing and unhealthy soils.

Source:

- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

### Environmental impacts of food consumption in Europe

Food consumption is among the main drivers of environmental impacts. On one hand, there is the need to fulfil a fundamental human need for nutrition, and on the other hand this poses critical threats to the environment.

Source:

- <https://doi.org/10.1016/j.jclepro.2016.06.080>

### Additives for health

Colours and sweeteners are just two of the most common additives used to give food a marketable quality. There are several hundred food additives allowed on the EU market. Since safety assessments are based on currently available evidence, the long-term health impact of additives intake is a growing concern. The findings of recent animal and cell-based tests suggest several additives have harmful effects on human health. The EU-funded ADDITIVES project proposes innovative tools developed to collect precise and repeated data, including names and brands, on foods and beverages widely consumed. Based on a combination of epidemiological studies and in vitro/in vivo tests, it will elucidate individual exposure to food additives in relation to obesity, cancer, cardiovascular diseases and mortality. Recent findings suggest several additives have harmful effects on human health. Based on a combination of epidemiological studies and in vitro/in vivo tests, the ADDITIVES project reveals individual exposure to food additives in relation to obesity, cancer, cardiovascular diseases, and mortality and proposes innovative tools to collect data, including names and brands.



Sources:

- [https://erc.europa.eu/sites/default/files/2023-06/H2020\\_factsheet-Food.pdf](https://erc.europa.eu/sites/default/files/2023-06/H2020_factsheet-Food.pdf)
- <https://cordis.europa.eu/project/id/864219> (DOI 10.3030/864219)

### Climate-friendly dieting

Switching to a healthier diet not only reduces your risk of disease, it also improves the sustainability of our food system. The EAT-Lancet Commission presents a global planetary health diet that is healthy for both people and planet. But it takes over many of the existing myths around food and some of the basics are not scientifically proven as nutrition results are difficult to evaluate.

Sources:

- <https://eatforum.org/eat-lancet-commission/the-planetary-health-diet-and-you/>
- <https://ourworldindata.org/food-choice-vs-eating-local>
- <https://ourworldindata.org/environmental-impacts-of-food>

### Phthalates criticism in fast food consumption

The public mainstream realises and criticizes that fast food contains components made of plastic to "bloat" up the products and make them appear bigger. Also, the packaging contains more plastic and phthalates – which are assumed to influence human fertility and have many other negative impacts.

Sources:

- <https://onlinelibrary.wiley.com/doi/epdf/10.1111/jmwh.13426?src=getftr>
- <https://doi.org/10.1007/s11356-023-25692-4>
- <https://www.cspinet.org/cspi-news/most-foods-contain-toxic-phthalates-now-what>
- <https://www.fda.gov/food/food-additives-and-gras-ingredients-information-consumers/phthalates-food-packaging-and-food-contact-applications>
- <https://link.springer.com/article/10.1007/s00204-016-1780-1>
- <https://doi.org/10.1016/j.scitotenv.2018.12.134>
- <https://doi.org/10.1016/j.emctp.2004.10.003>

### Changing household structures and food

The number of single-person households is rising worldwide. More inequality is observed. The same for people with different lifestyles. This is also associated with distinctive food-related consumption behaviour.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>
- <https://link.springer.com/article/10.1007/s12187-022-09931-7>
- <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0262673>
- <https://doi.org/10.1007/s11205-021-02838-w>
- <https://doi.org/10.3390/ijerph192114578>

### Functional foods and nutraceuticals

Developing food products with added health benefits and functional properties. There are pros and cons for these new foods – but a lot of activity in research and production. For companies, it is profitable in the long run.

Sources:

- <https://doi.org/10.1002/fsn3.3518>
- <https://doi.org/10.3390/nu12082289>
- <https://doi.org/10.1155/2021/8823222>
- <https://doi.org/10.1515/jcim-2022-0026>
- List of automated FOSTER search and topic modelling
- Buxton, Jane (2022): The Great Plant-based Con. Why eating a plants-only diet won't improve your health or save the planet. London, UK: Piatkus
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9559824/>

### **Pressure groups: pressure on retail**

Pesticides: Foodwatch puts supermarkets under pressure. The consumer protection organisation is calling on supermarket chains to change their range of bread and other cereal products to "pesticide-free production". The organisation is hoping for support from a report published on Tuesday and an online petition. According to Foodwatch, it has analysed data from the European Food Safety Authority (EFSA). The result: around one third of cereal products in Europe are "contaminated" with pesticide residues. However, the legally set maximum levels, i.e. the maximum permissible amount of active ingredient up to which a health risk is unlikely, were exceeded in very few cases.

Sources:

- Agrifood.Table 2023
- <https://www.foodwatch.org/en/most-supermarkets-lack-a-coherent-strategy-to-reduce-pesticides>
- [https://www.foodwatch.org/fileadmin/-INT/pesticides/2022-06-30\\_Pesticides\\_Report\\_foodwatch.pdf](https://www.foodwatch.org/fileadmin/-INT/pesticides/2022-06-30_Pesticides_Report_foodwatch.pdf)
- <https://www.investigate-europe.eu/posts/the-battle-over-pesticides-in-europe>

### **Consuming Air Proteins made of water air and energy**

ADM, Air Protein partner to scale "a new way of making food that only requires air, water and energy".

Sources:

- <https://pubs.acs.org/doi/10.1021/acs.est.9b06755>
- <https://www.foodnavigator-usa.com/Article/2023/05/18/adm-air-protein-partner-to-scale-a-new-way-of-making-food-that-only-requires-air-water-and-energy>
- <https://www.solein.com/>

### **3-D Printing for safer food consumption**

Use of 3-D printing to be safer and produce food that can be consumed immediately and does contain less contamination as it is not transported or contaminated by soil

Sources:

- <https://www.axios.com/2023/03/24/food-security-3d-printing>
- <https://new.nsf.gov/science-matters/3d-food-printing-healthy-eating-delicious-desserts>

### **Products for single households and specific consumer groups**

There is a trend, e.g., in Germany and the UK, toward smaller "family units". This change has particular implications for the scale and type of housing demand. For them, and for other consumer groups in an ageing society (e.g. older persons living alone) but also children, there need to be different products and services, for example offering meal subscriptions and ready-to-cook kits for easy and hassle-free meal planning.

Sources:

- <https://publica.fraunhofer.de/entities/publication/3aa6aedb-ed7f-4273-9ad2-c1dd13474bd5/details>
- <https://repository.up.ac.za/handle/2263/68801>

### Price sensitive consumers

Price-sensitive consumers are good examples to increase consumer engagement with local products. Hungarian or German consumers for example are very price-sensitive. How do you get consumers in other countries to consume more local, regional products? What marketing and sociological methods are available to do this? Many consumers have a low income and are thus price-sensitive – how can they be able to buy cheap but high quality food? This topic was proposed by the CDIs of the FOSTER project as important for their future.

Source:

- proposed by CDIs
- <https://mkt-bcg-com-public-pdfs.s3.amazonaws.com/prod/consumer-price-sensitivity.pdf>
- <https://www.newtonx.com/article/price-sensitivity/>
- <https://www.breakcold.com/explain/price-sensitivity>

## 6.5 Storing

### Advanced food storage and preservation technologies

Implementing cutting edge technologies for improved food storage and shelf life.

Sources:

- <https://www.agriculturaljournals.com/archives/2023.v5.i2.A.138/a-review-on-recent-advanced-spoilage-detection-techniques-for-fruits-and-vegetables>
- <https://agricultureandfoodsecurity.biomedcentral.com/articles/10.1186/s40066-017-0130-8>

### Intelligent food packaging and shelf-life extension

Developing packaging solutions that actively monitor food. There are many new ideas to extend shelf life with active packaging, such as new surfaces or silk proteins.

Sources:

- <https://www.tandfonline.com/doi/abs/10.1080/10408398.2022.2031099>
- <https://doi.org/10.1038/s44222-023-00137-2>

### Controlled atmosphere storage and modified atmosphere packaging

Creating optimal storage conditions by controlling or modifying the gas composition around food, "e.g. Microporus modified atmosphere".

Sources:

- <https://journal.envirocnj.in/index.php/ecj/article/view/616/534>
- <https://www.tandfonline.com/doi/abs/10.1080/10408398.2020.1811635>

**Active packaging**

Anti-microbial and anti-spoilage coatings for food packaging. Applying coatings to packaging materials to prevent microbial growth and food spoilage. One example is chitosan – essential oil coatings.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0144861721010031>
- <https://www.sciencedirect.com/science/article/pii/S0924224423003151>

**Reduction of plastic packaging**

Plastic is an important and ubiquitous material but often the way it is used and discarded does not run along with the economic benefits of a circular and sustainable approach and it harms the environment. The EU has published a vision for a circular plastics economy. Regarding the food system responsible consumers ask for a reduction of packaging – not only plastic– to avoid waste and environmental pollution, companies start rethinking packaging materials taking sustainability into account.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

**Biobased plastic packaging**

Bioplastics are not just one single substance, they comprise a whole family of materials with differing properties and applications. According to European Bioplastics, a plastic material is defined as bioplastic if it is either bio-based (materials created using renewable biomass sources), bio-degradable, or features both properties. There has been an increasing trend towards replacing conventional fossil-based plastics with bioplastics.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

**Packaging and health**

Advances in processing techniques, preservation, and packaging have enabled the food industry to consistently supply consumers with a wide array of healthy and fresh products all year round. Food packaging can contribute to preserving the quality and protecting food, ensuring convenience in distribution and handling.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

**Biodegradable and semi-biodegradable food packaging materials**

Immediate disposal of conventional single use non-biodegradable food packaging results in adverse environmental impact. Utilisation of either biodegradable or semi-biodegradable materials is a common approach toward achieving better sustainability.

Source:

- <https://ift.onlinelibrary.wiley.com/doi/full/10.1111/1541-4337.12873>

### **Edible packaging**

Edible packaging can be eaten on the go, without a need for waste collection, processing, recycling, or disposal. However, these are weaker than plastic. For example, if the packaging is too water soluble it will not hold up in humid climates, or it would also break down faster if kept cold and then exposed to condensation effects once removed from the refrigerator.

Sources:

- <https://link.springer.com/article/10.1007/s13197-023-05803-2>;
- <https://www.sciencedirect.com/science/article/pii/S2772502222000786>

### **Recycled (and upcycled) packaging**

Current rates of recycling are low and landfills are full. Producing food packaging out of recycled/upcycled plastics may help ease some pressure in this regard.

Sources:

- Polymers: <https://www.sciencedirect.com/science/article/pii/S0045653523003569>
- Substances added: <https://ift.onlinelibrary.wiley.com/doi/10.1111/1541-4337.13001>

### **Reusable food delivery packaging**

The use of re-usable packaging, both primary (those with direct contact with foods) and secondary (e.g. carrier bags) could significantly reduce carbon emissions compared to the current situation.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0048969721036421>
- <https://link.springer.com/article/10.1007/s11356-023-25884-y>

### **Minimal Processing enabled by hurdle technology**

Hurdle technology means combining various bacteria inhibiting or bacteria-killing factors (some of the "hurdles" are for example salt, reduced pH, reduced water activity, heat treatment, and appropriate packaging) to achieve safe products with acceptable shelf life and an acceptable taste and consistency.

Sources:

- For example fish: <https://www.sciencedirect.com/science/article/pii/S2468550X20300186>
- Tailor-made foods: <https://ftb.com.hr/archives/1837-minimal-processing-technologies-for-production-and-preservation-of-tailor-made-foods>

### **No packaging**

Package-free stores and supermarkets are starting to be common in bigger cities. These contain refill stations and bag-less aisles. Even conventional supermarkets are starting to encourage shoppers to bring their own containers and to trial refill stations. The transition is, however, complex, involving changes in the supply chain, the stores and buyers'

behaviours and skills. Despite the obvious environmental benefits of not producing packaging, the package-free movement must pay attention to the undesired increase in food waste due to the shorter shelf life of some foodstuffs.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0969698918310476>
- <https://lup.lub.lu.se/luur/download?func=downloadFile&recordId=8903648&fileId=8903649>

### **Internet of Things (IoT) for cold chain management and storage**

The Internet of Things (IoT) enables real-time monitoring. Using advanced smart sensors, data analytics, machine learning, and cloud connectivity in food storage, it can turn data into actionable insights about the condition of food. This continuous monitoring can ensure food is stored within the required temperature range and helps demonstrate it meets regulatory standards. Real-time monitoring, predictive analytics, and enhanced food safety measures. Radio Frequency Identification (RFID) technology could provide valuable real-time food-quality information in smart food packaging and is integrated as chipless technology. New technologies are also used to ensure proper temperature control throughout the supply chain to maintain food quality and safety. Attention must be paid as cold chains can help diseases such as COVID-19 to spread.

Sources:

- Cold storage management: <https://www.mdpi.com/1424-8220/22/13/4680>
- Cold chain management: <https://www.emerald.com/insight/content/doi/10.1108/IJLM-01-2017-0007/full/html>
- Prevent COVID-19 spread: <https://www.sciencedirect.com/science/article/pii/S0956713522001335>
- Perishable inventory management: <https://link.springer.com/article/10.1007/s10479-021-04277-9>
- <https://www.sciencedirect.com/science/article/pii/S2666833522000855>

### **Factors affecting the sustainability of reusable packaging systems**

Interest in reusable (e.g. returnable, refillable) packaging systems is growing due to the current waste management difficulties, particularly that of plastic waste. The environmental impact of packaging is huge. Reusable packaging systems can be significantly more sustainable than single-use alternatives, but a complex interplay of environmental, economic, social and technological factors affects their implementation and efficacy, and the switch from a single-use to a reusable packaging system is a food safety concern.

Source:

- <https://doi.org/10.1016/j.spc.2023.02.009>

## **6.6 Waste and Disposing**

### **Biorefineries: converting food waste to bio-based materials**

Converting food waste into valuable resources like compost and biogas through decomposition and other processes.

Sources:

- <https://www.mdpi.com/2304-8158/10/6/1174>
- <https://www.sciencedirect.com/science/article/pii/S0960852422011865>

### Food donation and redistribution programs

Redistributing surplus food to those in need through charitable organizations and community programs. Countries around the world have initiated addressing the recovery and redistribution of safe and nutritious food through, among others, developing guidance on the implementation of such actions.

Sources:

- [https://food.ec.europa.eu/system/files/2019-06/fw\\_eu-actions\\_food-donation\\_ms-practices-food-redis.pdf](https://food.ec.europa.eu/system/files/2019-06/fw_eu-actions_food-donation_ms-practices-food-redis.pdf)
- <https://www.fao.org/platform-food-loss-waste/food-waste/food-waste-reduction/recovery-and-redistribution-of-safe-and-nutritious-food-for-human-consumption/en>

### Digitalisation against food waste

From software and companies that track and ensure freshness along the supply chain, some with the help of IoT, to apps to distribute not-good-looking food or left-over food.

Sources:

- <https://www.supplychaindive.com/news/4-technologies-food-waste-in-supply-chain/532155/>
- <https://www.oddbox.co.uk/blog/7-apps-that-are-helping-reduce-food-waste>

### Shortening supply chains to help reduce food waste (and packaging)?

A glance at where food is lost or wasted makes it clear that food loss/waste is generated in all stages of its supply chain. Shortening supply chains has, therefore, the potential to help reduce the amount of food wasted. Farmers directly selling subscriptions to fresh food boxes and similar initiatives could then help reduced the amount of food wasted. This is, however, an understudied possibility and the effects on the amount of food wasted may largely depend on the specificities of each initiative.

Sources:

- <https://www.intechopen.com/chapters/86428>
- [https://zerowasteurope.eu/wp-content/uploads/2019/11/zero\\_waste\\_europe\\_report\\_short-food-supply-chain-fact-sheet.pdf](https://zerowasteurope.eu/wp-content/uploads/2019/11/zero_waste_europe_report_short-food-supply-chain-fact-sheet.pdf)

### Sustainable packaging materials, less plastics and biodegradable alternatives

Developing eco-friendly packaging materials that reduce environmental impact. From biodegradable packaging to edible packaging. Plastic is an important and ubiquitous material but often the way it is used and discarded does not run along with the economic benefits of a circular and sustainable approach and it harms the environment. The EU has published a vision for circular plastics economy. Regarding the food system responsible consumers ask for the reduction of packaging – not only plastic – to avoid waste and environmental pollution, companies start rethinking packaging materials taking sustainability into account.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S2772502222000786>
- <https://ift.onlinelibrary.wiley.com/doi/10.1111/1541-4337.12873>
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

- <https://web.archive.org/web/20240404071940/https://www.oecd.org/environment/plastics/Interim-Findings-Towards-Eliminating-Plastic-Pollution-by-2040-Policy-Scenario-Analysis.pdf>
- [https://read.oecd-ilibrary.org/view/?ref=1143\\_1143481-88j1bxuktr&title=Global-Plastics-Outlook-Policy-Scenarios-to-2060-Policy-Highlights](https://read.oecd-ilibrary.org/view/?ref=1143_1143481-88j1bxuktr&title=Global-Plastics-Outlook-Policy-Scenarios-to-2060-Policy-Highlights)

### Prices versus Waste

It is often assumed that there is a correlation between food waste and food prices. However, their relationship is far from clear. Other factors seem to drive food waste much more significantly than food prices.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0956053X23004701>
- <https://www.sciencedirect.com/science/article/pii/S0956053X23006438>

### No package

The increasing demand for package-free foodstuffs and the proliferation of package-free stores create a positive feedback loop that drives the rise in demand and availability. Despite the obvious environmental benefits of not producing packaging, consumers are responsible for the majority of food waste from the whole supply chain, so the package-free movement must pay attention to the undesired increase in food waste due to the shorter shelf life of some foodstuffs.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0969698918310476>
- <https://lup.lub.lu.se/luur/download?func=downloadFile&recordId=8903648&fileId=8903649>

### Food Waste Recovery Hierarchy

The Food Recovery Hierarchy prioritises actions organisations can take to prevent and divert wasted food. Each tier of the Food Recovery Hierarchy focuses on different management strategies for the food wasted. The benefits for the environment, society and the economy decrease with level height. Reasons: The FAO estimates that each year approx. one third of food produced for human consumption in the world is lost, degraded contaminated or wasted. A series of solutions may be implemented and are represented by avoidance and donation of edible fractions to social services or use to produce biofuels or biopolymers. A variety of (social and private) initiatives has evolved to use, e.g. vegetables not fitting the standard, waste cooking or up-cycling of non-food waste.

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0048969719360292?via%3Dihub>
- Fit4food2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>; <https://cordis.europa.eu/project/id/774088>

### Food waste reduction and upcycling initiatives

There is a tremendous waste of food. This relates to all levels from the agricultural sector to the end consumer. One reason is packaging sizes. But it can also be short expiration dates or ignorance about the shelf life of food. Implementing strategies to minimise food waste and repurpose food by-products. Food intended for human consumption that is eventually lost or wasted contributes to food insecurity and hinders nutrition, in a world where one in nine people are undernourished. It has been estimated that the food currently wasted in Europe could feed 200 million people. Food



waste is also an environmental problem because food production is resource intensive. Without a change in dietary habits and the reduction of food waste, the expected growing population and incomes will lead to an increase in demand for agricultural products of 50 % by 2050. In a context of rapid urbanisation and growing clarity regarding the unsustainability of cities, the project SHARECITY examined city-based food sharing economies and their potential to reorient eating practices. The project developed the first ever crowdsourced international food sharing database.

Sources:

- [https://erc.europa.eu/sites/default/files/2023-06/H2020\\_factsheet-Food.pdf](https://erc.europa.eu/sites/default/files/2023-06/H2020_factsheet-Food.pdf)
- <https://www.welthungerhilfe.de/lebensmittelverschwendung>
- <https://cordis.europa.eu/article/id/122721-the-best-place-for-my-surplus-food-is-in-your-stomach-but-how-to-make-that-saying-work>
- Project: <https://web.archive.org/web/20240624022743/https://sharecity.ie/>
- <https://www.unep.org/resources/report/unep-food-waste-index-report-2021>
- <https://journals.sagepub.com/doi/full/10.1177/0734242X15597775>

### **Circular economy approaches in the food industry**

Embracing sustainable practices that minimise waste and promote resource utilisation. Circular approaches are discussed in many EU contexts, e.g. by the SCAR Foresight, but there are also international projects fostering a circular economy in food systems. "Food is never waste - A global coalition" is a European initiative that supports countries in developing context specific interventions, ranging from policies and regulations to voluntary initiatives, to halve food waste by 2030 and reduce food losses by at least 25%. Sharing instead of owning can also contribute: Through the advancement of technology, e.g. digital platforms, social activities such as sharing, donating, neighbourhood help and swapping are gaining in reach and diversity. Alongside a growing number of local initiatives, this facilitates a shift in preferences away from ownership toward sharing

Sources:

- <https://www.sciencedirect.com/science/article/pii/S0304389421011183>
- <https://www.sciencedirect.com/science/article/pii/S095816692200115X>
- <https://reliefweb.int/report/world/food-security-commission-steps-support-global-action-transform-food-systems-eight>
- <https://doi.org/10.2777/025150>
- <https://doi.org/10.3389/fsufs.2021.650987>
- <https://www.bzfe.de/nachhaltiger-konsum/lagern-kochen-essen-teilen/foodsharing/>
- [foodsharing.de](https://www.foodsharing.de)

### **Biobased Packaging**

Bioplastics are not just one single substance, they comprise a whole family of materials with differing properties and applications. According to European Bioplastics, a plastic material is defined as bioplastic if it is either bio-based, biodegradable, or features both properties. There has been an increasing trend towards replacing conventional fossil-based plastics with bioplastics. Within the next years, the global production capacity of bioplastics is expected to reach a level of 7.85 million tons in 2019.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

## Packaging 4.0

Packaging 4.0 goes beyond active and intelligent packaging providing an interface to a rapidly evolving digital world, implementing Industry 4.0 concept into the food system. Packaging 4.0 allows digital connectivity and new functionality that also engages the consumer. Intelligent packaging solutions will communicate actively within the value chain, manufacturing, distribution and the consumer's home environment.

Sources:

- Fit4FOOD2030 project: <https://web.archive.org/web/20240616075900/https://fit4food2030.eu/> or <https://cordis.europa.eu/project/id/774088>

## Vermicomposting

Vermicomposting is a process that relies on earthworms and microorganisms to help stabilize active organic materials and convert them to a valuable soil amendment and source of plant nutrients.

Sources:

- <https://doi.org/10.1016/j.jenvman.2023.118585>
- <https://pubs.rsc.org/en/content/articlelanding/2023/EM/D2EM00324D>

## Fertilisers from "waste" and manure

Solid waste from the food system ends up in the toilet. Waste treatment plants can use chemical processes to treat this waste, with the goal of reducing the level of dangerous bacteria, called pathogens that could pose threats to human health. The goal of these treatments is for the end product to contain no detectable levels of dangerous bacteria. The waste material might be subjected to some combination of: Drying; Heating (Pasteurisation, the same method used to sterilise your milk); Composting. But the treatment methods aren't 100% effective – and it shows several problems. Class A biosolids, the end result of waste treatment, are supposed to be free of dangerous bacteria. DNA testing, however, shows that there are still plenty of virulence genes in the material. And when biosolids are added to soil, the level of virulence genes increases even further.

This could lead to a greater risk of damaging crops that are grown on that soil. "This doesn't mean that farmers and gardeners should completely give up on biosolids, or that they should no longer be used for crops. Biosolids, the result of cleaning the solid component of human waste, do also contain a lot of useful nutrients, e.g. phosphates, and chemicals that are great for plants. They also help rebuild depleted soil, preventing it from turning to dust and being carried away by the wind. Reusing them in a cycle is a better choice than just dumping or incinerating them... but scientists and government groups need to monitor the impact of human waste based manure on the microbes in the soil, as well. A deeper understanding could help prevent some of the food contamination reports and recalls." (citation from <https://medium.com/a-microbiome-scientist-at-large/the-risks-of-putting-shit-on-your-crops-445a4e8142df>)

Sources:

- <https://medium.com/a-microbiome-scientist-at-large/the-risks-of-putting-shit-on-your-crops-445a4e8142df>
- <https://doi.org/10.1093/lambio/ovad097>

### Food waste and resource efficiency

Food intended for human consumption that is eventually lost or wasted represents a complex challenge, as its reduction requires a change of established business practices and citizens' habits. Globally, around one-third of all food produced is lost or wasted along the food chain, from production to consumption (HLPE, 2014). In a world where hundreds of millions of people go hungry, that is a stark indication of the inefficiency of current food systems. Food losses and waste often translate into economic losses for farmers and other stakeholders within the food value chain, and higher prices for consumers, both of which affect food insecurity by making food less accessible to vulnerable groups. Reducing food losses and waste would increase the supply of available food and strengthen global food security.

Sources:

- <https://op.europa.eu/en/publication-detail/-/publication/86e31158-2563-11eb-9d7e-01aa75ed71a1>
- Project DAKIS: <https://www.bundesregierung.de/breg-de/aktuelles/agrarsysteme-der-zukunft-2194584> or <https://www.isi.fraunhofer.de/de/competence-center/foresight/projekte/dakis.html>

**All findings of this report will be used in the next steps of the FOSTER project: in the scenarios, in discussions and roadmapping activities with the CDIs, in the digital and human FOSTER Knowledge Platform. They are working material in anticipating certain futures, but they are no predictions as the future will be shaped by human beings and nature. All findings are uncertain as there are many activities for change that are starting now, and the consortium will also contribute to transformations in the next phases of the project FOSTER.**

# Bibliography



## Chapter 7 – Bibliography

### 7. Bibliography

**This bibliography only contains the literature cited in the Chapters 1 to 3. The publications as links, full publications or project websites for the scanned topics can be found directly in the Chapters 4, 5 and 6. From there, they will be integrated into the FOSTER digital Knowledge platform.**

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