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The food supply system – challenges of the present and plans for the future

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1. SUMMARY

In the coming decades, in order to meet the increasing food demand resulting from demographic growth, the application of different sustainable solutions becomes indispensable. Social and environmental changes pose a major challenge for the complex food supply system with many stakeholders who also have a significant impact on one another. In order to overcome the obstacles and to ensure the resilience of the food supply system to the future, it is necessary to have a thorough knowledge of the current situation and to be able to forecast future situations. It is also necessary to examine the possible effects of the proposed solutions. It is with these ideas in mind that our present work reviews the challenges of the food supply system and the directions for its sustainable transformation.

2. Definition of the food supply system

Foodstuffs play an important role in connecting communities, in expressing common values and preserving cultural traditions. Food that is grown, harvested, processed, marketed, transported, stored, sold, purchased and consumed connects people, their culture, their well-being and the health of the planet **[1]**.

The food supply system has been defined in different ways, but the following definition, based on consensus, was put forth by the *High Level Task Force on Global Food and Nutrition Security* of the United Nations (UN) in 2015: „A food system is defined as a system that embraces all the elements (environment, people, inputs, processes, infrastructure, institutions, markets and trade) and activities that relate to the production, processing, distribution and marketing, preparation and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes" **[2]**.

The modern, industrialized systems developed over the last 100-200 years are made up of several participants (elements), their processes are longer and the alternative solutions form so-called short supply chains with fewer stakeholders. Developed countries are dominated by long supply chains, which form a network of stakeholders from farm to fork in order to increase production volumes and thus, to reduce unit costs **[3]** (***Figure 1***).

3. Challenges of the food supply system

According to forecasts, the population of Earth, estimated at 7.7 billion in 2019, could reach 8.5 billion by 2030, 9.7 billion by 2050, and could grow to 10.9 billion by 2100 **[5]**. The most significant population growth is expected to take place in developing countries, where living standards and incomes are likely to increase as well. At the same time, better living conditions are expected to result in a higher consumption of animal protein (meat and meat products, milk and dairy products), vegetable oil and processed foods **[6]**. For these reasons, supplying the population of Earth with a sufficient quantity and quality food already presents many challenges to the system currently in operation.

One of the most serious challenges facing the food supply system is the high incidence of **food-related illnesses**. The seriousness of the situation is illustrated by the simultaneous presence of health damages due to overnutrition and malnutrition in the world.

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According to World Health Organization (WHO) data, 1.9 billion people no Earth were overweight or obese in 2014, while 462 million people were considered malnourished. The incidence of obesity has tripled in many countries since the 1980s, and it is becoming more common among children and young people. Another problem is that being overweight or obese is responsible for the death of 41 million people each year, and can be defined as one of the most serious risk factors for the development of non-communicable diseases. Within this group, cardiovascular diseases cause 17.9 million, cancer 9.0 million, respiratory diseases 3.9 million and the complications of diabetes 1.6 million deaths each year **[7]**. An inadequate diet contributes significantly to the development of the above diseases. In developed countries, the diet of the population is characterized by an excessive intake of meat, sugar, fat and energy, and low levels of consumption of whole grains, fruits and vegetables. Switching to a sustainable diet is also influenced by many behavioral factors that have not been studied extensively so far. Eker et al. **[8]** suggests that social norms (such as the acceptance of vegetarianism in society) may facilitate the transition to a plant-based diet. The way foods are grown or produced, their type, transportation, availability, purchase and consumption all have an impact on consumers' eating habits and diets.

The deterioration, damage or depletion of **natural resources** is significant, and reducing or eliminating these processes will pose great challenges for science and mankind in the future. Greenhouse gas emissions increased by 31.2% between 1990 and 2016. Major contributors to the emission are energy supply (34%), industry (22%), transportation (14%) and agriculture (13%) **[9]**. According to *European Environment Agency* (EEA) data, in Europe, the largest amount of water is used by agriculture (40%), followed by energy production (28%), mining and processing (18%), while the rest is used in households **[10]**. In the process of soil degradation, major roles are played by intensive agriculture, increased industrial activity and urban sprawl **[11]**. Biodiversity is primarily affected by the sectors with a direct impacting on it, such as agriculture, mining, logging, as well as water management and the fishing industry **[12]**.

The food supply system also faces major challenges in the use of natural resources. It is estimated that the food supply system is responsible for 60% of **global biodiversity loss**, 24% of greenhouse gas emissions, 33% of soil degradation, for 61% of overfishing and 20% of the depletion of freshwater auqifers **[1]**.

Despite significant differences in the dietary habits and cultivation practices around the world, today, only thirty plant species account for 95% of the food needs of mankind. This has an adverse effect on soil quality, species diversity and the resilience of the ecosystem. In Greece, for example, 95% of local cereal varieties have disappeared, while in Italy, although manuals written in the early 19thh century still described one hundred varieties of apples, nowadays only three varieties account for 80% of the harvest. The situation is similar in animal husbandry: breeds that are able to grow faster suppress slower growing local breeds **[13]**.

One of the objecitves of the Seventh Community Environmental Action Programme of the EU (1386/2013/EU) **[14]**, together with the framework in the field of marine environmental policy (2008/56/EC) **[15]**, is improving the environmental status of marine life and waters. Effective intervention is urgent, because currently 67% of the marine fish and shellfish population fail to comply with *Good Environmental Status* (GES; deaths due to fishing, reproduction capacity). Significant differences exist in the state of marine life across Europe. Despite the fact that there have been improvements in certain areas in recent years (for example, in the case of the Atlantic Ocean and the Baltic Sea), in other areas (for example, the Mediterranean and the Black Sea), the situation remains critical due to overfishing **[16]**.

One of the sectors responsible for the use of natural resources and for the production of greenhouse gases is food production. In 2013, the production and processing of raw materials and the delivery of foodstuffs to consumers' tables accounted for 26% of the total energy consumption of the European Union. The most prominent element of the food supply system in terms of energy use and greenhouse gas production is agriculture, including crop production and animal husbandry, accounting for nearly one third of the total energy use of the system, while also being responsible for 15-29% of greenhouse gas emission. Food processing requires 28% of the system's energy consumption. Using another grouping, post-agricultural activities, that is, processing, logistics and packaging together require half of the energy needed to operate the supply chain. Post-product activities (such as the disposal of food waste) account for less than 5% of the energy consumption of the system **[17, 6]**.

The *Food and Agriculture Organization of the United Nations* (FAO) estimates that, expresses in "primary product equivalent", 1,600 billion tonnes of food were lost worldwide in 2007; 300 billion tonnes of this would have been still edible. By comparison, total world agricultural production for food and non-food purposes in the same year was 6,000 billion tonnes **[18]**.

The FUSIONS (*Food Use for Social Innovation by Optimising Waste Prevention Strategies*) project, aimed at reducing food waste and loss, estimates that annual wastes and losses in the European Union, including edible and non-edible parts, totaled 88 million tonnes in 2012, which means an average of 173 kilograms per person. Compared to the annual food production, it can be stated that 20% of the food

produced within the Union goes to waste. More than half (53%) of the waste and loss is generated in the households, followed by processing (19%), hospitality (12%), agriculture (11%) and trade (5%) **[19]**.

Many elements and dimensions of the food supply system interact with each other, so interventions may cause unexpected results and side effects. This means that changing one circumstance (for example, reducing environmental pressure) will also effect another factor (such as employment or investments) **[20]**. Improvements in the efficiency of production processes lead to a reduction in the post of products and services, which stimulates consumption (boomerang effect) **[21]**. In addition, stakeholders of the supply system have different goals, so they may have different views regarding the intervention points. Due to this complexity, analyzing, regulating and changing production processes is a major challenge for all participants **[22]**. This situation is exacerbated by the fact that environmental drivers, trends and impacts are increasingly influenced by globalization, while consumption patterns and living standards are influenced by long-term megatrends **[21]**.

The challenges facing the food supply system clearly confirm the urgency of action to develop a sustainable, diversified, competitive and flexible production and consumption system.

4. New approaches to the food supply system

Because of the complexity of the system, working together to achieve common goals can lead to conflicts between stakeholders for which it is advisable to search for compromise solution. By focusing on relationships, thinking through the food system can identify the causes and relationships of the outcomes, and the resulting compromise situations can be handled well and can be mutually beneficial. Understanding the interplay between relationships will allow the individual benefits and harms to be addressed, while key action that can have a positive impact at multiple levels across a range of policy objectives can also be identified **[3]**.

4.1. Thinking in a system

It is not a new notion in terms of food, but systemic and transdisciplinary thinking has become increasingly popular in recent years. Thinking in a food system links the activities of producers, processors, distributors, traders and consumers with food safety and social and environmental impacts; in this way they are regarded as interacting activities embedded in a social, political, economic, historical and environmental context **[23]**. Understanding the dynamics of a complex supply system is an essential part of the transformation. It also requires the recognition of the relationships and interactions between the elements and external and internal factors, as well as the entire system.

4.2. Responsible research and innovation

While policies play an important role, understanding and managing the scientific foundations, challenges and interactions of food systems is key to ensuring resilience to the future. As a result of changes in the research and development environment, the need for responsibility-driven processed has increased today. On the one hand, innovation processes are increasingly subject to external influences and, on the other hand, these processes and their results are increasingly, and sometimes negatively, affect the environment. This has led to the development of the *Responsible Research and Innovation* (RRI) approach, according to which, partly to avoid adverse effects, scientific research and innovation necessarily has to become responsibility-driven, carefully examining their impact on society, individuals and the natural environment **[24]**. In other words, due to concerns and uncertainties, responsible research and innovation also includes ethical, social and environmental aspects **[25]** (***Figure 2***). The popularity of this approach is indicated by the fact that it appears more and more frequently in the scientific and technological policies of the European Union **[26]**.

5. International initiatives aimed at sustainability

The challenges facing the food supply system cannot be solved by themselves, since the system that integrates them is only one of several types of structures serving society and so it cannot be modified without affecting its close relationship with other systems. For this reason, most of the sustainability initiatives that have been launched at the international level have comprehensive objectives, the realization of which also have an impact on the food supply system. At the same time, building on these endeavors, specific initiatives to reform the food supply system have already been launched in the past. Below, some comprehensive initiatives specifically addressing the food supply system are presented.

5.1. UN – Agenda 2030 framework and sustainable development goals

In September 2015, 193 member states of the United Nations (UN) adopted the new integrated framework for sustainable development for the period 2015-2030 (*Transforming our world: The 2030 Agenda for Sustainable Development*), outlining ideas to eradicate poverty, combat inequalities and to protect the environmental system of our Earth. The Agenda focuses on *Sustainable Development Goals* (SDG). The 17 goals and the corresponding 169 sub-goals have been developed by professionals with the promotion of the three basic pillars of sustainability (economy, environment and society) in mind, to address the challenges ahead and to improve our habitat, economy and life **[28, 29]**. The goals include several sub-goals that affect the food supply system, such as eradicating hunger, establishing food safety and a

balanced diet, as well as promoting sustainable agriculture **[28]**.

5.2. The Paris Agreement

In the Paris Agreement adopted in December 2015 and entered into force on November 4, 2016, members of the *United Nations Framework Convention on Climate Change* (UNFCCC) committed to reduce greenhouse gas emissions, to adapt to global warming and to ensure the transparency of relevant cash flows **[30]**. With respect to global emission regulation, the agreement only indirectly refers to its magnitude and timing, as it only stipulates that global warming should remain well below +2 °C compared to the period before the industrial revolution, and efforts should be made to stop it at +1.5 °C. In addition, global emission growth must be stopped as soon as possible and thereafter should be decelerated in the second half of the 21st century **[31]**. The state of implementation of the agreement is scheduled to be reviewed regularly, first in 2023 and then every five years. The agreement's set of emission reduction rules, which sets the timetable for member states to meet the targets of the 2015 Paris Agreement, was adopted in December 2018 at the UN Climate conference held in Katowice. By October 2019, the agreement had been ratified by 186 of the 197 members of the Agreement, however, Russia had not acceded to it and the United States had announced its withdrawal in 2017.

5.3. Seventh environmental action programme

Since the mid-1970s, the environmental policy of the European Union has been guided by action programs setting out the priority objectives to be achieved for the given period. The current, seventh program for the period ending in 2020 was adopted in November 2013 by the European Parliament and the Council of the European Union. In the current *Environmental Action Programme* (EAP), the Union has agreed to step up its efforts to protect natural capital, to promote resource-efficient growth and innovation built on low carbon dioxide emission and to protect human health and well-being, while respecting the limits of Earth's resources **[32]**. According to the report of the European Environment Agency, to achieve the objectives of the seventh Environmental Action Programme (1386/2013/EU) **[14]**, it is advisable to move towards an integrated approach to addressing systemic environmental challenges that is sustainable in the long term, including the transformation of the existing approach and production and consumption structures **[21]**.

5.4. EAT-Lancet Commission recommendation

The food supply system has the potential to serve both healthy nutrition and environmentally sustainable food production, but current trends are jeopardizing the achievement of these goals. In response to this challenge, the EAT-Lancet Commission, composed of 37 experts from 16 countries, has developed its nutrition recommendation urging change, focusing on environmental sustainability and healthy eating. The reference diet recommended in their study published in 2019 is considered to be a win-win solution from both environmental and nutritional aspects: it is primarily a plant-based diet with minimal consumption of food of animal origin. In addition, countries around the world are encouraged to prioritize activities resulting in quality foods over quantity production, while minimizing losses **[17]**.

5.5. FOOD 2030 strategic framework

Launched in 2015, the FOOD 2030 program is the response (strategic plan) of the EU R&D&I policy to recent international political developments, including the aforementioned Sustainable Development Goals and the commitments of the Paris Agreement. The key elements of the R&D&I strategic plan for reforming the food supply system are healthy and sustainable nutrition, climate and environmental sustainability, circular economy and resource efficiency, as well as strengthening innovation and communities (***Figure 3***). An important objective is to reduce greenhouse gas emissions and civilization diseases by half by developing energy-efficient and flexible systems, while increasing social trust and participation. In addition, important elements of FOOD 2030 are maintaining and increasing the number of jobs, strengthening partnerships, increasing the value of communities and supporting knowledge transfer and education. FOOD 2030 stands for a sustainable food supply system for all **[33]**.

5.6. Project FIT4FOOD2030

Launched in 2017, the objective of the three-year Fit-4Food2030 Horizon 2020 project is to find solutions to the challenges of the food supply system (such as hunger, malnutrition, obesity, climate change, scarce energy, waste) through the support of the European Commission's FOOD 2030 policy frameworks, while integrating R&D&I possibilities. As part of this work, we may gain insight into the functioning of the food supply system, related research and innovation systems, breakthrough points and relevant practices. A further aim of the work is to inform stakeholders beyond the project through effective and targeted communication and dissemination activities, thus maximizing the effectiveness of the results and policy recommendations. Project work takes place at three levels, the EU Think Tank, the Policy Labs and the City Labs. The task of the Think Tank is to connect the European Commission with the stakeholders of the Food 2030 platform. The task of the Policy Labs is to map the national food supply systems, taking into account the priorities of FOOD 2030 and involving relevant stakeholders, to identify action points and to develop a proposal to support the transformation **[34]**. Hungary, with the support of the Ministry of Ag-

riculture and the Ministry of Human Capacities, has successfully applied for a national Food Policy Lab to be set up within the framework of the Fit4Food2030 project. The Hungarian Policy Lab is run by coordinators nominated by the Ministry of Agriculture, with assistance of colleagues from the Food Directorate of the Hungarian Chamber of Agriculture and the National Agricultural Research and Innovation Center, Research Institute of Agricultural Economics. City Labs use participatory and collaborative methods to develop, test and implement educational and competence development programs, and contribute to the transformation of the food supply system through city-level networking activities. Work at City Lab in Budapest is coordinated by the Environmental Social Science Research Group.

The Hungarian Policy Lab and City Lab, in cooperation with other regions and countries, actively contribute to the development of the European Union FOOD 2030 strategic framework.

6. Summary

The food supply system we currently know may change radically by 2050. New technology solutions will have a significant impact on the ways of cultivation and food production, on the product range and supply channels. However, today's food supply system is not prepared for the tasks ahead. There is an urgent need for action to achieve sustainability and to transform the system, through the implementation transdisciplinary systemic thinking and the integration of responsible research and innovation aspects. Many international action plans and proposals can guide this transformation, and the FIT4FOOD2030 project with domestic involvement plays a crucial role in determining the path to this, the domestic results of which will be discussed in more detail in our later articles.

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