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Sustainability of EU food policies: the coexistence of a plant-based diet and organic agriculture

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Statement of Original Authorship

I hereby declare that I have composed the present thesis autonomously and without use of any other than the cited sources or means. I have indicated parts that were taken out of published or unpublished work correctly and in a verifiable manner through a quotation. I further assure that I have not presented this thesis to any other institute or university for evaluation and that it has not been published before.

03/07/2023 Arianna Di Bono

Abstract

This thesis explores the sustainability of European Union (EU) food policies, with a focus on the coexistence of a plant-based diet and organic agriculture as potential contributors to a more sustainable food system. It highlights the urgency of transforming the current food system to avoid exceeding planetary boundaries. The analysis encompasses the current EU food system, production patterns, consumers' habits, and food security. It emphasises the promotion of a plant-based diet within the EU's Farm to Fork strategy. The role of agriculture and the promotion of organic methods under the Common Agricultural Policy are critically evaluated for their impact on the environment and human health. The thesis also examines the long-term sustainability implications of organic agriculture and a plant-based diet, considering environmental impacts, resilience of the food system, and shifts in consumers' dietary habits. The findings provide insights for shaping future EU food policies towards sustainability.

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Introduction

As defined by the Food and Agricultural Organisation (FAO), the term food system comprises the whole set of the actors involved in the production, aggregation, processing, distribution, consumption, and disposal of food. It also encompasses their relationship with the wider economic, social, and natural environment within which they operate. Furthermore, a food system incorporates several subsystems, including farming and waste management, which are strictly related to other sectors such as health, energy, and trade sectors. As a result, changes in one sub-system might lead to structural changes in the whole food system [1]. There is no generally accepted definition of what a sustainable food system is. Divergent perspectives and interests of numerous actors in the food system are reflected in definitions that vary in scale, change over time, and depend on context [2]. In accordance with FAO's definition, a food system is sustainable when it successfully achieves food security and an adequate amount of nutrients for the whole population, without jeopardising the environmental, economic, and social equilibrium and resources which are essential to provide food security for future generations [3].

It is generally agreed, however, that sustainable food systems should produce certain outcomes. It needs to deliver a positive outcome in both the economic, social, and environmental dimensions at the same time [4]. From an economic perspective, in a sustainable food system each actor involved should engage in commercial and fiscally feasible and profitable activities [2]. Socially, a food system is sustainable when it fairly deploys resources and products giving particular attention to vulnerable groups such as elders, children, and ethnic minorities. It should also foster the improvement of animal welfare, working conditions and socio-cultural traditions. Finally, an environmentally sustainable food system must take into consideration animal and planet health, carbon footprint, biodiversity, water,

[1] https://www.fao.org/3/ca2079en/CA2079EN.pdf
[2] European Commission, Directorate-General for Research and Innovation, Group of Chief Scientific Advisors, *Towards a sustainable food system : moving from food as a commodity to food as more of a common good : independent expert report*, Publications Office, 2020, https://data.europa.eu/doi/10.2777/282386
[3] https://www.fao.org/3/ca2079en/CA2079EN.pdf
[4] https://foodwise.org/learn/sustainability/#:~:text=The%20Four%20Pillars%20of%20a%20Sustainable%20Food%20System&text=A%20sustainable%20food%20system%20uses,economically%20viable%2C%20and%20socially%20just

and soil quality. Moreover, it should have a beneficial impact on the environment or, at least, a neutral one [2].

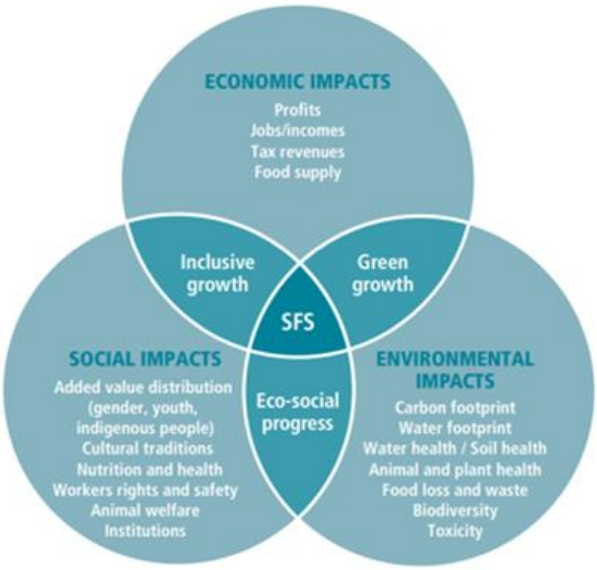


Figure 1: sustainability in food systems. Source: FAO ,2014.

The food system that has been established in the EU over the last 60 years is inherently unsustainable. Therefore, a comprehensive change of the whole EU food system is now imperative [5]. Due to the adoption of the Western diet and the increasing globalisation of supply chains, European diets have undergone significant changes in the last decades. As a result, the current EU food system has a detrimental impact on both human health and the environment. Rich in fat, sugar and salt, EU dietary patterns are mainly composed of processed food and animal products and are responsible for 90% of all premature deaths and the major cause of non-communicable disease (NCDs). Moreover, food production is one of the main drivers of biodiversity loss, desertification and land degradation and it causes approximately 30% of the whole anthropogenic greenhouse gas emissions. The food system is also causing severe inequalities, and the EU is torn between overconsumption, food waste and millions of people unable to afford a nutrient dense meal on a daily basis. The EU food system has also demonstrated a lack of resilience. Climate change-induced extreme weather events, Covid-19, the invasion of Ukraine, and unchecked financial speculation in food

5 https://www.arc2020.eu/sustainable-food-systems-law-eu-food-policy-coalitions-recommendations-for-a-meaningful-transition/#:~:text=The%20overarching%20objective%20of%20the,that%20operate%20within%20planetary%20boundarie

commodities all threaten the stability of the food system [6]. It is important to mention that food production has increased significantly over the past few decades, surpassing the rate of population growth by more than 30% since the early 1960s (IPCC, 2019) [7]. Nevertheless, this surplus did not result in the achievement of food security. Furthermore, the food system is expected to become increasingly strained due to rising food demand. It foreseen that by 2050, the production of 50-70% more food will be required to meet the anticipated growth in demand due to the increase in population, unless there is a change in dietary habits [8].

Consequently, several challenges are to be tackled in order to establish a sustainable food system which is rich in nutrients, respects human rights, preserves humans' health and does not harm biodiversity nor the environment. Increasing evidence suggests that human activities must be maintained within the "safe operating space for humanity" of the planetary boundaries for sustainable development to occur [8] [9].

Nine systems and processes are identified in the planetary boundaries framework as being crucial for balancing the state of the Earth system as a whole. Food production planetary boundaries indicate the maximum level of environmental impacts associated with food production on a global scale that does not undermine Earth's equilibrium. At the current state, global food production is sufficient to meet the food demand, but in doing so, it is disregarding and exceeding the planetary boundaries. In light of this, it is evident that the current dietary and food production patterns are not sustainable [10].

[6] https://eeb.org/work-areas/agriculture/food-systems/
[7] https://www.sapea.info/wp-content/uploads/sustainable-food-system-report.pdf
[8] https://www.sciencedirect.com/science/article/pii/S0959652622035211
[9] https://www.sapea.info/wp-content/uploads/sustainable-food-system-report.pdf
[10] https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/7b5iok5vqz_Bending_the_Curve__The_Restorative_Power_of_Planet_Based_Diets_FULL_REPORT_FINAL.pdf.pdf?_ga=2.233687830.980309191.1685539604-88222471.1682949894

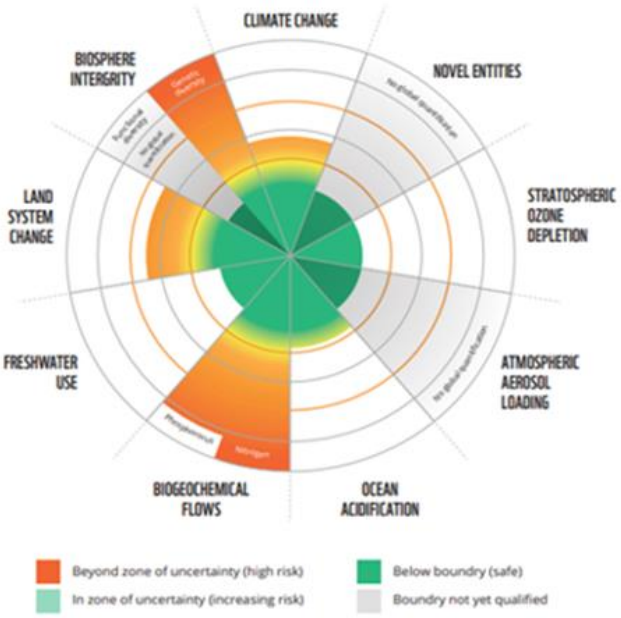


Figure 2: Planetary boundary framework. Source: Whitmee at al. 2015.

A transition towards a sustainable food system requires five paradigm shifts to take place in parallel [11]:

1. Ensure high quality water and soil availability and access.
2. Implement climate-resilient agricultural lands.
3. Providing healthy and sustainable diets to all.
4. Optimise supply chains making them shorter, greener and cleaner.
5. Promote sustainable development through trade.

As a final note, it is important to recognize that most of the challenges associated with food systems, food security and nutrition are highly complex while the possible solutions are cross disciplinary and constantly under discussion [12]. As food systems become increasingly globalised, these challenges are even more driven by interactions between different sectors. As a result, it is required an interdisciplinary and holistic approach to address them, involving

[11] https://eeac.eu/wp-content/uploads/2022/10/Towards-a-sustainable-food-system-_-An-EEAC-Network-Position-Paper-PV.pdf
[12] https://www.fao.org/3/ca2079en/CA2079EN.pdf

actions from both public and private sectors, as well as at the local, national, regional, and global levels. A diverse range of sectors must be involved, from agriculture to transport and education [13].

Scope and limitations of the study

The thesis aims to provide a comprehensive analysis of whether a sustainable food system can be achieved through the concurrent adoption of a more plant-based diet and organic agriculture. To address this objective, the following research objectives were established:

1) Analysing the current food system in the EU. For this purpose, the current food production patterns will be examined together with the consumers' eating habits.

2) Examining the Farm to Fork strategy. This objective focuses on assessing the effectiveness of the Farm to Fork strategy in promoting a sustainable food system, particularly in relation to encouraging a plant-based diet.

3) Assessing the role of agriculture and the new Common Agricultural Policy (CAP). This objective involves examining the role of agriculture and the promotion of organic methods within the new CAP, as well as evaluating its contribution to the objectives of the Farm to Fork strategy.

4) Evaluating the impacts of plant-based diet and organic agriculture. Adopting a plant-based diet and implementing organic agriculture practices will be evaluated in terms of their effects on the environment, health, and food security.

5) Assessing the long-term sustainability of organic agriculture and a plant-based diet. This final objective aims to determine whether the concurrent adoption of a plant-based diet and organic agriculture is beneficial in achieving a sustainable food system.

The research specifically concentrates solely on the aforementioned aspects and does not delve into other scopes, such as: fish farming, animal welfare, the role of vegetarian and vegan diets and the potential impacts on the economy, job market and trade relations and policies. It is important to highlight that considering and analysing these other key elements may alter the conclusions drawn in this research. Furthermore, it is also acknowledged that the current research on the effects of organic food consumption on human health is limited compared to other topics in nutritional epidemiology. Observational studies present a

particular challenge as they reveal that individuals who regularly purchase organic food tend to opt for more vegetables, fruit, wholegrain products, and less meat, indicating overall healthier dietary patterns. Consequently, when examining the associations between organic versus conventional food consumption and health outcomes, it is not always clear whether the outcomes are due to organic food consumption or not. Finally, due to the absence of specific targets and guidelines for adopting a plant-based diet within the EU, the research refrains from providing extensive projections on the future impacts of plant-based diet and of its concurrent adoption with organic agriculture.

Literature review

The literature on food sustainability, organic agriculture, and plant-based diets is extensive and reflects the growing importance of these topics due to factors such as the increasing global population, changing dietary patterns, and mounting environmental concerns.

However, one notable challenge is the absence of a universally accepted definition of food sustainability, leading to variations in the literature. Typically, sustainability definitions encompass ecological, economic, and societal dimensions, but their interpretation can vary depending on the context. While some researchers have provided insights into current trends and the interconnections between sustainability and the food supply chain, most articles tend to focus on specific themes or processes[13].

These themes and processes include sustainable sourcing (Ghadge et al., 2017), food traceability (Bosona and Gebresenbet, 2013), strategies for enhancing sustainability in the food chain (Sharma et al., 2017; Dania et al., 2018), tactics for sustainable supply chain management (Beske et al., 2014; Zhong et al., 2017), food safety (Siddh et al., 2018), measurement of sustainability in various aspects (Sharma et al., 2021), and the application of circular economy principles (Corallo et al., 2020). Despite the increasing number of empirical studies in this field, there remains a lack of an integrated perspective that comprehensively links recent trends and various facets of food supply chain management (FSCM). Many of these studies tend to have a narrow focus, exploring specific viewpoints without providing a broader exploration of the topic [14].

Numerous works emphasise the environmental and health benefits associated with organic agriculture (Das, Chatterjee, & Pal, 2020) and the impact of plant-based diets (Molina-Montes et al., 2020). Others compare organic products with conventionally grown ones (Rembiałkowska, 2007) or contrast plant-based products with dairy, meat, and fish products (Joan Sabaté & Sam Soret, 2014). Assessments of the environmental impact of specific foods and complete diets predominantly rely on climate impact analyses (Jones et al., 2016). However, comprehensive environmental assessments of complete diets are limited due to the

[13] https://academic.oup.com/ajcn/article/100/suppl_1/476S/4576675

[14] A systematic literature review of food sustainable supply chain management (FSSCM): building blocks and research trends | Emerald Insight

absence of established methodologies for estimating certain environmental effects, such as biodiversity loss, and the lack of specific environmental data for certain food items (Ridoutt et al., 2017). Research examining the environmental impact of diets often utilises per capita dietary data or theoretical diets based on dietary recommendations (Perignon and Darmon, 2022) [15]. Furthermore, there is a scarcity of works that specifically analyse food sustainability while considering the simultaneous adoption of organic agriculture and plant-based diets. Consequently, the objective of this thesis is to address this research gap by examining the impacts of these practices on the environment, health, and food security.

[15] https://www.cleanenergywire.org/factsheets/eus-farm-fork-strategy-impacts-climate-productivity-and-trade

Methodology

This chapter outlines the methodology employed to investigate the sustainability of EU food policies, specifically examining the coexistence of a plant-based diet and organic agriculture. A mixed-methods approach was chosen to address the research objectives effectively, combining quantitative data analysis to explore statistical trends and patterns, and qualitative content analysis to examine policy documents and relevant literature. The combination of quantitative and qualitative analyses allows for a robust examination of the potential benefits for human health, the environment, and food security.

Quantitative data were collected from secondary sources, such as Eurostat, Food and Agriculture Organization (FAO) and relevant EU reports and publications. Data on food production, consumption patterns, environmental indicators, and food security metrics were extracted to assess the current state of the EU food system and the possible development under the influence of the Farm to Fork and CAP policies. These data sources provided valuable insights into statistical trends and patterns related to plant-based diets, organic agriculture.

Qualitative data were collected through content analysis of policy documents and relevant academic literature. Official EU policy statements, reports, and academic publications were sourced from authoritative platforms such as the European Commission's official website and reputable academic databases. The content analysis focused on identifying key themes, goals, and issues set forth by each policy regarding the promotion of a plant diet and organic agriculture and their coexistence.

Chapter 1 Current EU food system

The EU food system relies on an intricate network of interconnections between different sectors to deliver food from producers to consumers [16] . The Treaty on the Functioning of the European Union (TFEU) outlines the legal foundation and the framework of underlying values of the EU food system, including the protection of consumers and secure supplies of agriculture and fishery products at affordable prices [2]. Moreover, the EU food system is regulated under various policies which cover all sectors of the food chain [17]. The Common Agricultural Policy (CAP) and Common Fisheries Policy (CFP) are included among these policies, as well as policies related to the environment, conservation, health and food safety, research and innovation, competition in the single market, trade, and development. It is also important to mention the EU's commitments in regard to the United Nations Sustainable Development Goals (SDGs) and the 2015 Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) [18]. Both of them are vital international initiatives. The SDGs, with 17 goals and 169 targets, address diverse issues like poverty, health, climate and education, promoting a holistic approach to development. The Paris Agreement aims to limit global warming to well below two degrees Celsius, engaging countries to set their climate targets and provide support to developing countries. They foster global cooperation, tackle interconnected challenges and emphasise accountability, transparency and sustainable development for a better future [18] [19] [20].

The food chain's sectors encompass primary production of food and its processing, production of feed, food storage, transportation, and retail sales [19] . Production, processing, distribution, and consumption are all crucial stages and the effective passage of goods between them is of primary importance to the food chain's functioning [2] . According to a recent Eurostat analysis, a total of 13 million enterprises and 29 million workers are involved

16 https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/652058/EPRS_BRI(2020)652058_EN.pdf

17 https://food.ec.europa.eu/horizontal-topics/general-food-law_en

18 https://unfccc.int/topics/cooperative-activities-and-sdgs/action-on-climate-and-sdgs

19 https://unfccc.int/process-and-meetings/the-paris-agreement

20 https://sdgs.un.org/goals

in the production, processing, distribution, preparation, and sale of food and beverages in the EU [21] . The EU food system is also supported by agribusinesses, transportation companies, and warehouses. Another significant component of the EU food system is the import and export of food and agricultural products to countries outside of the EU since it offers market opportunities, raw materials and broader selection of products to consumers. Finally, food is more than just a commodity essential for human survival; it has deep historical, cultural, and social meanings as well. As a result, the EU food system also incorporates consumers' choices and attitudes toward food consumption [17].

1.1 Production patterns

Through investments in capital, labour, and inputs (i.e. pesticides, mechanisation), the EU has significantly improved its productivity capacity since the 1960s, which has resulted in an increased agricultural output and in the production of specialised cereals and meats. Prior to early 2000 these developments were facilitated by price support schemes under CAP, resulting in overproduction. As a consequence of the focus on production and productivity, agro-ecosystems began to undergo dramatic structural changes, as they shifted from low-intensity mixed agriculture systems to regional specialisation, intensification, and land abandonment, posing a long-term threat to their sustainability. A significant change has particularly occurred in the livestock sector. It is estimated that the global meat production has quadrupled between 1961 and 2010, as has the egg production, and the milk production, which have more than doubled (HLPE, 2017) [22] .

Over the last few years, food production in the EU has faced a number of challenges in maintaining its resilience. As a consequence of climate change, adverse and extreme weather events have become more frequent, as well as the spread of zoonosis. Moreover, due to Covid-19, post-Covid recovery, and the Russian invasion of Ukraine the EU has experienced trade disruption, and higher prices for commodities, inputs and energy [24] . Despite challenges, EU agri-food trade performed well in 2022. Trade in agricultural products between the EU and extra-EU accounted for 7.6 percent of international trade in goods with a total trade

[21] https://ec.europa.eu/eurostat/documents/15216629/15230598/KS-FK-21-001-EN-N.pdf/20068cf7-5ae8-8020-4ed7-12b0ccadf854?t=1666944507652
[22] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/addressing-the-sustainability-dimension-of-eu-food-production/

(imports plus exports) value of €425 billion [23] . In light of the fact that exports (€229 billion) exceeded imports (€196 billion), a surplus of €33 billion was generated. In October 2022, the EU trade flows of agricultural and food products reached the value of €36.5 billion, surging to record levels from previous months [24] . During that month, the share of EU agri-food imports has reached €15.7 billion, determining a 3% increase compared with the previous month. In particular, imports from Ukraine raised by 25%, with sunflower oil, seeds and maize accounting for 70% of EU total food imports. Even with an increase in imports, the overall trade balance for the EU remains positive at €5 billion [25].

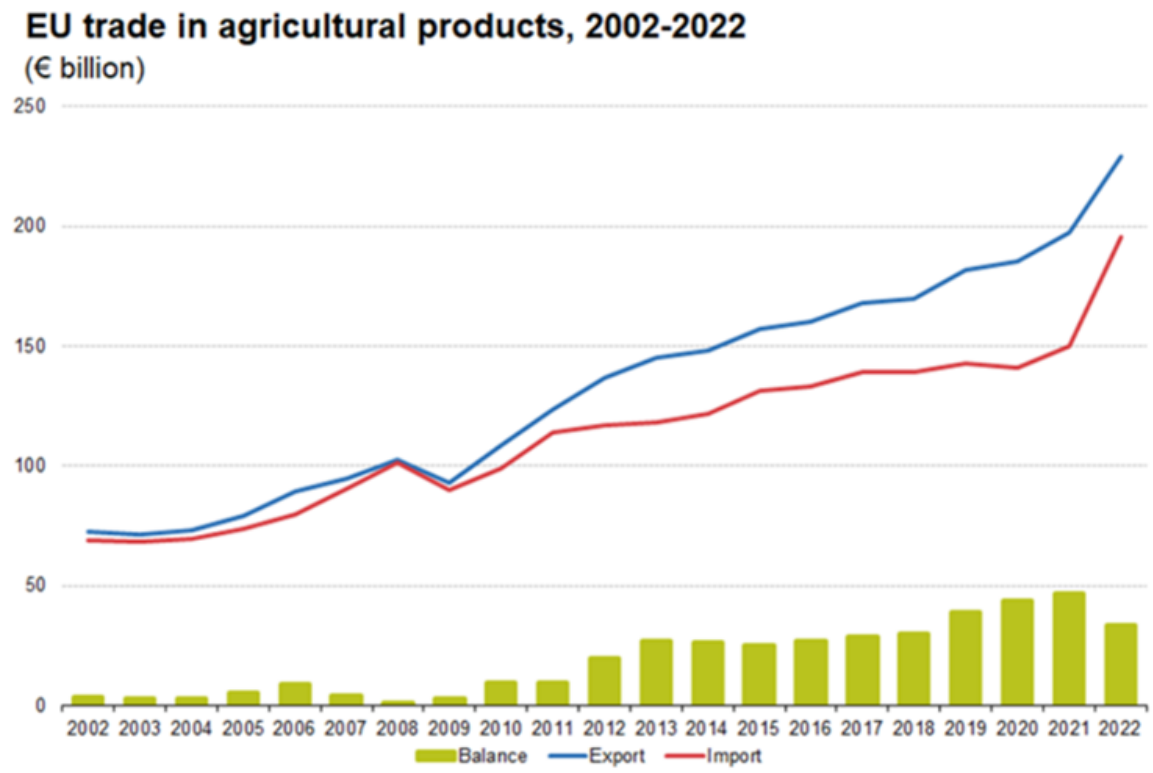


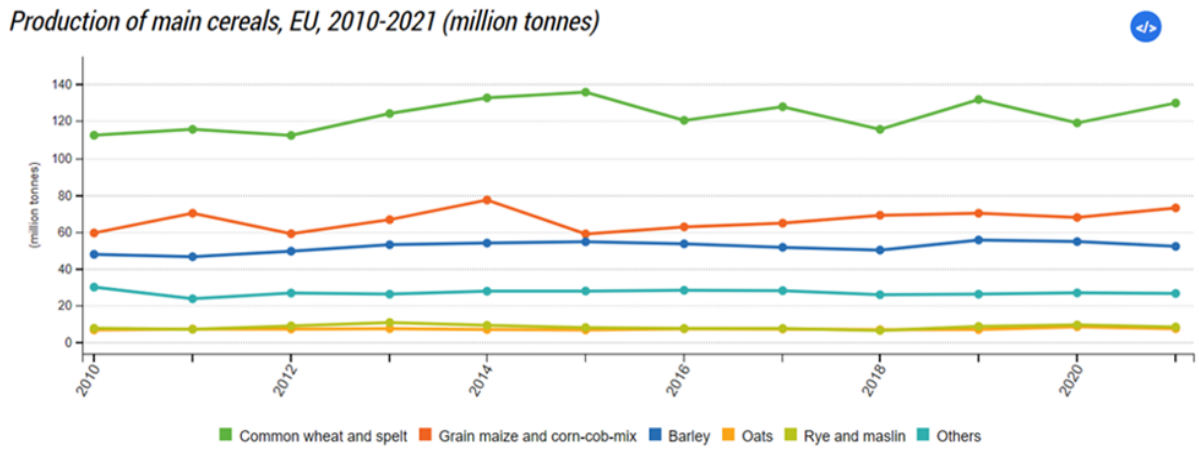
Figure 3: EU trade in agricultural products, 2002-2022. Source: Eurostat (online data code: DS-045409)

[23] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Extra-EU_trade_in_agricultural_goods#:~:text=The%20EU%20imported%20158%20million,than%20imports%20(1.6%20%25)

[24] https://agriculture.ec.europa.eu/news/increase-eu-agri-food-imports-october-2022-2023-01-31_en

- **Cereal production**

In 2021, 297.5 million tonnes of cereals (including rice) were harvested across the EU. In comparison with 2020, the output price of cereals in the EU was found to increase by an average of 28.4%. However, at the same time, there was an increase of 12.2 million tonnes (4.2%) which helped the EU to recover from the drought-affected level of the previous year. The overall production rebound was mainly driven by large increases in Romania (+5.3%) and France (+17.6%), which together accounted for 19.6 million tonnes of additional production. France alone harvested 66.9 million tons of cereals, which is equivalent to 22.5% of the total production of cereals in the EU. As for the production in other EU countries, 42.4 million tonnes of cereals were harvested in Germany (14.3 percent of the total EU), 34.0 million tonnes in Poland (11.4 percent of the total EU), 27.8 million tonnes in Romania (9.3 percent of the total EU), and 25.5 million tonnes in Spain (8.6 percent of the total EU). However, some Member States experienced severe declines in harvested cereal production, including Spain (-6.6%, a reduction of 1.8 million tonnes), Hungary (-10.2%, a reduction of 1.6 million tonnes) and Lithuania (-18.4%, a reduction of 1.2 million tonnes) [25] .



[25] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_production_-_crops#:~:text=Highlights&text=The%20EU%20produced%20297.5%20million%20tonnes%20of%20cereals%20in%202021.&text=In%202021%2C%20cereal%20production%20in,drought%2Daffected%20level%20of%202020.&text=The%20output%20price%20of%20cereals,an%20average%2028.4%20%25%20in%202021

Figure 4: production of main cereals, EU, 2010-2021. Source: Eurostat (online data code: apro_cpnh1)

- **Vegetable and Fruit production**

In the EU the specialisation of fresh vegetable production is less widespread than that of fresh fruit. In 2021 across the EU fresh vegetables were grown on 2.0 million hectares, yielding 67.2 million tonnes of crop. The most common fresh vegetables cultivated are tomatoes (17.9 million tonnes), onions (7.1 million) and carrots (5.3 million tonnes). As of 2021, Spain had the largest share of the EU's harvested fresh vegetable production (24.2%), followed by Italy (20.6%). But as for the other EU Member States, the production has never registered double-digit shares [24].

There are millions of tonnes of fruit, berries, and nuts produced in the EU every year. There were approximately 36.4 million tonnes of pome fruit (apples and pears) harvested in 2021, followed by 11.5 million tonnes of citrus fruits (oranges, satsumas and lemons), 6.0 million tonnes of stone fruit (peaches, nectarines, apricots, cherries, and plums), 2.6 million tonnes of tropical fruit (like figs, kiwis, avocados and bananas), 1.2 million tonnes of nuts and 0.7 million tonnes of berries. Among the EU's main producers of fruit, berries, and nuts in 2021, Poland (19.7%), Italy (19.3%), and Spain (17.8%) ranked first, second, and third, respectively. Due to its favourable weather conditions, the EU citrus production is dominated by Spain, which contributed to about three fifths (58.4%) of the total production [24] [26].

[26] https://ec.europa.eu/eurostat/en/web/products-key-figures/w/ks-fk-22-001

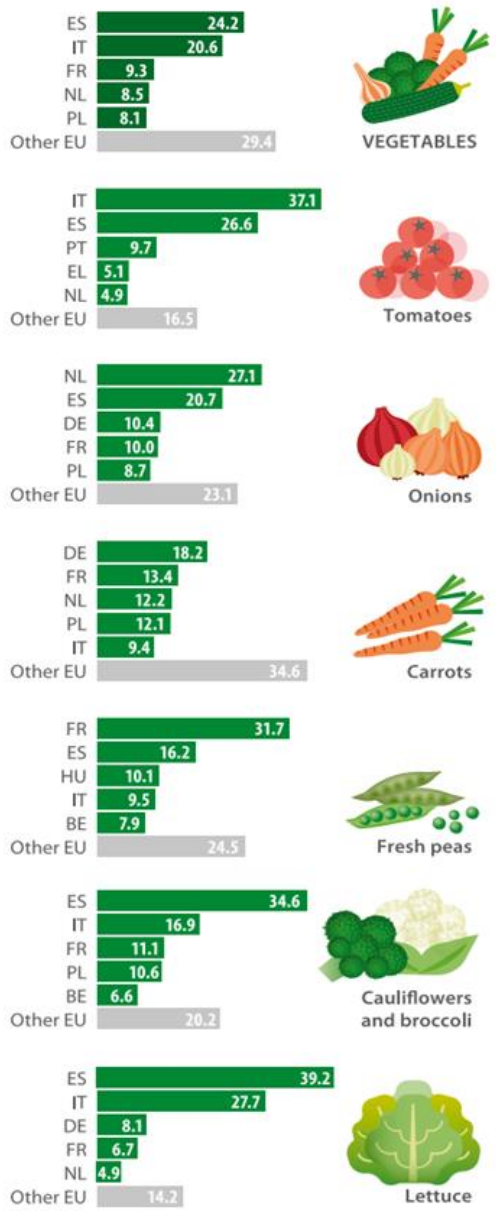


Figure 5: Share of EU production of various types of vegetable. Source: Eurostat (online data code: apro_cpnh1)

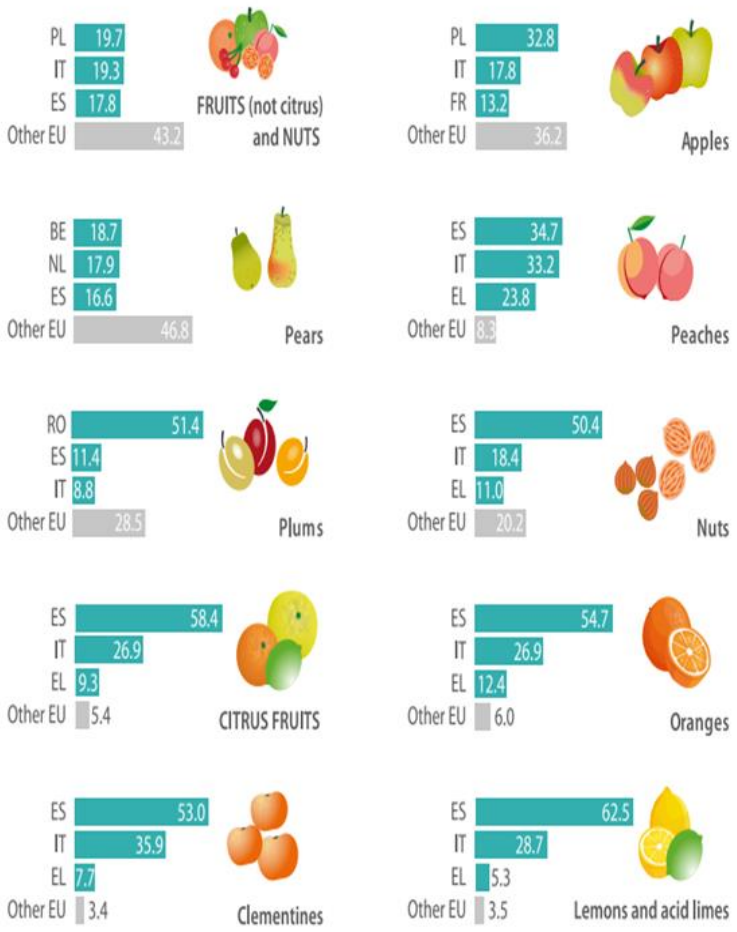


Figure 6: Share of EU production of various types of fruit, berries and nuts (Source: Eurostat (online data code: apro_cpsh1)

- **Meat production**

In the last two decades, livestock populations have declined throughout the European Union. The number of pigs, cattle, sheep, and goats in the EU decreased by an estimated 11.5 % from 326 million in 2001 to 289 million in 2021. Between 2020 and 2021, a 1.1% decline in the bovine animal population has been reported. Declines in sheep, goats and pigs were even sharper at 1.7%, 2.6% and 2.9%, respectively. Between 2006 and 2021, bovine meat production fell by 7.4 %, while the production of sheep meat and goat meat dropped by 40%. In contrast, during the same period, the production of poultry meat in the EU rose by approximately 41%, together with an increase by 9-8% in pig meat production, despite a decrease in pig population. Furthermore, only a few EU member states hold the majority of

EU livestock. In 2021, Spain was the leading county for the production of pig and sheep populations, providing around one quarter of the EU's production (24.3% and 25.1% respectively). In Greece a similar share was recorded in goat population, while France is one of the major contributors to the bovine population (22.9%) [24] [27] .

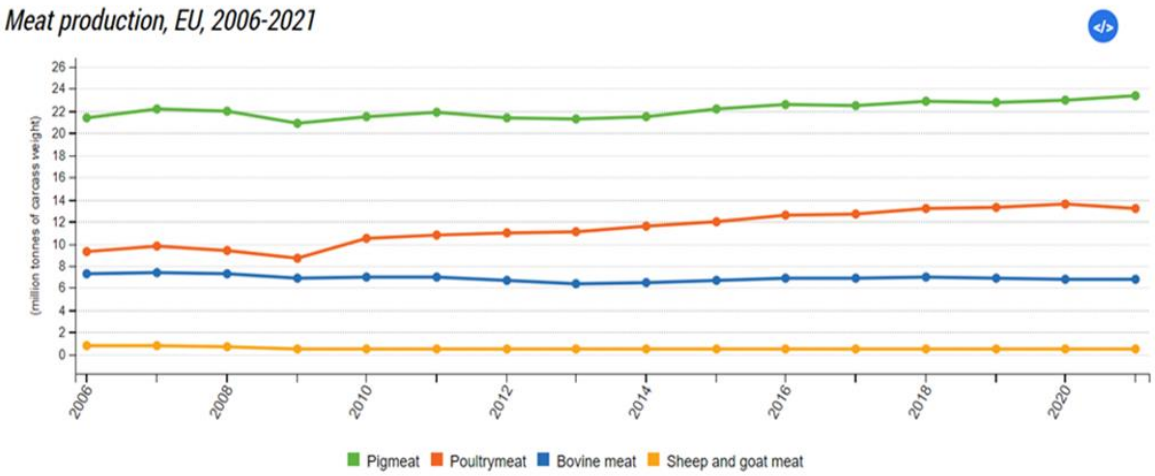


Figure 7: meat production in the Eu, 2006-2021. Source: Eurostat (online data code: apro_mt_Iscati)

- **Food waste**

In the European Union, nearly 59 million tonnes of food waste are produced per year (131 kg/person per year), resulting in a market value of 132 billion euros based on Eurostat's most recent estimates (Eurostat, 2022) [28]. For instance, in 2020, agriculture, forestry, fishing, and the processing of food, beverages, and tobacco produced 56.1 million tonnes of waste. In the same year, EU residents only generated 128 kilograms of food waste [29]. The majority of which, 55%, resulted from/ came from households, while the 18% from processing and manufacturing [28]. In 2020, the highest percentage of waste from agricultural, forestry and fishing activities was recorded in Spain and the Netherlands. With 29.5% and 22.8% of the

[27] https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=427096
[28] https://food.ec.europa.eu/safety/food-waste_en#:~:text=Related%20links-,About%20Food%20Waste,euros%20(Eurostat%2C%202022)
[29] https://ec.europa.eu/eurostat/documents/15216629/15559935/KS-FK-22-001-EN-N.pdf

EU's total waste coming from food and beverage production, they are responsible for more than half of the waste generated from food and beverage production. In terms of waste generated by food and beverage processing, the Netherlands leads the list with 22.8%, followed by France with 13.4% and Belgium with 12.1% 14. Food waste from households was collected in the most volume in Cyprus in 2020 with 397 kilograms per person, while Denmark ranked with 221 kilograms per person. In the majority of EU Member States, household waste is the primary source of disposed food waste. There were only 7 EU Member States reporting less than 100 kilograms of food waste collected per person, including Croatia with 71 kilograms and Slovenia with 68 kilograms [28].

The amount of food wasted is believed to be even higher according to other studies. As an example, the estimate from the report entitled 'No Time to Waste' suggests that the EU wastes 153.5 million tonnes of food every year . On the basis of these findings, the EU wastes more food than it imports. In 2021 the EU has, indeed, reached almost 138 million tonnes of imported agricultural products, which costed about €150 billion [30].

The impact of food waste on the environment is enormous, as it contributes to about 7% of EU greenhouse gas emissions (associated to the EU's consumption footprint) and reduces natural resources, such as water and land [31] . Hence, the reduction of food waste can have an enormous impact on reducing the resources used to produce food. It has been estimated that reducing EU food waste by 50% may save approximately 4.7 million hectares of farmland by 2030. The fight against food waste will have positive impacts on both the economy, society, and the environment. Indeed, it would contribute to increasing food for human consumption; reduce environmental impact; and save farmers, companies, and consumers money [29].

[30] https://eeb.org/eu-wastes-more-food-than-it-imports-says-new-report/
[31] https://food.ec.europa.eu/system/files/2023-04/fw_lib_reduce-food-waste-eu_faqs_0.pdf

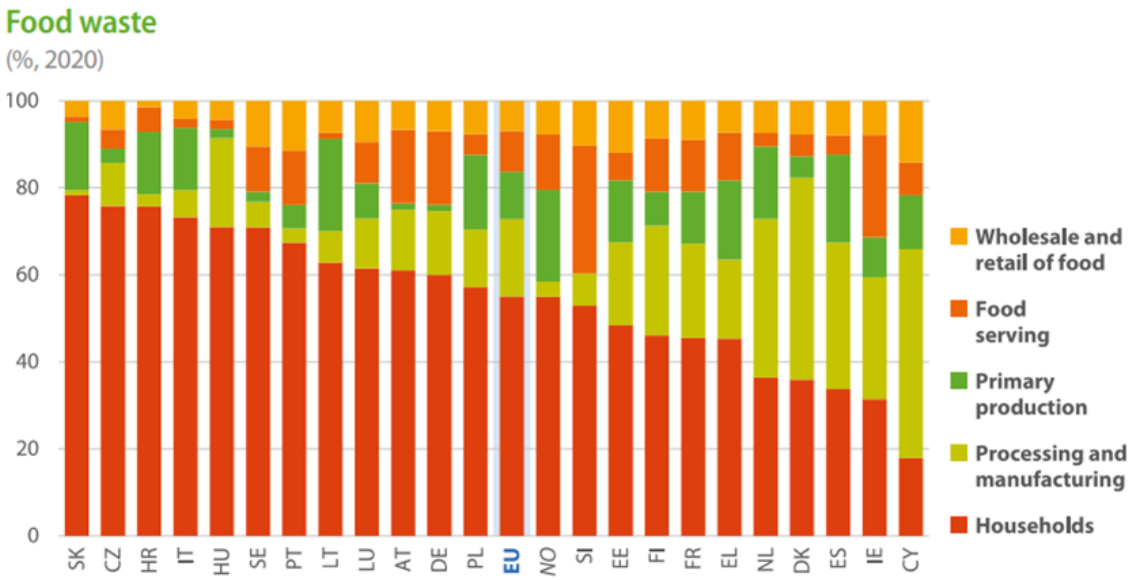


Figure 8: food waste, EU, 2020. Note: BE,BG,LV and RO not available. Source: Eurostat (online data code: env_wasfw)

1.2 Consumers' dietary habits

Consumers in the EU spend approximately 12.2% of their total income on food and non-alcoholic beverages. There can be significant variations in consumer choices across European countries due largely to cultural factors. On the whole, dietary habits are over-reliant on meat, dairy and starchy foods, while under-reliant on plant-based foods like fruit, vegetables, grains, legumes, and nuts compared to what is considered a healthy diet [32]. For instance, across the 27 EU Member States, only 12% of adults reported consuming five or more servings of fruit and vegetables daily, while 55% ate one to four servings and 33% ate less than one portion [31] . On the other hand, meat consumption is twice as high as the world average, while milk consumption is three times higher. Consumers tend to favour products that contain a high energy density, are rich in fats, or contain a high level of sugar or salt. Consumption of these products, most of which are highly palatable, cheap, and generally

[32] https://www.oecd-ilibrary.org/sites/49330565-en/index.html?itemId=/content/component/49330565-en

unhealthy, is highest in high-income countries, although middle-income countries have seen rapid growth in this regard as well [33] .

Consumption behaviours are determined by a combination of factors, but it is possible to identify the factors that seem to be most influential on consumers. Price is one of the most important factors that influence food purchasing decisions. Indeed, it has been estimated that dietary expenditures for a healthy diet are 60% higher than those for a nutrient adequate diet and are almost 5 times those for a calorie sufficient diet [34] . Social context as well as the habits of individuals have also a significant impact. A third important factor in determining consumers' choices is health. However, depending on the context, health concerns may provide opportunities or obstacles to sustainable food choices. Moreover, even though environmental awareness exists, it does not rank at the top of the list, as other elements, such as price, eating habits and shortage of time are prevailing [35].

The implications of these trends for both the environment and human health are significant. Europe's current dietary habits account for 27% of all environmental impacts[36] . For instance, the agricultural sector, mainly due to livestock production, is responsible for 25% of anthropogenic greenhouse emissions, the consumption of 70% of freshwater and the use of more than one third of arable land [34]. Furthermore, there has been an increase in overweight and obesity rates in nearly all European countries since 2000 [32] [37] . Over a quarter of children aged 5-12 and approximately 51% of the EU's adult population are overweight. Due to the reliance on energy-dense food and sedentary lifestyle, 16% of adults in all Member States are considered obese. As a result, healthcare systems are likely to be adversely affected. For instance, it is estimated that about 20 million people in the EU suffer from disease-related malnutrition, which costs the EU governments up to €120 billion every year (Freijer et al., 2013) [33] [35]. A notable point to observe is that in the majority of EU Member States, national

[33] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/food-security-challenges-in-an-eu-context/

[34] https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/652058/EPRS_BRI(2020)652058_EN.pdf

[35] https://valumics.eu/wp-content/uploads/2021/06/Valumics-Report-1-_Mapping-Behaviours.pdf

[36] https://publications.jrc.ec.europa.eu/repository/handle/JRC50544#:~:text=The%20report%20shows%20that%20current,reduced%20consumption%20of%20red%20meat

[37] https://www.sapea.info/wp-content/uploads/sustainable-food-system-report.pdf

dietary guidelines (NDGs) tend to be very similar to consumption patterns and in some cases appear to endorse the current state that is inadequate and sometimes also incompatible with the latest scientific evidence regarding healthy diets [38] . Thus, our current dietary patterns need to be changed substantially in order to promote better human and environmental health by 2050 according to growing evidence. For instance, the EAT-Lancet Commission Summary Report, argues/ states that in order to achieve sustainable health, consumption of red meat and sugar is recommended to decline by more than 50%. This decline should also be complemented by a 50% increase in the consumption of fruits, vegetables, legumes, and nuts [33].

1.3 Food security

As defined by the Food and Agriculture Organization (FAO), food security is the possibility for people to have physical and economic access to an adequate amount of safe and nutritious food in accordance with their dietary needs and food preferences, in order to lead a healthy and active life [33 36] . Therefore, food security not only entails the issue of availability, but also the ones of affordability and quality. Moreover, it is strictly interrelated with the concept of food self-sufficiency, which is defined as the extent to which a country is able to meet its own food needs from the domestic production. For self-sufficiency and food security to exist, the entire food chain must function properly [37].

Throughout the decades, the EU food system has evolved, in a way that made it able to achieve a high level of food security and self-sufficiency. European countries are generally well supplied with energy per capita and have a low percentage of undernourished citizens. Furthermore, the EU is largely self-sufficient (both in the short-term and in the long-term) [37] . According to the Global Food Security Index, which takes into account affordability, availability, and quality, the European Union is considered self-sufficient and has been

38 https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/7b5iok5vqz_Bending_the_Curve__The_Restorative_Power_of_Planet_Based_Diets_FULL_REPORT_FINAL.pdf.pdf?_ga=2.233687830.980309191.1685539604-88222471.1682949894

ranked very highly. Indeed, out of 113 countries surveyed, all EU countries rank among the top 50 [39] . Hence, in the EU, food insecurity is primarily associated with health issues caused by food, not a lack of access to food, and with production costs, transport costs, and governance rather than lack of resources. Although there is little public concern over food insecurity, the problem exists for the most vulnerable, and economic crises can cause it to worsen suddenly [37].

Since 2016, there has been an increase in global food insecurity and the phenomenon has further exacerbated in the latest years. The impact of the COVID-19 pandemic, coupled with a global deterioration in macroeconomic conditions, soaring fertiliser and energy prices, have resulted in continuous increases in the price of agricultural commodities since mid-2020 [40] . Due to Russia's military aggression against Ukraine, commodity prices in the world are rising at an alarming rate while food availability continues decreasing [33] . Consequently, the number of people experiencing food insecurity in Europe is on the rise, increasing from 57.4 million in 2019 to 69.5 million by 2020. Even prior to 2020, 8.6% of EU citizens were undernourished, with 9.3% unable to afford meat, fish, or vegetarian equivalents every two days [41] [42]. Therefore, even though food availability is not currently at stake, affordability is a top concern for the EU, especially in relation to low income and vulnerable groups, who are the most impacted. As reported by Eurostat, food prices in Europe increased by almost 9% in July 2022 compared with July 2021 [36] .The prices of fertilisers, as well as energy, have increased since 2021, causing farmers to incur production issues caused by higher input costs, which resulted in higher food prices [43] . There are a number of causes which have contributed to the rising costs of food, including inflation, war, and price speculation of some products such as cereals and vegetable oils [39] .The crisis has also revealed some vulnerabilities of the EU food production system, as well as the dependence of the EU agricultural sector on a number of critical imported inputs. These include energy, animal feed additives, and agricultural fertilisers. Fertiliser market distortions may affect EU farmers acutely, since

[39] Scientific Journal Warsaw University of Life Sciences – SGGW Problems of World Agriculture volume 17 (XXXII), number 4, 2017: 111–119 DOI: 10.22630/PRS.2017.17.4.87 Silvia Jacková , Zuzana Kapsdorferová , ďudmila Dobošová , Mária Kadleþíková4 Slovak University of Agriculture in Nitra

[40] https://www.consilium.europa.eu/en/policies/food-security-and-affordability/

[41] Russia's war on Ukraine: Impact on food security and EU response (europa.eu)

[42] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/food-security-challenges-in-an-eu-context/

[43] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1963

fertilisers constitute 18% of the input costs of arable crops, and Russia is the world's biggest fertiliser exporter [33] [39]. Due to sanctions, the EU will be obliged to replace 20% of Russia's import share and 35% of Belarus' import share for potash and phosphates, respectively. Moreover, the price of energy has led to some fertiliser producers in the EU temporarily stopping production [40]. It is also worth mentioning that the EU is a significant net importer of some products, such as seafood and sunflower oil, wheat and barley [33] [44]. Specifically, a quarter of the poultry meat imported to Europe is supplied by Ukraine, as well as almost half the cereals (52% of the EU's corn imports) and the vegetable/rapeseed oils (23% and 72% of EU imports respectively) [40] . Presumably, the replacement of these products in the short term will be challenging [33] .

Consequently, food security is at the top of the EU political agenda. According to the Commission Executive Vice-President Valdis Dombrovskis: "While the EU itself does not face a food security risk, we should still address food affordability issues and take steps to make our agriculture and food supply chains more resilient and sustainable to cope with future crises." [39] . With this aim, on the 23 of March 2022, the European Commission has presented a range of short-term and medium-term measures in order to tackle food insecurity as well as assist consumers and producers in the EU [39] . Among the measures enacted, with the purpose of improving yields sustainably, the Commission is committed to make a greater use of innovation, such as precision farming, new genomic technologies, improved nutrient management, integrated pest management, and biological pesticides to replace toxic chemicals [41] [45] . Resilience will be increased by reducing the dependency of European agriculture on imported energy, energy intensive feed, and feed imports. Furthermore, the Commission has introduced a €500 million support package to provide assistance to the producers most affected by the war in Ukraine [41] [43] . Finally, Member States have been granted temporary derogations from certain greening obligations, through an implementing act adopted by the Commission. In particular in 2022, in fallow lands which are part the Ecological Focus Areas it may be allowed the growing of any crops suitable for food and feed, while maintaining the full rate of greening payments [41] [43] [46] . As a consequence, farmers will be allowed to plant any crop within the 4 million hectares of land, an area the size of the Netherlands, which is normally left fallow with the aim of protecting and restoring

[44] https://www.europeanscientist.com/en/agriculture/farm-to-fork-how-the-ukraine-war-exposed-europes-farm-to-fork-green-plan-as-unsustainable/
[45] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0133
[46] https://www.politico.eu/article/5-takeaways-from-the-eus-plan-to-stabilize-the-food-system/

biodiversity [45] .Therefore, Europe has slowed the plans of the Green Deal, especially the Farm to Fork targets. This has sparked a debate on the EU's ability to safeguard food security and on the effectiveness and achievability of the recent EU policies on food sustainability [43] .

Chapter 2 Towards a more sustainable food system?

On 13 February 2019, the European Commission published a paper entitled *Towards a Sustainable Europe by 2030* in which it calls for "a comprehensive approach entailing a genuine change in the way we produce, transform, consume and distribute food by accelerating the transition to a sustainable food system based on circular economy principles and making innovative, healthy, environment and animal welfare-friendly, safe and nutritious food production one of our key European trademarks" (European Commission, 2019). A transition towards a sustainable food system is also recognised by the European Council as a necessity for people's health (European Council 2018), as well as providing significant opportunities for economic growth, business development, and technological advancements (European Council 2019) associated with the transition to climate neutrality [2]. Moreover, as stated by Frans Timmermans, Vice President of the European Commission, the Covid-19 pandemic has proven how vulnerable the current health and food systems are and the urgency to reconcile the demands of human activity with the demands of nature [47]. At the core of the Green Deal, the Biodiversity and Farm to Fork strategies intend to promote a sustainable relationship between the environment, biodiversity, and the food system, with the aim of protecting the health and welfare of EU citizens, along with enhancing the EU's competitiveness [46] [47] [48].

2.1 Farm to Fork Strategy

On 20 May 2020 the European Commission released the Communication *A Farm to Fork Strategy - For a fair, healthy and environmentally friendly food system* (COM (2020) 381) in an effort to provide healthy, affordable and safe food for European citizens. For the first time, the European Commission has presented a holistic strategy that encompasses production, consumption, and farmer adaptation throughout the food supply chain [49]. In fact, this strategy

[47] Factsheet: From farm to fork: Our food, our health, our planet, our future. (2020, May 20). European Commission. Retrieved July 6, 2023, from https://ec.europa.eu/commission/presscorner/detail/en/fs_20_908

[48] https://food.ec.europa.eu/system/files/2022-02/f2f_legis_iia_fsfs_5902055.pdf

[49] https://www.europarl.europa.eu/RegData/etudes/IDAN/2020/652206/IPOL_IDA(2020)652206_EN.pdf

addresses comprehensively the difficulties associated with the introduction of a sustainable food system, by recognizing that healthy communities, healthy individuals, and a healthy planet are inextricably linked. Specifically, it states that "a sustainable food system will be essential to achieve the climate, biodiversity and other environmental objectives of the Green Deal, while improving the incomes of primary producers and reinforcing the EU's competitiveness" [50]. With a budget of 72 million, this strategy is at the heart of the Green Deal and will play a pivotal role in the Commission's efforts to implement the United Nations Sustainable Development Goals [51].

The Farm to Fork Strategy's text consists of five sections [49]:

1) A brief overview explaining why the EU food system must be transformed into a sustainable one urgently.

2) How to achieve the EU vision for the future agri-food system: policy objectives and strategic goals.

3) The identification and development of enabling factors that will facilitate a fair transition and turn challenges into opportunities for sustainable development: engagement of all stakeholders, investments and research.

4) Contributions of EU external policies to the transition to sustainable agriculture and food systems: partnerships with developing countries, trade agreements, Green Alliances.

5) Concluding remarks, which emphasise that the F2F Strategy must be implemented in close coordination with the other Green Deal components.

The text sets out a total of 27 regulatory and non-regulatory measures, with the Common Agricultural Policy (CAP) and Common Fisheries Policy (CFP) serving as major tools in fostering innovative methods and sustainable production practices [49] [52] .The proposed

[50] https://food.ec.europa.eu/system/files/2022-02/f2f_legis_iia_fsfs_5902055.pdf
[51] https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf
[52] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en#:~:text=The%20Farm%20to%20Fork%20Strategy%20aims%20to%20accelerate%20our%20transition,reverse%20the%20loss%20of%20biodiversity

measures are scheduled to be implemented until 2024, following which an assessment will be conducted by mid-2023 (it has not been carried out yet) [49].

Among the measures, it is possible to identify six specific targets to be achieved by 2030 [53] [54]:

1) Reduce the use and risk of chemical pesticides by 50%.
2) Reduce the use of more hazardous pesticides by 50%.
3) The loss of nutrients should be reduced by at least 50%.
4) Fertiliser use should be reduced by at least 20%.
5) A 50% reduction in antimicrobial purchases for aquaculture and farmed animals.
6) Organic farming should be practised on 25% of agricultural land by 2030.

In addition to these targets, there are also six general objectives [53] .

1) Achieving sustainable food production.
2) Achieving food security.
3) Fostering sustainable practices in the food processing, wholesale, retail, hospitality, and food service sectors.
4) Encouraging the shift to healthy and sustainable diets.
5) Reduction of food waste.
6) Taking action to prevent food fraud in the food supply chain.

[53] https://www.arepoquality.eu/politics/farm-to-fork-strategy/
[54] https://www.farm-europe.eu/news/the-farm-to-fork-in-need-of-a-new-political-consensus/

Figure 9: Farm to Fork, main targets. Source: European Commission. Retrieved from: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

One of the most important initiatives outlined in the Farm to Fork Strategy is the development of a legislative framework for sustainable food systems (FSFS) which is expected to be adopted by the Commission by the end of 2023. The framework's core objective is to facilitate and accelerate the transition towards a sustainable food system. Furthermore, it will seek to enhance food system resilience, and promote policy coherence at the EU and national levels [52] [55]. Through the establishment of a common set of definitions, principles, and standards, and addressing the responsibilities of all parties involved, this framework would serve as the foundation for the development of a truly integrated food policy [54].

With the aim of ensuring food security and safety, improving public health, and minimising their socioeconomic impact, the Commission will also enhance its coordination of a common European response to crises affecting food systems. Specifically, it will evaluate the resilience of the food system and devise an emergency strategy in the event of a crisis to ensure a sufficient supply of food and food security. Furthermore, there will be a relaunch of

[55] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy/legislative-framework_en

the agricultural crisis reserve in order to make the best use of its resources during times of crisis for agriculture. The plan will establish a mechanism coordinated by the Commission and involving Member States that will be used to respond to food crises in addition to the risk assessment and management measures to be activated during crises. Depending on the nature of the crisis, it might include a variety of sectors from health to agriculture and transport [56].

As a means of encouraging the food industry to provide healthy and sustainable food products, the Commission will require nutritional information on the front of packaging. It will also undertake initiatives that encourage product reformulation, such as establishing nutrient profiles in order to limit the promotion of fat, sugar, and salt-rich products. As part of the sustainable food labelling framework, nutritional, climate, environmental, and social information will be included. Through this framework, consumers will be better able to choose healthy and sustainable diets. The Commission will also propose legally binding targets to reduce food waste across the EU by 2023 as part of its efforts to achieve the Sustainable Development Goal of 50% reduction in food waste by 2030 [47].

A final point to be noted is that the EU is committed to providing a role model in a sustainable transition not only within the EU, but also beyond it. Through bilateral and multilateral cooperation, the EU aims to enhance food security and nutrition outcomes, reduce deforestation, enhance biodiversity, and promote more sustainable farming and fishing practices. These priorities will be incorporated into the Commission's programming guidelines for cooperation with developing countries during the period 2021-2027 [56].

2.2 Promotion of a plant-based diet

As part of its efforts to advocate a healthy diet, the Farm to Fork strategy aims at shifting towards a plant-based diet to improve environmental conditions and curb obesity and non-communicable diseases associated with unhealthy dietary habits. The goal of a plant-based diet is not to make consumers vegetarians or vegans, but rather to encourage consumers to make more diverse protein choices while avoiding heavily processed foods, minimising

[56] https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_885

animal protein consumption, and eating more seasonal foods [57]. Plant-based diets are composed of healthy and sustainable food sources produced within planetary boundaries. Generally, these diets discourage overconsumption of any food due to its adverse effects on health, the environment and biodiversity. Plant-based diets are considered "win-win" consumption patterns since they provide health benefits to humans while having a minimal impact on the environment [58].Thanks to its limited intake of animal-derived foods, the Mediterranean Diet is an example of a plant-based diet which already exists in the European Union [57] .

According to the Farm to Fork strategy, poor diets, rich in meat products and high in fats and sugar, are identified as one of the leading causes of diseases and health care costs in the EU. It is estimated that in the European Union, chronic diseases, largely caused by an unhealthy diet, account for around 86% of deaths and 77% of incidences of disease. Furthermore, processed meat is classified as a carcinogen by the World Health Organization (WHO), while red meat is considered a potential cancer risk [59]. There is also scientific evidence associating the excessive consumption of animal products to an elevated risk of Alzheimer's disease, diabetes, cardiovascular disease, hypertension, in addition to several other diseases [58.] Almost 11 million deaths and 255 million disability-adjusted life-years (the number of years lost to illness, disability, and early death) have been associated with dietary risk factors such as sodium intake, wholegrain intake, and fruit intake in many countries, according to a Global Burden of Disease (GBD) study [57]. Another dimension that should not be neglected is the negative impact of air pollution on human health. Approximately 400,000 to 790,000 premature deaths are caused by air pollution every year in the European Union, mostly by emissions from the livestock sector [58].

Plant-based foods would improve health through increased intake relative to animal-sourced foods, according to the EAT-Lancet Commission on Food, Planet, Health. It has been estimated that by shifting towards a plant-based diet, up to 11 million people would reduce their risk of premature mortality. For instance, in Germany premature mortality might be reduced by approximately 20% [57]. A meat reduction would also have a significant effect on

[57] https://food.ec.europa.eu/system/files/2021-09/f2f_dialogue_event_20210520.pdf
[58] https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/7b5iok5vqz_Bending_the_Curve__The_Restorative_Power_of_Planet_Based_Diets_FULL_REPORT_FINAL.pdf.pdf?_ga=2.233687830.980309191.1685539604-88222471.1682949894
[59] https://www.epc.eu/en/Publications/The-Farm-to-Fork-Strategy-and-the-inconvenient-truth~33ac84

obesity rates and antimicrobial resistance in the EU, since EU citizens consume 50% more meat than medical experts recommend. A plant-based diet will not only reduce health risks, but also reduce the environmental impact of the food system [51].

When compared to other food categories, animal-derived products, especially red meat, tend to have higher environmental footprints per calorie. In turn, this negatively affects greenhouse gas emissions, the use of land, and biodiversity loss [60] [61]. In the EU, livestock farming is responsible for the 70% of greenhouse gas emissions which come from agriculture (10.3% of total greenhouse gas emissions in the EU). The majority of land used for agricultural production is devoted to the livestock sector, which accounts for approximately 68% of total agricultural land. As a result, the farming methods adopted have a significant impact on the environment, climate, and biodiversity. Land and water are polluted by the nutrients and pesticides used in this industry [62]. Furthermore, more than 40% of fresh water needed for agriculture is consumed by livestock farming. Globally, 7.99 gigatonne (Gt.) of the 14.3 Gt. of greenhouse gas emissions associated with the food industry come solely from red meat and dairy products. By adopting a plant-based diet, these emissions are expected to be reduced to 2.9 Gt. [62]. Animal farming is also largely responsible for the loss of biodiversity. A shift to plant-based diet might mitigate approximately 5% of global biodiversity loss [58].

The shift would also reduce our overall agricultural land use as well as cropland needs. In addition to minimising the usage of land, lowering meat consumption, particularly from intensive industrial livestock systems highly dependent on imported feed and fertiliser, would have a positive impact on animal welfare, the environment, and human health. If meat consumption were decreased by 50% in Sweden, as recommended by the Swedish dietary guidelines, as well as vegetables increased by 55g per capita per day, land use would decrease by 23%, as well as synthetic fertiliser use by 3%. The agricultural sector occupies half of all land that is habitable on earth, 80% of which is used for livestock production. In

[60] https://www.sciencedirect.com/science/article/pii/S0959652622035211
[61] https://eatforum.org/lancet-commission/eatinghealthyandsustainable/
[62] https://www.epc.eu/en/Publications/The-Farm-to-Fork-Strategy-and-the-inconvenient-truth~33ac84

spite of being the predominant land use for agriculture, meat and dairy products account for only 17% of worldwide energy consumption and 33% of protein consumption worldwide [63].

While the importation of crops suitable for human consumption to feed animals enhances the EU's ability to export meat and dairy products, the process results in substantial losses of nutrients and proteins. Only 20 calories are available for human consumption out of every 100 calories fed to livestock. Studies have shown that it would be possible for the EU to reduce greenhouse gas emissions and dependence on fossil fuel fertilisers, as well as become a net exporter of calories instead of a net importer, by reducing animal products by 40% and embracing agro ecological livestock farming that relies on grasslands and legumes [63].

Planetary Health Diet, developed by the EAT-Lancet Commission, offers a great example of a plant-based diet [64]. In this diet, guidelines are provided for a wide variety of food groups, allowing people to easily adjust them in accordance with local geography, culinary customs, and individual preferences [65]. Whole grains, fruits, vegetables, nuts, and legumes constitute a larger percentage of the diet's intake [66]. Daily, a consumption of 125 grams of dry beans, lentils, peas, nuts, and legumes is recommended by the guidelines [67]. At the same time, although acknowledging that meat serves as a valuable source of iron and vitamin B12, the guidelines advise consuming no more than 98 grams of red meat per week, 203 grams of poultry, and 196 grams of fish per week [65].

63 https://wwfeu.awsassets.panda.org/downloads/farm_to_fork__systemic_change_is_key_to_european_food_security_and_resilience.pdf
64 https://eatforum.org/eat-lancet-commission/
65 https://eatforum.org/content/uploads/2020/07/Diets-for-a-Better-Future_G20_National-Dietary-Guidelines.pdf
66 https://eatforum.org/eat-lancet-commission/the-planetary-health-diet-and-you/
67 https://eatforum.org/lancet-commission/eatinghealthyandsustainable/

Figure 10: The Planetary Health Diet. Source: EAT-Lancet. Retrieved from: https://eatforum.org/learn-and-discover/the-planetary-health-diet/

It is believed that as a result of the Planetary Health Diet being adopted in the European Union and the United Kingdom, the amount of crop needed could be drastically reduced, primarily through the reduction of overconsumption of animal products and additive sugars. By themselves, these decreases would offset almost all food imports from Ukraine and Russia. However, in order to fulfil all food production demands, it would be necessary to cultivate specific crops on land that has been spared from cultivation. Consequently, 65.2% (38.1 Mt) of wheat will have to be grown on fallow lands in order to compensate. Nevertheless, the wheat that would be saved from such a change in dietary practices in the EU and UK would be abundant enough to make up for the 19.4 million tons lost in wheat imports from Ukraine and Russia. Some of the saved wheat could also be exported to other countries to offset the shortfall [68].

[68] https://www.nature.com/articles/s43016-022-00634-4#ref-CR11

In light of the beneficial effects listed above, the EU is not only encouraging an increased consumption of legumes, fruits and vegetables, but it is also committed to enhancing its research into increasing the availability and source of alternative proteins [69] . Protein alternatives refer to foods with a high protein content that are not traditionally found in diets. Currently, five different types of protein alternatives are being explored in Europe: lab-grown meat, vegan alternatives to meat, fermented products, edible insects and algae. The purpose of these innovative products is to provide a viable alternative to traditional animal products by offering consumers a variety of delicious, sustainable, and nutritious protein-rich foods [70].

The European Union has funded several projects that are intended to pave the way for alternative proteins. The main ones are [70]:

- **ProFuture:** it is pioneering innovations in microalgae foods and feeds.
- **NextGenProteins:** it is dedicated to producing proteins from biomass.
- **SUSINCHAIN**: its mission is to create sustainable insect supply chains.
- **Smart Protein Project**: it aims at developing plant protein-based products derived from fava beans, lentils, chickpeas, and quinoa that are innovative, cost-effective, and resource-efficient. A variety of plant-based meat, seafood, dairy products, and baked goods are also produced with alternative protein sources, such as legumes and side streams from beer and pasta production.

Developing such large-scale collaborations is crucial to exploring the full potential of alternative protein sources, increasing our protein consumption variety, and eventually strengthening the resilience of our food system. It is important to note, however, that the environmental, health, and safety effects of these different types of foods are largely determined by ingredients, production methods, and processing techniques used, as well as consumption patterns [70].

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[69] https://www.euractiv.com/section/agriculture-food/news/farm-to-fork-strategy-softens-stance-on-meat-but-backs-alternative-proteins/

[70] https://www.eufic.org/en/food-production/article/5-trending-alternative-protein-sources-to-meat-in-europe#:~:text=There%20are%20five%20main%20protein,products%2C%20edible%20insects%20and%20algae

2.3 Barriers and opportunities

The Farm to Fork has the potential to be the starting point for developing a comprehensive and effective sustainable food system strategy. The European Union has an opportunity to shorten value chains, reduce fossil fuel dependency, and boost plant-based crop production while improving sustainability. Additionally, it would be possible to alleviate land pressures and mitigate the effects of the recent global food crisis. This would be accomplished through reducing the consumption of industrially produced meat in order to encourage healthier and more sustainable diets. All citizens and stakeholders are likely to benefit from this sustainable transition, which will result in improved lifestyles and improved health outcomes [2 51].

Indeed, by creating favourable food environments that encourage consumers to adopt healthy and sustainable eating habits, there will be a reduction in health-related costs and an improvement in the health of consumers. It is becoming increasingly important to consumers to purchase foods that are fresh, less processed, and sourced sustainably. However, the current cost of sustainable and healthy food is often higher, which makes them less accessible to many. This trend could be changed through the Farm to Fork Framework, by introducing provisions that would facilitate systematic changes, ensuring that sustainable food is placed on the EU market on better terms with other food products. In this way, consumers will be empowered to make sustainable food choices, and all parties involved in the food chain should be made aware of their responsibilities and opportunities in this regard [71].

Furthermore, as part of its commitment to SDG 12 (Ensure sustainable consumption and production patterns) the EU agreed to reduce food waste by 50% by 2030. SDG 12, focuses on sustainable practices to protect the environment, promote resource efficiency, improve working conditions, and encourage responsible consumption. Overall, it plays a crucial role in advancing the broader agenda of sustainable development by addressing the environmental, social, and economic aspects of consumption and production [72]

[71] https://food.ec.europa.eu/system/files/2022-02/f2f_legis_iia_fsfs_5902055.pdf
[72] https://sdgs.un.org/goals/goal12

The adoption of a legally binding 50% target will reinforce this commitment and enhance Member States' efforts. With implementing this binding target as part of the Farm to Fork strategy, there would be a chance to reduce food loss and waste throughout the supply chain. Waste reduction, particularly on farms, would improve the resilience of communities thanks to an increase in the amount of food available for consumption or sale. In the event of global or local shocks, this would represent a vital cushion for the economy. Food waste reduction will foster food security, as well as reduce greenhouse gas emissions and contribute to the EU's climate change objectives [73].

Through its Farm to Fork Strategy, the EU is also committed to advocating for sustainable food systems worldwide. Through this strategy, crucial sustainability provisions can be incorporated in free trade agreements along with an assessment of their effect on the different food systems. The EU should consider preferential trade frameworks based on sustainable production and distribution practices, as well as nutrition and health impacts. The EU's trade policies could also have a significant positive impact on developing countries by providing assistance and advice to those that are particularly vulnerable to future shocks due to their dependence on imported agricultural products [73] .

However, in addition to the several opportunities listed above, it is necessary to note that there are also several challenges and barriers that will have to be overcome to achieve the objectives of the strategy. A major barrier to the implementation of the Farm to Fork Strategy is the lack of clarity regarding what is meant by "food sustainability" and "sustainable food system". The European Commission does not provide a univocal definition of sustainability; rather, it describes the benefits of shifting toward a sustainable food system in terms of environmental, health, social, and economic factors. Thus, the concept remains somewhat ambiguous in the Farm to Fork Strategy, appearing as an all-encompassing solution without a defined conceptual framework. As a result, some issues arise. There is a broad range of objectives covered by the concept of food sustainability. This might lead to the emergence of policy inconsistencies. As a matter of fact, in some cases, the adoption of measures that contribute to the realisation of some of the strategy's underlying objectives may hinder or result in a step backward. There is a real concern for the emergence of policy incoherencies, as policy actions that contribute to realising some of the underlying objectives of the strategy

73 https://wwfeu.awsassets.panda.org/downloads/farm_to_fork__systemic_change_is_key_to_european_food_security_and_resilience.pdf

may impede or result in a step backwards for others. For instance, the promotion of grass-based ruminant systems, rather than the feeding of human-edible biomass to farm animals, could be an effective land-management strategy, but it could compromise efforts to reduce greenhouse gas emissions and increase biodiversity [74].

Furthermore, the Farm to Fork strategy does not adequately outline and address the issue of overconsumption and, consequently, excessive production of meat and dairy, which is one of the most urgent economic, social, and environmental challenges in the EU. Though the Commission's strategy acknowledges the need to move toward a more plant-based diet with fewer red and processed meats, it fails to make any real changes. It does not advocate meat production and consumption reduction and no concrete measures have been adopted to foster a shift to a more plant-based diet [75]. It is further noteworthy that despite the goals set forth in the strategy, considerable budgetary resources are spent on promoting meat in the EU. During the last three years, a total of 71.5 million euros have been allocated to European Union meat promotion programs [76] [77]. The EU-funded Smart Protein Project, on the other hand, has received only 9 million for 2020-2024, of which 8 million are provided by the EU. In light of these differences in funds, there have been questions raised regarding the compatibility of such expenditures with the stated objectives of the EU [77].

The strategy faces institutional challenges as well. The first challenge is the integration of the strategy into the Directorate-General for Health and Food Safety of the European Commission. Despite the fact that other Directorates-General were engaged in the development of the strategy, disputes within the Commission regarding the food sector may seriously undermine its implementation. As an example, the Directorate-General for Agriculture and Rural Development, demonstrates a strong commitment towards farmers' interests as well as preventing other Directorates-General from being involved in agricultural policy making. Similarly, the Directorate-General for Environment was unwilling to extend its mandate beyond the purely environmental to examine other dimensions of sustainability, such as socioeconomic issues, in the revision of the Green Procurement Criteria for food.

[74] https://www.nature.com/articles/s43016-020-00166-9

[75] https://www.epc.eu/en/Publications/The-Farm-to-Fork-Strategy-and-the-inconvenient-truth~33ac84
[76] https://euobserver.com/green-economy/155052
[77] https://euobserver.com/green-economy/144364

There are also institutional tensions between European Parliament committees, where political differences complicate matters further [78].

Besides challenges related to horizontal coordination, the EU and Member States also face challenges related to vertical coordination and competency. Due to the fact that the drivers and implications of the food system are cross-border, it is crucial to have effective multilevel governance arrangements in place. Many policy decisions are made by the Member States, including those concerning human health, tax policy (incentivizing or discouraging the consumption of certain foods), and the national strategic plans for the Common Agricultural Policy (CAP). Nonetheless, many Member State governments are hesitant to take wide-ranging environmental measures, particularly when they would disrupt corporate interests. Moreover, some Member States have voiced concern regarding possible breaches of the subsidiarity principle, according to which the EU may only take action if a proposed measure cannot be adequately implemented at the national level. Last but not least, the legislative framework for sustainable food systems, which is the most systemically relevant measure, has not yet been enacted [80] . In addition, the European Commission has temporarily halted the implementation of some of the sustainability initiatives outlined in the F2F, allowing the cultivation of fallow lands and derogating from the nitrogen directive to enable the increased use of nitrogen from animal manure in fertilisers [79]. There is a possibility that the Farm to Fork implementation may be compromised by these exemptions and delays in implementing the measures [80] .

As a result, it seems unlikely that a sustainable food system will be in place in the near future. However, the Farm to Fork strategy is not to be undermined or discarded. Despite its shortcomings, it offers the unique opportunity to tackle the underlying causes of long-term food security in a systematic and holistic manner. By combining an agroecological approach, minimization of food waste, healthier eating habits, and the promotion of fair trade, it may be possible for the European Union to become a net exporter of nutrients, calories, and proteins, while improving food security and resilience in the long run [80] . Therefore, bringing Farm to Fork to life is of paramount importance. In this process the EU Legislative Framework for

[78] https://www.theguardian.com/environment/2020/feb/14/eu-spending-tens-of-millions-of-euros-a-year-to-promote-meat-eating
[79] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_1964
[80] https://wwfeu.awsassets.panda.org/downloads/farm_to_fork__systemic_change_is_key_to_european_food_security_and_resilience.pdf

Sustainable Food Systems is expected to have a key role. Indeed, it should establish a 2050 vision for a sustainable food system and ensure that all food-related policies are aligned with one another [81]. As part of this strategy, it is necessary to include ambitious provisions in order to provide a coherent and unified approach, with the possibility of setting intermediate and final targets that apply to the entire food chain, from production to consumption, as well as an evaluation mechanism for monitoring progress [40].

[81] https://eeb.org/work-areas/agriculture/food-systems/

Chapter 3 The role of agriculture

Agricultural production falls almost solely under the jurisdiction of the EU, making it the most appropriate level at which to tackle sustainability issues. However, with the evolution of the CAP in recent years, national governments' roles in agriculture have taken on greater importance in the wake of greater national flexibility under the policy [2].

Aside from producing food, feed, and residual biomass products, the agriculture sector in Europe undertakes many other important tasks, including managing landscapes, rural development, and tourism. There are three main components of agricultural production (Gurria et al., 2017; Eurostat, 2016): crops, including grains, roots, fruits and tubers, along with crop residues such as straw and chaff; rearing livestock and grazed biomass used for feeding livestock [82].

In 2020 the total utilised agricultural area (UAA) across the EU was 157.4 million hectares [79]There is a significant variation in the proportion of agricultural land within EU Member States. Four Member States account for the majority of agricultural land in the EU: France (17.4%), Spain (15.2%) and Germany (10.2%) (Eurostat, 2020). About 25,5 % of crops are grown in Poland, Romania, and Italy; while the other Member States account for less than a third of the UAA (28.3%). Land used for agricultural purposes consists primarily of non-irrigated arable land (62%), grassland pastures (30.5% %), and areas with natural vegetation (16%) [83] [78].

[82] https://www.eea.europa.eu/publications/cc-adaptation-agriculture
[83] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_cropping_patterns

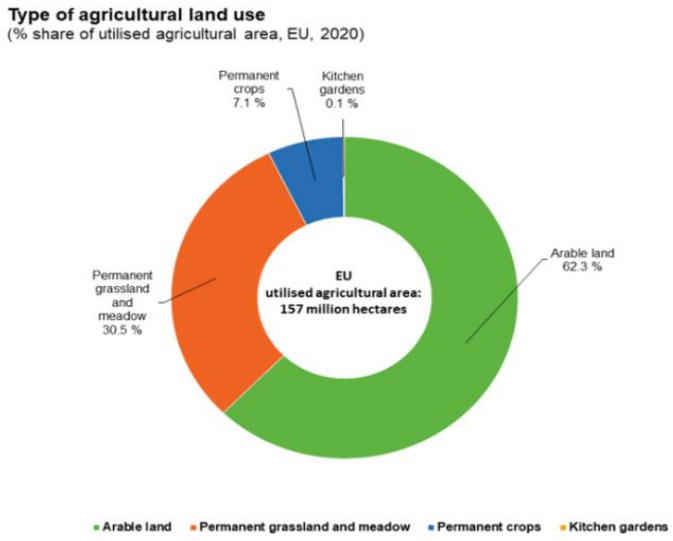

Figure 11: The Planetary Health Diet. Source: EAT-Lancet. Type of agricultural land use (% share of utilised agricultural area, EU, 2020). Source: Eurostat (online data code: ef_lus_main)

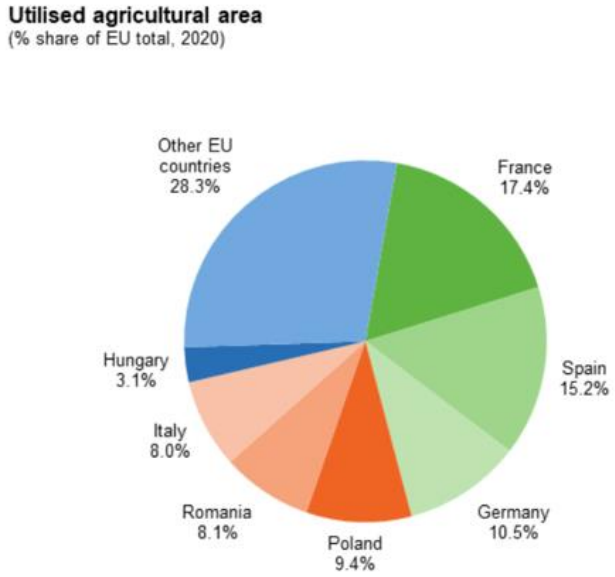

Figure 12: Utilised agricultural area (% share of EU total, 2020). Source: Eurostat (online data code: ef_lus_main)

Due to the fact that agriculture is dependent upon weather, climate change is heavily affecting the sector. At the same time, agriculture is also a major contributor to climate change, primarily through the release of greenhouse gases and air pollution [84] [85]. Indeed, agriculture is estimated to be responsible for 10-15% of the EU's greenhouse gas emissions. Methane (CH4) emissions from enteric fermentation represent the largest portion (38%) of the emissions [78] [79] [86]. The other two major air pollutants from agriculture are particular matter (PM10) and ammonia (NH3) [79]. Yet, this sector has the potential to play a crucial role in reducing EU emissions by 2030 and 2050. By converting land cover types and managing soil, agriculture could significantly mitigate air pollution and remove CO2 from the atmosphere[87]. A reduction in greenhouse gas emissions and a reduction in ammonia emissions will require a reduction in fertiliser, manure storage, and livestock emissions. Several methods can be used to accomplish this, including optimising fertiliser use, enhancing manure management efficiency, and increasing the efficiency of animal production [79].

The agriculture sector is a significant user of freshwater resources in Europe [88]. In 2015, the agriculture sector accounted for around 25 % of total water abstraction in Europe (EEA, 2018i). Freshwater use for agriculture in Europe is the largest in southern Europe (due to the dry climate), where abstraction for agriculture in the period 2010-2015 accounted for 55 % of total abstraction (EEA, 2018i). The share of agricultural land under irrigation varies among Member States, with a higher share of agricultural land under irrigation systems in southern Europe than in northern and western Europe. Climate change projections show that parts of Europe (especially southern Europe) will experience less precipitation and more frequent and severe drought events in the future, making water even less available to the sector [78].

Changes in mean temperature and precipitation as well as weather and climate extremes are already influencing crop yields and livestock productivity in Europe. Combined effects of changes in temperature, rainfall and atmospheric CO2 concentration influence crop yields and impacts differently across European regions. Potential positive effects related to

[84] https://agriculture.ec.europa.eu/system/files/2022-04/60-years-cap_en_0.pdf
[85] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/addressing-the-sustainability-dimension-of-eu-food-production/
[86] https://eeb.org/cutting-emissions-from-farming-project/
[87] https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/climate-change_en#:~:text=However%2C%20agriculture%20also%20accounts%20for,%2C%20residential%2C%20and%20commercial%20sectors
[88] https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/natural-resources/water_en

increased temperatures are expected mostly in northern Europe, while a reduction in crop productivity and an increased risk for livestock are projected in large parts of southern Europe (EEA, 2017b). Climate projections show that most of Europe will experience higher levels of warming than the global average; however, strong differences are expected across the European regions for global warming of 2 °C as well as for 1.5 °C warming (IPCC, 2018). Climate change can directly and indirectly impact agricultural production and the agro-ecosystems upon which they rely. Direct impacts include changes in phenology and calendars, displacement of cultivation areas and soil loss, changes in water supply and irrigation demand, and direct effects of increased levels of CO2 on growth. Indirect effects are those that arise as a result of direct effects that can have further negative impacts on agricultural production, for example increases in pests, diseases, invasive species and extreme events, such as very strong winds, hailstorms, intense heat and frosts. Impacts on agricultural production can lead to economic and social impacts related to livelihoods linked to the farming sector and food security. Given this, there is a cascade of impacts from climate change that affect agro-ecosystems and agricultural production, and in turn influence the price, quantity and quality of products, and consequently trade patterns, agricultural income and food prices [78] [79] [89].

3.1 CAP 2023-27

Launched in 1962, the Common Agricultural Policy (CAP) is adopted in all European countries and has played a crucial role in developing agriculture [90]. It is a partnership between the EU and its farmers, as well as between agriculture and society, which aims to [91]:

- Ensure a stable supply of affordable food by supporting farmers and improving agricultural productivity.
- Ensure reasonable living conditions for farmers in the European Union.

[89] https://www.eea.europa.eu/highlights/climate-change-threatens-future-of#:~:text=Climate%20impacts%20have%20led%20to,crop%20productivity%20in%20southern%20Europe
[90] https://www.organicseurope.bio/what-we-do/cap-and-rural-development/
[91] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en

- Take action to combat climate change and promote sustainable natural resources management.
- Preserve rural areas and landscapes throughout the European Union.
- Promote agricultural, agri-food, and related jobs to sustain the rural economy.

Financed by the European budget, the policy is governed at European level and consists of two pillars[10]. The first pillar consists of direct payments to farmers. The amount of these payments is usually determined by the size of the farm, and by the greening measures, and the marketing strategies adopted by the farm. The second pillar deals with rural development policy, including agri-environmental and climate measures (AECMs), which also cover organic farming. Unlike the first pillar, which is entirely financed by EU funds, the second pillar typically receives funding also from national and regional budgets [85].

The CAP 2023-27, which entered into force on 1 January 2023, is expected to lead to a fairer, greener, and performance-based CAP [86] [92]. With it, European farmers are expected to have a more sustainable future, small farms will be provided with enhanced assistance, and EU countries will have an increased degree of flexibility in tailoring measures to the specific needs of their regions [87]. As part of the European Green Deal, rural development and agriculture play an essential role, and the CAP 2023-27 will be a crucial tool in achieving the Farm to Fork and Biodiversity goals [87]. Given its importance, CAP is expected to account for about 40-45% of the EU's overall Green Deal expenditures. Furthermore, with €387 billion of funding allocated to the CAP for the period 2021-27, it represents the largest fraction of the EU budget (26% of the total) [93]. These funds are derived from two different sources: the European agricultural guarantee fund (EAGF), whose contribution amounts to €291.1 billion; and the European agricultural fund for rural development (EAFRD), which will provide €95.5 billion. In the EAFRD budget, Next Generation EU has provided €8 billion to support rural areas in making structural changes needed to meet the Green Deal and digital transition targets. As a result of these enhanced investments, the CAP has been revised to incorporate stronger agricultural innovation and knowledge systems (AKIS) to facilitate the development, dissemination, and widespread use of innovative technologies [88] [89].

[92] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en
[93] https://www.cleanenergywire.org/factsheets/eus-farm-fork-strategy-impacts-climate-productivity-and-trade

Furthermore, it is the responsibility of each EU country to propose a national CAP Strategic Plan (CSP), encompassing rural development, financial assistance, and market interventions. The EU requires its countries to have a higher overall environment and climate ambition in their strategic plans than they had in previous programming periods (no 'backsliding' principle). A compliance assessment of the proposed CAP strategic plans with EU environmental and climate commitments will also be carried out by the Commission; particularly with regards to the Farm to Fork goals for 2030. Hence, EU Member States must ensure that their CAP plans are in compliance with revised EU environmental and climate legislation, and to make any necessary amendments [88]. Although the new Strategic Plan Regulation maintains the two-pillar architecture, it also introduces a performance-based delivery model and a more subsidiarity-oriented approach. By doing so, Member States have been granted more flexibility and accountability in designing CAP Strategic Plans at the national level in accordance with their local conditions, needs, and capabilities in the agricultural sector [85 88]. The new regulatory framework entails [88 94]:

- New social conditionality by 2025 with the aim of enhancing the rights of farmers and farm workers. It is based on the following EU legislative frameworks: Directive 2019/1152 on Transparent and Predictable Working Conditions, Directive 2009/104/EC on Minimum Safety and Health Requirements for use of work equipment by workers, Directive 89/391/EEC on Improvement of Safety and health of workers, Regulation 492/2011 on Freedom of movement for workers within the EU.
- An innovative *Green Architecture* which includes:
    1. New Eco-schemes with allocated funds of 25% of the first Pillar, which will be implemented following a transition phase of two years (2023-4). Member States will be required to comply with them, while farmers may choose to opt out.
    2. Nine Good Agricultural and Environmental Land Conditions (GAECs) as part of the first Pillar.
    3. Adoption of Agri-Environmental and Climate Measures (AECMs) that will account for 35% of the second Pillar's budget.

[94] https://www.robert-schuman.eu/en/european-issues/0607-the-common-agricultural-policy-2023-2027-change-and-continuity

Undoubtedly, the new centrepiece of CAP's environmental commitment is represented by the eco-schemes. The objective of these ecological programs is to support farming practices that are climate- and environment-friendly, such as organic farming and agroforestry, while also improving animal welfare [90].

Apart from the two Pillars structure, the new CAP revolves around ten key goals. They outline the fundamental objectives of the European Union in agriculture and rural development in terms of economic, environmental, and social sustainability and provide the foundation for the national CAP Strategic Plans [87] [95].These goals are [91] [96]:

1. Provide a fair income to farmers.
2. Enhance competitiveness.
3. Increase the value of farmers in the food chain.
4. Taking action to fight climate change.
5. Protect the environment.
6. Preserve biodiversity and landscapes.
7. Encourage generational renewal.
8. Foster a vibrant rural environment.
9. Protect the quality of food and health.
10. Assist the development of new knowledge and innovation.

[95] https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-policy-objectives-cap-2023-27_en
[96] https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans_en

Figure 13: CAP 10 key objectives. Source: European Commission. Retrieved from: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-policy-objectives-cap-2023-27_en

Stronger requirements are also included in the new CAP compared to the previous one. As an example, conditionality rules are more far-reaching in a number of areas. In CAP 2014-20 direct payments were given to farmers if they performed three practices: preserving grassland, crop diversification and devoting a part of land to ecological focus areas. On the other hand, under the new CAP farmers will be allowed to diversify their crops only when it contributes to the preservation of soil quality, and crop rotation will be mandatory for all farms of more than 10 hectares [88] [97]. Furthermore, fruit and vegetable sector interventions in the EU must spend at least 15% of their funding on actions that serve the CAP's specific environment and climate objectives, compared to 10% of the previous one. A final feature of the new CAP is its integration of climate tracking. After 2025, the Commission will propose a delegated regulation in order to accurately measure and assess the CAP's impact on

[97] https://agriculture.ec.europa.eu/system/files/2022-02/factsheet-newcap-environment-fairness_en_0.pdf

mitigating climate change [90] [91]. In light of what outlined above, it is clear that the new CAP is a crucial step towards making the EU's agricultural and forestry systems more sustainable [90].

3.2 Organic agriculture

"Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system." (FAO/WHO Codex Alimentarius Commission, 1999) [98].

Organic gardening and farming embrace the understanding that all living things are interrelated and interdependent, and that the environment in which they grow is much more than just the combination of its constituent parts [94]. Hence, it is crucial to ensure that food production is carried out in a way that preserves ecological equilibrium [93].

By adopting a proactive approach, soil and environment are treated as resources that must be nurtured for future generations [99]. Organic agriculture is also founded on a set of core principles [100]:

- Prohibition of genetically modified organisms (GMOs).
- Ban on the use of ionising radiation.
- Avoidance of artificial fertilisers, herbicides and pesticides.
- The use of hormones and antibiotics must be limited to animal health emergencies.

[98] https://www.fao.org/organicag/oa-faq/oa-faq1/en/
[99] https://www.cpublishingmedia.com/wp-content/uploads/2020/11/Organic-Farming-for-Sustainable-Agriculture.pdf
[100] https://agriculture.ec.europa.eu/farming/organic-farming/organic-production-and-products_en

These principles require the use of practices that are not only designed to protect but also strengthen the environment [101]. The advantages of organic farming over conventional agriculture include the use of fewer pesticides, the decrease in soil erosion and nitrate leaching into surface and groundwater, as well as the recycling of animal waste [102]. By utilising practices such as composting, cover crops, and crop rotation, organic agriculture improves soil condition, eliminating the need for synthetic pesticides and fertilisers that drain the soil of nutrients and harm the environment [97]. For effective weed and pest control, organic farmers choose resistant varieties and breeds and employ methods that promote natural pest control. The welfare and health of animals are protected by limiting animals' stocking levels, which reduces disease outbreaks and requires fewer medical treatments [96].

Biodiversity is not only an objective, but also an important tool for organic farming, since diversity of animal and plant species helps prevent disease and pest infestations [95 97]. As a result, with organic agriculture, natural habitats are nurtured and protected in recognition that a diverse biological landscape is crucial for food production, as well as human and environmental well-being [98]. It has been shown in several studies that organic agriculture contributes to the conservation of non-agricultural biodiversity while also offering a viable alternative in cases where human activities are allowed in protected areas. Protected areas are surrounded by large areas of land, which require agro-ecosystem management approaches that ensure the safety and integrity of the landscape. In protected areas, these buffer zones play a pivotal role in conservation efforts. When organic methods are used on farmland adjacent to or connected to a protected area, wildlife habitats are not threatened and there is no contamination of air, water, or soil [95].

In order to produce nutritious food, it is also essential to maintain a healthy soil, and the improvement of soil fertility is one of the key components of organic farming. Crop production and soil quality are enhanced by organic practices through crop rotation, minimization of tillage, natural fertilisers, organic manure, and the absence of pesticides and herbicides. In Europe, organically grown soils are proven to have higher levels of biological activity which improves soil structure and nutrient recycling [95 97]. The use of organic practices also helps safeguard water resources from contamination caused by toxic and long-lasting chemicals. Finally, organic agriculture is effective in reducing our carbon footprint

[101] https://www.ota.com/environmental-benefits-organic
[102] https://www.britannica.com/topic/organic-farming

and mitigating climate change due to its prohibition of petroleum-based fertilisers and the absorption of carbon dioxide [97].

Not only does organic agriculture benefit the environment, but it also helps improve public health [103]. In contrast to conventionally grown products, organically grown products have lower levels of nitrates and pesticide contaminants and offer greater nutritional value, including vitamin C, iron, magnesium, and phosphorus [104]. Organic food has also lower levels of nitrates and pesticide contaminants and offer greater nutritional value, including vitamin C, iron, magnesium, and phosphorus. As a result, consumers and farmers are at a lower risk of being exposed to toxic and persistent chemicals when they use organic products. Pesticides pose a particular threat to children. The availability of organic food provides parents with the option of purchasing products that are not contaminated with toxic chemicals [100] [105]. According to the *Norwegian Mother, Father and Child Cohort Study* (MoBa), conducted on 28,000 mothers and their newborns, preeclampsia risk decreased in women who consumed organic vegetables frequently during pregnancy [106]. An estimated 62,000 people took part in *NutriNet-Santé's* study, which assessed for the first time changes in body weight over time associated with organic food consumption. Study findings indicated that consumers of organic food had a lower BMI increase over time compared to consumers of conventional foods. High consumers of organic food were also found to have a 31% lower risk of obesity [102]. Furthermore, in recent years, there has been a growing concern regarding the extensive use of antibiotics in conventional animal production as a major cause of antibiotic resistance in humans. In accordance with EU provisions, routine prophylactic medication of animals in organic production is not permitted. This means that organic agriculture may have a role of paramount importance in lowering antibiotic resistance [102].

The European Union has recognized organic farming's many benefits in recent decades. Policies regarding organic agriculture were harmonised for the first time around 30 years ago. Since then, CAP contributed significantly to the advancement of organic farming methods in

[103] https://www.frontiersin.org/articles/10.3389/fpubh.2019.00340/full
[104] https://www.hsph.harvard.edu/news/features/health-benefits-organic-food-farming-report/
[105] https://www.ota.com/health-benefits-organic#:~:text=Not%20only%20does%20organic%20production,and%20grains%20when%20compared%20to
[106] https://ehjournal.biomedcentral.com/articles/10.1186/s12940-017-0315-4

Europe. In almost every EU country since the 1990s, farmers have been provided with assistance to convert their farms to organic production and keep them accordingly [107] .

In the last decade there has been a steady increase in the share of agricultural land in the EU that is devoted to organic agriculture. A significant increase occurred between 2012 and 2020, with the rate rising from 5.9% to 9.1% [108]. In 2020, the EU's organic acreage reached/stood at 14.7 million, up from 13.8 million hectares in 2019 and 9.5 million hectares in 2012 [98] [109]. Among all EU member states, France had the highest level of production of organic crops in 2020, with 2.5 million hectares. In the same year, Spain and Italy had over 2 million hectares dedicated to organic agriculture, resulting in an increase of 1.6 million hectares of organic agriculture within the EU as a whole. As of 2020, the combined organic area of France (17.1%), Spain (16.6%), Italy (14.2%) and Germany (10.8%) comprised more than half (58.7%) of all organic land in the EU. On the other hand, organic farming accounted for less than 5% of agriculture in eight EU Member States, with the lowest proportions found in Ireland and Malta. However, with the exception of Poland, all EU member states saw a growth in organic farming between 2012 and 2020. For instance, Bulgaria, France, Croatia, and Hungary all saw an increase of at least double the area, while a bit more than one fifth of the organic area in Poland has been lost (-22.3%) [96].

Although there are considerable variations between Member States, organic farms tend to be larger than conventional farms and are usually run by younger farmers [101]. In terms of the crops cultivated, permanent grassland (42%) makes up the bulk of the farmland, followed by green fodder (17%), cereals (16%), and permanent crops, including vineyards, olives, and fruits (11%). Though there has been significant growth, EU organic livestock production still accounts for a modest percentage of total EU animal production, varying from 1% to 7% [100] [101].

Moreover, a farm is classified as organic in the EU if it complies with Regulation 834/2007 on organic production and labelling of organic products. Details on the procedure for implementing this Regulation are provided by Regulation 889/2008. As the organic sector continues to flourish, the regulatory framework continues to evolve in order to strengthen the

[107] https://www.organicseurope.bio/what-we-do/cap-and-rural-development/
[108] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Developments_in_organic_farming
[109] https://agriculture.ec.europa.eu/news/organic-farming-eu-decade-growth-2023-01-18_en

organic industry's foundation [99]. Therefore, recently there has been a revision of the previous provisions, which resulted in the adoption of the new organic regulation (EU) 2018/848. Published in June 2018, it became effective on 1 January 2022. The regulation places a stronger emphasis on fostering small-scale production and short distribution chains [98]. The concept of soil-based production is strengthened, and new components such as biodiversity protection, ensuring a nontoxic environment and promoting long-term fertility have been added. It also calls for encouraging the use of genetically diverse plant species and animal breeds with a high level immunity to disease and pest resistance [98 110].

With this legislation the European Parliament aimed at ensuring consumers of the high quality of organic products, as well as enhancing a harmonised approach across the EU countries. Most of the rules are intended to provide consumers with the same level of quality assurance throughout Europe and to improve the effectiveness of the control mechanisms [23]. In order to achieve the 25% goal of organic farming the Commission has also devised a strategy, which includes three main pillars: boost consumers' trust and increase demand; increase conversions and strengthen the whole value chain; and employ organic agriculture as a means to foster environmental sustainability [111].

3.4 A greener and fairer CAP?

The CAP is a crucial tool to help achieve the Farm to Fork and Green Deal's objectives. The policy has the potential to promote sustainable agricultural practices and to provide assistance to farmers during this transition [112]. Nonetheless, its effectiveness will depend heavily on how the three green architecture instruments are incorporated by the Member States into their national strategic plans [113 114]. So far there has been only a modest effort to address environmental concerns in CAP strategic plans across Europe, which will result in a lack of

[110] https://www.mdpi.com/2304-8158/8/5/144
[111] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/addressing-the-sustainability-dimension-of-eu-food-production
[112] https://eeb.org/new-ngo-report-cap-national-strategic-plans-will-not-deliver-on-eu-green-deal/
[113] https://link.springer.com/article/10.1007/s13280-023-01861-0
[114] https://www.birdlife.org/wp-content/uploads/2022/04/Analysis-Space-For-Nature-CAP-strategic-plans-April2022.pdf

meaningful environmental improvements [115] [116]. As an example, not enough investments are being made by all countries in order to reach the 25% organic farming goal by 2030. IFOAM Organics Europe indicates either that Member States set targets that are insufficient to contribute to the 25% target set by the European Union, or that they allocate budgets that are too low to accomplish the objectives set forth. The payment amount has even been reduced in France, Germany, and Spain in comparison to the period 2014-2022. This infringes the no-backsliding principle as laid in Regulation (EU)2021/2115 on CSPs, Article 105. Further, the limited eligibility to Eco-schemes and Rural Development measures for organic farmers in Spain and Germany undermines organic farming's competitiveness [111] [112].

Another goal with CAP is to "foster sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency". However, CAP strategic plans also do not provide sufficient protection for soil thereby allowing soil degradation and nutrient loss to continue. Overall, there is a lack of compliance by Member States with the requirements for soil conditionality (GAEC 5, 6, and 7) [117]. There are several eco-schemes proposed by member states that are intended to improve soil and nutrient quality. However, many eco-schemes only improve existing soil conditionality standards very marginally and lack ambition in their overall approach. As an example, France, Hungary, and Poland will enact eco-schemes for crop diversification that are implemented in a way that has only a marginally positive environmental impact. This is because the echo-schemes aren't concerned about plot size and diversity; but just call for farmers to grow a variety of crops. As a result, without the addition of a diversified crop rotation, these measures will have no positive impact on soil's health [105].

A European Court of Auditors report (2020) further criticised CSPs for failing to take adequate measures to prevent biodiversity loss on farmland [103]. For the conservation and restoration of biodiversity on farmland, at least 10% of the land must be left fallow [118]. Strategic plans under the CAP may not sufficiently contribute to achieving the 10% objective. This can be attributed to a variety of factors, such as: exemptions, inadequate baseline requirements, and the employment of weighting factors that artificially overstate the actual area. Moreover, reaching the 10% biodiversity goal is further jeopardised by the already

[115] https://corporateeurope.org/en/2020/10/cap-vs-farm-fork
[116] https://www.arc2020.eu/are-the-cap-strategic-plans-up-to-the-task/
[117] https://eeb.org/wp-content/uploads/2022/06/Briefing-Soil-Health-No-Branding-V2.pdf
[118] https://www.birdlife.org/wp-content/uploads/2022/04/Analysis-Space-For-Nature-CAP-strategic-plans-April2022.pdf

mentioned European Commission implementing act which permits Member States to cultivate crops on fallow lands within the EFAs [119]. Despite the fact that the derogation will only affect 1% of the UAA, it has symbolic value and political implications. Essentially, it creates a precedent for agri-food lobby groups to request waivers on conditionalities in the next CAP plan [104].

Finally, there may be incompatibilities between CAP goals, resulting in trade-offs. In the short term, environmental and economic impacts pose the greatest trade-off. By using eco-friendly methods, farmers may incur higher production costs along with reduced livestock and crop productivity, resulting in possibly lower farm incomes. A rise in the price of agricultural products, however, will result in an increase in farm incomes. Therefore, strategies aimed at mitigating climate change and preserving the environment may need some adjustments in order to limit the negative effects that they may have on farm incomes. Several tools can be mobilised simultaneously: by increasing the period of time necessary for the transition to occur (with, however, the risk of a too slow transition); by employing all productivity-enhancing techniques, including genetics and precision farming; and by developing supplementary sources of income for farms. To ensure that all households are able to consume healthy and sustainable meals, it is imperative to provide compensation measures to the most vulnerable. However, application of these corrective measures may be challenging due to the distribution of competences between the EU and the Member States [109].

Another trade-off involves conflicts between ecological objectives. For instance, using environmentally friendly methods rather than using chemicals would be beneficial for the environment in many respects. But without a change in agricultural production, this may result in an overall increase in agricultural emissions. As a means of preventing an increase in emissions, agricultural production should be modified in conjunction with a reduction in meat consumption and livestock production (Wirsenius et al. 2011; Röös et al. 2022). It is clear that the unsustainable agricultural system in Europe is associated with an unsustainable food system (Détang-Dessendre et al. 2020). Therefore, even though structural changes are needed if CAP is to be truly effective, these changes are not sufficient. For CAP to be truly effective,

[119] https://www.arc2020.eu/cap-strategic-plans-and-food-security/

it must be implemented in conjunction with other policies aimed at encouraging sustainable and healthy eating habits (Guyomard et al. 2020) [108].

Chapter 4 Organic agriculture and plant-based diet: long term perspective on sustainability

It is estimated that the world's population will reach or even surpass 9 billion by 2050 [120]. In 2035, the EU27 population is forecast to grow to 525 million and will reach a record high of 526 million people in 2040 [121]. As a result, the global consumption of food is projected to rise by 70% . Thus, during the next 35 years, global food production will have to increase at a pace unprecedented in human history [122]. Assuming the demand for food keeps growing as forecast, in 2050 the world will require 120% increased water usage, 42% additional cropland, and a 14% increase in deforestation, leading to a 77% rise in greenhouse gas emissions [118] .

As outlined in the previous chapters, food production depends on ecosystem services, so preserving them is of utmost importance. It is already evident that climate change and the resulting extreme weather events, including droughts, forest fires, disease outbreaks, and pest infestations, are already having an adverse impact on our ability to provide abundant and healthy food to an ever-growing population [123]. In the absence of urgent action, climate change will lead to a reduction in food availability, higher food prices, and increase hostilities as countries compete for resources such as freshwater and fertile soil. Moreover, the food system also limits the potential for other sectors to achieve their climate goals, since, based on current trends, it represents the bulk of the global greenhouse gas emissions budget for achieving the 2°C target. As a result, meeting the Paris Agreement will be a virtually impossible task [118]. As such, ensuring the food security of the food system and its resilience will be a daunting task in the future. For food sustainability to be achieved and, therefore, food security to be guaranteed, sustainable production and sustainable diet must be considered simultaneously [124].

[120] https://www.frontiersin.org/articles/10.3389/fnut.2021.772573/full
[121] https://ec.europa.eu/commission/presscorner/detail/en/STAT_11_80
[122] https://www.foodsecurity.ac.uk/challenge/
[123] https://unfoundation.org/blog/post/climate-change-and-the-future-of-food/
[124] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/addressing-the-sustainability-dimension-of-eu-food-production/

4.1 Environmental impacts

Organic agriculture and a plant-based diet are widely acknowledged for their significant positive impact on the environment [125]. The environmental benefits of embracing a plant-based diet primarily stem from its capacity to reduce emissions associated with meat production. Extensive research demonstrates that plant-based proteins result in substantially lower emissions and demand less land and water compared to conventional meat sources [126]. For example, when compared to animal-based proteins, plant-based alternatives emit only 1/8 of the CO2 -equivalent per kilogram for chicken, 1/3 for eggs, 1/12 for beef, and 1/9 for pork [127]. Furthermore, the stark contrast in greenhouse gas (GHG) emissions becomes apparent when analysing the production of 1000 kcal of lamb or beef, generating 14 and 10 kg of GHG emissions, respectively, in comparison to merely 1 and 3 kg for 1000 kcal of lentils. Additionally, the water usage for producing 1 serving of beef or pork amounts to 1211 and 469 litres, respectively, whereas only 220, 57, and 30 litres are required to produce 1 serving of dry beans, tofu, or tomatoes [128].

According to the Food for Thought study, published by Boston Consulting Group (BCG) and Blue and Blue Horizon Corporation, a significant decline in meat consumption by 2035 is projected to have a profound environmental impact. The study suggests that this shift could eliminate carbon dioxide emissions from the atmosphere equivalent to Japan's annual emissions, while also saving an astounding 39 billion cubic metres of water. To put it into perspective, this amount of water would be sufficient to supply the city of London for 40 years [123] [129] . Supporting this, a study led by Oxford University indicates that even if we were to eliminate fossil fuel emissions immediately, meeting the Paris Agreement targets would still be unattainable without transitioning away from conventional animal agriculture.

[125] https://www.annualreviews.org/doi/full/10.1146/annurev-resource-100517-023252
[126] https://www.sciencedirect.com/science/article/pii/S2666833521000320
[127] https://web-assets.bcg.com/a0/28/4295860343c6a2a5b9f4e3436114/bcg-food-for-thought-the-protein-transformation-mar-2021.pdf
[128] https://academic.oup.com/advances/article/10/Supplement_4/S275/5624061?login=false#185744939
[129] https://www.euronews.com/green/2021/03/26/peak-meat-how-plant-based-alternatives-will-take-over-europe-by-2035

Notably, animal products contribute to an astounding 82% of European carbon emissions. Research suggests that embracing a plant-based diet could lead to a significant reduction in emissions ranging from 30 to 90% [130].

Regarding organic agriculture, it considers the long-term impact of agricultural interventions on the agro-ecosystem, acknowledging the gradual nature of environmental changes [131]. It offers advantages by fostering beneficial interactions within the ecosystem, supporting agricultural production and nature conservation. Key practices in organic farming include soil-building techniques like crop rotations, inter-cropping, symbiotic associations, cover crops, organic fertilisers, and minimum tillage. These practices promote soil fauna and flora, improving soil formation, structure, and stability, resulting in a more resilient and sustainable environment [125].

Organic farming fosters more diverse habitats and a greater variety of species. Comparative studies between organic and conventional farms in Switzerland, Denmark, and the UK reveal that semi-natural areas are more common on organic farms than conventional ones. This difference in land use positively impacts rare insects and spiders, increasing their abundance by 55% and diversity by 27% compared to conventional farming practices. Additionally, organic farms host a richer diversity and density of rare plant species in open arable land. The positive effects of organic farming extend to pollinators, beneficial insects, and herbivores, as it enhances their diversity and density while promoting wild bee species' reproduction rates. Multiple studies have consistently demonstrated that organic farming plays a pivotal role in supporting species diversity, population numbers, and the thriving of wild bees [132].

[130] https://gfieurope.org/blog/almost-half-of-europeans-want-more-plant-based-options/
[131] https://www.fao.org/organicag/oa-faq/oa-faq6/en/
[132] https://www.organicseurope.bio/content/uploads/2022/04/IFOAMEU_advocacy_organic-benefits-for-climate-and-biodiversity_2022.pdf?dd

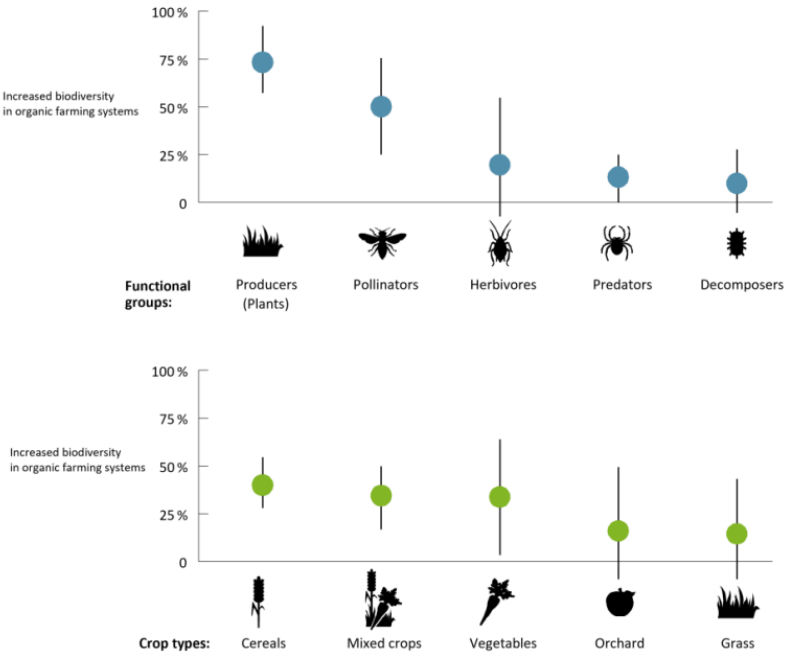

Figure 14: Differences of biodiversity on organic systems compared to conventional farms. Source: IFOAM, Organics Europe. Retrieved from: https://www.organicseurope.bio/content/uploads/2022/04/IFOAMEU_advocacy_organic-benefits-for-climate-and-biodiversity_2022.pdf?dd

Soil is vital to organic agriculture, surpassing conventional methods in preserving water quality by eliminating harmful chemicals (Gomiero et al., 2011) [133]. Non-organic crops globally receive around 115 million tonnes of nitrogen annually, with only 35% utilised by plants, leading to 75 million tonnes of nitrogen run-off into water bodies each year. Similarly, 56% of phosphorus fertiliser goes unused, posing an environmental threat. This nutrient run-off causes eutrophication, depleting water oxygen and harming marine life. In contrast, organic plants primarily obtain nutrients from humus colloids in the soil rather than water-soluble synthetic fertilisers. This gradual nutrient release to the plants reduces the risk of nutrient leaching and enhances organic farms' resilience to drought, resulting in 40% higher

133 https://senr.osu.edu/sites/senr/files/publication_files/Lorenz%20and%20Lal%20Adv%20in%20Agron.pdf

yields compared to non-organic farms during periods of drought and extreme climate conditions [134].

Organic agriculture plays a key role also in mitigating the greenhouse effect and global warming by sequestering carbon in the soil [125]. It increases carbon return to the soil, enhancing productivity and favouring carbon storage, ultimately reducing carbon in the atmosphere [125 128]. Higher soil organic carbon content directly correlates with greater agricultural mitigation potential against climate change. Studies consistently demonstrate significantly higher soil organic carbon levels in organic farming systems [125]. For example, a long-term experiment in Tuscany, Italy, revealed that soils managed under organic agriculture for 15 years had higher soil organic carbon stocks (27.9 vs. 24.5 Mg C ha1) compared to conventional management (Lazzerini et al., 2014) [129 130 133] . Furthermore, it exhibits lower energy consumption per hectare and per unit of product due to its reliance on on-farm processes instead of external energy inputs. Research suggests that organic agriculture consumes approximately 15% less energy per unit produced [126 129 130 133] . A Swiss study indicated that despite potential increased machinery usage and mechanical weeding in organic farming, energy demand per hectare was 22% to 35% lower annually compared to conventional farming. Additionally, energy demand per kg of harvested dry matter ranged from 2% to 17% lower in organic farming (Nemecek at al, 2011) [135].

In the EU, achieving the 25% organic land share target would have a number of significant benefits. Firstly, it would lead to a notable reduction of 2.7 million tonnes (Mt) in synthetic nitrogen fertiliser use, which is equivalent to 26% of what would be used without organic farming. This reduction aligns with the 20% fertiliser reduction goal in the Farm to Fork Strategy and has benefits for water quality, biodiversity, and greenhouse gas (GHG) emissions. It could also cut down agricultural emissions by up to 25 Mt CO2e, including 9.5 Mt CO2e from the manufacturing sector's energy use in N-fertiliser production and distribution. Secondly, if organic farming covered 90-95% of the land, it could result in a significant decrease of 20-23% in overall pesticide use across the EU27, contributing significantly to the 50% reduction target in the Farm to Fork Strategy [125 128 132 133] .

[134] https://austorganic.com/environ mental-benefits-of-organic/

[135] Nemecek et al, 2011. Life cycle assessment of Swiss farming systems. I. Integrated and organic farming. Agricultural systems, 104, 217-232

Moreover, achieving the 25% organic target has the potential to reduce greenhouse gas emissions by up to 68 million tonnes carbon dioxide equivalents (Mt CO2e), which amounts to 15% of the total agricultural GHG emissions in the EU. This corresponds to a reduction of about 1.6-1.7 tonnes of CO2e per hectare of agricultural land. These figures include the carbon sequestration resulting from incorporating temporary grassland into organic crop rotation plans. Furthermore, hitting the 25% organic target could lead to a reduction of up to 450 thousand tonnes (kt) in ammonia (NH3) emissions, accounting for 13% of the total NH3 emissions in the EU27. This reduction would have positive effects on air quality and indirectly reduce GHG emissions. Lastly, organic cropland would experience a significant 30% increase in biodiversity, contributing to an overall enhancement of 5-10% in farmland biodiversity across the European Union [125] [128] [132] [133].

To sum up, achieving the 25% organic land share target in the EU would result in substantial reductions in synthetic nitrogen fertiliser and pesticide use, as well as greenhouse gas emissions and ammonia emissions. Additionally, it would foster a notable increase in biodiversity [134].

4.2 Resilience of the food system

A key question in the debate on how organic agriculture and plant-based diets will impact food production in the future is if they will be able to produce enough food to feed the growing world population and if they will provide adequate nutrition [136] [137]. The comparison between conventional and organic yields is a central theme of the discussion [132]. According to several studies, organic agriculture produces lower yields than conventional agriculture. The production of organic agriculture is estimated to be equivalent to 80% of that of conventional agriculture, however this varies from 19-25% with respect to different types of crops and geographical regions [132] [138] . Hence, organic methods may need 23-33% more farmland to

[136] https://academic.oup.com/ajcn/article/100/suppl_1/476S/4576675
[137] https://www.cambridge.org/core/journals/renewable-agriculture-and-food-systems/article/abs/organic-agriculture-and-the-global-food-supply/93DD2635AC706B08EE68B881D17A143B#access-block
[138] https://knowledge4policy.ec.europa.eu/publication/crop-yield-gap-between-organic-conventional-agriculture_en

achieve the same level of output as conventional agriculture [132] [139]. These data led to criticism towards Farm to Fork's aim of cultivating 25% of farmland using organic methods. It has been argued that by using fewer fertilisers and expanding organic agriculture, food production in the EU will decrease. As a result of this reduction, less environmentally friendly practices are likely to be employed, and agriculture will probably extend into natural areas. Changes in land use could lead to increased greenhouse gas emissions in the sector, overshadowing organic farming's positive environmental impacts [132] [134].

It's important to note that estimates of the amount of food that needs to be produced to feed the world's population only take into account current trends in food consumption. However, a substantial amount of food is wasted or lost throughout the value chain, and high consumption rates of meat and dairy products cause considerable resource inefficiencies [132] [135]. Hence, reducing food waste and switching towards a plant-based diet would reduce the need for food production [132] [134] [135]. For instance, a FAO 2050 projection indicates that organic agriculture would be able to meet 60% of the world's dietary requirements by halving the amount of animal feed and food waste [132] [133]. On a European level, it has been estimated that a complete conversion of agriculture to organic methods by 2050 could provide food for 530 million people [140] [141]. Furthermore, the Stockholm Resilience Centre has undertaken groundbreaking research to quantify the impact of global food production and consumption patterns on the planetary boundaries. This study offers a compelling insight: embracing a plant-based diet, reducing food waste by half, and enhancing current farming methods can effectively nourish the projected global population of 10 billion by 2050 without exceeding the limits set by these planetary boundaries [137] [142].

As regards ensuring adequate intake of nutrients, a review has demonstrated that adopting a plant-based diet that meets nutritional requirements without increasing costs is achievable (Nelson et al. 2016)[138] [143]. By reducing meat consumption, significant calorie losses can be eliminated, thereby reducing the amount of farmland required. Consequently, transitioning to

[139] https://agriculture.ec.europa.eu/system/files/2023-04/agri-market-brief-20-organic-farming-eu_en.pdf
[140] https://read.organicseurope.bio/publication/eu-food-and-farming-policy-and-food-security/addressing-the-sustainability-dimension-of-eu-food-production/
[141] https://www.livekindly.com/global-shift-vegan-diet-sustainably-feed-10-billion-people/#:~:text=Switching%20to%20a%20plant%2Dbased,today%20in%20the%20journal%20Nature
[142] https://academic.oup.com/advances/article/10/Supplement_4/S275/5624061?login=false#185744939
[143] https://www.euroveg.eu/wp-content/uploads/2021/02/EVU_-Three-Pillars-for-a-Sustainable-European-Food-System_final.pdf

a plant-based diet holds the potential to offset the decline in organic yields. This is primarily attributed to the inefficiency of converting plant protein into animal protein. The majority of calories derived from crops fed to animals remain unavailable to humans [138] [139]. Although cereals fed to animals eventually make their way into human diets through meat and dairy consumption, this process is highly inefficient in terms of calorie and total protein production. For instance, beef exhibits an energy efficiency of approximately 2%, meaning that only 2 kilocalories of beef are obtained for every 100 kilocalories fed to a cow. Consequently, this inefficiency results in an estimated food loss of 234 kg of human-edible cereals per person annually. Notably, in most European countries, less than one-third of cereal production is utilised for human consumption [138] [139].

In the view of Dr. Pyett, the Program Manager for Proteins for Life at Wageningen University & Research (WUR), the world currently produces enough plant proteins to sustain the global population. Based on FAO data, WUR indicates that in 2018, the world produced 630 million tons of protein, with 109 million tons coming from animal sources and 520 million tons from plants (with half of the plant protein being processed into animal feed). Considering that the World Health Organization recommends an average adult human requires between 50 and 60 grams of protein daily, it implies that nearly 8 billion people on Earth would need a total of 172 million tons of protein annually to maintain good health. Given that about 1/3 of agricultural production is typically lost during various stages like harvest, processing, transport, or consumer waste, the available plant protein worldwide per year stands at approximately 346 million tons. As meat consumption is reduced, the global availability of vegetable proteins is more than sufficient to meet the protein needs of the world's population [144].

Among plant-based proteins, legumes, in particular, offer a plethora of health benefits to humans due to their rich nutrient profile, including carbohydrates, vitamins, minerals, and fibres. Within this group of nutrient-dense options, peas stand out as an excellent choice for diverse food formulations, effectively boosting protein intake. Notably, chickpeas shine as a primary source of high-quality protein in the diet. Plant-based proteins play a pivotal role in human nutrition, providing an abundant supply of essential nutrients, vitamins, and minerals. Additionally, these plant-derived foods offer a comprehensive array of essential amino acids,

[144] https://www.wur.nl/en/newsarticle/the-world-can-be-fed-with-only-plant-based-food.htm

crucial for promoting overall nutritional well-being. It is also noteworthy, as discussed in the previous chapter, that organic farming can further enhance these health benefits [145] .

Taking into account the points highlighted above, the simultaneous adoption of organic agriculture and a plant-based diet holds significant promise in optimising our food supply while offering notable health and environmental benefits [132] [133]. Following the FAO's definition of food sustainability, this approach has the potential to contribute to the achievement of a sustainable food system that guarantees food security and safeguards the environment without exceeding planetary limits. As emphasised by Dr. Springmann, a senior researcher at the Oxford Martin Programme on the Future of Food and the Nuffield Department of Population Health at the University of Oxford, relying on a singular solution is insufficient to avoid crossing planetary boundaries. However, through the collective implementation of multiple solutions, there is promising evidence to suggest that we can sustainably feed the growing population (Springmann, 2018) [137] .

4.3 Shift in consumers' choices

In recent years, driven significantly by the Covid pandemic, there has been a remarkable surge in consumer demand for organic and plant-based foods, fuelled by increased awareness of health and environmental concerns [146]. The European organic market has experienced consistent growth, reaching nearly €45.2 billion in 2019, marking a substantial 10.3% increase compared to 2018. This growth is noteworthy, having more than quadrupled between 2004 and 2019, and reaching an all-time high in 2020 with retail sales surging by 14.9% to reach €52.0 billion [147] [144]. Among the key markets, Germany stands out with the highest growth rate at 22.3%. Per capita consumer spending on organic food has doubled in the last decade. Impressively, in 2020, Swiss and Danish consumers led the way in spending on organic food, reaching €418 and €384 per capita, respectively. Denmark has become a global leader with the highest organic food sales share, reaching 13.0% in 2020 [148]. In

[145] https://www.frontiersin.org/articles/10.3389/fnut.2021.772573/full
[146] https://agriculture.ec.europa.eu/news/organic-farming-eu-decade-growth-2023-01-18_en
[147] https://www.agencebio.org/wp-content/uploads/2022/01/Organic-Sector-EU-2021.pdf
[148] https://www.fibl.org/en/info-centre/news/exceptional-growth-of-the-european-organic-market-2020

parallel, plant-based foods have undergone an enormous transformation, becoming mainstream goods [149]. In parallel, plant-based foods have undergone an enormous transformation, becoming mainstream goods. The EU market for alternative proteins, including meat and dairy alternatives, has witnessed steady growth in recent years, with sales increasing by 10% annually between 2010 and 2020 [150]. According to the *Food for Thought study* report, the rapid expansion of plant-based meat alternatives is projected to propel Europe towards a "peak meat" scenario by 2035. The report forecasts that plant-based proteins will claim 11% of the meat, seafood, and dairy market by 2035, resulting in a consumption of 97 million metric tons [151].

The surge in consumer demand for alternative proteins that are delicious, affordable, and easily accessible has reached unprecedented levels. Recognizing this growing trend, ProVeg, in partnership with Innova Market Insights, conducted a comprehensive study as part of the Smart Protein project in June 2021. This extensive study involved more than 7,500 individuals from ten European countries, namely Austria, Denmark, France, Germany, Italy, Netherlands, Poland, Romania, Spain, and the UK. The participants were surveyed to assess their attitudes towards plant-based food consumption, their level of trust in these products, their current dietary habits, and the primary factors influencing their food choices [152] [153]. Approximately 40% of European consumers expressed their intention to reduce meat consumption, with 46% already having reduced their meat intake, and nearly 30% planning to decrease dairy consumption. Among flexitarians, 73% reported a significant reduction in meat consumption. Conversely, almost 30% of Europeans expressed their intention to consume more plant-based dairy and meat products. Regarding perceptions of plant-based products, about 45% of flexitarians believe there is a lack of plant-based choices in supermarkets and restaurants, while 50% consider these options to be too expensive and desire more information about them. Organic labelling is considered important by more than 60% of flexitarians, vegans, and vegetarians when it comes to plant-based food products.

[149] https://smartproteinproject.eu/wp-content/uploads/FINAL_Pan-EU-consumer-survey_Overall-Report-.pdf
[150] https://www.eufic.org/en/food-production/article/5-trending-alternative-protein-sources-to-meat-in-europe
[151] https://www.euronews.com/green/2021/03/26/peak-meat-how-plant-based-alternatives-will-take-over-europe-by-2035
[152] https://smartproteinproject.eu/wp-content/uploads/FINAL_Pan-EU-consumer-survey_Overall-Report-.pdf
[153] https://www.innovamarketinsights.com/trends/rise-of-the-flexitarian-helping-to-shape-european-meat-alternatives-market/

According to Euromonitor, flexitarians accounted for 42% of global consumers in 2020, indicating their significant influence in driving the plant-based food sector. Interestingly, a survey by the NPD Group revealed that nearly 90% of plant-based meat consumers were meat eaters (The NPD Group, 2019) [148] [149].

The research findings highlight the main barriers to be the availability and price of plant-based food products, as well as a lack of information and social interactions. Approximately 45% of respondents expressed that there is insufficient choice in plant-based food when eating out, emphasising the need for more plant-based options in restaurants and supermarkets. Additionally, 38% believe that plant-based meals or snacks are not readily available when dining out. Half of flexitarians stated that plant-based products are too expensive, underscoring the importance of reducing the prices of plant-based food [148] [149].

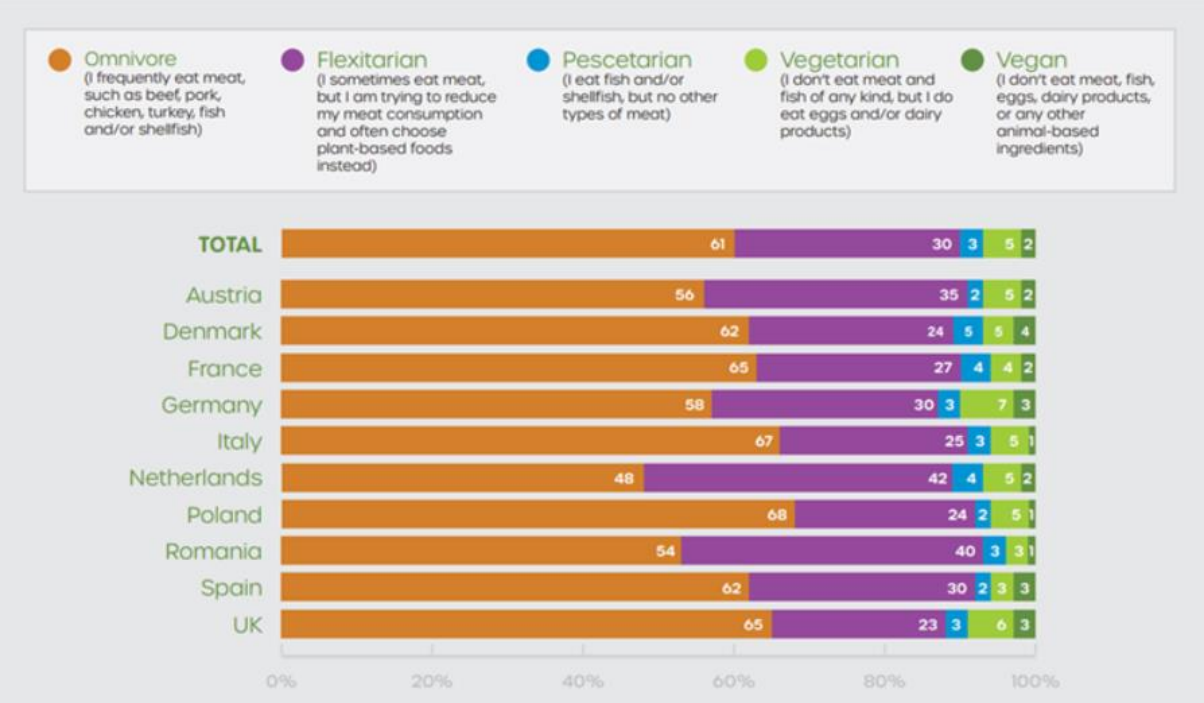

Figure 15: Dietary lifestyle by country. Source: Smart Protein Project. Retrieved from: https://smartproteinproject.eu/wp-content/uploads/FINAL_Pan-EU-consumer-survey_Overall-Report-.pdf

Indeed, the cost of both organic and plant-based food is generally higher compared to conventional options. Organic food comes with a higher price tag because it more accurately reflects the true cost of production, which involves substituting labour and intensive

management for chemicals. These chemicals have health and environmental costs that are borne by society. The price of organic food includes not only the production costs but also additional factors that are not considered in the price of conventional food. These factors include environmental enhancement and protection, which helps avoid future expenses related to pollution mitigation. For instance, higher prices of organic cash crops compensate for lower financial returns during rotational periods required for building soil fertility. Other factors include higher standards for animal welfare, the avoidance of health risks to farmers due to pesticide handling, and rural development through additional farm employment and fair incomes for producers. Mounting evidence suggests that if all the indirect costs of conventional food production were factored into the price, organic food would cost the same or potentially even less than conventional food. This indicates that the higher price of organic food reflects the true costs involved and incorporates the benefits of environmental sustainability, animal welfare, farmer health, and rural development [154].

Plant-based products generally carry a higher price compared to conventional protein sources. Nielsen data reveals that, on average, plant-based meat is twice as expensive as beef, over four times as expensive as chicken, and more than three times as expensive as pork [155]. This is mainly due to the fact that, in comparison with traditional animal products, plant-based ones can be more complex and costly to produce and process. For instance, extracting proteins from plant sources and refining them to enhance taste, texture, and nutritional profile typically require intricate and extensive processing methods. These additional steps in the production process contribute to higher production costs. Despite the rapid growth of the plant-based protein market in recent years, it remains relatively smaller compared to the traditional animal protein market. This limited scale hinders the full realization of economies of scale, resulting in higher production costs. However, as demand continues to surge and production scales up, prices are expected to gradually decrease.

The *Food for Thought study* report supports this projection, stating that by 2035, protein alternatives will achieve price and quality parity with traditional proteins. As the market expands and technological advancements occur, the production costs of plant-based proteins are anticipated to decrease, making them more affordable and accessible to a broader range of

[154] https://www.cpublishingmedia.com/wp-content/uploads/2020/11/Organic-Farming-for-Sustainable-Agriculture.pdf
[155] https://gfi.org/wp-content/uploads/2021/12/Reducing-the-price-of-alternative-proteins_GFI_2022.pdf

consumers. The economic recession of 2020 has resulted in a decline in consumers' discretionary spending, raising concerns about the potential impact of high prices on the adoption of plant-based alternatives. However, the perceived added value of these alternatives can help mitigate price sensitivity. One significant motivating factor for consumers willing to pay a premium is the belief that plant-based alternatives offer health benefits. This trend is particularly evident in the milk alternatives market, especially with non-soy options. Almond, oat, coconut, and pea-based alternatives have driven innovation in this category, as they are widely regarded as healthier and more easily digestible compared to traditional cow's milk. Euromonitor International's Industry Forecast Model indicates a reduced negative correlation between price and volume growth in the United States, as plant-based alternatives have become more competitively priced relative to dairy products. While price remains a constraint on adoption in markets like the United Kingdom and Sweden, other positive demand drivers exert a stronger influence. These drivers include lifestyle trends centred around health consciousness and the adoption of flexitarian diets [150] [151] [156].

Figure 16: Retail volume sales ‘000 Tonnes, 2019-2014 CAGR %. The chart represents the total percentage of other milk alternatives in selected markets. This is decomposed into positive and negative percentage points effects for individual demand drivers. Source: Euromonitor International’s Industry. Retrieved from: https://www.euromonitor.com/article/coronavirus-accelerates-shift-towards-plant-based-food

[156] https://www.euromonitor.com/article/coronavirus-accelerates-shift-towards-plant-based-food

Conclusion

The established food system in the EU over the past 60 years is inherently unsustainable, posing detrimental impacts on human health and the environment. The urgency to transform the entire EU food system has become imperative to ensure food security for future generations without surpassing planetary boundaries. Furthermore, the Covid-19 crisis and the war in Ukraine have underscored the need to enhance the resilience of the EU food system.

To address these challenges, in 2020 the European Commission introduced the Farm to Fork strategy, aiming to create a fair, healthy, and environmentally friendly food system for European citizens. Among its objectives, the strategy fosters the adoption of a plant-based diet and the implementation of the EU agricultural area farmed organically. Given these goals, the Farm to Fork is closely tied to the CAP 2023-2017, which aims to be more environmentally friendly. For the first time, the EU has applied a holistic strategy which encompasses production, consumption, and farmer adaptation throughout the food supply chain, recognizing the interconnectedness of healthy communities, individuals, and the planet. These policies are crucial for reshaping Europe's food production, supply chain, consumption patterns, and agriculture in the coming decades.

However, it is imperative to recognize that, due to structural issues and delays in the implementation, they also lack the necessary efficiency, which raises concerns about the risk of failing to achieve the desired goals. Therefore, a comprehensive and strategic overhaul of these policies is essential for their successful enforcement and to address the pressing challenges we face. Towards this end, it is imperative that they are aligned with their intended objectives. Several suggested actions include the introduction of a clear definition of "food sustainability", specific guidelines and targets for the adoption of a plant-based diet, a reduction in the budget allocated to meat-promotion campaigns, and the alignment of the CAP strategic plans with the objectives outlined in the Farm to Fork Strategy.

Indeed, achieving the concurrent adoption of a plant-based diet and organic agriculture has been shown to have a positive effect in fostering the transition towards a sustainable food system. They both have beneficial impacts on health, the environment and help strengthen the resilience of the food system. In their promotion, consumers' choices will play a key role.

It is important to note that even though consumers' awareness of climate change and its consequences is increasing, yet there is still a gap between awareness and actual consumption. To influence consumer choices, clear and improved information should be provided, including awareness campaigns on labelling standards, certifications, and the benefits of plant-based and organic food. Tax adjustments can also be effective incentives to influence consumer behaviour, with a focus on reforming taxation policies for animal-based products that impose negative externalities on the environment, climate, and health. Incentives should also be created to encourage increased consumption of plant-based products through reduced taxes on fruits, vegetables, and legumes. Existing barriers, such as disadvantages faced by plant-based milk alternatives in VAT systems, should be eliminated to ensure a level playing field.

In conclusion, transitioning to a plant-based diet and increasing the share of organic agriculture holds immense promise for building a sustainable food system within the EU. However, to realise this potential, it is imperative to address the inefficiencies in the current food system and policies. A comprehensive and integrated approach that encompasses changes in food production and consumption patterns is essential. By implementing strategic reforms, raising awareness, and fostering collaborations, we can pave the way for a more sustainable, resilient, and ethical food system that meets the needs of present and future generations.

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