Sustainable Food Systems as a Driver for the Implementation of the SDGs: Taking Stock of SDG 2 and Future Perspectives

STUDY

European Economic
and Social Committee

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General information

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Abstract

SDG2 (Zero Hunger) aims to achieve food security and productive and sustainable agri-food systems. It also underpins the achievement of many other SDGs, including the goals related to health, climate action and biodiversity among others. According to many international studies, SDG2 is particularly off-track in Europe and globally and many targets might not be achieved by 2030 including those related to healthy diets and sustainable agri-food systems. In Europe, multiple crises have impacted food security and the livelihoods of farmers, small-scale food producers and other stakeholders and the impact of climate change might further exacerbate these trends. This study presents new insights to promote the transformation of the EU's agri-food system building on three principal instruments: (1) SDSN's SDG Index indicators and dashboards; (2) model-based scenarios oriented toward 2030 and 2050 using the methodology developed by the Food, Agriculture, Biodiversity, Land-Use and Energy (FABLE) Consortium and (3) New survey data collected for this study from experts and practitioners in the European agri-food industry in collaboration with the EESC. The study makes four overarching recommendations, and calls above all, for more effective multistakeholder engagement mechanisms at the EU and member states' level to define long-term pathways and specific policies to advance the sustainability of agri-food systems in Europe. We also emphasize the importance of concerted international action and demand-side measures, including incentives to move toward healthier diets, to achieve simultaneously several SDGs related to agri-food systems, climate mitigation and biodiversity.

Executive Summary

1. According to international studies, SDG2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture) is particularly off-track at the global level and the EU level. While ensuring carbon capture and supporting diverse habitats, agrifood systems are responsible for more than a third of annual anthropogenic GHG emissions (Crippa et al, 2021), employ an estimated 1.2 billion people globally and are deeply interconnected. The EU faces persisting challenges related to healthy diets, the environmental, social and economic sustainability of agricultural systems. Agri food systems also generate large international spillovers including deforestation and biodiversity threats.

2. This study presents new insights to promote the transformation of the EU's agri-food system building on three principal instruments: (i) SDSN's SDG Index indicators and dashboards; (2) model-based scenarios oriented toward 2030 and 2050 using the methodology developed by the Food, Agriculture, Biodiversity, Land-Use and Energy (FABLE) Consortium and (3) New survey data collected for this study from experts and practitioners in the European agri-food industry in collaboration with the European Economic and Social Committee .

3. We explore the possibility of achieving SDG 2 and other sustainability objectives in the EU by 2030 and 2050 with the FABLE tools. FABLE's particularity is its decentralized bottom-up modelling approach where EU results are derived from the aggregation of national pathways developed by country-based teams of researchers and experts. We are looking for including more EU countries and a closer collaboration with stakeholders in the EU to improve the relevance of our results in the EU context in the future.

4. Our results show that the adoption of healthy diets is essential to simultaneously achieve SDG 2, climate mitigation goals, and biodiversity targets in the EU. Essential components of this dietary shift are rebalancing protein intake from animal to plant-based foods and increasing the consumption of fresh fruits and vegetables. Multi-stakeholder dialogues will be essential to ensure affordability of healthy diets, address labour implications, and ensure a just transition.[1]

5. Higher consumption of fruits and vegetables and legumes are mainly satisfied through lower food loss and waste, an increase of imports, and some reallocation from feed use to food use for legumes leading to no significant increase in production for these commodities in Europe. Investments in these sectors to increase competitiveness[2] could avoid an increased dependency of the EU on imports.

[1] See Chapter 3.4 of the Strategic Dialogue of the Future of EU Agriculture. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/agriculture-and-green-deal/strategic-dialogue-future-eu-agriculture_en

[2] The EESC defines competitiveness in the following way: "In order for a comprehensive European food policy to be truly relevant for European consumers, it is essential that the price and quality of food produced sustainably in the EU is competitive. This means that the European agri-food sector is able to deliver food for the consumers at prices that include extra costs for criteria such as sustainability, animal welfare, food safety and nutritional value, but also a fair return to the farmers, and at the same time, maintains its position as the preferred choice for the vast majority of consumers."

5.1 A shift toward sustainable livestock practices—such as extensive grazing—can offer benefits for biodiversity, provide organic fertilizer, and retain on-farm labour. While this study highlights the possible tensions for the provision of enough organic fertilizers to achieve the 25% organic farming EU target when livestock numbers are reduced, it has limitations due to the lack of differentiation of livestock production systems within the EU.

6. The combination of demand side and supply side measures create new opportunities for alternative land uses due to agricultural land saving e.g., for reducing food and feed imports, and/or increase land use for non-food purposes such as afforestation, natural regrowth of vegetation, or renewable energy production. Each alternative land use should be assessed in line with its potential to contribute to EU sustainability objectives and the income benefits for farmers, through economic incentives for ecosystems services or diversification of the production.
7. New survey data collected for this study from a sample of 40+ experts and practitioners all over Europe suggest that while some of the legislation adopted during the previous European Commission (2019-2024) might set the right vision for the future of agri-food systems, in particular the Farm-to-Fork strategy, more strategic and effective implementation mechanisms are still needed.

7.1 In particular, respondents emphasize the need to boost the social sustainability of the agri-food system by strengthening financing mechanisms and other forms of support for a just transition. Respondents also underline the importance of political leadership and better coordination across sectors and ministries, the need for stronger measures related to marketing and financial incentives in support of healthier diets as well as more effective and inclusive stakeholder engagement mechanisms at the EU level to inform the transformation of agri-food systems.

Key recommendations:

- **Recommendation 1. New stakeholder engagement mechanisms are needed at the EU and national level for effective policy implementation and to define long-term pathways for sustainable agri-food systems.** The farmers' protests in Brussels and in EU member states in 2024 call for more structured engagement at all levels and across a diversity of stakeholders in the agri-food system (including farmers, manufacturers, distributors, consumers, policymakers, investors and scientists). Recommendations made by the EESC and the *Strategic Dialogue on the Future of EU Agriculture* to create respectively a "European Food Policy Council" or "European Board on Agri-food (EBAF)" might help strengthening the governance of agri-food systems in the EU, and its international dimension. A higher diversity of modelled scenarios in each member state, reflecting the variety of positions of local stakeholders but highlighting the aggregated impact at the EU level, may support a more appeased, integrated and context-specific policy dialogue on the future of the EU agri-food industry.

- **Recommendation 2. Demand-side measures, especially dietary shift, must be a top priority of the incoming EU leadership for sustainable agri-food systems and better health outcomes**. Our study echoes the findings from other studies and emphasizes the important role of dietary shifts, including the shift toward more plant-based diets, in achieving climate and biodiversity goals. Healthier diets can also support better health outcomes and help contain the rise in health budget expenditures in the coming years. However, this requires the deployment of financial incentives and other policies including changes in marketing rules and reinforcing the role of local producers in this transition to start a virtuous cycle for the whole value chains in the EU. At member states level, education policies, including at an early age, and school meals can also be further mobilized to promote healthy diets.

- **Recommendation 3. Short-term and long-term trends, call for more ambitious mechanisms to safeguard livelihoods of farmers, small-scale food producers and other stakeholders and to ensure a just transition.** Geopolitical tensions and rising inflation, including rising food prices, have impacted food security and livelihoods of farmers and other food actors. Households in or near poverty are much more likely to be food insecure than those with higher incomes. Looking ahead, the impact of climate change will continue to affect agricultural supply via heat waves, water scarcity, soil degradation and biodiversity loss (among others). These short- and long-term trends call for close monitoring of affordable and healthy diets, investments now to strengthen the resilience of the agri-food system in the EU and more accessible and effective financing mechanisms to support the transition. Overall, agri-food stakeholders surveyed for this study call for continued political leadership, effective implementation of agreed strategies and rules – especially Farm-to-Fork and the use of strategic procurement – as well as financial and non-financial support for the transition but not necessarily for the introduction of new regulations.

- **Recommendation 4. Ahead of the COP30 in Brazil, and other major conferences, the EU should play a leadership role *globally* to advance SDG 2 (Zero Hunger) and to clean up international food supply chains.** SDG 2 (Zero Hunger) can support the implementation of all of the other Sustainable Development Goals. Global cooperation is critical to address negative international spillovers generated via the agri-food supply chains on deforestation and health outcomes (among others). The new EU leadership will have numerous opportunities over the period 2024-2029 to emphasize the importance of concerted actions and investments for more sustainable agri-food systems, notably at the Nutrition for Growth summit in France and forthcoming COP30 in Brazil both in 2025. Concerted action at the World Trade Organization (WTO) is also critical to clean up international food supply chains and safeguard livelihoods. In the context of the SDGs, the new leadership of the EU could prepare a second Voluntary Review ahead of the 2027 SDG Summit at Heads-of-State level with a strong emphasis on SDG2 (No Hunger) including both its internal and international dimensions and its importance in the post-2030 global framework for sustainable development.

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Context / Introduction

Sustainable food and land use systems are crucial to feed the growing population in the world, support socio-economic prosperity and address the climate and biodiversity crises (Barbero Vignola et al, 2024). While healthy ecosystems are vital for ensuring carbon capture and supporting diverse habitats, food production and land use systems are responsible for approximately one-third of global greenhouse gas (GHG) emissions and unprecedented loss of biodiversity and forest cover. The SDSN considers sustainable food, land, water and oceans as one of the six key SDG transformations which can contribute to achieving other SDGs (Sachs et al, 2019). The UN Independent Group of Scientists also identified - sustainable food systems and healthy nutrition patterns as one of their six entry-points for SDG achievements (IGS, 2023). In Europe, the EESC has called on numerous occasions for a comprehensive approach to managing food systems, emphasizing the need to connect economic, environmental, and socio-cultural sustainability[3].

Since the 1990s, the EU member states have made significant progress towards greater sustainability of food and land systems. Yet this progress is being threatened by international and domestic factors, including a backlash against the European Green Deal (EGD) in a context of rising inflation and geopolitical tensions. From 2005 to 2022, agricultural greenhouse gas emissions in the EU showed an overall decrease of 5%, with an additional estimated reduction of 2% between 2022 and 2023, and member states collectively project that, without the implementation of additional policies and measures, agricultural emissions will rise from current levels through to 2030 (EEA, 2024). The carbon sink of European forests has deteriorated over the last few years due to extreme climate events and higher timber harvesting intensities (Urrutia et al, 2021). If these trends continue, the EU will increase its net emissions from the land sector rather than decreasing them. In parallel, biodiversity is in notable decline, as indicated by significant reductions in bird populations; between 1990 and 2022, the common bird index fell by 14%, and the common forest bird index by 3%, due to pressures from agricultural intensification, habitat loss, climate change, and other human-driven factors (EEA, 2024). Unhealthy diets increasingly lead to obesity and other adverse health effects in the EU as emphasized recently by the European Parliament (Aouati, O. et al, 2024).

Food businesses across the supply chain, including many European farmers and fishers, cooperatives, agri-food companies, retailers, wholesalers, and other types of companies, have started to move toward more sustainable agricultural practices and healthy and sustainable products in line with the European Green Deal (EGD). The farmers' protest and demonstrations all over Europe in early 2024 reinforce the importance of a just transition towards sustainable and resilient land-use systems in the EU and the need to ensure sustainable rural and urban development.

SDG 2 (Zero Hunger), presented in detail in Box 1, was one of the goals under in-depth review at the UN High-Level Political Forum (HLPF) in 2024. As emphasized by the Food and Agriculture Organization (FAO) and the latest Sustainable Development Report 2024, no country in the world has achieved or is on track to achieve SDG2 (Zero Hunger) with persisting issues related to

[3] See for instance: EESC - Food price crisis: the role of speculation and concrete proposals for action in the aftermath of the Ukraine war; EESC - Towards a European Food Policy Council as a new governance model in the future EU Framework on Sustainable Food Systems; EESC - Towards a sustainable food labelling framework to empower consumers to make sustainable food choices; EESC - Promoting healthy and sustainable diets in the EU (own-initiative opinion); EESC - Improving the food supply chain; NAT/913 - Promoting autonomous and sustainable food production strategies for the post-2027 CAP; NAT/821 Aligning food business strategies and operations with the SDGs for a sustainable post-COVID-19 recovery (own-initiative opinion) | EESC (europa.eu); NAT/856 Towards a sustainable plant protein and plant oil strategy for the EU; NAT/844 Food security and sustainable food systems; NAT/839 EU Long-term vision for rural areas.

undernourishment, unhealthy and unsustainable diets, unsustainable agriculture and/or agricultural productivity (or a combination of those) (FAO, 2024; Sachs et al, 2024). The EU faces major challenges related to SDG2 (Zero Hunger) and other SDGs related to food and land systems, notably SDG15 (Life on Land). Recent studies and reports have analysed efforts made by the previous European leadership to move toward more sustainable agri-food systems in the EU and proposed a way forward (Lamy et al., 2024). More specifically, the final report of the Strategic Dialogue on the future of agriculture launched after the protests earlier in 2024 was released in September 2024 (European Commission, 2024) included a series of recommendations structured around five major pillars: (i) sustainable, resilient and competitive EU agri-food systems; (ii) sustainable agri-food systems (iii) transformative resilience; (iv) attractive and diverse sector; (v) knowledge and innovation.

The present study aims to contribute to the broader efforts to strengthen evidence-based policies and stakeholder engagement to advance the sustainability transition of the agri-food sector in the EU. More specifically the study provides:

(1) A sound diagnosis of progress made and persisting gaps on SDG 2 (Zero Hunger) in the EU and individual member states.

(2) An overview of options, synergies and trade-offs across various pathways and scenarios that aim to maximize the productivity of agricultural systems, more healthy diets, a just transition and ambitious environmental and biodiversity targets.

(3) Clarity on the persisting policy bottlenecks to adopt and implement ambitious sustainable food & land-use policies, as perceived by multiple stakeholders.

The study builds in tools developed by the SDSN and other consortiums, including the SDG Index and FABLE Pathways, and on stakeholder consultation via new primary survey data collected for this study as well as a workshop organised in October 2024 involving various stakeholders from the EU agri-food sector.

Box 1.1. SDG2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Target	Indicator
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.	2.1.1 Prevalence of undernourishment 2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age. 2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight) 2.2.3 Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (percentage)
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size 2.3.2 Average income of small-scale food producers, by sex and indigenous status
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.	2.5.1 Number of (a) plant and (b) animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities. 2.5.2 Proportion of local breeds classified as being at risk of extinction.
2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	2.a.1 The agriculture orientation index for government expenditures 2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round	2.b.1 Agricultural export subsidies.
2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely	2.c.1 Indicator of food price anomalies.

1. Progress and persisting challenges on SDG 2 (Zero Hunger) in the EU: Insights from the SDG Index

SDG 2 (Zero Hunger) stands out as one of the goals where progress is weakest globally. And yet, sustainable food and land systems are vital for addressing the climate and biodiversity crises and to feed a growing global population whilst supporting socio-economic prosperity. The SDSN considers sustainable food and land use systems as one of the six key SDG transformations (Sachs et al., 2019).

The FAO defines sustainable agri-food systems as those where “food is nutritious and accessible for everyone, [and] in which natural resources are managed in a way that maintains ecosystem functions to support current and future human needs,” (FAO, 2018). Agricultural productivity has risen sharply in the past few decades, however, increased production has generally been accompanied by greater environmental damages and resource depletion, requiring transformations in business-as-usual agriculture, to address water scarcity, soil degradation, biodiversity loss, decreasing fish stocks, deforestation, air pollution, and greenhouse gas emissions (FAO, 2018).

1.1 Overall performance on SDG 2 (Zero Hunger)

Currently, no country in the world has achieved or is on track to achieve SDG2 (Zero Hunger) with persisting issues related to undernourishment, unhealthy and unsustainable diets, unsustainable agriculture and/or agricultural productivity (Sachs et al., 2024).

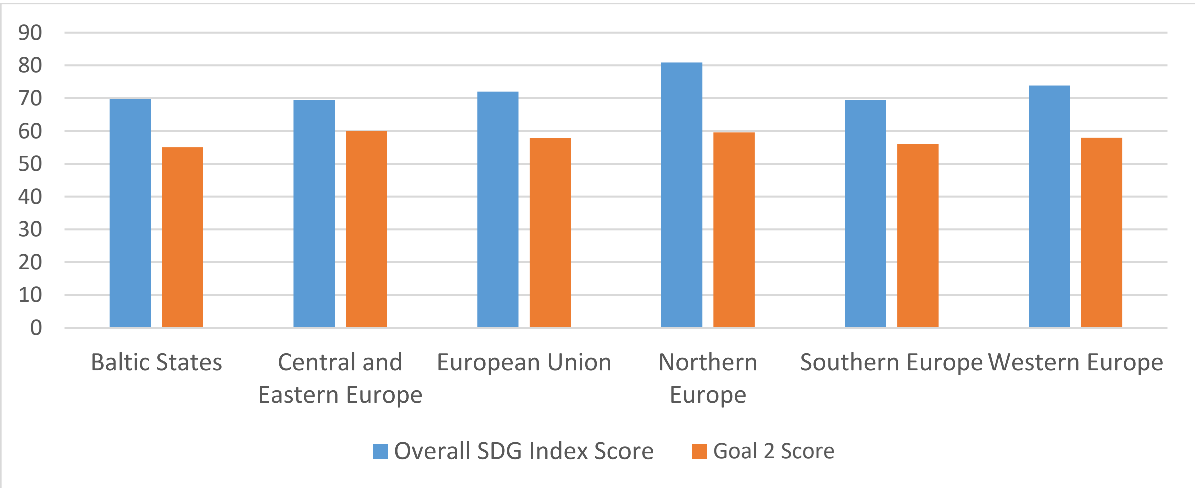
Since 2019, the Europe Sustainable Development Report (ESDR) has presented the SDG Index and Dashboards for Europe and provided an annual overview of the European Union’s progress towards the SDGs, as well as the progress of 38 individual European countries, including the 27 EU member states (Lafortune et al., 2024). The report, prepared by the SDSN in collaboration with SDSN Europe and the European Economic and Social Committee (EESC) builds on several rounds of consultations with scientists, experts and practitioners from across Europe.

According to the latest ESDR 2023/24, the EU faces major challenges related to SDG2 (Zero Hunger) and other SDGs related to food and land systems, notably SDG15 (Life on Land) (Figure 1.1). The goal scores for SDG 2 further highlight the divergence between Europe’s performance on sustainable agri-food systems and overall SDG progress (Figure 1.2). Across the EU, SDG 2 is among the goals lagging furthest behind. In addition to the dashboard, which gives a visual indication of progress on each SDG, the report also publishes a trend indication for each goal. The trend indicates whether – if current levels of progress are extrapolated into the future – the country is projected to meet the SDG performance thresholds by 2030. The overall trend dashboard for SDG 2 (Figure 1.3) indicates that – at current rates of progress – no European country is on track to meet the goal by 2030.

Figure 1.1: EU SDG Dashboards

Source: Lafortune et al, 2024

Figure 1.2: Gap between overall SDG Index Score and SDG2 Goal Scores across EU sub-regions



Source: Authors, based on Lafortune et al, 2024

Figure 1.3: SDG Index Scores and Evaluations of Goal 2 (Zero Hunger) of the EU-27

SDG Index Score	Country	SDG 2: Dashboard	SDG 2: Trend
80.6	Finland		→
80.6	Sweden		→
80.0	Denmark		→
77.7	Austria		↓
75.4	Germany		→
74.4	Czechia		→
73.7	Slovenia		↓
73.0	Estonia		→

72.9	France		→
72.8	Poland		→
71.4	Ireland		→
71.0	Belgium		→
70.1	Slovakia		→
70.1	Netherlands		↓
70.0	Croatia		→
70.0	Portugal		↓
69.9	Italy		→
69.6	Spain		→
69.5	Latvia		→
69.0	Hungary		↓
67.8	Luxembourg		→
67.7	Lithuania		→
65.9	Malta		↓
65.2	Greece		→
62.6	Romania		→
61.0	Cyprus		↓
59.5	Bulgaria		↗
72.0	European Union		→

Source: Lafortune et al, 2024

1.2 Detailed performance by indicator

The SDGs' official indicator framework released by the UN Statistical Division covers undernourishment in Target 2.1 and malnutrition in Target 2.2. The official framework also covers agriculture in terms of its productivity, Target 2.3, and sustainability, Target 2.4, including biodiversity in crops and livestock, Target 2.5. The following section provides a statistical review of EU performance on indicators used to evaluate SDG progress in the SDG Index. It remains difficult to identify a comparable measure to track the notion of social sustainability of agri-food systems and fair distribution of income across the agri-food supply chain.

Food security: Undernourishment

Whilst combatting undernourishment continues to be a critical challenge in many low- and middle-income countries, food insecurity and undernourishment remains far more limited in the EU. The entirety of the EU has established the lowest levels of undernourishment as measured by the FAO, with the exception of Malta where undernourishment has risen since 2020. In EU candidate countries[4], levels of undernourishment are somewhat higher, but still low on a global scale. As emphasized by a recent report of the European Parliament's Agricultural Committee food availability in the EU "is not generally considered to be at risk" although the disruption in international food supply chains and inflation have increased the cost of food and burden on households' budget (Loi et al., 2024).

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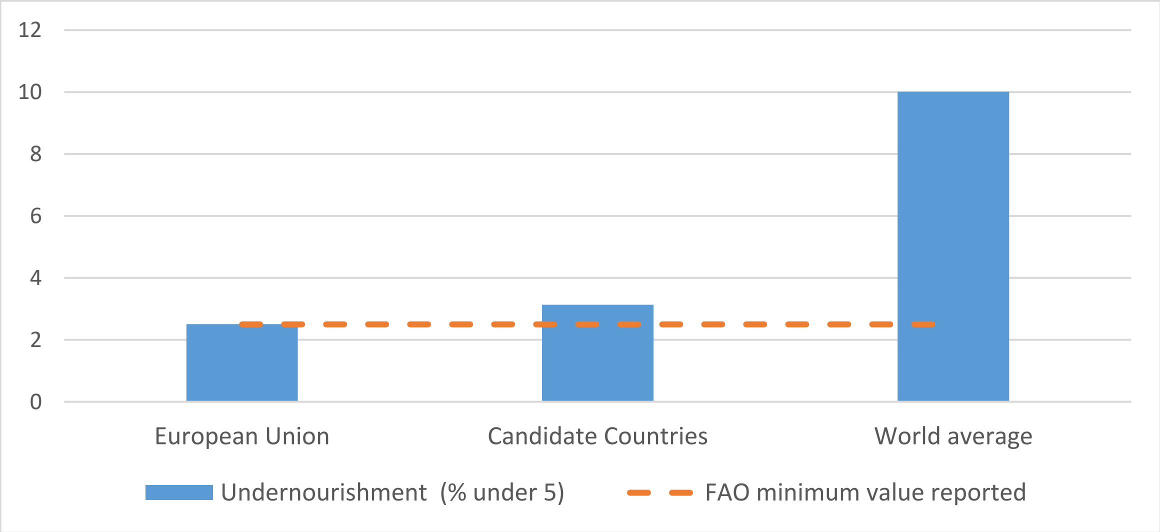
[4] Albania, Bosnia & Herzegovina, Georgia, Moldova, Montenegro, North Macedonia, Serbia, Türkiye, Ukraine

Figure 1.4: Prevalence of undernourishment in the EU-27, candidate countries, and the world



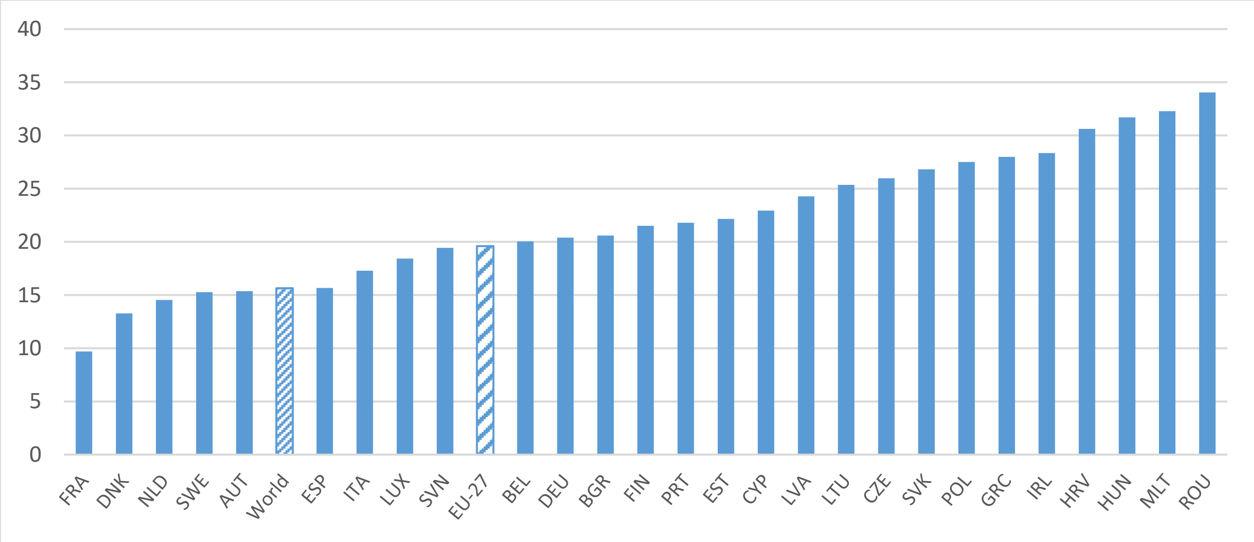
Source: FAOSTAT

Malnutrition / unhealthy diets: Obesity prevalence

The obesity rate measures the percentage of the adult population that has a body mass index (BMI) of 30kg/m² or higher, based on measured height and weight. Obesity is a complex disease that can lead to other non-communicable diseases. It is a major public health challenge both globally and in Europe, where it is a major determinant of disability and death (WHO, 2022). In the EU, obesity was previously addressed through Action Plan on Childhood Obesity 2014-2020. The revision and follow-up of the plan is slated to be integrated into Europe's Beating Cancer Plan and in Europe's strategy for reducing non-communicable diseases (European Commission, 2023; European Parliament, 2023).

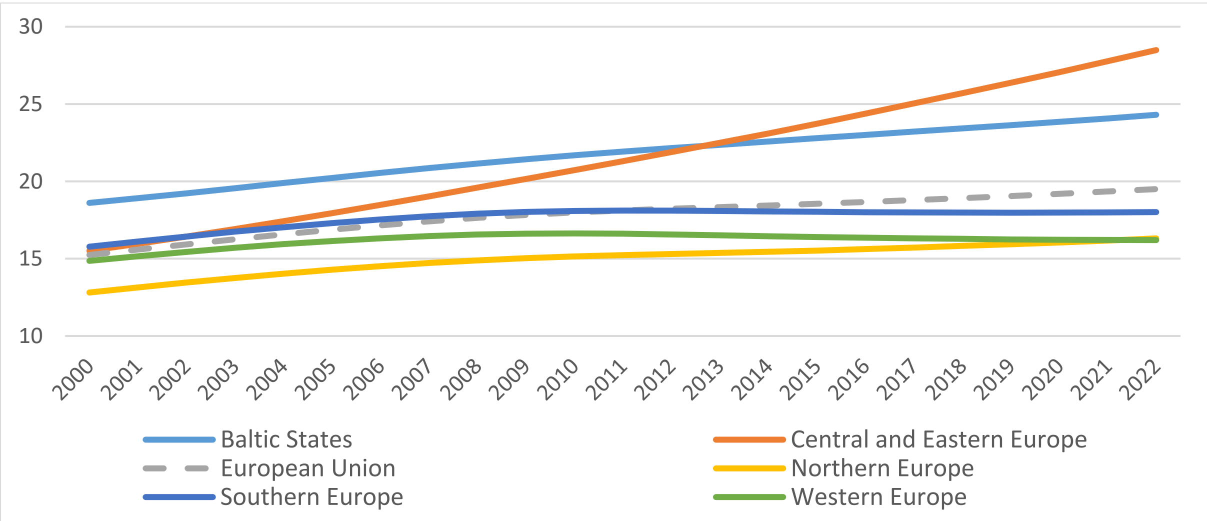
Among EU countries, there are important differences in obesity rates. According to the latest estimates released earlier this year by WHO in partnership with the NCD Risk Factor Collaboration, France has an obesity rate of less than 10%, while in other member states such as Hungary, Malta and Romania, every 1 in 3 people suffer from obesity (WHO, 2024; Phelps et al., 2024). In most EU countries obesity prevalence has steadily risen since the turn of the century, and EU's subregions have followed a similar pattern (Figure 1.6). In Southern Europe and Western Europe, obesity prevalence has stabilized since 2015 but remains much higher than at the beginning of the 2000s. In some sub-regions, obesity rates have continued to rise. WHO points out that the COVID-19 pandemic may have further contributed to the rise in obesity rate, with many children and teenagers engaging in less physical activity and consuming more foods high in fat, sugar and salt (WHO, 2022).

Figure 1.5: Prevalence of obesity, BMI ≥ 30 (% of adult population) in the EU-27, 2022



Source: WHO

Figure 1.6: Trends in Obesity prevalence in EU sub-regions, 2000 to 2022

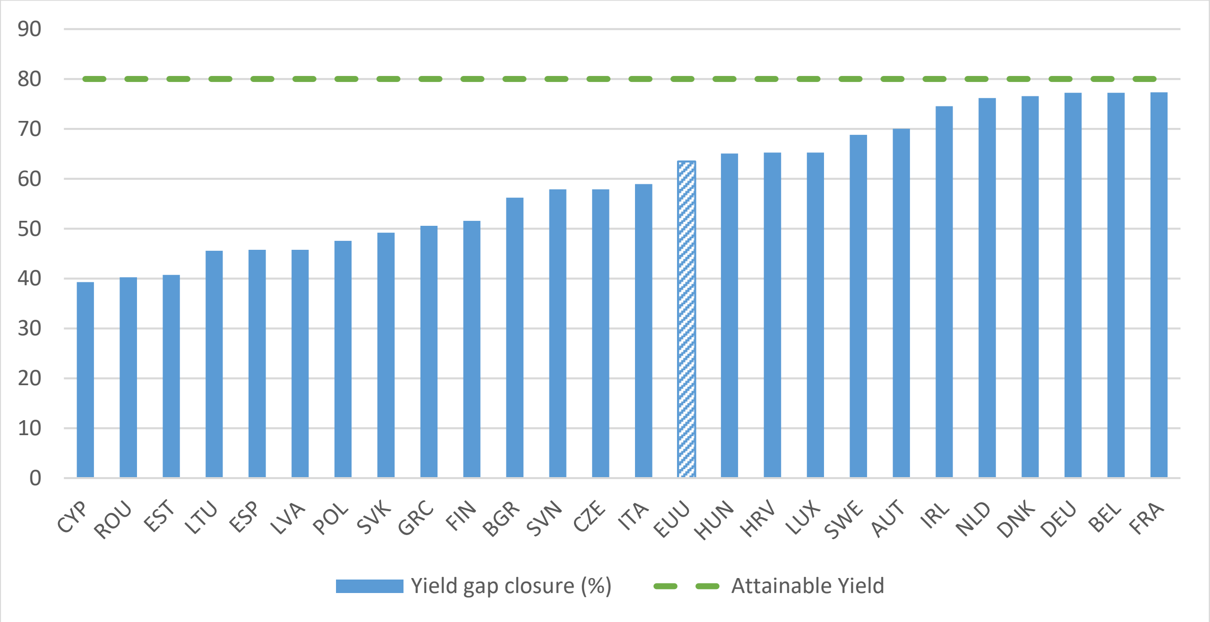


Source: WHO

Agricultural productivity: Yield Gap Closure

The yield gap closure (%) is a measure of agricultural efficiency, whereby actual crop yields are compared to the potential yield if crops are farmed under optimum growing conditions. Due to diminishing marginal returns on additional inputs and labour, farms can reasonably expect to obtain 80% of their yield potential, also called the "attainable yield," (Rattalino Edreira et al., 2021). Overall compared with the rest of the world yield gap closures are relatively high in Europe, although there are important differences across EU member states (Figure 1.7).

Figure 1.7: Yield gap closure (%) in the EU-27



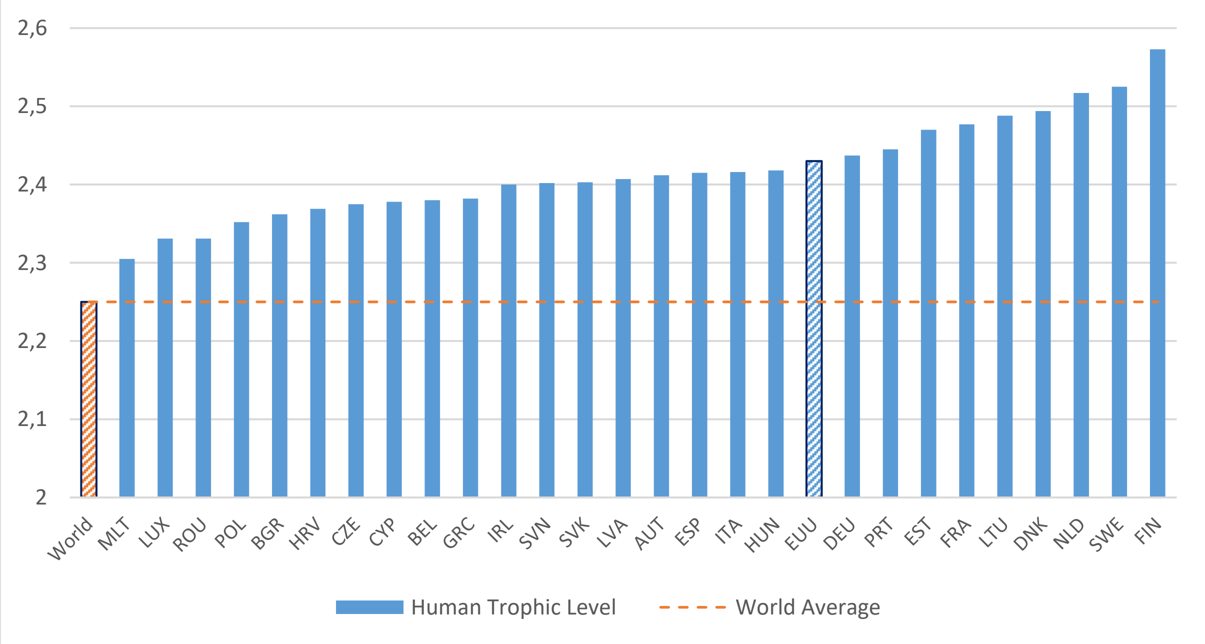
Source: Global Yield Gap Atlas

Sustainability of diets: Human Trophic Level

Demand-side solutions are also important for transforming food systems. When consumers choose to consume products that are intensive in energy, inputs, and land, the environmental impact is unsurprisingly greater than from foods low in such requirements. The Human trophic level (Figure 1.8) is a measure of the energy intensity of diet composition and reflects the relative amounts of plants as opposed to animals eaten in a given country.

In general, the global human trophic level "has increased with time, consistent with the global trend toward diets higher in meat," with a clear link between countries' incomes and dietary trends (Bonhommeau et al., 2013). Northern Europe's human trophic level has been historically high but has declined over the last decade due to policies to encourage less meat-consumption. Decoupling socio-economic prosperity from HTL will be a key demand-side measure for sustainable agriculture in the years to come.

Figure 1.8: Human Trophic Level (best 2-3 worst), 2021

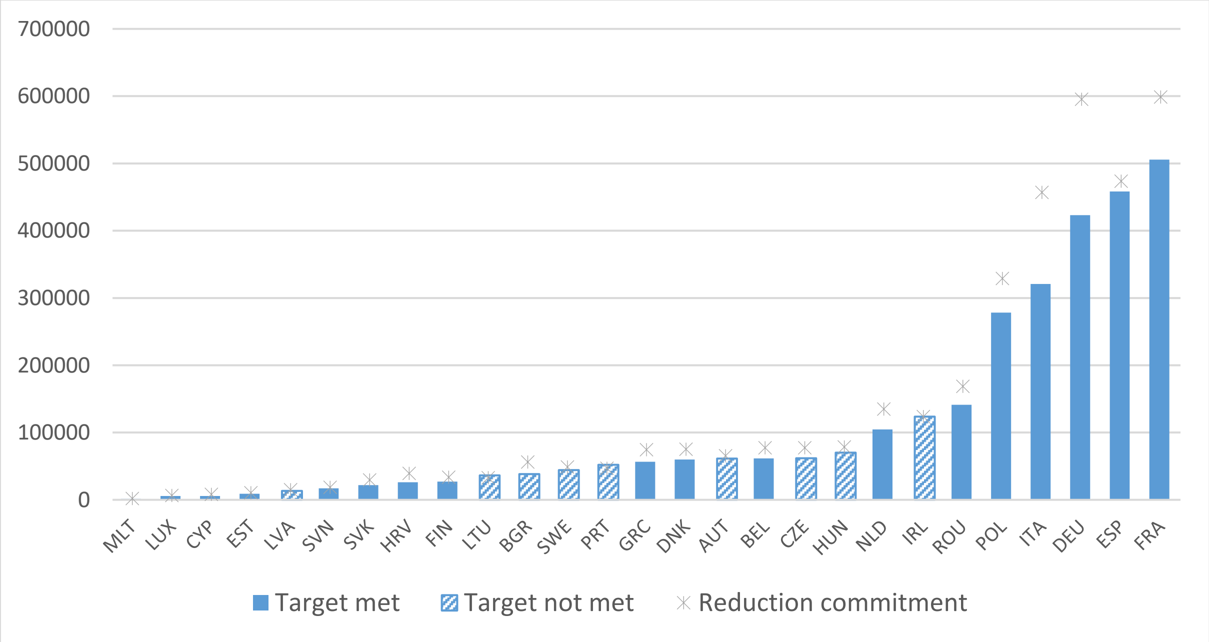


Source: Bonhommeau et al. (2013)

Sustainable agriculture: Ammonia emissions from agriculture

On the supply-side, excessive agricultural inputs harm the environment and human health. Ammonia volatilizes from decomposing organic matter, mainly livestock manure, and is subsequently released in the air (Eurostat, 2017). Ammonia pollutes air as a precursor to pm2.5 (Wyer et al., 2022), acidifies and corrodes soil, and constitutes a major water pollutant. Ammonia emissions come predominantly from the agricultural sector and are monitored under the National Emission Ceilings Directive (EEA, 2024). Under the directive, countries have national emissions reductions targets established with respect to their 2005 levels. Figure 1.9 presents ammonia emissions in an absolute perspective with respect to their targets.

Figure 1.9: Ammonia emissions from agriculture (tonnes) with respect to national emission reduction commitments, 2021



Source: Eurostat and the EEA. Note: Ammonia emissions in reference year 2022 assessed against reduction commitments, as published by EEA, 2024.

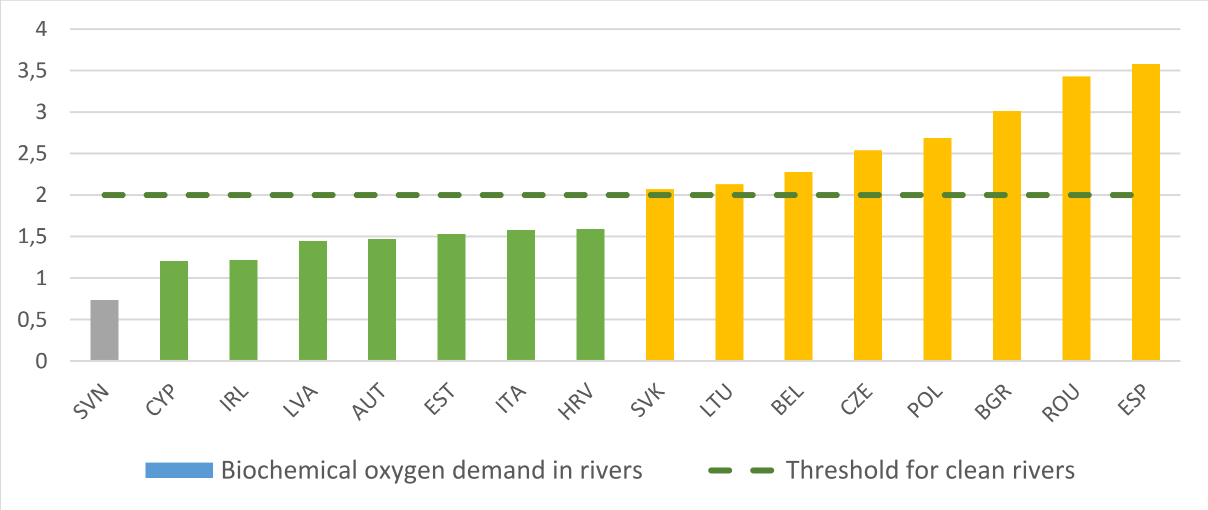
In general, the largest producers of ammonia in absolute terms have generally all fulfilled their ammonia reduction targets, with France and Germany well below the targets. In nine member states, ammonia emissions are still above the reduction commitments according to the most recently submitted 2022 data points (EEA, 2024). Ammonia emissions are shown in absolute terms, to allow for comparisons with national reduction commitments. However, the data standardized into a relative perspective (per hectare), indicate that despite their overall large degree of emissions, France’s and Spain’s farms emit far less ammonia (less than 20 kg per hectare) than member states such as Luxembourg, Belgium, Cyprus and the Netherlands, which all emit more than 40kg of ammonia per hectare of agricultural land.

Sustainable agriculture: Biochemical Oxygen Demand in Rivers

Similarly to ammonia, organic pollution from agricultural run-off (animal excrement, pesticides and other chemicals) and wastewater are harmful to aquatic ecosystems and make drinking water unsafe for humans. Organic pollution depletes oxygen availability (eutrophication), deteriorates the ecological status of water, and in extreme cases lead to extinction of local fish and aquatic invertebrates (EEA, 2023). The amount of organic pollution is measured by the quantity of oxygen needed by aerobic microorganisms to decompose organic substances (biochemical oxygen demand, BOD). Rivers are very clean when levels of biochemical oxygen demand are lower than 1, and they are considered at least somewhat polluted starting from levels of 2 (Eurostat, 2024).

Slovenia has the cleanest rivers in Europe (among countries with sufficient measuring stations to generate data). Seven other member states are at safe levels of BOD. In contrast, Romania and Spain’s rivers have almost twice the recommend levels, and six other member states have rivers that are, on average, too polluted to be considered safe.

Figure 1.10: Biochemical oxygen demand in rivers (mg O_2/litre)

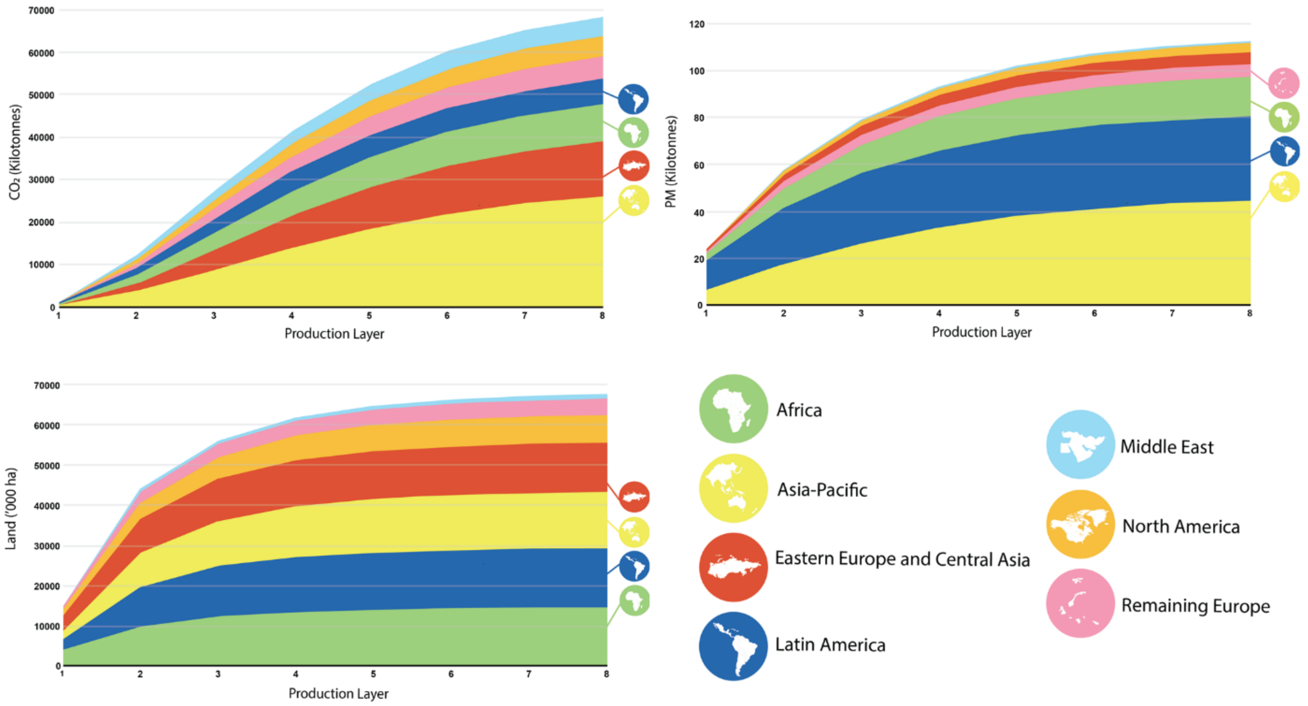


Source: Eurostat

1.3 Trade-related impacts / International Spillovers of Food Systems

Several dedicated studies have quantified the spillover impacts of EU countries and the EU as a whole (Malik et al. 2024; Fuller et al. 2024; Malik et al. 2023, Malik et al. 2021). Malik et al., 2023 analysed the spillovers generated by the EU's food sector specifically and found that EU's food imports was responsible for nearly half its total land-use footprint, whilst generating CO2 emissions (5% total) and pollution (9% of the total NOX footprint, 16% of the total PM footprint, 6% of the total SO 2 footprint) in the food-producing countries abroad. Figure 1.11 shows the magnitude of EU's food sector spillovers by indicator (CO2, particulate matter and land-use), among world regions abroad where the impacts happen. Asia-Pacific bears the brunt of most of the spillovers related to CO2 emissions and pollution, whereas land-use spillovers mostly occur in Africa and Latin America. The EU also continues to export toxic pesticides banned within the EU (Corporate Europe Observatory, 2022). The latest research suggests that *global* cooperation might be more effective for climate and people than unilateral measures in dealing with negative spillovers, including carbon leakage (Xinlu et al, 2024).

Figure 1.11: Location and magnitude of the spillover effects from the EU's Food supply chains (CO2 emissions, particulate matter, and land use).



Source : Malik et al (2023)

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2. Pathways for a sustainable agri-food system in the EU

The EU has established a strong level of self-sufficiency in its agricultural sector. This ensures EU agricultural sector's ability to meet domestic demand for cereals, sugar, as well as most animal products, including dairy and meat. At the same time, it has become a leading exporter for wheat and barley but also for many processed agricultural products. However, some major challenges remain.

The issue of food insecurity remains a significant concern, with the advent of the global pandemic caused by the SARS-CoV-2 virus and the subsequent conflict between Russia and Ukraine reversing the declining trend of food insecurity observed over the past decade. A total of 36.2 million people is unable to afford a nutritionally adequate meal every day. Households with incomes below the poverty line are twice as likely to experience difficulties in affording a proper meal compared to those with average incomes.

Despite the stabilization of annual food inflation below 5% and the commencement of a decline in retail food prices in early 2024, prices remain considerably higher than they were two years ago (Eurostat, 2023). The global food price crisis has been exacerbated by the war in Ukraine, leading to supply disruption of vital food items such as wheat and sunflower oil. The crisis is not only due to the conflict but to structural and systemic problems that create hunger and threaten people's livelihoods globally. Global physical grain trade is highly concentrated around four companies controlling 70-90% of global grain trade: Archer-Daniels-Midland, Bunge, Cargill and Louis Dreyfus. These companies not only exercise an oligopoly over global grain trade, but also over information about market fundamentals, and are also highly financialised. Food should not be treated as a financial asset as it is not a commodity like many others (EESC Opinion, 2022).

Furthermore, there are growing challenges regarding dietary habits with rising overweight and obesity rates in Europe. Because overweight and obesity are risk factors for several noncommunicable diseases (NCDs), cancers, cardiovascular disease, dementia and diabetes, they increase the overall health expenditure on these conditions (OECD, 2019). Additionally, obesity is associated with a reduction in life expectancy by up to four years. A reduction in labour force, combined with a shorter life span, have a detrimental effect on economic growth, potentially reducing GDP by up to 4.5 percentage points.

Over the past five years, the EU agricultural sector has benefited from increased labour productivity and public investments in research and development (European Commission, 2023a). However, in 2023, farmers have shown their discontent through large-scale protests in in several European countries. The occurrence of extreme weather events, elevated input costs, fluctuating commodity prices, potential labour shortages in the agricultural sector, a fair remuneration of farmers within the value chain, and an increasing dependency on imports collectively present considerable challenges (EESC News, 2024). These issues are further complicated by logistical and transport constraints many countries were facing (European Union, 2024).

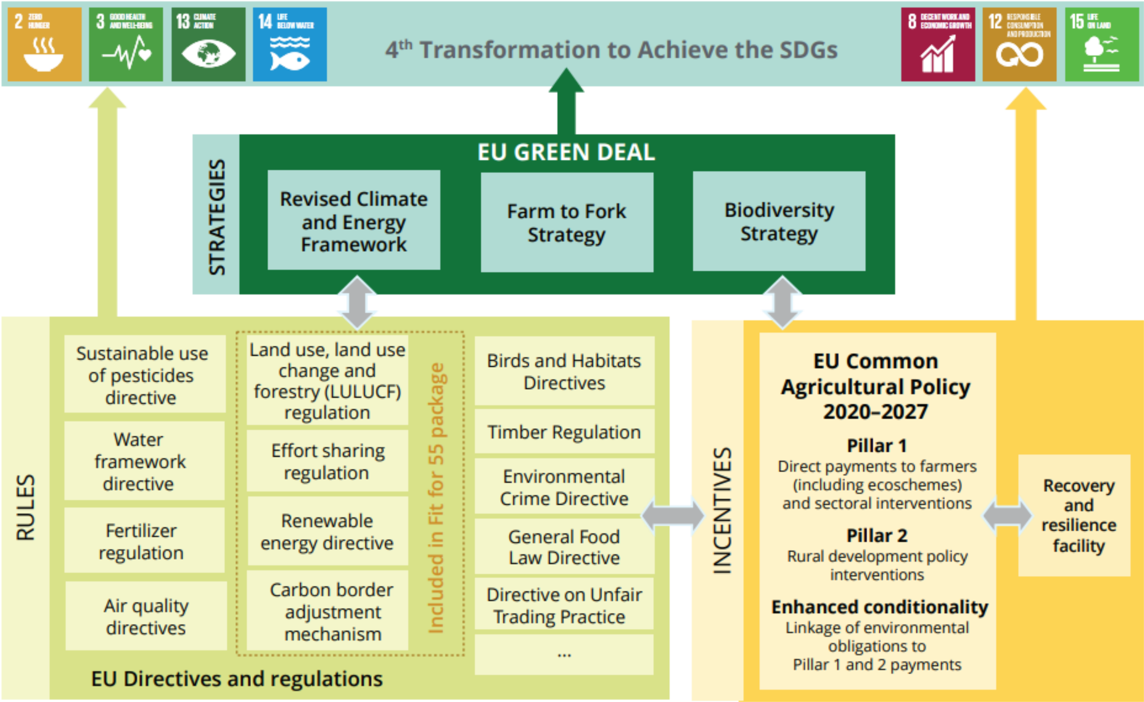
The profitability of EU farms has been adversely affected, particularly since 2023, when agricultural prices began to decline despite the high costs of inputs and operations. In fact, the agricultural price decrease has not been evenly transmitted across the supply chain. Delays in price adjustments, particularly at the processing and retail stages, have sparked tensions and have been a central issue in recent protests. Farmers call for more equitable distribution and better monitoring of price transmission mechanism (European Union, 2024). A swift implementation of the Directive on Unfair Trading Practices is necessary to ensure a fair distribution across the chain (EESC Opinion, 2021).

While the most sustainably managed (‘high nature value’) farmland can sequester carbon and support diverse habitats, the environmental impact of food production remains substantial. The agricultural sector accounts for approximately 45% of the EU’s total environmental impacts and the livestock sector accounts for over 80% of agricultural emissions (European Commission, 2020). Europe was one of the first regions where nitrogen became an environmental issue and despite progress to reduce nitrogen surpluses, Europe remains an excess nitrogen area overall. Over 2016-2019, 14.1% of groundwater still exceeded the nitrates concentration limit set for drinking water and eutrophication touched 81% of marine waters, 31% of coastal waters, 36% of rivers and 32% of lakes (Erisman et al., 2011). The pace of change is not enough to prevent damage to human health and preserve fragile ecosystems in line with the Green Deal’s objective of reducing nutrient losses by at least 50% by 2030 (European Commission, 2024a).

Several mechanisms have been put in place to drive the food and land systems towards greater sustainability in the EU (Figure 2.1). The Common Agricultural Policy (CAP), which has been set-up in 1962, is the only available mechanism that provides financial incentives to the agricultural sector. While the initial primary objectives of the CAP were to provide enough, stable, and affordable food for EU citizens and a fair standard of living for farmers, five major reforms have broadened the range of objectives to rural development, food safety, environment, and animal welfare and decoupled support from production. The EU has also set-up legally binding rules to limit negative externalities of agri-food production on both the environment, and human health.

With the EU Green Deal, which was approved in 2020, two important strategies related to food and land systems have been launched: first the ‘Farm to Fork’ Strategy represents the first comprehensive approach in the EU to include and take care of all relevant actors involved in the food production and consumption chain which is an important step to bring different binding national policies into place (EESC, 2021). Secondly, the ‘EU Biodiversity’ Strategy has the objective halting environmental degradation, facilitating a path to recovery and ensuring that Europe’s biodiversity loss is halted. The recently adopted EU nature restoration law shall thus contribute to the long-term recovery of damaged nature across the EU’s land and sea areas, to achieve EU climate and biodiversity objectives.

Figure 2.1: Overview of the EU food and land policy framework



Source : Section 3 in Lafortune et al., 2021

The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium brings together teams of local experts representing 24 countries to model alternative futures for food and land-use systems and identify potential trade-offs and synergies within the system. FABLE has developed a decentralized modelling framework (Mosnier et al., 2023) that allows local ownership for national and sub-national level modelling, while accounting for the interdependencies between countries and the need for collaboration to stay within planetary boundaries (Rockström et al., 2009). Recent global results have shown the difficulty to simultaneously achieve many SDGs related to food and land systems (FABLE, 2024). The continuation of current trends widens the gap with targets related to climate mitigation, biodiversity protection and water quality while pursuing commitments that have been already taken by countries would improve the situation but are still largely insufficient.

This section aims to delve into alternative futures of the food, agriculture, and land systems in the European Union (EU) by 2050 as modelled by the FABLE Consortium. Our results for the EU are the aggregation of the results for five countries which are represented separately in the Scenathon 2023, Denmark, Finland, Greece, Germany, and Sweden, and one region, the Rest of the EU which includes the other countries from the EU. We first present the main assumptions that shape these different futures (scenarios). Then, we show the key results related to the evolution of supply and demand for the agricultural products, land use, nitrogen use, GHG emissions from agriculture and land use change, biodiversity, and on-farm employment highlighting the main levers towards greater sustainability. Finally, we compare the results with other quantitative foresight studies available for the EU and recommendations for modelling food and land systems in the EU are suggested.

2.1 Methods

2.1.1 The Model

For the Scenathon 2023 all countries and regions used the FABLE Calculator (FABLE-C) (Mosnier et al., 2020). The FABLE-C is an Excel-based model designed to project the evolution of food and land-use systems from 2000 to 2050. It focuses on agriculture as the main driver of land use and land-use change, operating under the assumption that demand and supply quantities for each commodity balance out. The model incorporates data on 88 raw and processed agricultural products from both crop and livestock sectors and relies heavily on the FAOSTAT database for its primary inputs but can be enriched with national statistics. For every five years, the FABLE-C provides estimates on a range of indicators (model outputs) related to food security, agricultural markets (in quantities), land and land use change, and environmental impacts such as GHG emissions and biodiversity. Depending on a certain number of assumptions related to the evolution of the demand, productivity, trade, or environmental constraints, the evolution of agricultural production, exports and import, and consequences on land use, land use change, water, nitrogen and phosphorous use, and related climate and biodiversity impacts are computed.

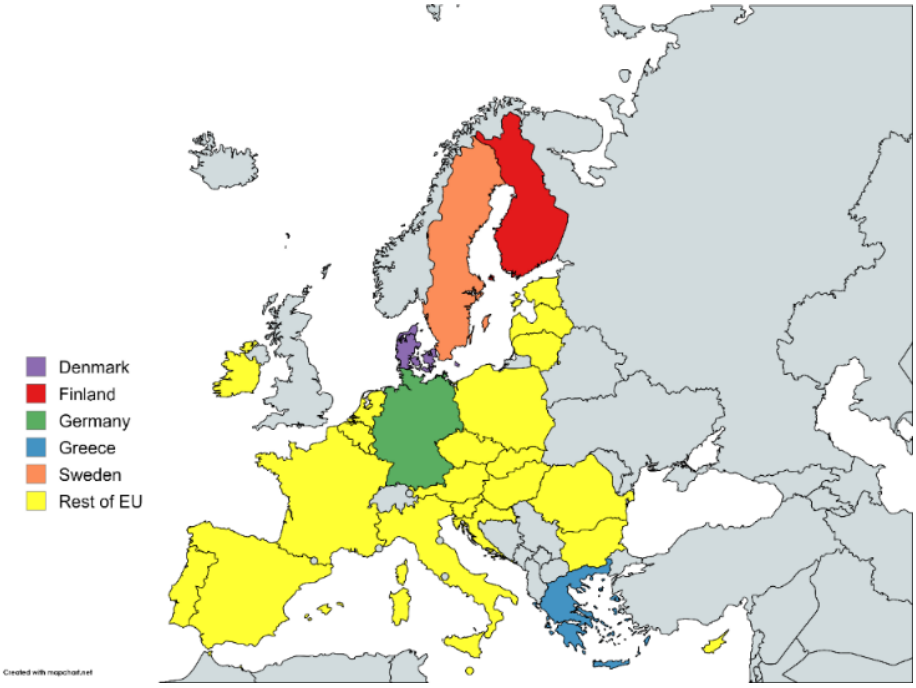
2.1.2 The Scenathon

The results presented in this outline draw from the FABLE Scenathon 2023 (FABLE, 2024). A 'Scenathon' (marathon of scenarios) is a collaborative modelling effort where local research teams design national pathways that could be compatible with national and global sustainability targets. The Scenathon 2023 involved 22 countries across all continents including five from the EU (Denmark, Finland, Germany, Greece, and Sweden). These five EU countries were represented individually because they all have a FABLE local research team. For all countries without a FABLE team, the FABLE Secretariat modelled them through six regions, including one for the 'Rest of the EU' (Figure 2.2). Three pathways were compared:

- **Current Trends (CT)** which represents a low-ambition trajectory primarily shaped by existing policies, offering a glimpse into a future heavily reliant on current practices and policies,
- **National Commitments (NC)** which attempts to predict how food and land systems will evolve if national strategies, pledges, and targets concerning climate, biodiversity, and food systems are met, and
- **Global Sustainability (GS)** which identifies how additional actions could potentially help to align national and regional pathways with global sustainability targets.

For each pathway, several iterations were made to ensure the equilibrium between all countries and regions' exports and imports i.e., national pathways reflect the evolution of global demand in the alternative pathways. **Export volumes from each exporting country and region are proportionally adjusted to match global imports for each product and time step.**

Figure 2.2: Coverage of the EU in the FABLE Scenathon 2023

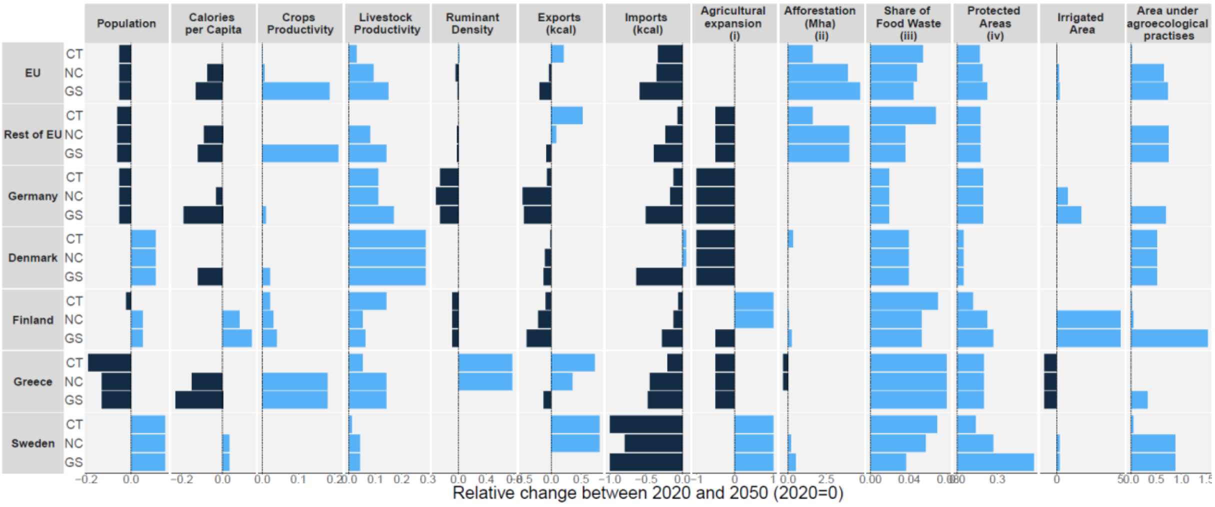


Source: Authors

2.1.3 Scenarios

For each pathway, FABLE teams made assumptions on the evolution of parameters in their national FABLE-Cs. For the non-participating EU 27 countries grouped under the Rest of the EU region ("R_OEU"), the FABLE Secretariat made assumptions (Figure 2.3). Throughout the process, FABLE teams engage national stakeholders to review their assumptions and initial findings, seek technical advice, and identify knowledge gaps. For the development of these pathways, FABLE teams from Denmark, Finland and Greece consulted with local stakeholders to test the feasibility of their assumptions and results at the national level. In addition, the FABLE Secretariat invited third parties to share their feedback on the assumptions via the FABLE Consortium website. However, limited time and resources constrained the reach of this engagement. **This study is an opportunity to gather additional feedback and insights for future improvements in the scenarios and assumptions used for the EU.**

Figure 2.3: Overview of assumptions made in each pathway in each national or regional FABLE-C within the EU and the aggregated result for the EU



Note: Relative changes can come both from the country team's scenario assumptions and from the combined effect of multiple scenarios assumptions in the FABLE-C. (i) 'Agricultural Expansion' is expressed in code, taking the value 1 for 'Free expansion scenario', -0.5 for 'No deforestation' and – 1 for 'No Agricultural expansion'. (ii) 'Afforestation (Mha)': results are expressed in net increase rather than relative change. (iii) 'Food Waste': results are expressed % of consumption which is wasted in 2050. (iv) 'Protected Areas': results are expressed in % of total land in 2050. In this figure, crop productivity only reflects the assumption related to the closure of yield gap obtained through higher fertilizer use i.e., the impact of irrigation area changes and agroecological practices change on productivity is computed separately. More information in the Annex.

Population: After comparison with other national sources (Danmarks Statistik, 2024; Naftemporiki, 2023; Rapo, 2021), the UN-DESA World Population Prospects UN medium projection has been used in all countries and rest of EU FABLE-C except for Greece where the UN No Change scenario has been used. Between 2020 and 2050, the EU population is projected to decline by 5% across all three pathways due to long life expectancy, low death rates, and low birth rates, resulting in a shrinking and ageing society which is more than Eurostat's projections where population reduction is less than 1% (Eurostat, 2024) (The higher the population, the higher is the estimated domestic demand in the future. Table 2.1). The higher the population, the higher is the estimated domestic demand in the future.

Table 2.1: Comparison of assumptions used for population in the national and regional FABLE-C within the EU and the EUROSTAT projections (in million inhabitants)

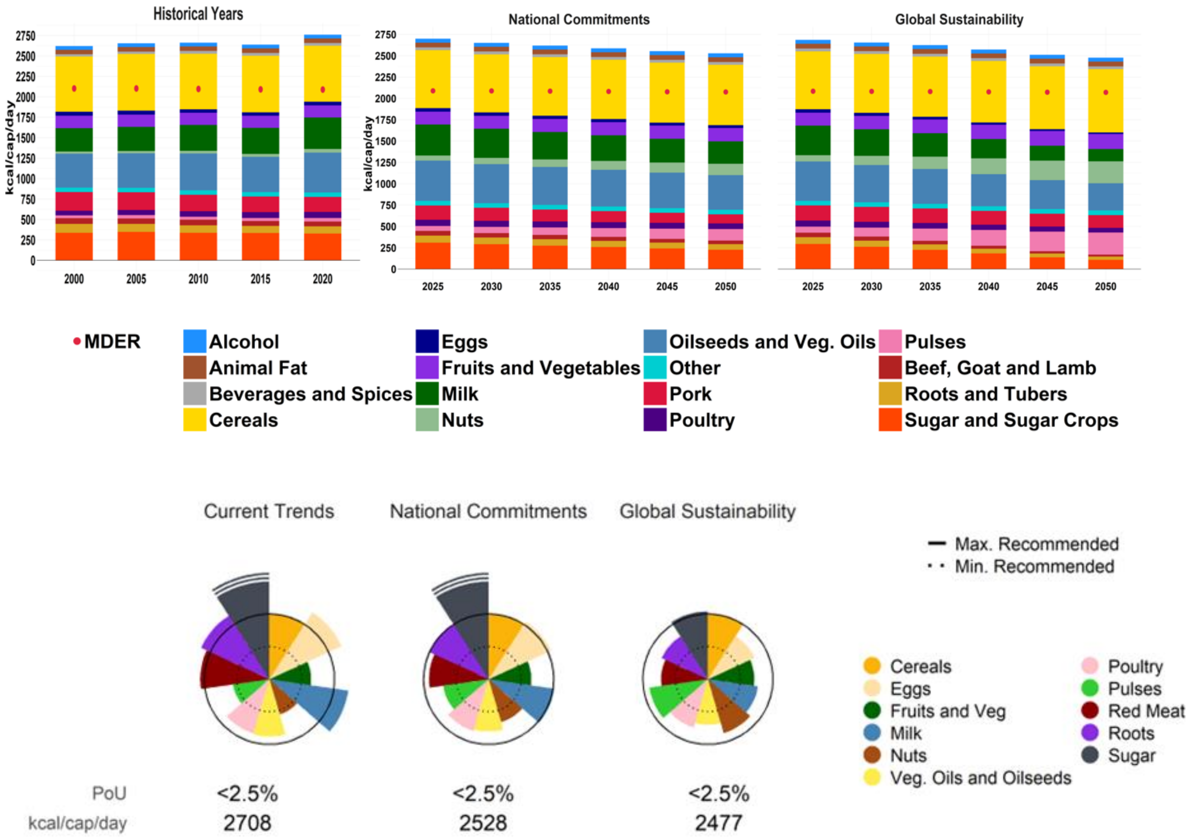
Location	Historical		Projections for 2050	
	FABLE-C	EUROSTAT	FABLE-C	EUROSTAT
EU	**445.3**	**451.4**	**422.4 (CT),423.4 (NC and GS)**	**447.9**
Denmark	*5.8*	*5.9*	*6.4*	*6.2*
Germany	*83.3*	*84.5*	*78.9*	*84.8*
Greece	*10.5*	*10.4*	*8.5 (CT), 9.1 (NC and GS)*	*9*
Finland	*5.5*	*5.6*	*5.4 (CT), 5.8 (NC and GS)*	*5.5*

Sweden	*10.4*	*10.6*	*11.9*	*12.1*
Rest of EU	*329.7*	*334.4*	*311.2*	*330.3*

Source: Douzal et al. 2024 and EUROSTAT 2024

Diets **-** In the CT pathway, the average diet in the EU is expected to remain unchanged at 2,760 kcal per capita per day, which is 32% above the average Minimum Dietary Energy Requirement (MDER),[5] and shows an overconsumption of sugar, animal-based products (except poultry meat), and tubers compared EAT-*Lancet* maximum recommended levels (EAT-Lancet Commission, 2019) (Figure 2.4). In contrast, daily calorie intake in the NC and GS pathways is projected to decrease by up to 20% in NC, aligning with the recommended boundaries of the EAT-*Lancet* planetary health diet (EAT-Lancet Commission, 2019). This dietary shift would result in a substantial reduction in the calorie intake from animal-based products, oilseeds, vegetable oils, and sugar, while increasing consumption of plant-based foods—particularly pulses and nuts, and to a lesser extent, fruits, vegetables and cereals. Denmark, Finland, and Sweden assume dietary shifts in line with the Nordic Nutrition Recommendations 2023 (Ministry of Food, Agriculture and Fisheries of Denmark, 2023; Nordic Council of Ministers, 2023).

Figure 2.4: Assumptions about the composition of diets in the EU between 2020 and 2050 (top) and comparison of the level of consumption by food group with the recommended ranges by the EAT-Lancet commission (bottom)

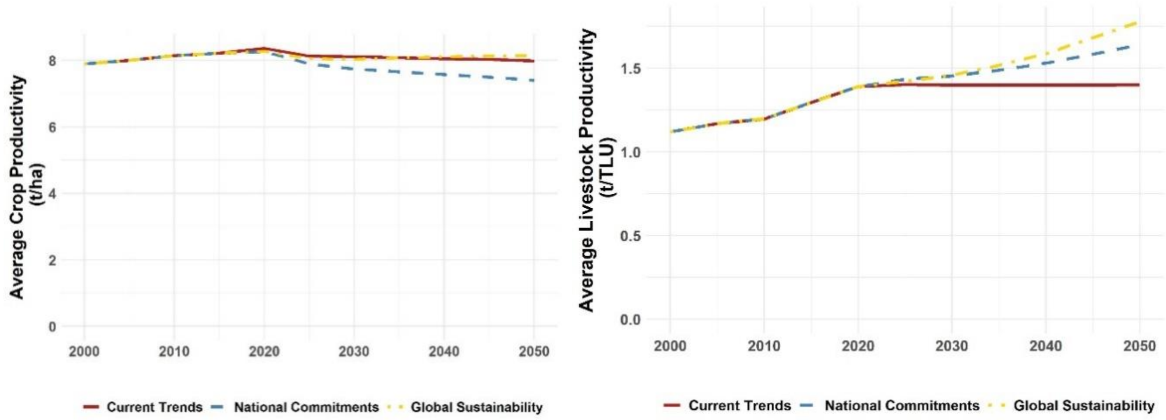


Productivity **-** The overall effect of different assumptions on the evolution of crop productivity in the EU is shown in Figure 2.5. This results from the combination of crop yield growth due to further yield

[5] It is computed as the weighted average of the kilocalorie requirement by age group and sex and the population in these categories i.e., this average reflects the demographic structure within the EU.

gap closure in the GS pathway (while this is stable in CT and NC) and some expansion of irrigated area, and lower crop yields due to a higher adoption of agroecological practices e.g., organic farming, in NC and GS[6]. At the EU level, livestock productivity is projected to increase between 2020 and 2050 across all three pathways, with the highest growth forecasted in (+30% by 2050 compared to 2020) (Figure 2.5), and average number of ruminants per hectare of grassland is assumed to remain relatively stable in the EU (Figure 2.3).

Figure 2.5: Evolution of average crop productivity (left) and average livestock productivity evolution (right)



Note*: The average livestock productivity at the EU level is computed as the weighted productivity by herd type and country by herd size in livestock units. The average crop productivity depends on the assumption on the yield gap closure due to higher fertilizer use and technological development, the expansion of irrigated area, and the adoption of agroecological practices. Sine the average productivity is computed as a weighted average, it also depends on the evolution of the demand between 2020 and 2050 that affects the composition of animal type in the total livestock herd or the crop type in the total cropland area.*

Afforestation **-** By 2030, afforestation is expected to reach 1.9 million hectares under the CT pathway, 3.5 million hectares under NC, and 3.9 million hectares under GS. This goes beyond the EU Green Deal target of planting 3 billion trees by 2030—equivalent to about 1 million hectares of afforestation if there are about 3,000 trees planted per hectare (European Commission, 2021; Teagasc - Agriculture and Food Development Authority, n.d.).

Agroecological practices **-** The agroecological practices represented in the FABLE-C are cover crops, cultivar mixtures, diversified farming practices, embedded natural habitats, organic farming, and reduced tillage. They impact crop productivity and the substitution of synthetic fertilizers with manure in organic farming.[7] The area under agroecological practices is expected to remain stable at 31% of the cropland area in the CT pathway but is assumed to increase to cover half of the EU's cropland area by 2030 in NC and GS. By 2030, the EU aims to have at least 25% of agricultural land under organic

[6] The impacts of future climate change on crop productivity are not included in this study because they tend to be overoptimistic, partly because they consider the positive effect of CO_2 fertilization and exclude the impacts of extreme climate events which are expected to be more frequent also within the EU (European Environment Agency, 2024). For instance, the latest results from the ISIMIP project show that an impact of climate change in the EU on crop yields within the range of -19% and +32% in 2050 compared to 2020 with generally positive impacts for wheat and rapeseed and negative impacts for corn. The values refer to RCP 7.0 derived from the climate model IPSL-CM6A-LR. Data comes GGCMI runs (Jägermeyr et al., 2021), aggregated to ISO using SPAM (IFPRI, 2019; Yu et al., 2020).

[7] The representation of the impacts of these agroecological practices on biodiversity, CO2 sequestration, and other input use such as pesticide, labour and water in the FABLE-C is under progress.

farming (European Commission, 2024b). However, our assumptions under both NC and GS fall slightly below this target with 20% of the harvested area expected to be under organic farming by 2030.

2.2 EU Results

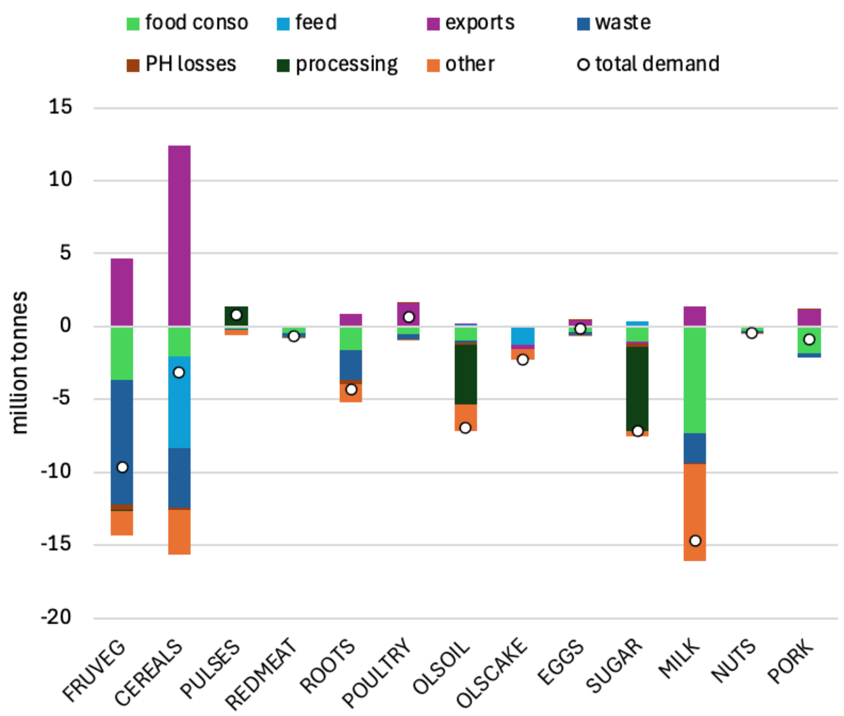
The results at the EU level are computed as the aggregation of the results obtained for Denmark, Finland, Germany, Greece, Sweden, and the Rest of the EU region. The following results include the 27 countries of the European Union.

2.2.1 Demand and supply

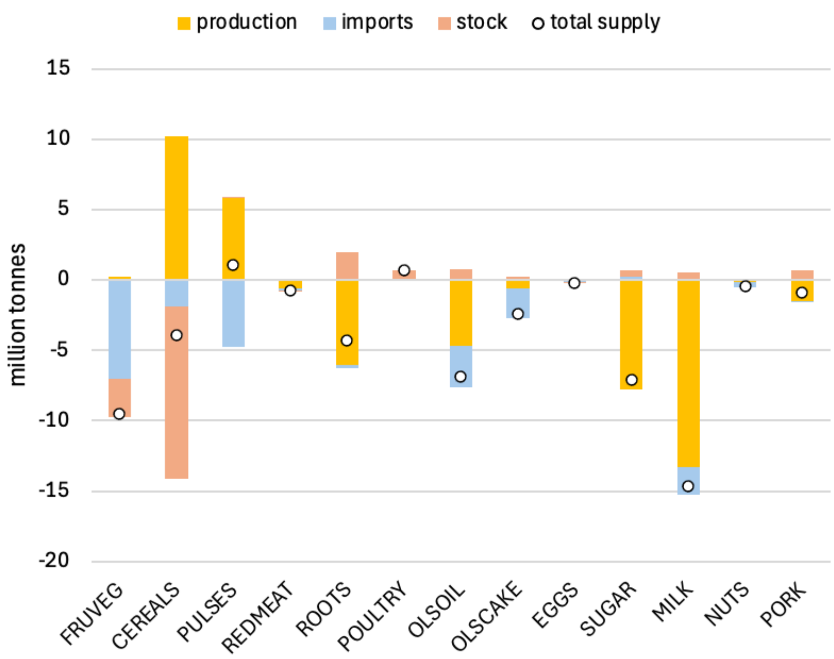
The FABLE-C assumes market equilibrium i.e., that the sum of all supply sources is equal to the sum of all demand sources in each time step. Figure 2.6 shows what are the main drivers behind the evolution of production by commodity group in the EU between 2020 and 2050 in CT. Our aggregated results show that the total demand decreases for all commodity groups except pulses even though, exports increase for most commodity groups. Production does not adjust proportionally to these changes because it also depends on the evolution of imports and of stocks. For instance, the higher production of cereals in 2050 compared to 2020, despite a reduction of the total demand over this period is mainly caused by a change in stock, and despite a reduction in the net demand for fruits and vegetables, production slightly increases because imports are cut.

Figure 2.6: Absolute change between 2020 and 2050 in the different components of the uses (top) and the internal supply (bottom) for EU agricultural products in the Current Trends pathway

a) Demand elements



b) Supply elements



***Notes**: fruveg=fruits and vegetables, redmeat = beef and mutton and goat meat, pulses include soybean, olsoil = oilseeds and vegetable oils, olscake = oilseed cakes. a) food conso= food consumption, PH losses= post- harvest losses, waste= food waste at retail and household level, exports = exports outside the EU, other = demand for seed, for feed if it is not explicitly represented in the FABLE-C, and for processing in case the processed products are not explicitly represented in the FABLE-C such as the dairy products. Another demand is for biofuel feedstock but no significant change in biofuel demand is assumed between 2020 and 2050 at the EU level, so it does not appear on the figure.*

2.2.2 Land use

In 2020, according to FAOSTAT, forest occupied 40% of the land in the EU, followed by cropland (28%), other land (18%), and pasture (13%). During the past two decades, agricultural land has reduced by 10% (FAOSTAT). In the future, total agricultural land reduces by 1% in CT, 14% in NC and 27% in GS between 2020 and 2050. The reason for the decrease in CT is that the total domestic food consumption will reduce between 2020 and 2050 due to a slightly lower population (-5%) and unchanged consumption level per capita for food and other use (cf. Scenarios section). In the other pathways, the reduction of agricultural land is mostly driven by pasture due to the assumed reduction of animal product consumption (even more pronounced in GS) and to a smaller extent to the increase in livestock productivity and the reduction of food waste.

For cropland, the higher internal consumption of plant-based products and the expansion of some agroecological practices with lower productivity in NC and GS could have led to a higher cropland area but our results show a reduction both compared to 2020 (-5% and -12% respectively) and compared to CT (Figure 2.8). Higher gains in crop productivity assumed in NC and GS, a reduction of other non-food uses within the EU, a reduction in exports and an increase in imports depending on the products more than offset the higher food demand for crops in NC and GS (Figure 2.7):

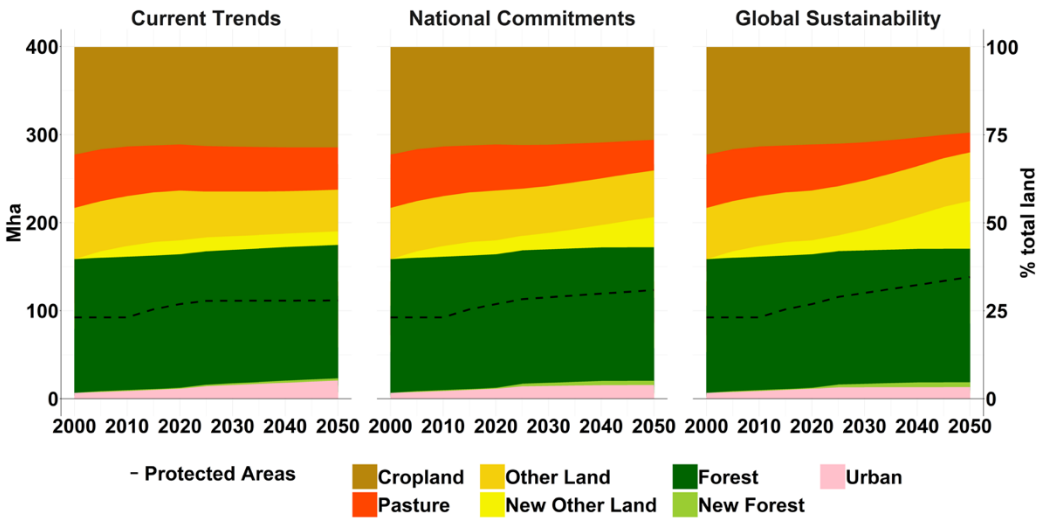
- **Even though cereals currently represent only one fourth of the internal human caloric intake, they represent two thirds of the harvested area in the EU** (FAOSTAT). More than half of the cereal production is used for animal feed and 13% is exported (FAOSTAT). Our results show a reduction of the internal demand for cereals for feed (up to -44 Mt in 2050 compared to CT) and to a lower extent for exports to the rest of the world (up to -14 Mt) due to the contraction of the demand for animal products in NC and GS leading to a saving of up to 15 Mha cropland (in GS) which is reallocated to other crops or abandoned.
- **Oilseeds currently represent 20% of the total harvested area in the EU** (FAOSTAT). The assumed reduction in oil consumption and the reduction of the demand for animal feed leads to a reduction in production (-4Mt) and in imports (-6 Mt)[8].
- **The higher consumption of fruits and vegetables in NC and GS compared to CT (up to +14 Mt in 2050) does not translate in a significant increase in cultivated area of fruits and vegetables** because it is satisfied by lower food loss and waste assumed in NC and GS compared to CT (+10 Mt) and an increase of imports (+4 Mt).
- **The food demand for pulses is also assumed to increase significantly in NC and GS compared to CT but the harvested area surprisingly reduces within the EU** (up to -0.8 Mha in 2050): production slightly increases as well as productivity gains, higher imports satisfy half of the additional demand, and there is a reallocation from soybean processing for animal feed to food.
- **The most spectacular increase in harvested area resulting from NC and GS assumptions is computed for nuts**: while nuts represent only 2% of current total harvested area in 2020 in the EU, the share increases up to 6% in NC and 7% in GS due to alignment of the EU diet on the EAT-Lancet recommendation and even though in our results, between 70% (NC) and 80% (CT and GS) of the nuts consumption is satisfied by imports.

Our results do not reveal problematic trade-offs between the targets for afforestation and expansion of protected areas up to 35% of the total land area in NC and GS, and the agricultural production in the EU on the other side. It should be noted that imports are mainly based on historical shares of the EU consumption by product which was imported in 2020. Our results show that depending on the competitiveness of EU compared to the rest of the world and the productivity gains potential without comprising the other EU sustainability objectives (e.g. GHG, water quality, biodiversity), higher EU domestic production of, for example, fruits and vegetables and pulses, in NC and GS could be tested in the future.

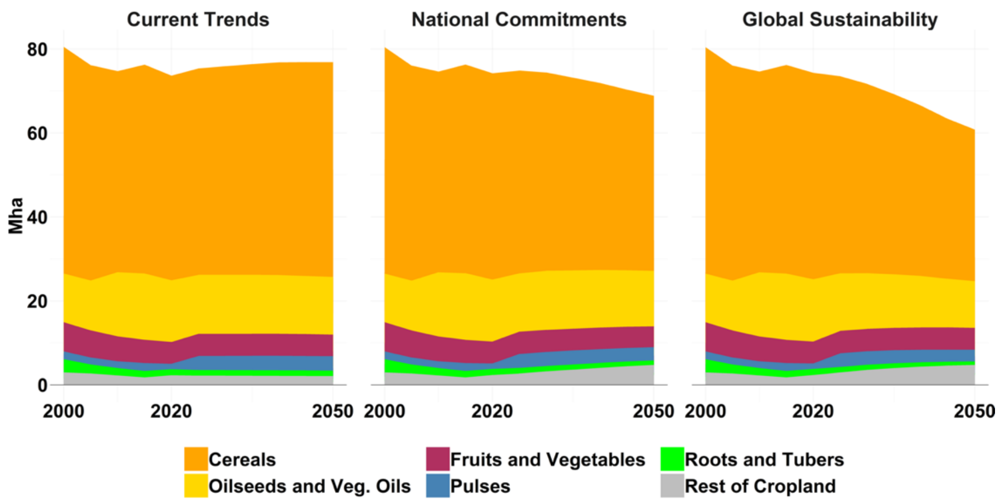
[8] Considering the importance of non-food demand for oilseeds / vegetable oils (46% in 2020) and the fact that price effects are not included in this analysis an increase of non-food use could offset the drop in food and feed demand.

Figure 2.7: Evolution of the land cover types (top) and the harvested area by crop group (bottom) in the EU between 2000 and 2050 across the three pathways

a) Land cover types

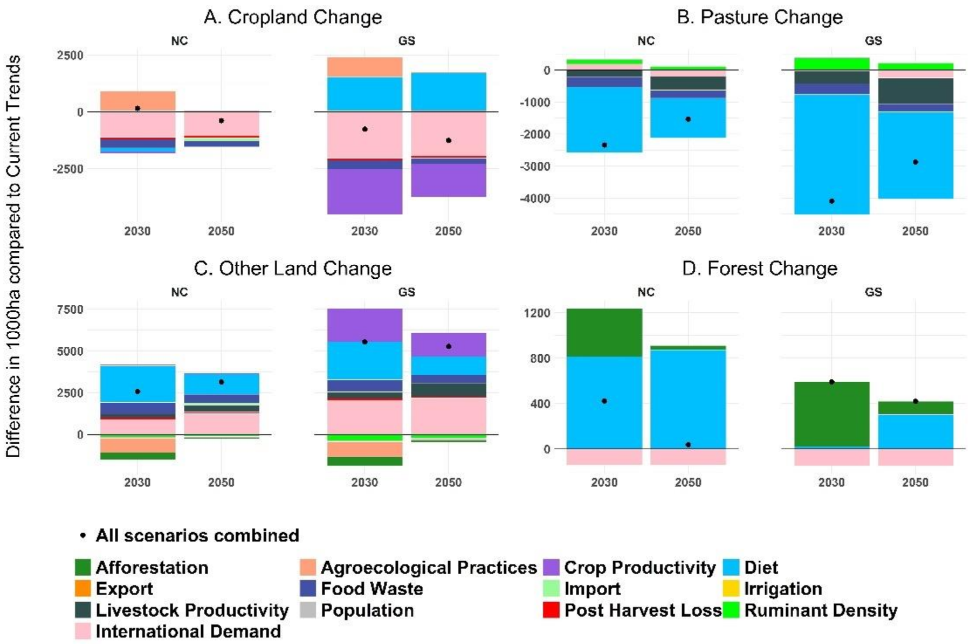


b) Harvested area by crop group



Note: Other land is all land which is neither used for agriculture nor for settlements, new other land is the abandoned agricultural land which is assumed to revert to other land.

Figure 2.8: Impact of each scenario on the evolution of each land cover type in EU



Note: the year 2030 refers to the period 2025-2030, while the year 2050 refers to the period 2045-2050

2.2.3 Nitrogen in agriculture

Total N excretion from animals is almost equal to the use of mineral fertilizer in Europe and about half of the manure excreted is applied to cropland (Oenema et al., 2007, FAOSTAT). The regions of most intensive livestock production in Europe include Denmark, the Netherlands, Belgium, Brittany (France), Spain, Poland, the UK and the Po Valley (Italy) (Erisman et al., 2011).

Our results show only a slight decrease in nitrogen application on agricultural land between 2020 and 2050 in CT (-2%): the reduction of manure left on pasture (-900 kt) is partly offset by a higher application of manure on cropland (+193 kt) and an increase in synthetic fertilizers application (+304 kt). The reduction of manure excretion is driven by the reduction of livestock herds between 2020 and 2050, which is more pronounced for ruminants and pigs (-8-9%) due to the stronger relative demand reduction. On the other hand, the higher share of wheat and soybeans in total harvested area, explains the increase in synthetic fertilizer as application is higher compared to the other crops.

Under NC and GS, synthetic nitrogen application is projected to decrease by 12% and 11% respectively by 2030 compared to 2020, both falling short of the EU's target of a 20% reduction by 2030 (European Commission, 2024a). According to our results, the EU target will just be met by 2050 in NC (-21%) and GS (-20%) compared to an increase of 4% in CT. The reduction of synthetic fertilizer application is achieved through a reduction of both internal and external demand for animal-based products, cereals and sugar which have higher fertilization rates than the other crops on average in the EU, and the adoption of organic practices (Figure 2.9) where we assume that synthetic N is fully replaced by organic N. At the EU level, in the GS pathway, because the increase of organic farming takes place at the same time the demand for animal-based products reduces, this leads to the entire use of organic manure for application on cropland at the EU level (Figure 2.10) and some nitrogen shortages in some countries in 2050 (Greece, Denmark, Germany, and the region Rest of the EU).

These results are probably quite unrealistic due to the current difficulties of transportation of manure across long distances and across borders within the EU. Moreover, the Nitrate Directive limits the application of manure to 170 kg N per hectare per year. The availability and use of other organic fertilizers such as composts, biochar, or residues will need to be assessed in future work. Finally, while we have assumed a 1:1 substitution of mineral and N in manure, mineral and organic fertilizers differ markedly regarding their transformation in soils and utilization of the applied nutrients by plants e.g., the direct utilization of N from organic fertilizers in the year of application is relatively small.

Figure 2.9: Evolution and source of nitrogen inputs from agriculture in the EU until 2050 in the three pathways

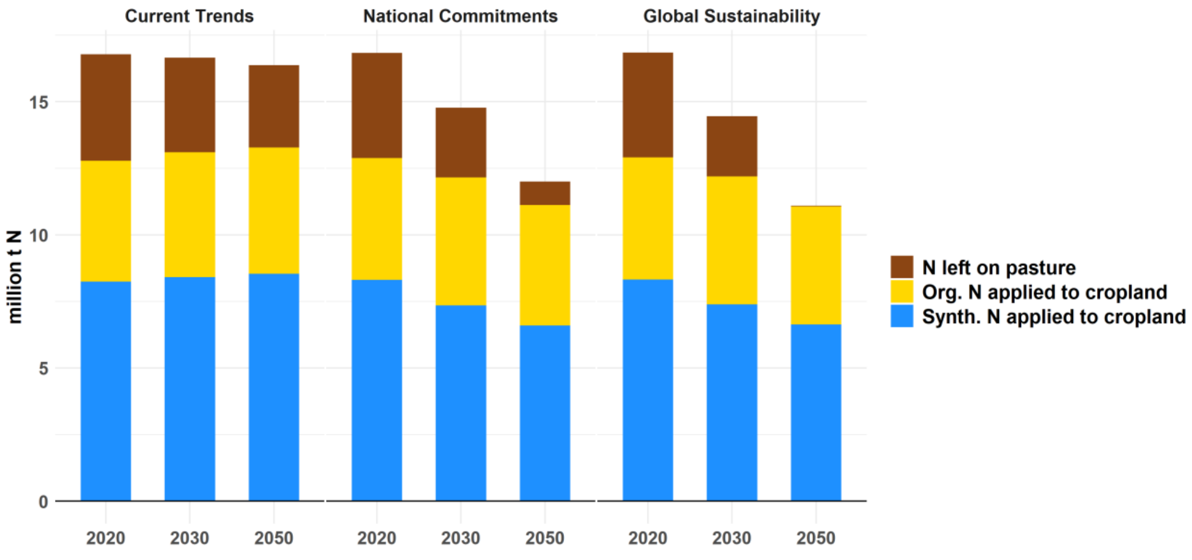
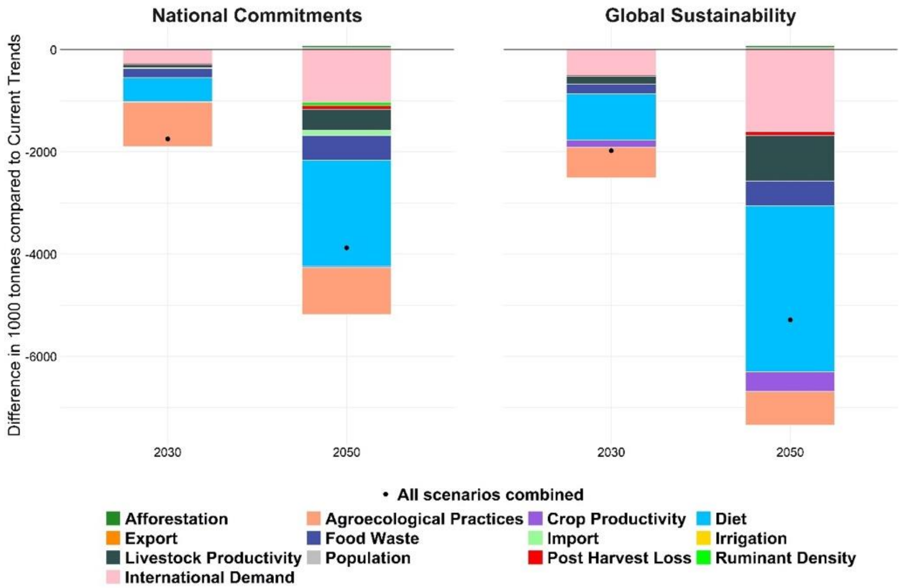


Figure 2.10: Impact of each scenario on the evolution of nitrogen use in the EU



2.2.4 GHG emissions from agriculture and land use change

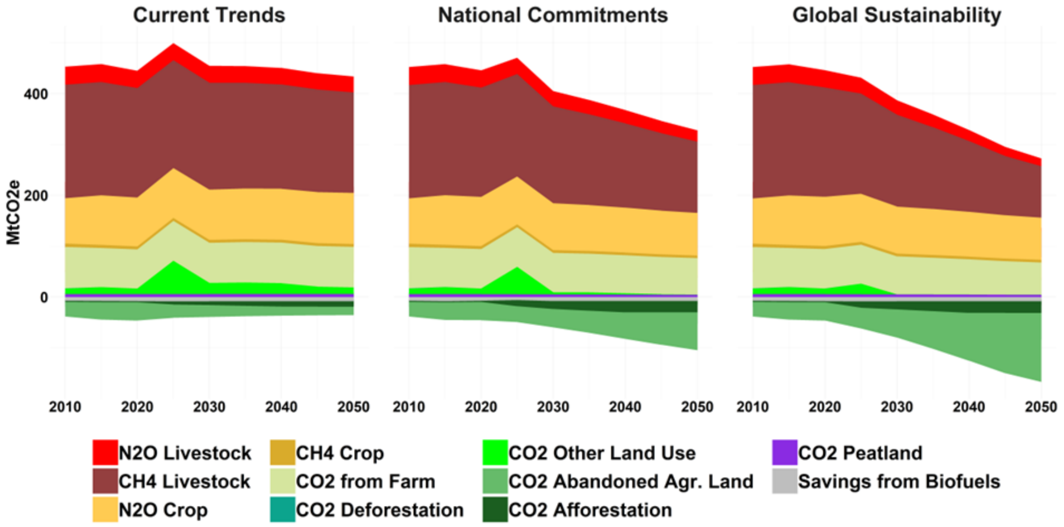
Our results show quite stable GHG emissions from agriculture under CT with a 3% reduction between 2020 and 2050. This is coherent with the projections from the EEA of only a slight reduction of total GHG emissions from agriculture by 5% between 2020 and 2050 with existing measures. The NC pathway is more optimistic than the EEA projections with new measures: our results show a reduction of 25% of agricultural GHG emissions between 2020 and 2050 while EEA projects a 10% reduction only. Additional measures which are accounted for in the two studies are likely different. As we can see on Figure 2.12, the main drivers for the GHG emissions reduction from agriculture (methane and nitrous oxide) is the assumed dietary change within the EU and the reduction in EU exports which are not represented in the projections from member states. Increases in productivity and the reduction of food waste are other levers that contribute to the reduction of agricultural GHG emissions in our results. The CH_4 emissions are those which decrease the most. The GS pathway reinforces the NC results leading to a 38% reduction by 2050 compared to 2020. The EU Commission has set a GHG emissions target of 350 $MtCO_2e$ by 2040 for the agricultural sector (European Environment Agency, 2023) which is equivalent to an absolute reduction of 30 $MtCO_2e$ between 2020 and 2040. This is achieved by 2035 in NC and by 2030 in GS.

It is estimated that the land use, land use change and forestry (LULUCF) sector removed net 230 $MtCO_2e$ from the atmosphere in 2021 (EEA, 2023) while the LULUCF regulation sets a net removal target of 310 $MtCO_2e$ by 2030 at the EU level but EEA projections do not achieve this level, even with additional measures (-240 $MtCO_2e$) in a context where the carbon sink from LULUC has continuously decreased since 2010 due to reduced sequestration in harvested wood products and in managed forest. Our results only capture a small fraction of these dynamics since these two categories are not included in the FABLE-C. While net GHG from land use change are quite stable in CT, the abandonment of agricultural land and to a lower extent, increased afforestation efforts, are expected to increase CO_2 sequestration in NC and GS. Net GHG sequestration from LUC reaches 96 and 158 $MtCO_2$ by 2050 in NC and GS respectively (Figure 2.11).

It should be noted that the spike in our results in 2025 emissions (Figure 2.11) is artificial due to the absence of information on the evolution of agricultural stocks after 2020 (last calibration year), stocks in 2025 fall abruptly to zero in the FABLE-C. This creates an increase in production (to compensate for the absence of supply from stocks) which leads to the conversion of non-forest natural land to agriculture and associated CO2 emissions. The uncertainty related to our LUC GHG results is also large e.g., due to the lack of information on the potential regrowth of natural vegetation after agricultural abandonment without assistance.

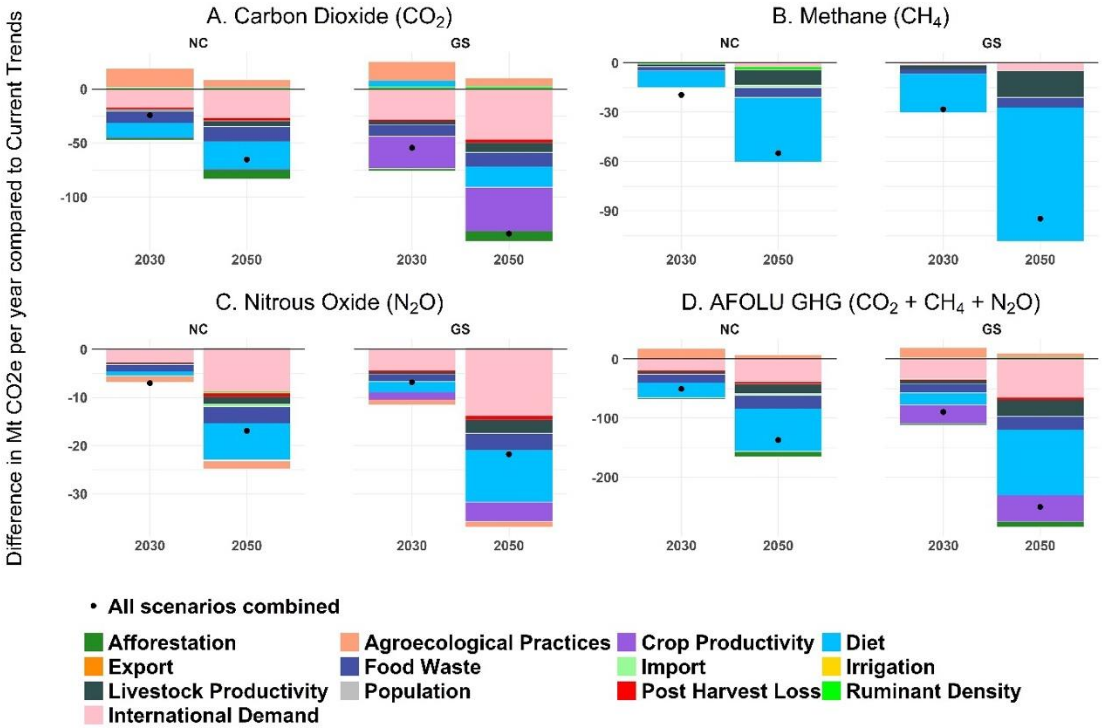
Beyond the measures that are included in the FABLE-C, the EEA highlights the additional mitigation potential of fallowing of histosols, improved crop rotation and improved grassland management. The carbon sequestration potential in soils and above ground on agricultural land is currently under improvements through the agroecological module of the FABLE-C.

Figure 2.11: Evolution of GHG emissions from agriculture and land use change across the pathways in EU



Note: We use AR6 global warming potential (CO2=1, CH4 = 27.2, N2O = 273); on-farm CO2 emissions are displayed for information although they are reported under the transportation sector and not AFOLU; in the FABLE-C, CO_2 sequestration comes from natural regeneration of abandoned agricultural land and assisted afforestation. We do not take into consideration carbon sequestration within managed forests nor within agricultural land.

Figure 2.12: Impact of each scenario on the evolution of AFOLU GHG emissions in EU



2.2.5 Biodiversity

The State of Europe's Nature 2020 shows that biodiversity continues to decline at an alarming rate within Europe and that agricultural activities, grasslands abandonment and urbanisation are the major pressures on habitats and species followed by pollution. Agriculture contributes to almost half of the pollution reports with significant impacts on standing waters, rivers and marine habitats and their species.

While forest habitats exhibit the highest proportion of improving trends among the various groups of habitats, grasslands show a deteriorating conservation status due to their dependency on sustainable management measures such as traditional or extensive grassland management. These pressures on grasslands also badly affect pollination capacities. The removal of small landscape features mainly affects reptiles and smaller mammals. Birds are most affected by the conversion of one type of agricultural land to another (extensive to intensive or change in type of crop grown) and by drainage. The use of plant protection chemicals such as pesticides negatively impact butterflies and insects and insect eating birds.

In the FABLE-C, we use an area-based indicator called Land where Natural Processes Predominate (LNPP). LNPP refers to land where there is a low human disturbance and/or ecologically relatively intact vegetation, providing space and habitat for biodiversity to thrive (FABLE, 2022). Current LNPP area is derived from three datasets: low impact areas, key biodiversity areas, and intact forest landscapes. In the FABLE-C, LNPP areas reduce with the conversion of natural land to agriculture and increase with the recovery of natural vegetation after agricultural abandonment and assisted afforestation. All the other drivers of biodiversity loss mentioned above are not reflected in our results.

Our results show a reduction of 2020 LNPP areas by 3% by 2050 in CT, by 1% in NC and no change for GS but an increase of "new" LNPP area after 2020 that limits marginally the loss of LNPP to 2% in CT but increases the overall LNPP area by 12% and 24% between 2020 and 2050 in NC and GS respectively. The increase in LNPP is mainly driven by the increase of new LNPP in other land due to agricultural land abandonment. This movement is particularly strong in the region rest of EU, in Germany, and in Greece while the LNPP area remains quite stable in Denmark and Finland.

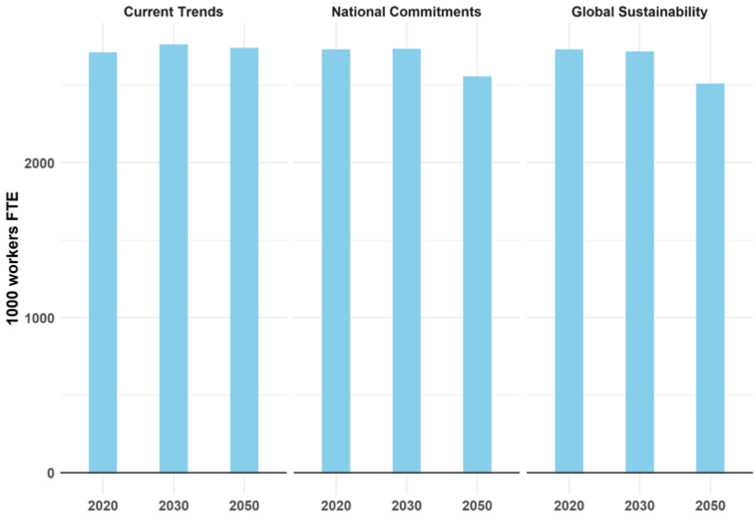
The main limitations of these results for biodiversity are 1) the lack of spatialisation which leads to coarse assumptions on the share of current LNPP area that will be affected by agricultural expansion, 2) the lack of distinction of management type on agricultural land, particularly on grassland, as extensive and intensive grassland management practices have opposite impacts on biodiversity, i.e. the abandonment of extensive grassland does not lead to gains in biodiversity as it is currently assumed in the model.

2.2.6 On-farm employment

It was estimated that close to 22 million full-time equivalent (FTE) workers carried out farm work in 2013 in the EU countries (EUROSTAT, 2023) and 9.1 million Annual work units in 2018 (Schuh et al., 2019). This number was constantly and rapidly declining over 2005-2013 with an overall reduction of 30% between 2003 and 2018 (Schuh et al., 2019). If the same trend is observed in all countries within the EU, the most dramatic reductions of the labour force in the agricultural sector are observed in Central and Eastern Europe countries (EUROSTAT, 2023). This is partly driven by the aging of the farmers, the income gap between the agricultural sector and the rest of the economy, and the difficulty for new entrants to establish themselves due to high land costs and problems to access credit.

The evolution of the labour in agriculture in the FABLE-C depends on the computed labour requirements i.e., what would be needed to satisfy the projected production levels for crops and livestock. This is based on fixed labour intensity (in FTE workers/ha for crops and FTE workers/head for livestock) by commodity or commodity group and does not account for labour supply constraints. These limitations must be kept in mind when we analyse the results. Between 2020 and 2050, total on-farm labour needs expressed in the number of workers in FTE slightly increase in CT and decrease in NC and GS (Figure 2.13). Overall, these changes look small compared to the historical decline over the last 15 years. The main drivers are the reduction of the livestock production in the NC and GS pathways which is more labour intensive than other crops that see an increase in their production in these pathways compared to CT.

Figure 2.13 – Evolution of on-farm labour needs in the EU between 2020 and 2050 across the three pathways



2.3 Comparison with other studies

Table 2.2 – Overview of the selected publications

***Light orange:** Dietary shift is included among the tested scenarios; **Light blue:** Dietary shift is NOT included among the tested scenarios.*

Authors (affiliation)	Title	Model used
Poux and Aubert, 2018 (IDDRI)	An agroecological Europe	TYFA
European Commission, 2020 (EC)	Impact Assessment for stepping up Europe's 2030 climate ambition	PRIMES-GAINS-GLOBIOM
Beckman et al., 2020 (USDA)	Economic and food security impacts of agricultural input reduction under the EU green deal's farm to fork and biodiversity strategies	GTAP-AEZ
Barreiro et al., 2021 (JRC)	Modelling environmental and climate ambition in the agricultural sector with the CAPRI model	CAPRI
Bremmer et al. 2021 (Wageningen University)	Impact Assessment of EC 2030 Green Deal Targets for Sustainable Crop Production	25 case studies + AGMEMOD
Latka et al., 2021 (EU Horizon consortium)	Paying the price for environmentally sustainable and healthy EU diets	CAPRI, MAGNET, GLOBIOM
Röös et al., 2022 (EU consortium)	Agroecological practices in combination with healthy diets can help meet EU food system policy targets	BioBaM, SOLm
Guyomard et al., 2023	The EU Green Deal improves the sustainability of food systems but has uneven economic impacts on consumers and farmers	New partial equilibrium model for the food system of the EU-27
Rieger et al., 2023	From fork to farm: impacts of more sustainable diets in the EU-27 on the agricultural sector	CAPRI-FARMIS-MAGNET
Stepanyan et al. 2023	Impacts of national vs European carbon pricing on agriculture	CAPRI

Table 2.3 Comparison of the measures represented in each study

Light orange: *Dietary shift is included among the tested scenarios;* ***Light blue:*** *Dietary shift is NOT included among the tested scenarios.*

Reference	Results
Poux and Aubert, 2018 (IDDRI)	By 2050, phasing out of pesticides and synthetic fertilizers, the redeployment of extensive grasslands and landscape infrastructures, the reduction of non-food uses of biomass, and the adoption of healthier diets lead to a decline in EU agricultural production (40% for livestock products), but it is enough to meet the European demand for food (thanks to dietary shifts), maintain 92% of the current total agricultural land (including agro-ecological infrastructures), and maintain the current level or wheat exports. Zero trade balance is assumed for the other products. GHG emission reduction mainly come from the reduction of nitrogen use.
European Commission, 2020	Agriculture is highlighted as the most challenging sector to reduce non-CO_2 emissions, partly because EU farming is seen as relatively efficient overall. Using technical mitigation options, non-CO2 agriculture emissions could be further reduced by 25% compared to the baseline in 2050 in the most ambitious scenario.
Beckman et al., 2020 (USDA)	Compared to current situation, a reduction of pesticide use by 50%, fertilizer use by 20%, antimicrobial use for livestock by 50% plus the removal of 10% of existing farmland from agricultural use lead to a reduction in EU agricultural production by 7 to 12% a reduction of EU exports and an increase in worldwide food prices between 9% and 89%.
Barreiro et al., 2021 (JRC)	By 2030, the reduction of the risk and use of chemical pesticides by 50%, the use of fertilizers by at least 20%, the increase of organic farming to 25% of agricultural land and at least 10% of agricultural area under fallow lead to a loss of productivity and increased prices. The production of most EU agricultural products falls – crops and livestock- between 10 and 20%, exports decrease and imports increase. Reductions in nitrogen surplus, nitrogen leaching, ammonia emissions, and GHG emissions (-20% and -14% for non-CO2 only) are observed. If the EU acts alone, significant carbon leakage with two-thirds of the resulting reduction in non-CO2 emissions from agriculture in the EU being offset by higher emissions in the rest of the world. The decline in EU production and variations in prices and income can be lowered by 1/5 with a CAP implementation in line with the 2018 Legal Proposal and targeted to accelerate the transition.
Bremmer et al., 2021	The realisation of the objectives to reduce the risk and use of pesticides by 50% and to reduce nutrient losses (50%) have significant impacts on yield levels (up to 50% reduction) with higher losses for perennial crops. The decline in yields negatively affects production and generates a decrease of supply in the EU home market, which induces increases in commodity prices and a deterioration of trade. The income of farmers is likely to suffer since revenues tend to decline, probably at a faster pace than expected cost declines.
Latka et al., 2021 (EU Horizon consortium)	By 2050, two types of tax scenarios, one focused on three groups of food products which are important markers of diet quality: vegetables and fruits, red and processed meat, and sugar and the second on total calorie intake lead. Considerable price changes are required to achieve the calorie intake reduction and the food pattern shifts. These high taxes may push the models beyond the range of validity of their implemented consumer price responsiveness. This leads to GHG savings in the EU or in the rest of the world depending on the model.
Röös et al., 2022	They compare five explorative storylines, developed in a stakeholder process, for future food systems in the EU to 2050. Results show that large-scale implementation of agroecological practices without concurrent changes on the demand side could aggravate existing environmental pressures. However, our second agroecological storyline showed that if large-scale diffusion of agroecological farming practices were implemented alongside drastic dietary change and waste reductions, major improvements on environmental indicators could be achieved and all relevant EU policy targets met. Economic modelling showed a need for drastic changes in consumer preferences towards more plant-based, agroecological and local foods, and for improvements in technology, for these storylines to be realised, as very high taxes and tariffs would otherwise be needed.

Guyomard et al., 2023	They assess the isolated or joint impact of three groups of measures: agroecology or supply-side measures, reduction of post-harvest losses and dietary shits towards less calories and more plant-based products. They reduce EU food GHG by 20% and biodiversity damage by 40–50% relative to 2019 levels. The nutritional indicators of food consumption are improved. Consumers win economically thanks to lower food expenditures. Livestock producers lose through quantity and price declines. Food/feed field crop producers win when the increase in food consumption of plant products outweighs the decrease in feed consumption. The negative effects of the 'agroecology' lever for European consumers are dampened because the cost of agricultural products is only a small part of food prices.
Rieger et al., 2023	They test a shift of European consumption towards the EAT-Lancet recommendations. The results indicate that the agricultural sector could benefit from a dietary shift, though the results are mixed at country, regional and farm levels. In particular, countries and regions that are highly specialized in animal farming are likely to lose income— at least in the short run—while regions with higher shares of vegetable and fruit farms can expect income gains, with magnitude of income changes roughly between -30% and +30%. Total consumer expenditures for food rise by 29% in 2050, mainly driven by the high consumer prices for vegetables and fruits. Imports of fruits and vegetables are more than ten times greater than in the reference scenario, but EU exports of beef, pork, and dairy products would increase.
Stepanyan et al. 2023	They test the impact of the inclusion of the agricultural sector into a carbon pricing scheme - 100€/tCO2eq carbon tax- once for Germany only, and second for the EU. The unilateral action by Germany leads to net EU agricultural emissions reduction (-4.5%), although, the effect obtained by the EU-wide implementation of carbon pricing in agriculture is fivefold larger (-23%). Without the deployment of the full set of mitigation technologies in agriculture, maximum agricultural GHG reduction in the EU would be 9.8%. Anaerobic digestion at the farm scale is the most adopted mitigation option since it generates additional revenues by producing renewable energy, and therefore, has the highest mitigation impact. Stimulating the use and transferability of the technological GHG mitigation options in agriculture would be key in the EU but also in third countries to alleviate the emission leakage. All simulated scenarios harm consumer welfare slightly and improve producer welfare in the EU and Germany. Beef is the most affected commodity in the EU as it shows the highest price increases. In all scenarios, beef consumption is substituted by poultry meat and under the EU-wide scenarios beef is also substituted by pork.

We have selected ten publications related to the modelling of more sustainable agricultural sector in Europe that have been published between 2018 and 2023. They are based on a diversity of models even through CAPRI. CAPRI is a partial equilibrium model with a detailed representation of the agricultural sector with a strong focus on Europe and is frequently used in various EU Commission services (such as DG AGRI, DG ENV, DG CLIMA, and the JRC). We have highlighted in the above tables the studies that only focus on supply-side measures in blue and the studies which include scenarios on dietary shifts within the EU in orange (they can as well represent some supply-side measures depending on the studies).

The supply-side measures focus on a reduction of pesticide and fertilizer use, the allocation of a share of agricultural land to fallow or green infrastructures, and taxing emissions from agricultural production with the implementation of alternative mitigation technologies in agriculture. While the EU healthy food consumption targets are vague, the assumptions about the corresponding dietary shift vary across studies: most have used the EAT-*Lancet* recommendations, some have used a mix of national dietary guidelines, and others some nutrition indicators. Independently of the method, all conclude that this will result in a reduction of the consumption of animal-based products and sugar and an increase in plant-based proteins, and when this is represented in the model, an increase of the consumption of fruits and vegetables as this was assumed in this study. All these measures are successful in reducing GHG emissions from agriculture, even though the EU objective can most likely be met only when measures targeting both the agricultural production and the food demand are simultaneously implemented.

Benefits are also highlighted for biodiversity. However, these studies already show that achieving these environmental targets is hard and will require large structural changes. Our findings are line with these conclusions.

The model which has been used in this study is not an economic model and do not represent the impact on prices and in this light, other studies are needed to complement our analysis. In the literature, the main difference between the studies that focus only on supply-side measures and those who include demand-side measures is the impact on prices and trade. While the supply-side measures tend to reduce productivity and increase production costs, the demand-side measures increase the price of the goods which are more demanded and reduce the price of the goods which are less demanded. The only implementation of more sustainable supply-side measures almost systematically results in an increase in EU prices, a reduction of the EU agricultural production, a deterioration of EU trade, and higher consumer expenditure. The impact on farmers' income tends to be negative but varies across studies and sectors. The combination of supply-side and demand-side measures leads to a brighter future, the production within the EU increases for some commodities, some EU exports increase after price reduction, and consumers benefit from lower prices for some commodities. However, some producers are hit even harder – mainly the beef and dairy producers who are not competitive enough to export- and prices of some commodities such as fruits and vegetables increase tremendously while higher imports are also needed to satisfy the growing demand.

Based on the FABLE results presented in this study and the results of other studies, we emphasize the need to strengthen EU modelling on five directions to better inform the debate on the sustainable transformation of food and land systems:

1. **Account for the cost and the time required for learning and implementing new mitigation technologies and new agronomic practices** to satisfy the environmental constraints and minimize the impact on productivity. Some insights on who will bear this cost and how can this transition be accelerated will strengthen the modelling work with more realistic assumptions.

2. **Include the benefits from a better environment on agriculture.** None of the cited studies include such feedback e.g., through increased soil fertility, better pollination, lower impacts of climate change, or higher resilience to climate shocks. An assessment of the magnitude of these impacts and the level of the savings that can be generated can ensure that long-term benefits are also captured by the models.

3. **Represent the diversity of livestock production systems and their impacts on multiple indicators** to offer new perspectives on the evolution of the sector in line with the multiple targets of the EU and better livelihoods for breeders.

4. **Precise and enlarge the number of alternative healthy diets that are tested to foster discussion and buy-in**. The average EU diet is not healthy and leads to high health and environmental costs but the healthy diet tested in the context of the EU should be better tailored to the local context, together with consumers, producers, and nutrition experts.

5. **Design contrasted trajectories outside the EU.** The offset of environmental benefits in the EU by increased environmental damages outside the EU (negative spillovers) following higher non-EU production is a risk. Roundtable discussions with the main trade actors could be particularly useful.

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Detailed explanation of values represented in Figure 2.3: Overview of assumptions made in each pathway in each national or regional FABLE-C within the EU and the aggregated result for the EU

Relative changes can come both from the country team's scenario assumptions and from the combined effect of multiple scenarios assumptions in the FABLE-C.

Population: relative difference between population in 2020 and population assumed in 2050 by the country team.

Calories per capita: refers to the targeted dietary changes hypothesized by the country teams. Therefore, these do not consider any constraints that could prevent these desired changes after the modelisation process.

Crops productivity: only reflects the assumption related to the closure of yield gap obtained through higher fertilizer use i.e., the impact of irrigation area changes and agroecological practices change on productivity is computed separately. The unit is t/ha.

Livestock productivity: assumption related to the relative change in livestock productivity between 2020 and 2050

Ruminant density: assumption related to the relative change in ruminant density between 2020 and 2050

Export and Imports: the assumptions made by country teams are based on quantitative change on export of agricultural products and share of consumption which is imported. However, in the figure, the export and imports are expressed in kcal. By using FAO data, each product has been associated to a certain kcal content, and then multiplied by the quantity assumed.

Agricultural expansion: it is expressed in code, taking the value 1 for 'Free expansion scenario', -0.5 for 'No deforestation' and – 1 for 'No Agricultural expansion'.

Afforestation: results are expressed in net increase rather than relative change. The unit is Mha, and the value come directly by the assumption made by the country teams.

Food Waste: results are expressed as % of consumption that is wasted in 2050, rather than relative change.

Protected areas: refers to the percentage of total land projected to be designated as protected by 2050, based on the targets set by the country's teams. The result is expressed as a percentage of the total land area in 2050.

Irrigated areas: the percentage change applied to different crops assumed by country teams have been weighted by cropland area composition in 2020. This means that variation in cropland composition between 2020-2050 are not considered in the computation of the relative difference of irrigated area between 2020 and 2050.

Area under agroecological practices: the percentage increase applied to different crops assumed by country teams have been weighted by cropland composition in 2020. This means that variation in cropland composition between 2020-2050 are not considered in the computation of the relative difference of area under agroecological practices between 2020 and 2050.

The EU assumptions have been computed by aggregating the assumptions made by country teams for the five EU countries and the rest of EU region. Before aggregation, livestock productivity of the countries has been weighed by the herd dimension of the country, crop productivity, irrigated area and area under agroecological practices by the harvested area in 2020, ruminant density by pastureland in 2020, calories per capita by the population in 2020.

Export and imports (kcal) and population have been directly summed up in 2020 and 2050 before computing the relative difference. Afforestation has been directly aggregated. Protected areas values have been aggregated at EU level, as well as the total land: the share has been then computed.

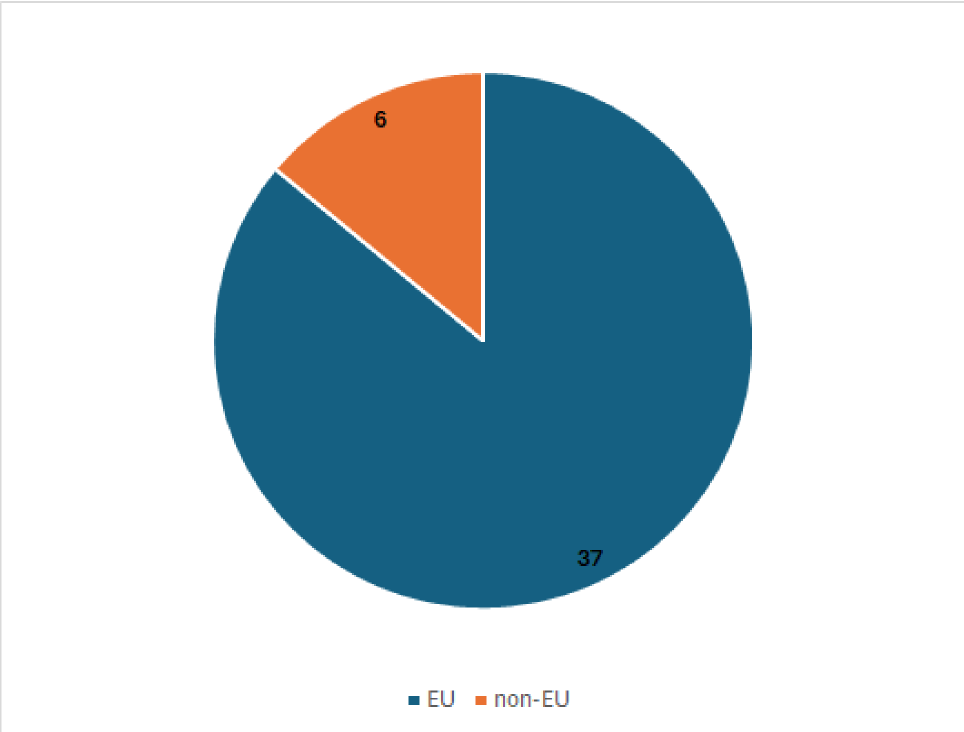
3. Policy options, bottlenecks and stakeholder engagement

This third section discusses policy options to move toward a more sustainable food and land system in the EU. It builds on two principal sources of information: (1) A survey collected from a diversity of practitioners and experts in food systems from all over Europe; (2) The outcome of the workshop conducted in Brussels in mid-October 2024 where preliminary findings of this study were discussed. Building on the findings described in the two previous sections, we aim to identify persisting policy bottlenecks and potential way forward to achieve ambitious sustainability objectives in the food and land sector in the EU.

3.1 Survey design and respondent information

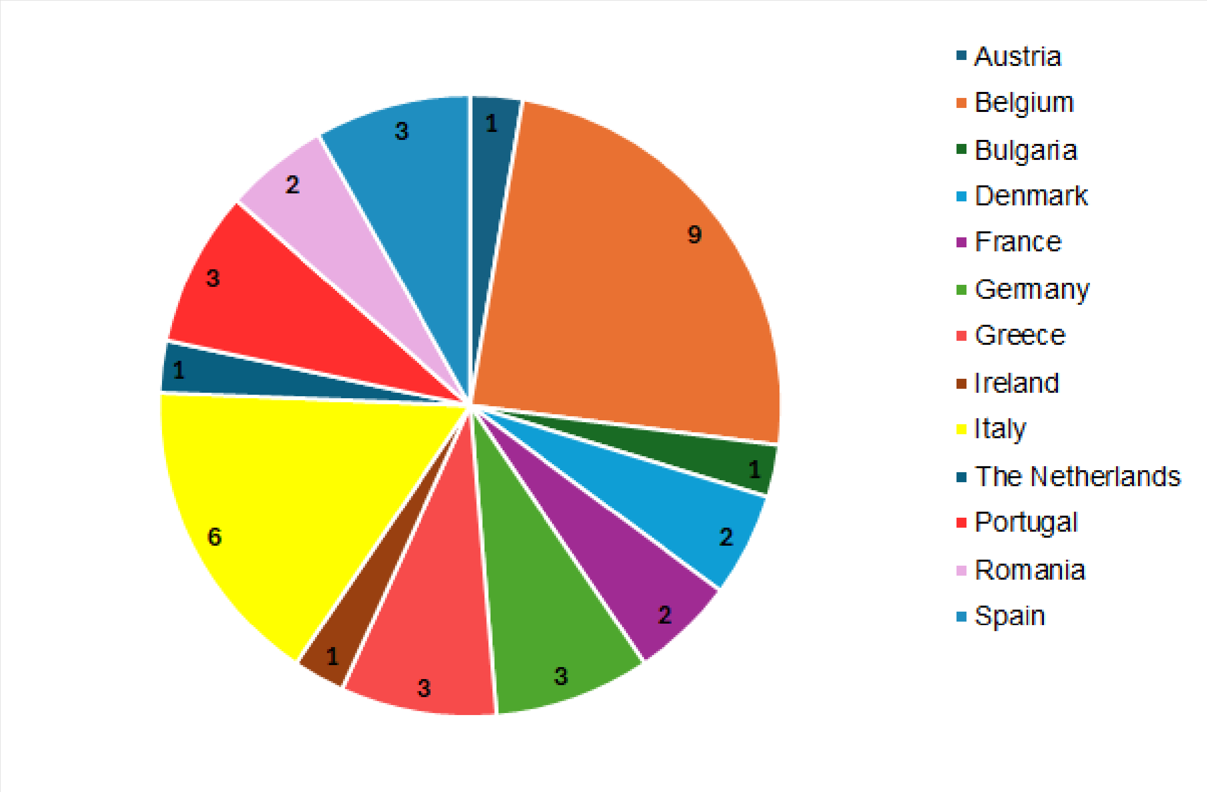
The survey data were collected via an online questionnaire and collected between July and September 2024. The survey included 5 questions. Overall, we received 43 responses. The vast majority (37) came from respondents based in the EU, but we also considered responses provided from non-EU countries in Europe (e.g. candidate countries, Switzerland and the UK). The breakdown of responses across EU member states reveals that more respondents were based in Belgium and Italy, which can be partly attributed to responses received from Brussels-based organisations with a European wide mandate and responses received from the Rome-based Food and Agricultural Organisation (FAO). Most respondents to the survey were representatives from NGOs, Research Centers, and Universities as well as business associations.

Figure 3.1 Respondent information: EU vs non-EU



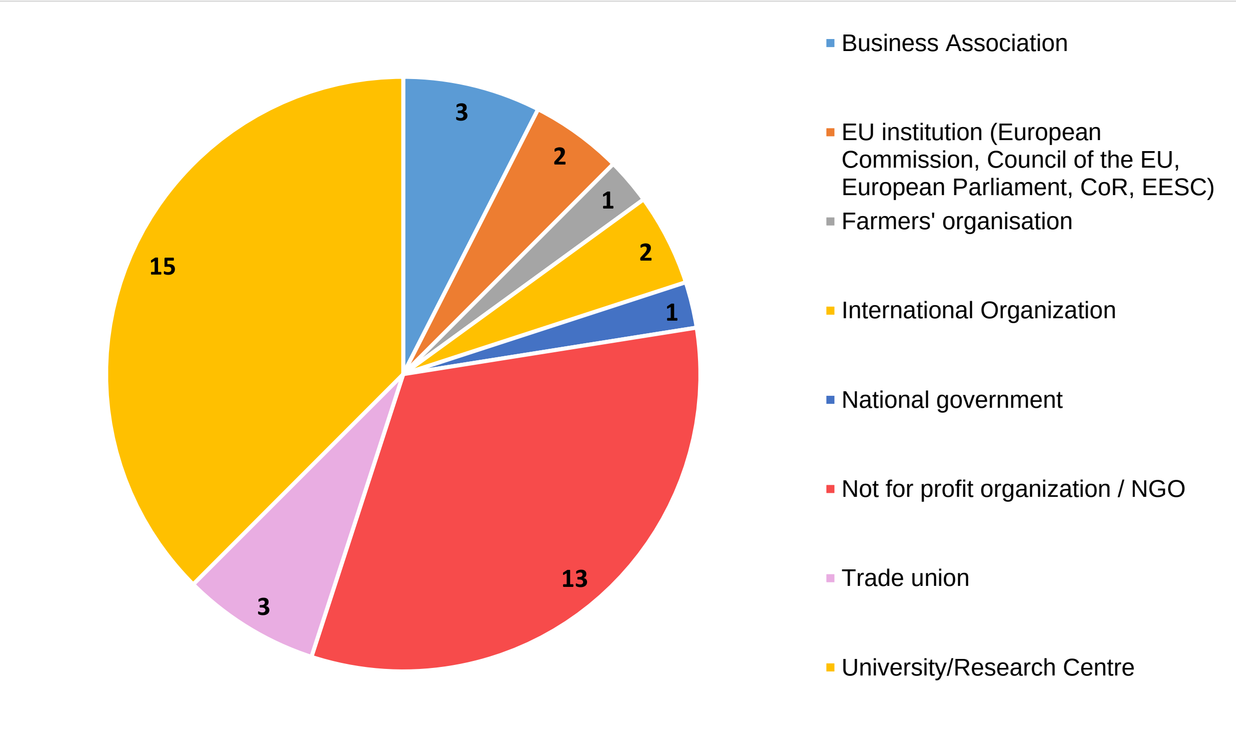
Source: Authors

Figure 3.2 Respondent information: Breakdown by EU member states



Source: Authors

Figure 3.3. Respondent information: Organisation type

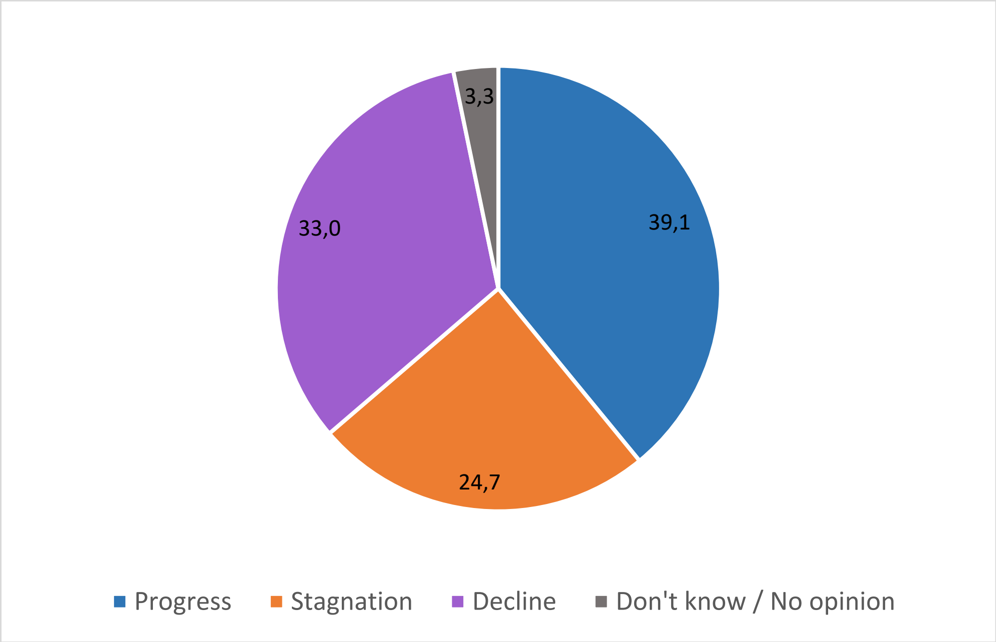


Source: Authors

3.2 General assessment

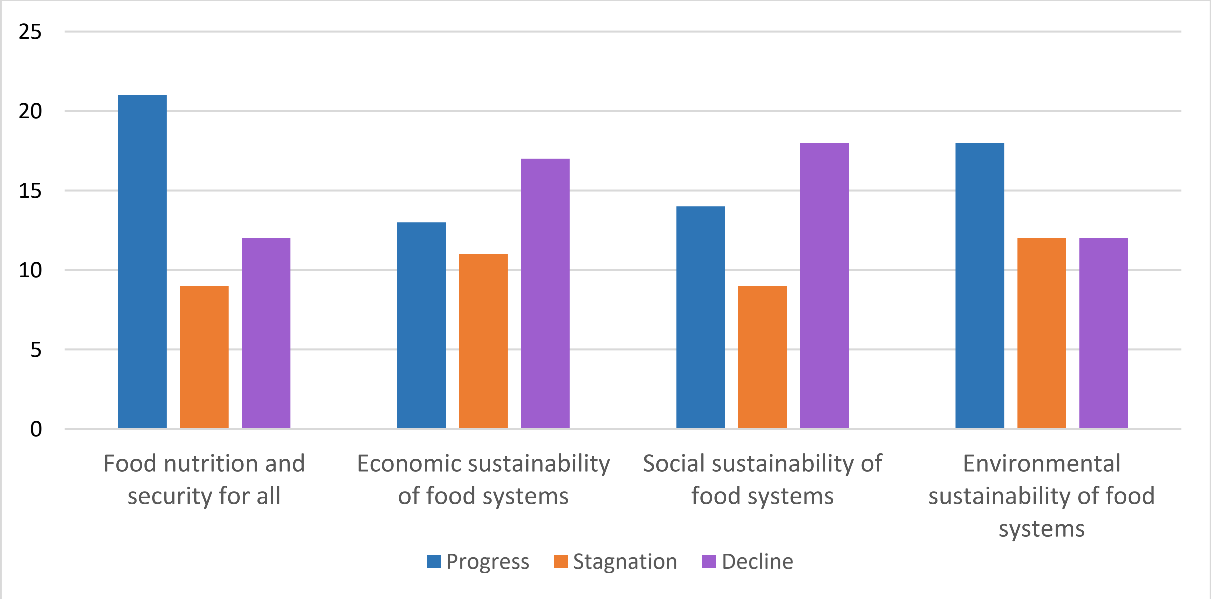
Overall, over the period 2019-2024, about 40% of respondents believed that the EU made progress in moving toward the various elements of sustainable food systems. A quarter of respondents believed the EU stagnated, and a third believed that the EU declined. The breakdown by sub-dimension reveals that this is driven overwhelmingly by the sentiment that the EU did not progress on the social and economic dimensions of the sustainability of food systems. By contrast, a small majority of respondents recognized the effort and progress made by the EU in advancing the environmental sustainability of food systems.

Figure 3.4. In general, over the period 2019-2024, how would you assess the progress of the European Union in moving toward the various elements of sustainable food systems? (%)



Source: Authors

Figure 3.5. In general, over the period 2019-2024, how would you assess the progress of the European Union in moving toward the various elements of sustainable food systems? (number)

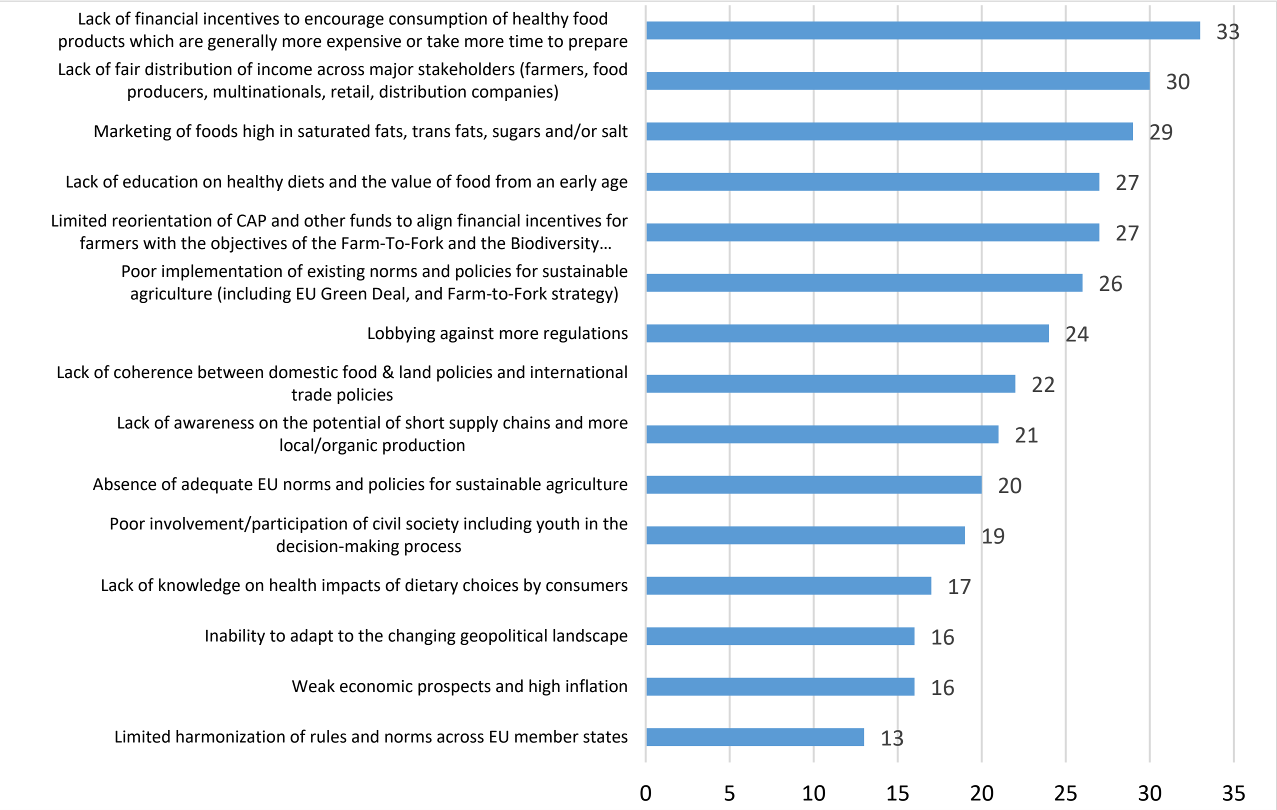


Source: Authors

3.3 Policy challenges

In terms of major policy challenges in order to advance toward more sustainable EU agri-food systems, three-quarters of respondents emphasized the lack of financial incentives to encourage the consumption of healthy products. A significant proportion of respondents (60%+) also emphasized the lack of fair distribution of income across major stakeholders, the marketing of unhealthy food, the lack of education on healthy diets from an early age, the limited reorientation of the CAP and other funds to align financial incentives for farmers with the objectives included in F2F and the biodiversity strategies, and poor implementation of existing norms and policies (including the EGD and F2F) as major challenges. By contrast the limited harmonization of rules and norms across EU member states, the lack of knowledge on the health impact of dietary choices and more cyclical factors, such as the inability to adapt to changing geopolitical landscape and the weak economic prospects and rising inflation, were less frequently considered by respondents as major obstacles, although most respondents recognized that these were also important to address to support a sustainable and resilient agri-food sector in the EU.

Figure 3.6. More specifically, what are the most pressing challenges faced by the EU regarding its efforts to transition toward sustainable food systems? Major challenge (number)



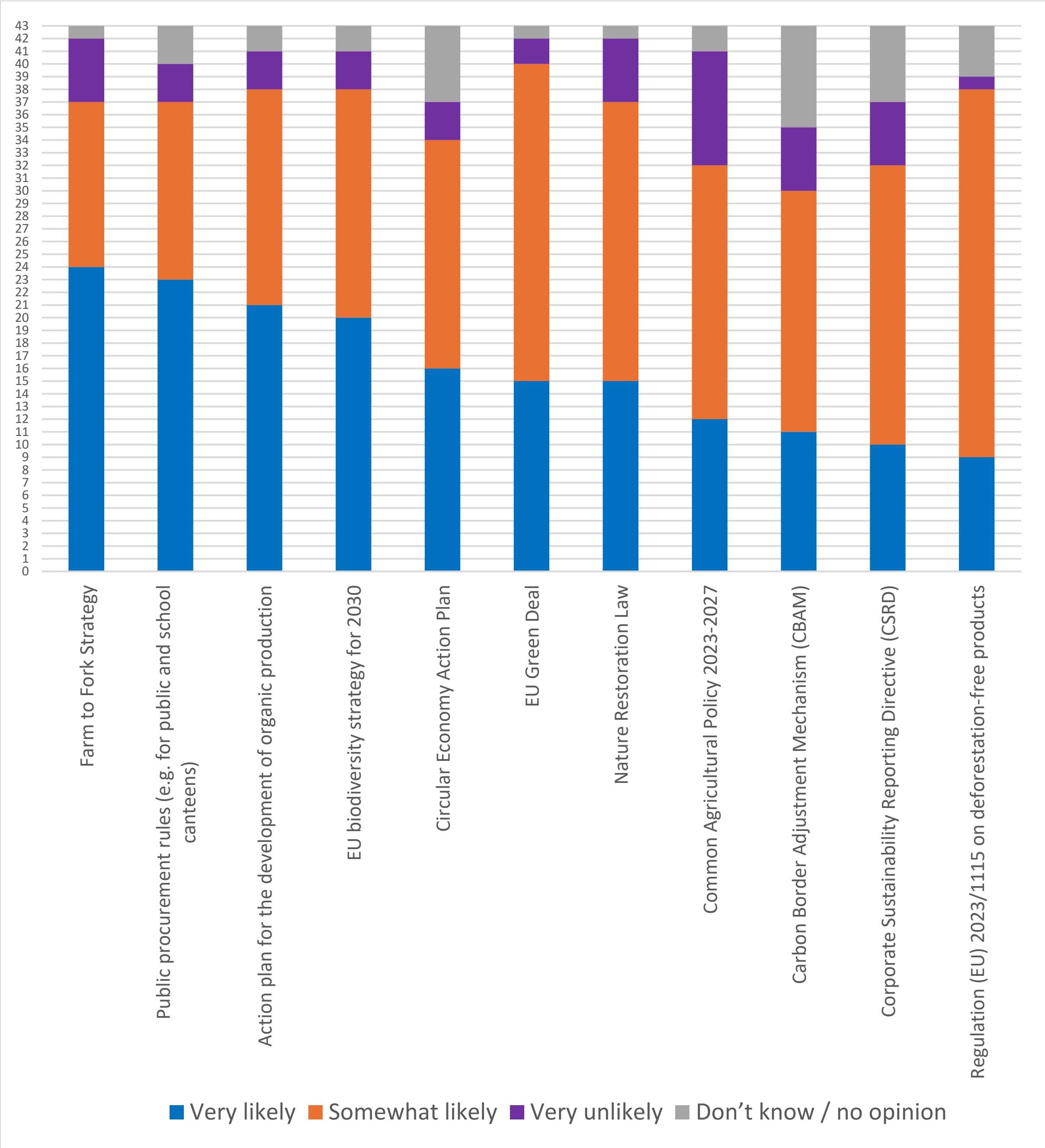
Note: Ordered in descending order starting with responses item with the largest number of “Major challenge” responses.
Source: Authors

3.4 Current policy landscape and ambition

A majority of respondents considered that Farm to Fork and public procurement rules were the most promising policy instruments to help the EU move toward sustainable food systems. By contrast, there is more scepticism about the potential positive effects, CSRD, CBAM and CAP, which may be due to the content of the policy documents itself (e.g. vision, ambition, enforcement mechanisms etc.)

and/or perceived inability to implement these policies due to financial, technical or other reasons. Regarding the "Regulation on deforestation-free products", most respondents used the middle response and believed that it is "somewhat likely" to help the EU move toward sustainable food systems.

Figure 3.7. In your view, how likely are the following policy instruments to help the EU move toward sustainable food systems? (number)

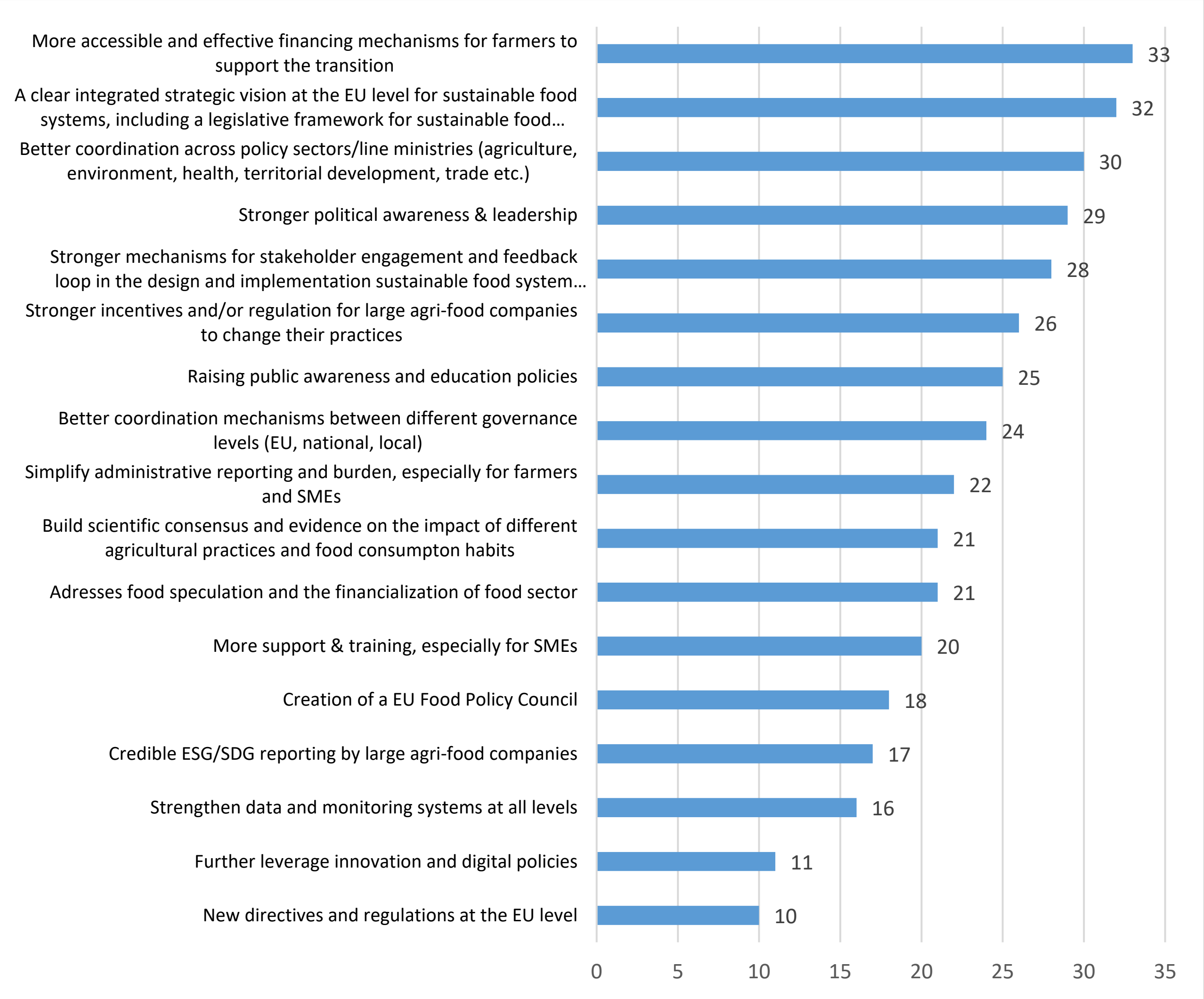


Note: Ordered in descending order starting with responses item with the largest number of "Very likely" responses.
Source: Authors

3.5 Policy levers & mechanisms

In terms of bottlenecks and levers, three-quarters of respondents emphasized the importance of moving toward more accessible end effective financing mechanisms for farmers to support the transition and adopting a strategic and holistic vision for sustainable food systems. The need for stronger political awareness, stronger coordination across ministries and sectors and stronger stakeholder engagement mechanisms were also emphasized. By contrast less than a quarter of the respondents call for new directives and regulations at the EU level.

Figure 3.8. What are in your view the most important bottlenecks / priorities which must be urgently addressed in order to accelerate the transition toward sustainable food systems in the EU? Major priority (number)



Note: Ordered in descending order starting with responses item with the largest number of "Major priority" responses.
Source: Authors

Outlook

The main objective of this study on SDG2 (Zero Hunger) in the EU was to assess persisting gaps, possible pathways and policy bottlenecks based on existing data and models – notably the work of the FABLE Consortium – and new survey data. Overall, the transition toward sustainable agri-food systems to achieve 2030 and mid-century sustainability targets will inevitably lead to significant changes in food production and consumption systems across all scenarios, including diets, with major implications on labour and trade policies in the EU.

Our analysis suggests that stakeholders in the EU agri-food sector call for (i) a clear strategic vision and continued political leadership, (ii) to further leverage economic and financial levers to promote healthy diets and support farmers that might lose from this transition and (iii) for stronger coordination mechanisms across policy sectors but also with agri-food stakeholders including cooperatives, agri-food companies, retailers, wholesalers, and other types of companies. This echoes recommendation #14 of the Strategic Dialogue on the Future of the EU Agriculture which calls for governance change and a new "culture of cooperation, trust and multistakeholder participation among the actors and within institutions". Recommendations made by the EESC and the Strategic Dialogue to create respectively a "European Food Policy Council[9]" or "European Board on Agri-food (EBAF)" might help strengthening the governance of agri-food systems in the EU. Rather than new directives and rules, stakeholders emphasized the importance of effective and fair implementation of existing strategies including notably the F2F and procurement rules, in close cooperation with the actors of the agri-food sector.

Internationally, the new EU leadership will have several opportunities to advance concerted actions and investments for more sustainable global food supply chains. The forthcoming COP30 in Brazil in 2025 will be particularly important notably to advance *global* efforts on the climate change, biodiversity and nutrition nexus but also in mobilizing local and indigenous communities and knowledge. Similarly, the Second World Summit For Social Development in Qatar in 2025 and the Nutrition for Growth summit in France in 2025 as well as concerted action within the WTO will also be important to advance global cooperation for food security and a just transition toward sustainable agri-food systems. In the context of the SDGs, we encourage the new leadership of the EU to prepare a second Voluntary Review ahead of the 2027 SDG Summit at Head-of-State level with a strong emphasis on SDG2 (No Hunger) including both its internal and international dimensions and the latest insights from the various existing data and models for sustainable agri-food pathways. Agri-food systems underpin the achievements of the other SDGs, both their social and environmental dimensions, and as such should remain an important component of a renewed and ambitious post-2030 global agenda for sustainable development.

9 https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/towards-european-food-policy-council-new-governance-model-future-eu-framework-sustainable-food-systems

Annex – Part 3: SDSN & EESC Survey on sustainable food systems as a driver for the implementation of the SDGs

Background:

Sustainable food and land use systems are crucial to feed the growing population in the world, support socio-economic prosperity and address the climate and biodiversity crises. Food and land use systems are responsible for approximately one-third of global greenhouse gas emissions and unprecedented loss of biodiversity and forest cover. SDG 2 aims to "End hunger, achieve food security and improve nutrition and promote sustainable agriculture." This SDG was under review this year at the 2024 UN High-Level Political Forum on sustainable development (HLPF) in New York. Farmers play a pivotal role in this transformation. Food businesses across the supply chain, including European farmers and fishers, cooperatives, agri-food companies, retailers, wholesalers, and other types of companies, are already working to make progress on sustainability and to offer consumers healthy and sustainable products in line with the European Green Deal.

Several policy documents and directives have been introduced by the current European Commission since 2019, including the Farm-to-Fork strategy, EU biodiversity strategy and the Common Agricultural Policy 2023-2027 (among others). The SDSN and EESC are carrying out a study which will assess persisting gaps toward achieving sustainable food systems in the EU and which also aims to identify pathways and persisting bottlenecks to inform the priorities of the future EU leadership.

This short survey includes five questions and should not take longer than 10 minutes to complete. It aims to collect opinions from a diverse range of stakeholders on challenges and policy priorities to promote sustainable food systems in the EU. The results will be included in a study to be published by the EESC by the end of 2024.

Deadline to respond: **September 10, 2024**

Contacts:

- Maria Diaz, Senior Manager, Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium, maria.diaz@unsdsn.org

- Grayson Fuller, Senior Manager, SDG Index & Data, UN Sustainable Development Solutions Network (SDSN), grayson.fuller@unsdsn.org

- Sara Allali, Junior Economist, SDSN. sara.allali@unsdsn.org

Respondent information:

First name

Surname

Title

Country

Organisation

Organisation type:

- EU institution (European Commission, Council of the EU, European Parliament, CoR, EESC)
- International Organisation
- National government
- Trade union
- Business Association
- SME
- Farmers' organisation
- Multinational in the agri-food business
- Not for profit organisation / NGO
- Youth organisation
- University / Research Centre
- Other: Please specify

Definition of key terms:

Food systems: Encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded.

Sustainable food systems: a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised.

Healthy diets: A healthy diet is health-promoting and disease-preventing. It provides adequacy without excess, of nutrients and health-promoting substances from nutritious foods and avoids the consumption of health-harming substances (UNFS Scientific Group, 2021).

Nutritious foods: "One that provides beneficial nutrients (e.g., protein, vitamins, minerals, essential amino acids, essential fatty acids, dietary fibre) and minimizes potentially harmful elements (e.g. antinutrients, quantities of sodium, saturated fats, sugars)" (UNFS Scientific Group, 2021; GAIN, 2017; drawing on definitions published by Drewnowski, 2005; and Katz et al. 2011).

Q.1. General assessment:

In general, over the period 2019-2024, how would you assess the progress of the European Union in moving toward the various elements of sustainable food systems?

1.a. Food nutrition and security for all?

a. Major progress

b. Moderate progress

c. Stagnation

c. Moderate decline

d. Major decline

e. Don't know / No opinion

1.b. Economic sustainability of food systems?

a. Major progress

b. Moderate progress

c. Stagnation

c. Moderate decline

d. Major decline

e. Don't know / No opinion

1.c. Social sustainability of food systems?

a. Major progress

b. Moderate progress

c. Stagnation

c. Moderate decline

d. Major decline

e. Don't know / No opinion

1.d. Environmental sustainability of food systems?

a. Major progress

b. Moderate progress

c. Stagnation

c. Moderate decline

d. Major decline

e. Don’t know / No opinion

Q.2. Policy challenges:

More specifically, what are the most pressing challenges faced by the EU regarding its efforts to transition toward sustainable food systems?

	Not a challenge	Moderate challenge	Major challenge	Don’t know/No opinion
Lack of knowledge on health impacts of dietary choices by consumers				
Marketing of foods high in saturated fats, trans fats, sugars and/or salt				
Lack of education on healthy diets and the value of food from an early age				
Lack of awareness on the potential of short supply chains and more local/organic production				
Lack of financial incentives to encourage consumption of healthy food products as they are more expensive or take more time to prepare				
Lobbying against more regulations				
Absence of adequate EU norms and policies for sustainable agriculture				
Poor implementation of existing norms and policies for sustainable agriculture (including EU Green Deal, and Farm-to-Fork strategy)				
Limited reorientation of CAP and other funds to align financial incentives for farmers with the Farm-To-Fork and the Biodiversity Directive objectives				

Lack of fair distribution of income across major stakeholders (farmers, food producers, multinationals, distribution companies)				
Lack of coherence between domestic food & land policies and international trade policies				
Limited harmonization of rules and norms across EU member states				
Inability to adapt to the changing geopolitical landscape				
Weak economic prospects and high inflation				
Poor involvement/participation of civil society including youth in the decision-making process				
Other: Please specify				

Q.3. Current policy landscape and ambition:

In your view, how likely are the following policy instruments to help the EU move toward sustainable food systems?

	Very unlikely	Somewhat likely	Very likely	Don’t know / no opinion
EU Green Deal				
Farm to Fork Strategy				
Common Agricultural Policy 2023-2027				
EU biodiversity strategy for 2030				
Circular Economy Action Plan				
Nature Restoration Law				
Action plan for the development of organic production				
Carbon Border Adjustment Mechanism (CBAM)				
Corporate Sustainability Reporting Directive (CSRD)				

Regulation (EU) 2023/1115 on deforestation-free products				
Public procurement rules (e.g. for public and school canteens)				
Other, please specify:				

Please specify (e.g. perceived level of ambition, implementation mechanisms, etc.).

….

Q.4. Policy levers & mechanisms.

What are in your view the most important bottlenecks / priorities which must be urgently addressed in order to accelerate the transition toward sustainable food systems in the EU?

	Not a priority	Somewhat a priority	Major priority	Don't know / no opinion
More accessible and effective financing mechanisms for farmers to support the transition				
Stronger political awareness & leadership				
A clear integrated strategic vision at the EU level for sustainable food systems, including a legislative framework for sustainable food systems (planned under the F2F strategy)				
New directives and regulations at the EU level				
Better coordination across policy sectors/line ministries (agriculture, environment, health, territorial development etc.)				
More support & training, especially for SMEs				
Better coordination mechanisms between different governance levels (EU, national, local)				
Raising public awareness and education policies				
Stronger mechanisms for stakeholder engagement and feedback loop in the design and implementation sustainable food system policies, including SMEs and farmers at all levels				

Creation of an EU Food Policy Council				
Build scientific consensus and evidence on the impact of different agricultural practices				
Simplify administrative reporting and burden, especially for farmers and SMEs				
Further leverage innovation and digital policies				
Strengthen data and monitoring systems at all levels				
Credible ESG/SDG reporting by large agri-food companies				
Stronger incentives and/or regulation for large agri-food companies to change their practices				
Other: Please specify				

Q.5. Final comments

Please provide any final thoughts:

[Open question]

Would you like to remain anonymous, or do you accept to be listed in the acknowledgement section among the experts consulted for this study?

- I prefer to remain anonymous
- I agree to be listed in the acknowledgement section

European Economic and Social Committee

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