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# EUROPEAN AGRICULTURE: STRUCTURAL CHANGES, ENVIRONMENTAL CONSTRAINTS AND CLIMATE IMPACTS

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This contribution outlines the past transformations and future challenges facing European agriculture, distinguishing between structural changes and environmental constraints. While the agricultural sector experienced dramatic productivity growth during the 20th century, this success generated unintended environmental consequences, rendering agriculture a primary driver of environmental degradation as well as the sector most vulnerable to it. Key structural shifts, notably the consolidation of land into fewer, larger farms and the demographic challenge of an aging farming workforce, are discussed, and the sector's environmental constraints and tradeoffs are introduced using the planetary boundaries framework. Finally, two empirical studies on the impacts of climate change on the Italian agricultural sector conducted by the author are presented.

## 1. Introduction

Agriculture and food are a vital and central component of our societies. They not only provide the required calories to the population but also influence many other factors that determine societal well-being, like the landscape and environment, health, and cultural heritage. Agriculture is arguably one of the oldest economic sectors, dating back millennia, and throughout history, it has witnessed many significant revolutions and innovations. However, until the last century, agricultural productivity growth was still quite modest, and the vast majority of the global population was involved in agricultural production and lived in rural areas. It is only in the 20th century with mechanization, agronomic advances, synthetic fertilizers, genetic innovations, and a strong investment in R&D and institutional capacity (the so-called Green Revolution) that agricultural productivity increased dramatically, and consequently, the share of labor employed in the agricultural sector dropped significantly. Societies all over the world moved from being essentially rural and pastoral to urban and industrial, with this trend particularly advanced in the most developed regions, like, for instance, the European Union. This process has been so comprehensive that the previous socio-economic structures of farming have largely faded from collective memory, making it difficult to fully grasp the extent of the sector's rapid evolution from its historical configuration.

These transformations responded to the needs of societies during the century: a growing population (especially in developing countries) and the need to ensure food security and availability in a context of chronic famines and food shortages. In the European case, countries after the Second World War found

themselves in need to improve agricultural production, in order to ensure food availability for the population. The agricultural sector was still underdeveloped and labor-intensive. A growing population and increased living standards, however, meant that food demand was also rapidly growing in a context where Europe was still a net food importer. The modernization of the European agricultural sector became, therefore, a primary social and political objective, both to ensure food security for its population and to reduce its dependence on external countries. The establishment of the Common Agricultural Policy (CAP) with the Treaty of Rome in 1957 responded primarily to these needs, with the goals of increasing agricultural productivity, promoting technological innovation, improving farmers' income, and ensuring food security, among others (Sotte and Brunori, 2025).
In this respect, the story of agricultural transformation in the last century has been a story of success. In developing countries, yields grew by 208 % for wheat, 109 % for rice, 157 % for maize, 78 % for potatoes between 1960 and 2000 (Pingali, 2012). These productivity advancements lead to significant poverty reduction, and moreover, preserved thousands of hectares of natural land from land use change, with important implications for environmental quality and climate change. In Europe, also thanks to the CAP, agricultural production increased considerably, and the continent switched from being a net food importer to being a net food exporter in only a couple of decades.

However, these successes came with significant trade-offs, as the drive for increased productivity introduced a series of unintended consequences. The agricultural sector is currently one of the main drivers of environmental degradation and climate change, due to the same production practices that allowed it to grow so effectively. The extensive use of pesticides, synthetic fertilizers, and intensive farming practices led to a decline in soil quality and fertility, a drop in biodiversity indicators, and an increased dependence of the food system on fossil fuels. These pressing issues are coupled with other factors, like changing demographic features, participation in global value chains, and societal preferences, meaning that the challenges that agriculture will face in the coming decades and the demands that our societies will place on the agricultural system are profoundly different from those of the last century.
At the European level, these challenges and demands can be framed under two broad drivers: structural changes and environmental concerns. Structural changes encompass all those aspects related to the agricultural production system, ranging from the demographic composition of the farm workforce to the ownership profile of land, innovation in production technologies, industry organization, and governance structures. Environmental concerns instead stem directly from the specific positioning of the agricultural sector, acting as a primary driver of environmental degradation while simultaneously being the main activity affected by these changes. Among these, the impacts that climate change will have on agricultural productivity are arguably the concern that has the most extensive literature, dating back at least to the seminal work of Mendelsohn et al. (1994). In line with this literature, this contribution presents two of the author's empirical studies that assess the impacts of climate change on agricultural production within the Italian context.
Underscoring these challenges, agricultural policies are currently a primary concern of European policymaking, and the sector continues to attract public attention, as shown, for instance, by the numerous protests that spread around Europe (Finger et al., 2024). In 2024, the European Commission (EC) initiated the discourse regarding the future of agricultural policies and launched the "Strategic Dialogue on the Future of EU Agriculture", a collaborative document drafted by representatives and stakeholders from the agricultural sector, civil society, rural communities, and academia.

Building on the recommendations outlined in the Strategic Dialogue, the European Commission then presented the 2025 Communication 'A Vision for Agriculture and Food' (European Commission, 2025), establishing a roadmap to 2040 to ensure policy alignment with the proposed vision. These policy developments have sparked a lively debate among stakeholders and analysts across the member states. For instance, Arfini et al. (2025) discussed the Italian case and related considerations. While the 2025 Vision was seen by some as a realist and pragmatic step to correct the perceived excesses of the European Green Deal (European Commission, 2019) and of the Farm to Fork Strategy (European Commission, 2020), others perceived it as a dilution of the much-needed environmental ambitions originally set out in that framework. However, the influence of new political majorities, persistent global instability, and emerging socio-economic concerns suggests that the future trajectory of these policies remains subject to significant uncertainty, making it difficult to predict what the long-term outcome will be.

Against this backdrop, this contribution aims to provide a brief introduction to the future challenges facing European agriculture over the coming decades, focusing on structural changes and environmental constraints. To this end, it integrates and summarizes two empirical analyses conducted by the author that assess the impacts of climate change on production in the Italian agricultural sector.

The discussion is organized as follows. Section 2 provides a brief introduction to the structural changes reshaping the European agricultural landscape, while Section 3 examines the tightening environmental constraints and trade-offs faced by the sector. Building on this context, Section 4 presents the two empirical assessments of climate impacts in Italy, and Section 5 provides concluding remarks.

# 2. Structural Changes

The structural features that define an economic sector encompass all aspects related to the production and market system, such as the internal organization of production (e.g., labor intensity), the relationships of purchases and sales among firms, the number and relative size of firms and other actors, ownership structures, and governance of the system.

In the agricultural sector, structural change is conventionally framed as a transition that, starting from a background of small firms using labor-intensive technologies, leads to a situation with fewer and larger firms that have substituted a significant share of the labor input, adopting capital-intensive technologies. This transition is driven by a complex interplay of technological innovation, demographic shifts, evolving market demands, and regulatory policy encouragement, and the EU statistical records provide clear evidence of this ongoing transformation. For instance, Figure 1 shows the percentage change in the number of farms and in total agricultural area in the EU between 2005 and 2020, considering different farm size classes.

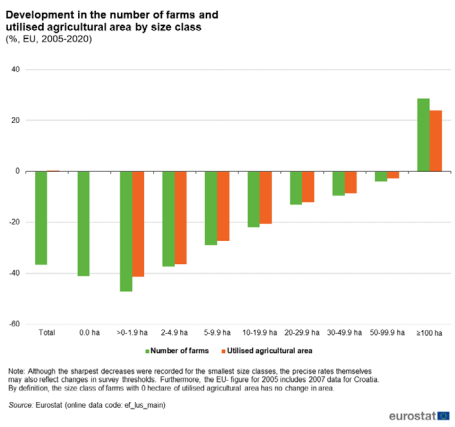


**Figure 1**: Development in the number of farms and utilized agricultural area by size class, source (Eurostat, 2022)

Farms below 100 ha declined both in numbers and in area cultivated, while large farms, which cultivated over 100 ha, are the only size class that is increasing both in numbers and in total area cultivated in the EU. Moreover, it has been shown that as farms grow larger, they also specialize in cereal cropping and grazing livestock at the expense of permanent crops, granivores, and mixed farming (Neuenfeldt et al., 2019).
It is worth noticing that for decades this structural transition was seen as a desirable outcome, and it has been historically the main focus of agricultural policies promoted by the EU and by member countries. Especially in the first decades of European integration and in the southern countries, the agricultural sector still employed a vast workforce in small farms with low productivity, meaning that capital intensification and farm enlargement became two key objectives in order to increase farm incomes and to free up workforce for a developing industrial sector.
The trend of farm and land concentration can be reasonably expected to continue also in the coming decades, but whether this is an inevitable and desirable process is not straightforward. For instance, the relationship between farm size and productivity is not necessarily linear, and especially given the heterogeneity of farm specializations, it might well be that in many situations, smaller farms are more efficient and more dynamic.

A second aspect closely related to this first one is given by the demographics of the agricultural workforce. Figure 2 displays the age class of farm managers in the EU. The majority of farmers are older than 55 and young farmers (under 35) are only 6.5 %.

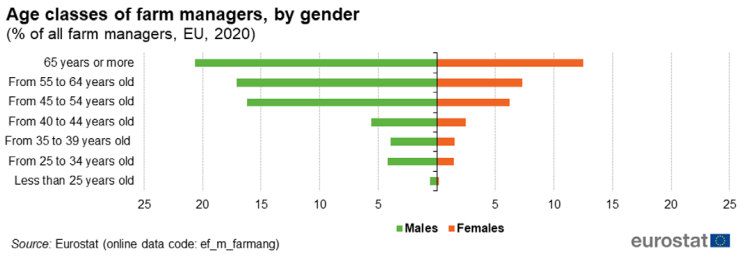


**Figure 2**: Age classes of farm managers, by gender, source (Eurostat, 2022)

Overall, older farm managers tend to work on smaller farms, but the figures are quite heterogeneous at the spatial level, meaning that in some regions, farm managers are even more disproportionately older. Coupled with the general decline in rural population, these figures highlight the potential for very significant issues in the generational renewal of farmers, which could be particularly acute in less developed or mountainous rural areas. These demographic shifts can be particularly concerning given the multifunctional importance of the sector, as the abandonment of farming could undermine the preservation of landscape and infrastructure, the maintenance of cultural heritage, and the delivery of critical environmental and water management functions.

# 3. Environmental Constraints

Agriculture has a unique dual relationship with the environment. Unlike other industrial sectors that can operate in controlled environments, most of the agricultural production is inherently tied to biological and climate cycles, and weather (for instance, in the form of Growing Degree Days (GDD), i.e., accumulated heat over the growing season) can indeed be considered as a primary input of production.

However, this dependence is reciprocal. Despite being the sector most sensitive to shifting weather patterns, agriculture is also a major contributor to environmental decline, with its activities responsible for up to 22% of global GHG emissions (IPCC, 2022). Its impact is, however, not only related to climate change, but also to other environmental damages, like biodiversity loss, water pollution, and biogeochemical cycles. A popular framework that is employed to visualize the extent of contributions to environmental degradation is Planetary Boundaries, which provides a way to assess the sustainability of our society on multiple environmental dimensions, indicating the safe environmental space in which a society can sustainably operate. The chart in Figure 3 (te Wierik et al., 2025) shows that the global food systems are currently estimated to be beyond all nine food system boundaries, and for at least five of them, they also exceed the whole society boundaries.

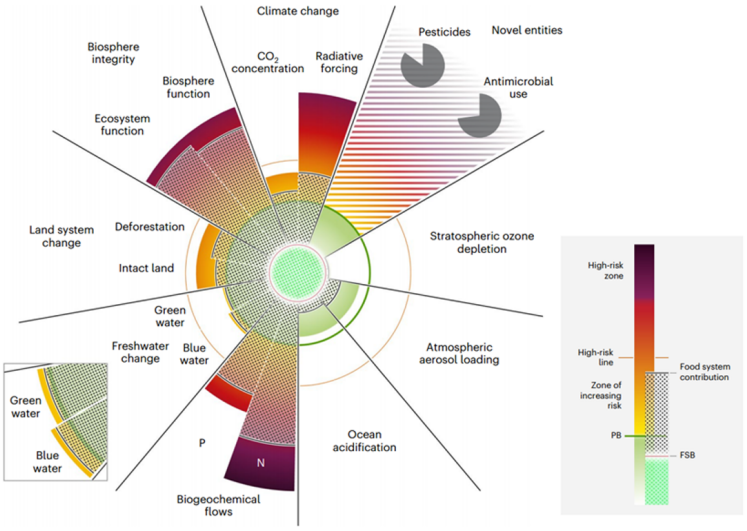


**Figure 3**: Status of the food system across PBs and the FSBs. The pink circle indicates the food system boundaries (FSBs), and the green circle indicates planetary boundaries (PBs), source (te Wierik et al., 2025)

However, identifying an optimal and feasible policy pathway to address environmental degradation remains a formidable challenge, given the complexities underlying the society-environment nexus. For climate change mitigation, a recent scenario analysis (Fellmann, 2025) provides a clear intuition of the tradeoffs faced in the EU by modeling two divergent CAP policy scenarios for 2040. In the first scenario, policies prioritize productivity and investment, and yield increased output and lower food prices, but also higher agricultural emissions. Policies in the second scenario are instead centered on environmental and climate action, and successfully reduce local greenhouse gas (GHG) and nitrogen emissions, but at the cost of reduced domestic output, higher consumer prices, and increased reliance on imports, which lead to carbon leakage through shifted emissions elsewhere, with a net effect on global emissions thus being ambiguous.

This example shows that reducing environmental footprints is often inherently difficult, as there is no 'silver bullet' solution that comes without significant compromise. The widespread farmer protests of recent years and the political backlash against the architecture and goals of the European Green Deal further testify to this tension. However, these environmental challenges will not subside. On the contrary, they can be expected to become increasingly acute over the coming decades.

# 4. Empirical Approaches to Climate Impacts

This section briefly introduces the findings of two research projects that aim to identify the impacts of climate change on agricultural production in Italy, using observational data and econometric techniques. These types of analyses provide evidence of the sensitivity of the agricultural sector and of its extent of adaptation to climate change. As a consequence, they prove to be a valuable input to policymakers, allowing for a more precise quantification of adaptation benefits, the identification of high-risk regions, and the allocation of mitigation and adaptation resources.
The first study investigates the evolution of temperature sensitivity and climate adaptation of cereal yields in Italy over the period 1952–2023. We constructed a long panel dataset of agricultural yields provincial data for maize, common wheat, and durum wheat, the three main cereals cultivated in Italy. The novelty of the study is given by the availability of a long time series of yield data, which is complete and covers all Italian provinces. Our results indicate that heat sensitivity for maize decreased significantly over the years, while common and durum wheat displayed unchanged or only marginally declining sensitivity. For instance, while in the first two decades (1952-1969) a 1 °C increase in temperature during the growing season would lead to a 7.5 % drop in maize yields, in the period after 2006, the same increase would lead only to a 2 % change.

In the second paper (Coughlan et al., 2026), we employed a structural model of crop production in order to distinguish between a direct agronomic effect of temperature and an adaptation effect, driven by an adjustment in fertilizer and pesticide use in order to cope with increasing temperatures. We applied the model on Italian farm-level data of corn and common wheat production over the period 2008-2022, and found that farmers do indeed adapt their input use to increases in temperature, and at the median temperature in the growing season, this adaptation offsets 11 % of the temperature damage on corn yields. These results prove once again the tradeoffs and linkages between agricultural production and environmental outcomes, since fertilizers and pesticides are shown to be a possible (yet partial) adaptation measure against climate change, while at the same time their intensive use is a primary cause of environmental degradation related, for instance, to biodiversity loss, eutrophication, or human health risks.

# 5. Conclusions

European agricultural production will face multiple and complex challenges in the coming decades. The dual pressures of structural changes and tightening environmental constraints mean that identifying sustainable pathways will be inherently difficult and subject to significant tradeoffs. As demonstrated by recent policy debates and academic research, there is no "silver bullet" to solve these intertwined issues without significant compromise. Addressing this transition will require a careful balancing of farm productivity and economic viability with unavoidable environmental conditions. In this context, ongoing empirical assessments can provide useful context to help policymakers weigh these differing priorities and support the sector as it adapts to future conditions.

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