*Q Open*, 2025, **5**, qoaf007
https://doi.org/10.1093/qopen/qoaf007
Advance access publication date: 17 February 2025

**Editorial**



# Unravelling complexity of policies for climate change mitigation in agriculture

The agriculture and food industry has long been acknowledged as a significant contributor to climate change, due to greenhouse gas emissions from livestock farming, the application of fertilizers to soils, land-use changes, and energy-intensive practices. Although anticipated contribution to climate change mitigation is limited, agriculture has potential to sequester carbon through regenerative farming techniques, reduce emissions through optimized farming practices and livestock policies, and generate renewable energy sources like biofuels. Similarly, the food industry's exploration of alternative production methods, reduction of food waste, its role in dietary shifts, and adoption of circular economy principles have begun to redefine its role from a contributor to a solution-provider in the fight against climate change. This paradigm shift emphasizes the need to more holistically integrate the agricultural and agri-food sector into comprehensive climate policy frameworks and research. The integration, however, has been rather loose.

Until now, research on climate change mitigation has been mainly conducted within segregated domains, such as (1) environmental studies focusing on greenhouse gas (GHG) emission, nutrient cycles, soil and water quality etc. (e.g. Andrade et al. 2021 and Bhattacharyya et al. 2022); (2) farm-level management and behavioural economics addressing adoption of climate-friendly management techniques (e.g. Knook et al. 2020, Mills et al. 2020, and Barreiro-Hurle et al. 2023); (3) consumer and market studies targeting changing diet, labelling, as well as pricing mechanisms (e.g. Latka et al. 2021, Edenbrandt and Lagerkvist 2021, and Lemken and Langen 2023); and (4) simulation modelling of policy instruments and/or scenarios on regional scale on the production side (e.g. Perez Dominguez et al. 2020, Dumortier and Elobeid 2021, and Jansson et al. 2021) or demand side (e.g. Säll and Gren 2015). Experts and their findings usually stayed within their domains, so no complete picture of climate change mitigation in agriculture could be drawn. For this reason, the editors of this special section organized an European Association of Agricultural Economists (EAAE) seminar in Berlin in October 2022 with the specific purpose to provide a discussion forum and bring together agricultural economists working on climate change mitigation. The articles in this special section explore the complexities of climate policy choices and their impact on environmental and welfare outcomes. Although their scope and methodological background differ, the articles intersect in common challenges we summarize below.

The first challenge refers to the choice between a regulatory approach and reliance on market forces. The former means setting up targets of emission reduction across the vertical (farm—regional—global scale) and the horizontal (sectoral) dimensions, for example, uniform standards and limits for all farms. The latter implies pricing agricultural emissions, so that emission reduction is encouraged at farms with the lowest marginal abatement costs. The findings by Tarruella et al. (2023) confirm that market-based policies are more cost-effective, as they allow heterogeneous economic agents to respond according to their circumstances and preferences. In the current EU climate architecture, quantitative emission reduction targets by Member State are set in the Effort Sharing Regulation (EU) 2018/842 for all emission sources, including agriculture outside energy and heavy industry covered by the EU's Emissions Trading Scheme (excluding emissions from the Land Use, Land Use Change, and Forestry (LULUCF) sector which are covered in a separate

Regulation). The national emission reduction targets use per capita gross domestic product to capture the heterogeneity among the Member States when distributing the common climate targets. The differences in national abatement costs, in contrast, are not taken into account for the current allocation of climate targets. Moreover, assuming an equal contribution of every Effort-Sharing sector to the common targets within each Member State also ignores the heterogeneity of abatement costs across sectors. On the one hand, previous research quantified the marginal abatement costs of GHG reduction in agriculture as higher than in other Effort-Sharing sectors (Kokemohr et al. 2022 for a Norwegian case study). While the increasing digitalization of agriculture may close the gap to other sectors (Finger 2023), there is also a risk that due to the heterogeneous adoption of new technologies the already high heterogeneity within agriculture increases. On the other hand, the share of agricultural emissions in the Effort-Sharing emissions balance differs across the Member States. In this regard, some EU Member States define national climate targets specifically for agriculture that are usually substantially below a proportional contribution of agriculture to the Effort-Sharing targets (Spiegel et al. 2024), and it remains unclear whether the lower contribution of agriculture to these targets would be compensated by other Effort-Sharing sectors. This inconsistent approach to emission reductions targets across Member States (vertical) and Effort-Sharing sectors (horizontal dimensions) results in a remarkable heterogeneity across Member States in terms of agricultural climate policies and their progress in reducing agricultural emissions (Spiegel et al. 2024). To this end, while explicitly formulated emission reduction requirements under a regulatory approach seem attractive, especially in light of binding climate targets, in practice emission targets result in uncoordinated national mitigation policies in agriculture and neglect marginal abatement costs of mitigation efforts that could be optimized via market forces.

Both a regulatory approach and a pricing mechanism for emissions reduction require emission accounting, and the second challenge is the difficulty to accurately monitor GHG emissions in the agricultural and food sector. Adequate accounting systems which can link management practices of farmers and other actors to climate outcomes are needed. Establishing an efficient regulatory system as well as monetary incentives to achieve mitigation at low cost remains a challenge, not least because it involves many actors with different goals (such as dairy companies, farmers, or policy-makers). The fact that Denmark has a relatively low number of agricultural holdings[1] (37,090) compared to many other countries like Italy (1,130,530) or France (393,030) and an already well-developed system of collecting farm data helps to explain why Denmark is pioneering in agricultural carbon pricing (Svarer et al. 2024).

The third challenge is likewise relevant for both a regulatory approach and a pricing mechanism and goes back to the global nature of climate change. Carbon leakage is one of the major barriers to introducing a climate policy, especially in agriculture, since carbon leakage risk in agriculture is estimated to be comparable to that of energy-intensive and trade-exposed industrial sectors in the organisation for economic co-operation and development (Fournier Gabela and Freund 2023). Carbon leakage is mainly caused by a competitiveness loss due to unilateral climate policy. Nordin et al. (2024) quantify the effects of different designs of a Carbon Border Adjustment Mechanism (CBAM) aiming to level up differences in climate policies at the EU borders. In fact, the global emission reduction may be limited despite a CBAM due to comparatively high emission efficiency of the EU agriculture combined with low price elasticities of demand for emission-intensive food in the EU. Nordin et al. (2024) demonstrate that a CBAM is not a straightforward solution to the carbon leakage issue and has to be complemented by other policies, for example, targeting emission efficiency or a shift in demand towards animal-free proteins (Agora Agriculture 2024). At the same time, Mittenzwei et al. (2023) add that a uniform emission cut based on multilateral negotiations would likely result in a 'lowest common denominator' outcome, hence causing a lower total emission cut than if each

country would freely decide on its own policy. On the other hand, while a unilateral climate policy might be more ambitious, it runs the risk to initiate carbon leakage that requires a more sophisticated and multidimensional solution than a CBAM.

The last but not least challenge refers to the lack of a clear political will for higher contributions from agriculture to greenhouse gas mitigation targets. There is also a lack of concrete proposals on policies to reduce GHG emissions and limited knowledge on how society views the role of agriculture. We see how many assumptions the articles in this special section have to make in their analyses, and there are still plenty of scenarios to simulate and evaluate. The outlook for post-2030 is highly uncertain. Carbon pricing provides a good example of this challenge. Even if carbon pricing would evolve as a relevant option for Europe's agricultural climate policy, whether it would be an extension of the existing EU ETS system, a separate system similar to Cap and Trade, a GHG emission certificate, or a tax, would still need to be decided, although a comprehensive overview of alternatives and practical examples is available (European Commission 2023). A follow-up progress report on agricultural emissions reduction by the European Scientific Advisory Board on Climate Change (ESABCC 2024) formulates issues to be taken into account when introducing a carbon pricing scheme for agriculture, including the technical complexity of measuring emissions and removals, and its potential environmental and socio-economic impact. The Scientific Advisory Board expects to deliver its recommendations on climate change mitigation and climate resilience in agriculture in the second half of 2025 (ESABCC 2025). At the same time, work is continuing on defining the methodologies for certifying carbon removals under carbon farming following adoption of Regulation (EU) 2024/3012 on carbon removals and carbon farming, although the use case for these certificates has yet to be clarified.

To conclude, the discourse on climate policy in agriculture faces multiple challenges. The intricate interplay between heterogeneity of European agriculture and the lack of precise political direction, exemplified by the uncertainties surrounding post-2030 scenarios, necessitate further analysis, simulation, and robust policy formulation. Agri-food systems can and should play a much bigger role in climate policies (Mirzabaev et al. 2023). As the EU advances towards climate neutrality in other sectors, agriculture's role in climate policy will inevitably grow. Unlike other sectors, agriculture cannot achieve zero emissions, so its remaining emissions must be offset through enhanced carbon sequestration in other sectors, mainly the LULUCF sector. We hope the EAAE seminar and this special section will serve as a kick-off for further initiatives facilitating the dialogue between policy-makers, experts, and stakeholders on climate change mitigation in agriculture.

## Acknowledgements

First, we thank the European Association of Agricultural Economists (EAAE) for supporting the 181st EAAE seminar on 5–7 October 2022, in Berlin, Germany. Next, we thank QOpen, the editorial team, and, in particular, Iain Fraser for his initiative and support in launching the special issue. Last but not least, we thank all the authors of this special section, reviewers, and the EAAE seminar 181 participants for their input.

## Conflict of interest

None declared.

## Data availability

No new data were created or analysed in this study. Data sharing is not applicable to this publication.

## End Note

1 The numbers of agricultural holdings are as of 2020. Source: Eurostat.

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