Climate Change Mitigation in Agriculture beyond 2030: Options for Carbon Pricing and Carbon Border Adjustment Mechanisms

Atténuation du changement climatique dans l'agriculture après 2030 : options pour la tarification du carbone et les mécanismes d'ajustement aux frontières

Klimaschutz in der Landwirtschaft nach 2030: Optionen für Carbon-Bepreisung und Carbon-Obergrenzen

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Introduction

In the Paris Agreement on Climate Change, a consensus was reached among 196 participating entities, reaffirming their commitment to undertake decisive and expeditious worldwide measures to mitigate greenhouse gas emissions (GHG) for '… holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels' (EC, 2018). Attaining these ambitious targets within the European Union (EU) will necessitate substantial endeavours encompassing all economic sectors, including the agricultural sector.

In the EU's current climate policy, there are three pillars: (i) the Emissions Trading System (ETS), (ii) the non-ETS or effort-sharing pillar (ESR), and (iii) the Land Use, Land Use Change and Forestry (LULUCF) sector. The agricultural sector falls under the ESR pillar until 2030, with targets for the entire ESR pillar (European Parliament, 2023). Under the revised ETS Directive, the ETS will be extended to maritime transport and fuels for road transport and buildings. After 2030, agriculture and LULUCF will be the only sectors not directly addressed by carbon pricing (European Council, 2023). This paper shows that mitigation measures for the agricultural sector to 2030 and beyond are lacking, while the climate policies of EU Member States (MSs) in agriculture are isolated and imply neither coordination nor collaboration between the MSs. We provide reflections and policy recommendations to address these issues.

What can we learn from climate targets 2020 and 2030?

When formulating the EU-wide multisectoral targets, the question of their allocation among individual countries and sectors inevitably arises. The ESR climate targets for 2020 and 2030 offered an answer to the national distribution (based on national GDP per capita) but not the sectoral one. Only some EU Member States have formulated climate targets for agriculture, e.g. Denmark (Klimaraadet, 2023) or France (Ministères Écologie Énergie Territoires, 2015). Despite the EU-wide policy framework in the form of the Common Agricultural Policy, there are no formulated climate targets specifically for agriculture at the EU level. This might have been one of the reasons why agriculture contributed less to GHG reduction up to 2020 than other ESR sectors in most of the EU Member States (Figure 1).

> "L'inclusion du secteur agricole dans un système de tarification du carbone semble être une approche prometteuse pour atteindre les objectifs climatiques nationaux et régionaux."

Figure 1 demonstrates that most EU Member States project less GHG emission reduction in agriculture by 2030 (in % of 2005 level, x-axis) than targeted for all ESR sectors (y-axis) except Croatia. For instance, Germany's target is to reduce GHG emissions from the ESR sectors by 50

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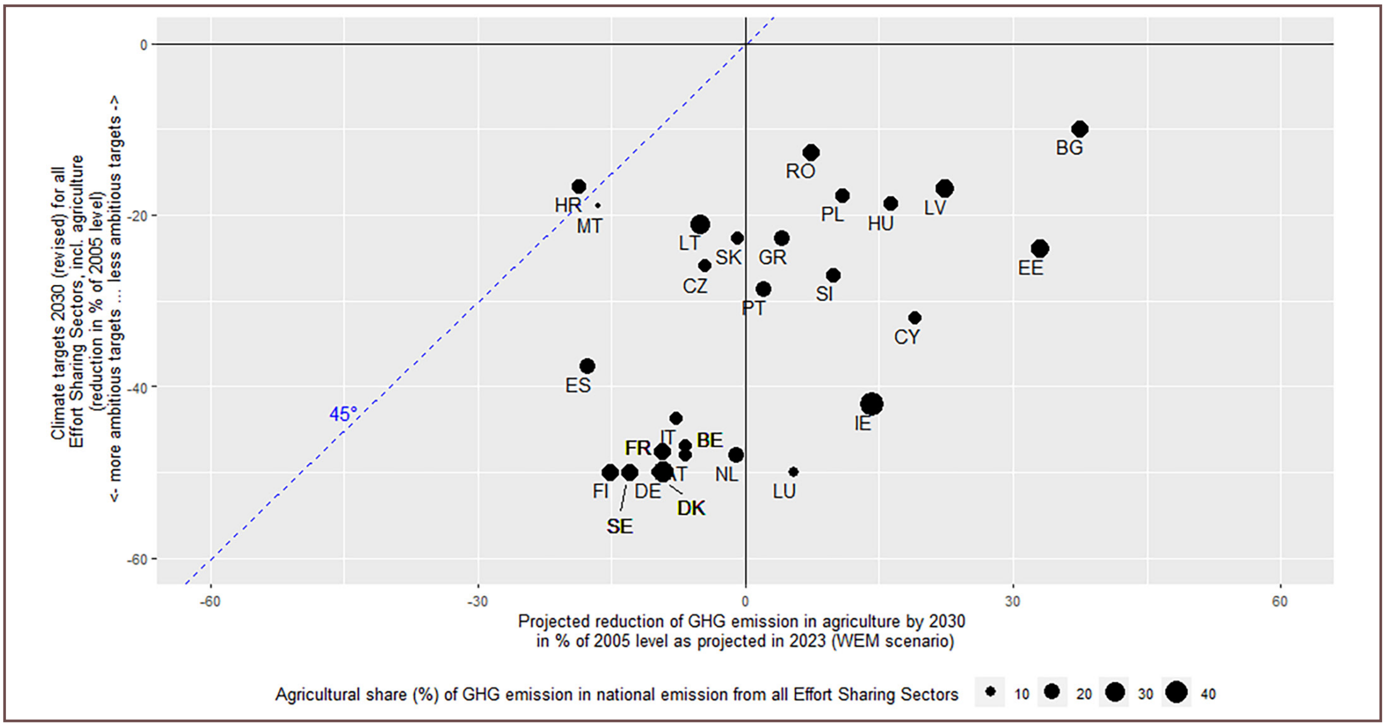
Figure 1: ESR climate targets 2030 and projected GHG emission reduction in agriculture by 2030



Note: For Sweden, projections submitted in 2021 were used since the data for 2023 are not available.
Source: Authors' elaboration based on data from the European Environment Agency (2023) and European Parliament (2018).

per cent of the 2005 level, yet its agricultural sector is projected to achieve less than a 10 per cent reduction (Figure 1). Many Member States are projected to emit even more GHG from the agricultural sector by 2030 compared to 2005 despite reduction targets for the ESR sectors (the right-hand side of Figure 1). It means that other ESR sectors must compensate for a GHG increase in agriculture and achieve the targets independently. This is particularly critical in Member States with a relatively high share of agricultural GHG emissions in the ESR GHG balance, like Ireland (see the size of the bubbles in Figure 1). The reader should note, however, that a reduction of agricultural GHG emissions might be linked to carbon leakage in some cases. For instance, Malta (Malta. BR5, 2023) admits that a decrease in livestock population accompanied by increased import of meat and dairy products contributed much to GHG emissions reduction in agriculture in the past. The same issue might apply to imported feed. We discuss carbon leakage in greater detail later in the paper.

This means that a proportional contribution of all ESR sectors to 2030 climate targets is not observed and cannot be expected, due to the heterogeneous costs of GHG reduction across countries and sectors. Indeed, assuming proportional allocation of ESR climate targets to all ESR sectors, including agriculture, we see that some Member States face a heavier burden

Anaerobic digesters are the most effective technological option in terms of mitigated emissions in livestock-producing Western European countries © Michael Welling, Thuenen Institute.

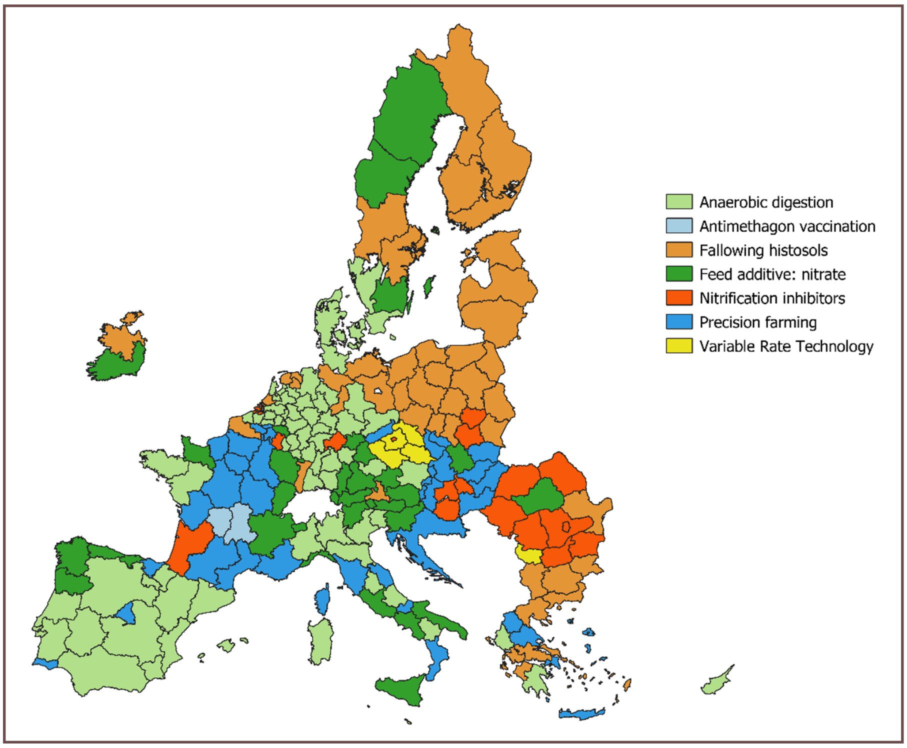
on agriculture due to a higher GDP per capita combined with a higher share of GHG from agriculture, like Ireland and Denmark. As a result, MSs with the most ambitious climate targets are also further away from achieving them in the agricultural sector if we assume proportional sectoral allocation of climate targets. We additionally see that Member States with more ambitious climate targets have intensive agriculture (Spiegel *et al.*, 2023). So, there is little space for cost-effective climate change mitigation due to the high marginal abatement cost. Instead, more innovative solutions are required. These MSs need to invest a lot into R&D (and they do) to develop new practices. Policymakers should realise that climate targets cannot be achieved only by cost-effective measures to increase efficiency. This is even more the case if climate targets after 2030 are strengthened. One example of a more radical innovative solution is carbon pricing in agriculture. The following section considers it in greater detail.

What role can market-based instruments such as carbon pricing play?

Considering GHG emissions as negative externalities of agricultural activity, their reduction can either be achieved by government regulation or via a market-based instrument. The former includes setting limits or regulations for emission reduction; the latter means introducing a price for GHG emissions. While regulatory mechanisms for GHG emissions in agriculture are already in place in the EU, for example through the Common Agricultural Policy, market-based instruments for GHG emissions reduction are still missing. But carbon pricing is a cost-effective mechanism that can be utilised to limit GHG emissions by creating financial incentives through price signals (World Bank, 2021). Moreover, for other sectors outside agriculture and land use, carbon pricing instruments in the form of carbon taxes or emissions trading systems are already widely accepted. As of the year 2023, a total of 73 carbon pricing instruments have been implemented worldwide, encompassing approximately 23 per cent of GHG emissions (World Bank, 2023). Carbon tax involves imposing a predetermined, fixed price on GHG emissions. Entities that emit carbon are required to pay this tax based on the quantity of emissions they release into the atmosphere. On the other hand, emissions trading systems (ETS) implement a quantitative restriction on the allowable amount of GHG emissions per entity. These emissions allowances or permits are distributed among the regulated entities. If an entity exceeds its allocated allowance, it must purchase additional permits to cover the excess emissions. The price of these permits is determined by the market based on the supply and demand for emission permits. Therefore, while carbon tax assures cost certainty, ETS assures environmental certainty.

A recent study by Poppe *et al.* (2021) concludes that carbon credits might be a cost-effective solution to the problem of peat soils in agricultural use in the Netherlands. Stepanyan *et al.* (2023) show that 100€/t CO_2eq carbon tax on EU agriculture can reduce the GHG emissions in 2030 by about 93 million tonnes of CO_2eq, therefore, reducing the gap between the total projected and targeted 2030 emissions in the EU by 14 per cent. This study finds that over half of the emissions reduced in the EU agricultural sector can be attributed to technological mitigation options, and the rest to production changes. This highlights the importance of allocating resources to research and development (R&D) initiatives that focus on creating cost-effective and easily implementable mitigation technologies specifically tailored for the European Union (EU) agricultural sector. It is essential to take into account both the economic feasibility and environmental consequences of these technologies. Additionally, the impact of these technologies goes beyond pure GHG mitigation. For example, they can benefit the Water Framework Directive by reducing runoff and leaching, emphasising the broader environmental implications of investing in such R&D initiatives. Figure 2 presents the most effective technological options in terms of mitigated emissions at NUTS-2 level. Anaerobic digesters are most effective in livestock-producing Western European countries with, on average, larger farm sizes. The costs of anaerobic digesters are farm

Figure 2: Most effective technological mitigation measure in terms of mitigated emissions at NUTS-2 level



Source: Authors' development based on Stepanyan *et al.* (2023).

size-dependent, meaning that the larger the farm size in livestock units, the lower the costs. The technologies targeting the animal sector, other than anaerobic digesters, are utilised in regions with a high share of animal production but, on average, small farm sizes. The potential for fallowing histosols is also substantial, and it is the dominant mitigation measure in countries that have a high share of histosols on grassland and arable lands. Note that only the N2O emissions from histosols are reported here being categorised under the Agricultural Emissions classification by UNFCCC; the CO2 emissions from histosols are reported under the LULUCF emissions. Mitigation technologies targeting the crop sector are most effective in regions characterised by a higher share of crop production and high overfertilisation rates. Additionally, these mitigation technologies also play a significant role in reducing emission leakage to third countries. Given the potential for further reduction in leakage rates through consumer-side policies and border taxes, the inclusion of the agricultural sector in a carbon pricing scheme appears to be a promising approach towards achieving national and regional climate targets (see Box 1). The simulated carbon price negatively affects consumer welfare due to increasing prices. However, the relative change in consumer welfare is negligible – around 0.04 per cent. Animal products show the highest price increase, consequently reducing their consumption. Beef meat, in particular, shows the highest consumer price increase, i.e. 8.2 per cent, leading to a reduction of human consumption of beef by around 4.4 per cent.

Isermeyer *et al.* (2019) examine to what extent carbon pricing could be introduced in the agricultural sector and what challenges would have to be overcome. Two challenges are particular for the agricultural sector: first, due to many actors and diffuse emissions (in contrast to industrial plants for example) the determination and also the control of emissions is challenging and might cause high transaction costs; second, the

Agriculture is now seen not only as a sufferer of climate change but also as an important mitigator © Melina Niemann, Thuenen Institute.

avoidance of emissions in Europe might cause relocation effects, so-called leakage effects. The transaction costs of measuring emissions and their control might be reduced if 'bottlenecks' were utilised. For example, a 'bottleneck' for the nitrous oxide emissions could be the fertiliser industry. Here, one can target a reasonable number of companies. As for carbon leakage, leakage within the EU is minimised as long as climate targets EU-wide are consistently and consequently enforced. This could also lead to production shifts within the EU, but the common EU targets can still be reached. Yet, carbon leakage to third countries is considered as one of the major concerns that could hamper the introduction of carbon pricing or another mitigation instrument in a particular country or region. We devote the final section to strategies for minimising leakage.

How can we minimise carbon leakage?

Carbon leakage happens when a country's or region's mitigation policy increases GHG emissions in countries or regions with laxer climate policies. In agriculture, this spill-over effect could occur if domestic carbon pricing raises the production costs of emission-intensive goods produced domestically relative to goods produced abroad. This competitiveness loss could mean cheaper foreign products substitute domestic products in domestic and foreign markets. As a result, production and GHG emissions could rise in foreign countries. Importantly, because many agricultural products have a much higher emission intensity in foreign countries, this production expansion could offset much of the original emission savings envisaged by the domestic mitigation policy. For example, if the production of a certain agricultural product expands in countries with large amounts of native forests, like Brazil or Indonesia, this could generate large amounts of CO_2 emissions through deforestation. Furthermore, carbon leakage risk reduces the required social and political support necessary to achieve climate targets in time. For example, carbon leakage risk counts as one of the main barriers to pricing European agricultural GHG emissions (Grosjean *et al.*, 2018).

Box 1: Carbon pricing in agriculture in practice.

New Zealand and Denmark recently announced the introduction of carbon pricing into their agricultural sectors. It is little wonder these two countries are pioneering, as both are characterised by high shares of agricultural emissions and ambitious climate targets. Nevertheless, the exact implementation of carbon pricing in agriculture in these two countries remains unclear. In New Zealand, it is still under discussion whether agricultural emissions will be priced via the country's ETS or via an alternative system still to be developed by 2025 (Ministry for the Environment and the Ministry for Primary Industries, 2022). In 2022, such an alternative pricing system was outlined, resulting from stakeholders advocating for a so-called farm-level 'split-gas levy', i.e. separate prices for emissions from biogenic methane and nitrous oxide (*ibid.*). The Danish government plans to introduce a carbon tax to the agricultural sector (European Commission, 2023a), which would gradually rise to about 750 DKK (~100€) by 2030. A study by the Danish Council on Climate Change on the effects of adopting such a tax shows that it is likely to incentivise structural changes since few cost-attractive mitigation options are available, especially in the cattle sector (Danish Council on Climate Change, 2023). Significant effects might also be expected abroad depending on the implementation of carbon pricing in agriculture in both countries. Likewise, it remains unclear whether other countries could copy the developed carbon pricing mechanisms since both agricultural sectors have certain peculiarities, and the mechanisms should be tailored accordingly. A recent consultancy study by the European Commission (2023b) offers a comprehensive overview of carbon pricing models in agriculture, including theoretical underpinning and some practical examples.

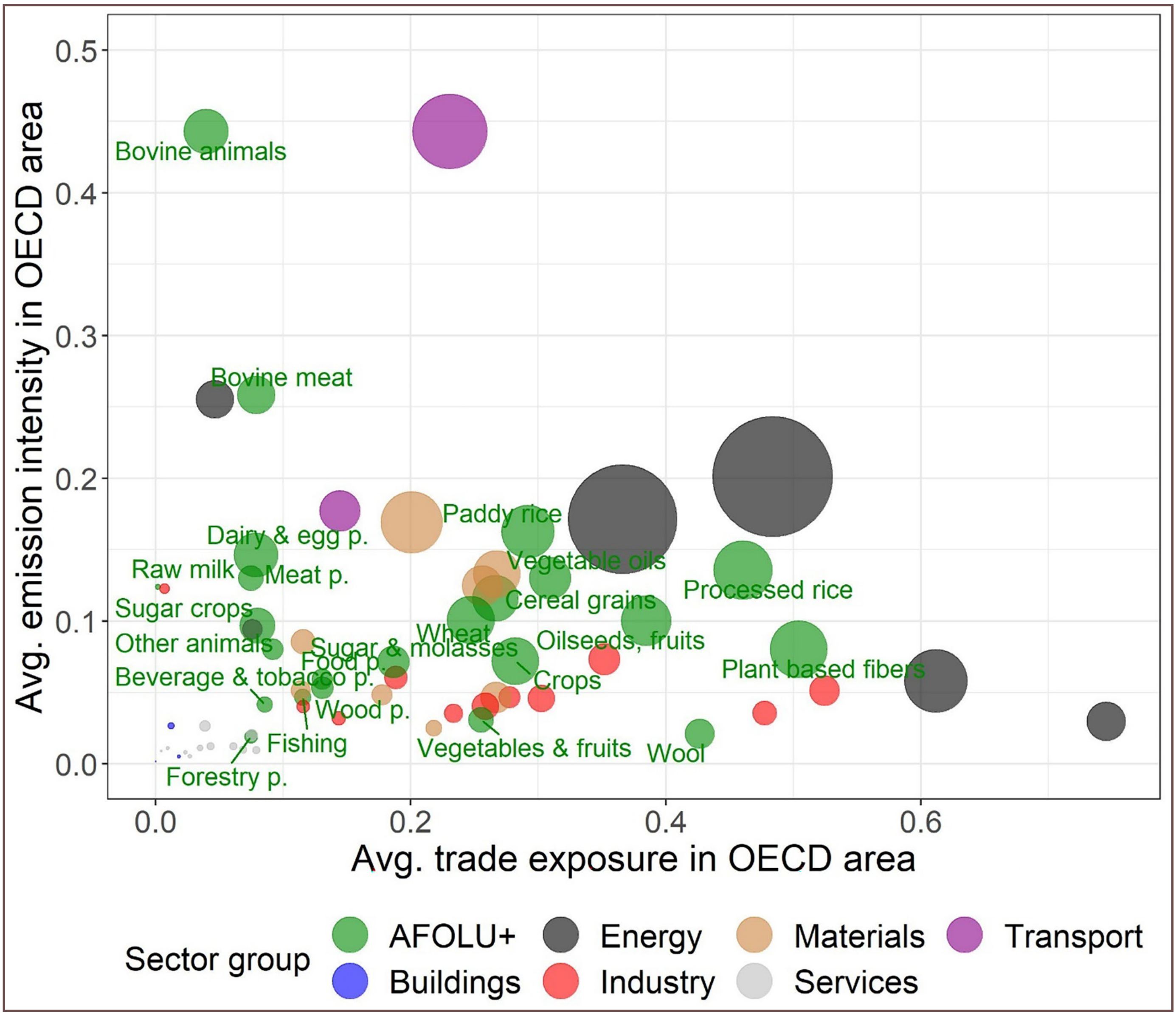
"Die Einbeziehung des Agrarsektors in ein CO2-Preissystem scheint ein vielversprechender Ansatz zur Erreichung nationaler und regionaler Klimaziele zu sein."

Several articles simulating unilateral carbon pricing in agriculture find relatively high carbon leakage magnitudes (Arvanitopoulos *et al.*, 2021). A recent article shows for the first time that potential carbon leakage risk in agriculture might be comparable to that of energy-intensive and industrial sectors in OECD countries (Fournier Gabela and Freund, 2023). Importantly, this study also shows that this risk is not only considerable if agricultural GHG emissions are subject to a carbon price but also if agricultural production inputs become more expensive due to mitigation policies in other economic sectors, such as fertilisers. Figure 3 shows sectors' emissions intensity and trade exposure indicators under a hypothetical scenario in which both sectors' direct emissions from production as well as indirect emissions from inputs used in production bear carbon costs. Multiplying these two indicators, the method used by the EU-ETS to identify sectors vulnerable to carbon leakage, one finds that many agricultural sectors would enter the list of the most vulnerable sectors. Under the different climate policy scenarios, these sectors include bovine animals, bovine meat, processed and paddy rice, plant-based fibres, cereal grains, wheat and vegetable oils. Naturally, the previous carbon leakage magnitude depends on several factors, including mitigation efforts in other countries, foreign products' emission intensities and consumer preferences.

High-ambition countries can reduce carbon leakage risk from unilateral agricultural mitigation policies in two complementary ways (Matthews, 2022). Firstly, they can strive to reduce foreign products' emission intensity. For example, they can encourage greater climate action in foreign countries and provide financial and technical assistance, e.g. for more climate-smart agriculture in these countries. These objectives can be pursued through different types of intervention, including multilateral climate agreements, such as the Paris Agreement's Financial and Technology Transfer Mechanism, tariff-based preferences in trade agreements, and mandatory due diligence requirements. However, although these mechanisms offer several advantages, they also have different disadvantages. For example, while tariff-based mechanisms can foster climate action in partner countries, trade agreements could bring about further competitiveness losses due to increased imports. Furthermore, although several countries have already pledged in their Nationally Determined Contributions to increase mitigation efforts in the agricultural sector, the Paris Agreement does not reduce concerns about carbon leakage due to the lack of policy harmonisation and enforcement mechanisms (King and van den Bergh, 2021).

Second, high-ambition countries or regions can also try to offset domestic producers' competitiveness losses. A carbon border adjustment mechanism (CBAM) offers an interesting solution in this direction.

Figure 3: GHG emission intensity versus trade exposure across different sectors in OECD countries



Notes: The area of a bubble is proportional to the cross-country variation of the EITE metric in OECD countries.
Source: Authors' elaboration, adapted from Figure 3 in Fournier Gabela and Freund (2023) licensed under CC-BY-4.0.

The idea behind the CBAM is to impose the domestic carbon price on the emissions embodied in imported products and rebate exported products from domestic carbon costs. This way, domestic products would compete on equal terms in domestic and foreign markets. An advantage of a CBAM compared to excluding or compensating high carbon leakage risk sectors, e.g. through the free allocation of emission allowances, is that it does not weaken the carbon price signal. Furthermore, an agricultural CBAM could benefit from the experience and capacities acquired through the EU-CBAM, which, starting in 2026, will gradually replace the current free allocation system. However, although it might sound simple in theory, implementing a CBAM is complex due to several factors, including data limitations, legal constraints and equity considerations (Böhringer *et al.*, 2022). For example, compared to import and export levies implemented in the EU before 1985, the CBAM calculation would have to be based on carbon prices instead of market prices and on emissions embodied in traded products. Moreover, compared to other sectors, an agricultural CBAM would imply further difficulties. For example, the accurate measurement, reporting and verification of agricultural GHG emissions is complicated due to the diffuseness and multiple sources of these emissions. Likewise, an agricultural CBAM could represent an unacceptable burden on less developed countries due to their high dependence on agricultural exports, and raise concerns related to food security. Although reducing the scope of the CBAM system could help overcome some of these difficulties, such a system could reduce the effectiveness of CBAM in reducing carbon leakage. Because of this, interested countries need to thoroughly evaluate the benefits and costs of an agricultural CBAM before implementing it, including its

Support of climate-smart agriculture abroad, e.g. via investments in research and development, can reduce carbon leakage © Folkhard Isermeyer, Thuenen Institute.

alignment with the objectives of the Paris Agreement.

> "The inclusion of the agricultural sector in a carbon pricing scheme appears to be a promising approach towards achieving national and regional climate targets."

Policy conclusions

Ambitious action in climate mitigation in agriculture is crucial for meeting the climate neutrality targets in Europe. Currently, multisectoral climate targets have been defined until 2030, and mitigation measures have been proposed in national climate mitigation plans. However, the expected contribution of agriculture by 2030 and beyond remains unclear, as well as pathways to reach it. In the outline above, we discussed options for carbon pricing and instruments to reduce leakage when introducing a market-based instrument. We conclude with three take-home messages. First, any of the options requires coordinated policy. The agricultural sector needs more precise guidance for climate change mitigation. The whole food system, including food processing and final food consumption, must be considered for policy impact analysis as carbon pricing is transferred from production to the consumer level. Second, climate change mitigation actions can cause carbon leakage and conflict with goals such as biodiversity gain, food production and farm income. Although preventing all of them is impossible and inefficient, a policy should minimise adverse effects. One can expect other countries to follow Danish and New Zealand examples of carbon pricing in agriculture. Although each nation considers its framework and characteristics when designing such a policy instrument, a uniform design would reduce adverse effects and the need for border adjustments. Finally, unlike other sectors they talk about low-carbon rather than climate-neutral agriculture (Chen *et al.*, 2022). Agricultural GHG emissions can only be minimised and compensated by negative emissions in other sectors, e.g. the LULUCF sector. This fact requires clear links between the sectors in GHG balancing and highlights the need for well-defined climate targets for agriculture.

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Summary

Climate Change Mitigation in Agriculture beyond 2030: Options for Carbon Pricing and Carbon Border Adjustment Mechanisms

In the EU's climate policy, agriculture is covered as an Effort-Sharing (ESR) sector, i.e. a sector beyond the Emission Trading System and LULUCF. Despite ambitious climate targets for the ESR sectors and an emerging focus on the need for agriculture to make a substantial contribution to climate change mitigation, agriculture has contributed much less to achieving climate targets than other ESR sectors in most EU Member States. A more radical mitigation instrument is required since the potential to increase climate efficiency in EU agriculture is limited. Carbon pricing is considered an effective instrument and is widely adopted in other sectors worldwide. Options on how to reduce related carbon leakage are discussed. Our recommendations for efficient climate change mitigation policy in agriculture are threefold. First, the agricultural sector needs more precise guidance and clear climate targets. Second, although preventing all conflicts between climate change mitigation actions and other policy goals is impossible and inefficient, a policy could minimise adverse effects. Third, since agricultural GHG emissions can only be minimised and compensated by negative emissions in other sectors, well-defined intersectoral coordination is required.

Atténuation du changement climatique dans l'agriculture après 2030 : options pour la tarification du carbone et les mécanismes d'ajustement aux frontières

Dans la politique climatique de l'Union européenne, l'agriculture est considérée comme un secteur de partage de l'effort, c'est-à-dire un secteur au-delà du système d'échange de quotas d'émission et de l'UTCATF. Malgré des objectifs climatiques ambitieux pour les secteurs de partage de l'effort et une attention croissante portée à la nécessité pour l'agriculture d'apporter une contribution substantielle à l'atténuation du changement climatique, l'agriculture a beaucoup moins contribué à la réalisation des objectifs climatiques que les autres secteurs de partage de l'effort dans la plupart des États membres de l'Union européenne. Un instrument d'atténuation plus radical est nécessaire car le potentiel d'augmentation de l'efficacité climatique dans l'agriculture européenne est limité. La tarification du carbone est considérée comme un instrument efficace et est largement adoptée dans d'autres secteurs à travers le monde. Nous examinons les options sur la manière de réduire les fuites de carbone associées. Nos recommandations pour une politique efficace d'atténuation du changement climatique dans l'agriculture sont triples. Premièrement, le secteur agricole a besoin d'orientations plus précises et d'objectifs climatiques clairs. Deuxièmement, bien qu'il soit impossible et inefficace de prévenir tous les conflits entre les mesures d'atténuation du changement climatique et d'autres objectifs publics, une politique pourrait minimiser les effets négatifs. Troisièmement, puisque les émissions de gaz à effet de serre agricoles ne peuvent être minimisées et compensées que par des émissions négatives dans d'autres secteurs, une coordination intersectorielle bien définie est nécessaire.

Klimaschutz in der Landwirtschaft nach 2030: Optionen für Carbon-Bepreisung und Carbon-Obergrenzen

In der EU-Klimapolitik wird die Landwirtschaft als ein Sektor der Lastenteilungsverordnung (ESR) verstanden, d. h. als ein Sektor außerhalb des Emissionshandelssystems und der LULUCF (Landnutzung, Landnutzungsänderung und Forstwirtschaft - **L**and **U**se, **L**and-**U**se **C**hange and **F**orestry). Trotz ehrgeiziger Klimaziele für die ESR-Sektoren und der zunehmenden Erkenntnis, dass die Landwirtschaft einen substanziellen Beitrag zum Klimaschutz leisten muss, hat die Landwirtschaft in den meisten EU-Mitgliedstaaten viel weniger zur Erreichung der Klimaziele beigetragen als andere ESR-Sektoren. Neue Klimaschutzmaßnahmen sind erforderlich, da das Potenzial zur Steigerung der Klimaeffizienz in der EU-Landwirtschaft begrenzt ist. Die Carbon-Bepreisung gilt als wirksames Mittel und wird weltweit und weitreichend in anderen Sektoren eingesetzt. Wir diskutieren Optionen, wie die damit verbundene Verlagerung von Carbon-Emissionen verringert werden kann. Wir haben drei Empfehlungen für eine effiziente Klimaschutzpolitik in der Landwirtschaft: Erstens braucht der Agrarsektor präzise Vorgaben und klare Klimaziele. Zweitens ist es zwar unmöglich und ineffizient, alle Zielkonflikte zwischen Klimaschutzmaßnahmen und anderen Politiken zu vermeiden, aber die negativen Auswirkungen könnten minimiert werden. Drittens: Da Treibhausgasemissionen der Landwirtschaft nur durch negative Emissionen in anderen Sektoren minimiert und kompensiert werden können, ist eine klar definierte sektorübergreifende Abstimmung erforderlich.