Climate adaptation and mitigation in the agri-food system

Recommendations for coherent EU policies

European Scientific Advisory Board on Climate Change

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About the European Scientific Advisory Board on Climate Change

The European Scientific Advisory Board on Climate Change (hereafter 'the Advisory Board') is an independent scientific advisory body that provides the EU with scientific knowledge, expertise and advice relating to climate change. The Advisory Board identifies actions and opportunities to achieve the EU's climate neutrality target by 2050. The Advisory Board was established by the European Climate Law of 2021, with a mandate to serve as a point of reference for the EU on scientific knowledge relating to climate change by virtue of its independence and scientific and technical expertise.

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Recommendations

Only a systemic transition, featuring both structural and technical change, can climate-proof the European agri-food system, while also addressing concerns about the environment, public health and the EU's strategic autonomy. As current EU policies are inadequate to drive the necessary transition, there is a need for a coherent and adaptive policy mix that combines mutually reinforcing instruments and evolves over time as knowledge, technologies and conditions change.

The European Scientific Advisory Board on Climate Change sets out six recommendations to advance climate adaptation and mitigation within the agri-food system and guide ongoing and coming EU policy processes.

Recommendation 1. Gradually remove climate-harmful payments
The EU should remove CAP payments for the most greenhouse gas-intensive practices already over the next CAP period and explore alternatives to replace the current system of broader income support in the longer term.

Recommendation 2. Introduce a greenhouse gas pricing system for agriculture
The EU should introduce a dedicated greenhouse gas pricing system for agriculture, designed to apply the polluter pays principle in a gradual and adaptive manner that encourages the entire agri-food value chain to reduce agricultural emissions and scale up carbon dioxide removals.

Recommendation 3. Provide targeted transition support
The EU should provide targeted financial and non-financial support to farmers to tackle key barriers, seize opportunities, and ensure a fair and just transition, with a key focus on the most greenhouse gas-intensive and/or least climate-resilient production systems with limited transition capacity.

Recommendation 4. Help farmers cope with unavoidable climate-related impacts
The EU should strengthen the set of instruments that help farmers cope with unavoidable climate-related impacts, such as acute losses from extreme climate-related hazards or gradual productivity losses, while ensuring that such instruments do not undermine the incentive for proactive and transformational adaptation.

Recommendation 5. Encourage healthy, climate-friendly diets and reductions in food waste
The EU should establish an overarching food policy framework that promotes healthy, climate-friendly diets and reduces food waste across the value chain, while safeguarding equitable access to sufficient, nutritious and affordable food for all consumers.

Recommendation 6. Ensure adequate public funding
The EU should ensure sufficient and well-timed public funding – as a complement to private funding – to finance transition support, risk-management tools and innovation in the agri-food system. To this end, it should explore different options, including the reorientation of existing resources and mobilisation of new revenue streams.

Summary

Climate-proofing the EU agri-food system is essential for food security and climate neutrality

Climate change is increasingly undermining the EU agri-food system

The EU agri-food system underpins Europe's food security, rural livelihoods and strategic autonomy, while playing a central role in the Union's economy and land stewardship. Spanning the full value chain from the production of agricultural inputs to food waste management, it provides biomass for food and non-food purposes, represents 7% of EU gross value added, and employed 30 million people in 2023, including around 8.5 million in agriculture. It has become the third largest net-exporting industry of the EU, with net exports for food and drink products reaching EUR 48 billion in 2024. Finally, the system manages 38% of the EU's land surface and is therefore a key steward of ecosystem services and natural resources.

Climate change is increasingly undermining these roles. More frequent and severe climate-related hazards, such as droughts, floods, heatwaves, pests and diseases, are already affecting agricultural productivity, ecosystem services and rural livelihoods. Agricultural losses from extreme weather events currently amount to around EUR 28 billion per year on average and are projected to increase to around EUR 40 billion per year on average by mid-century.[1] Southern European regions are particularly exposed and could face catastrophic risks by 2050.

These trends challenge the assumption that existing production systems and policy frameworks can sustain food security and rural economies under a rapidly changing climate.

The agri-food system is a major contributor to climate change

The EU agri-food system is a major source of greenhouse gas emissions, currently accounting for approximately one third of total EU net greenhouse gas emissions. Within the agri-food system, agricultural production is the main emitter, accounting for 55% of the system's greenhouse gas emissions. In addition, EU demand for imported agricultural commodities, such as vegetable oils and oilseeds, is associated with substantial greenhouse gas emissions outside the EU.

Climate-proofing the EU agri-food system requires two complementary strategies

The agri-food system thus sits at the centre of Europe's climate challenge: it both faces increasing climate risks and is a major source of greenhouse gases. Climate-proofing the system requires a parallel pursuit of two complementary strategies.

- **Climate adaptation.** The Advisory Board has previously urged the EU to prepare for increasing climate risks, consistent with a pathway to 2.8–3.3 °C of global warming by 2100 which would translate into even higher levels of warming in Europe. As one of the most at-risk parts of the economy on the continent, this also requires the EU agri-food system to adapt to climate change at the farm, landscape and system levels. These efforts can be

[1] Under the IPCC SSP2-4.5 scenario, which assumes a continuation of current adaptation and mitigation efforts.

guided by the Advisory Board's six guiding principles[2] and related policy recommendations for the development of an effective EU adaptation framework.

- **Climate mitigation.** To limit the most severe climate risks, adaptation needs to be combined with rapid and sustained global mitigation efforts. As part of these efforts, the EU has committed to climate mitigation targets under its Nationally Determined Contribution to the Paris Agreement and the European Climate Law. Given its substantial share in total EU greenhouse gas emissions, the agri-food system's contribution to these targets is indispensable.

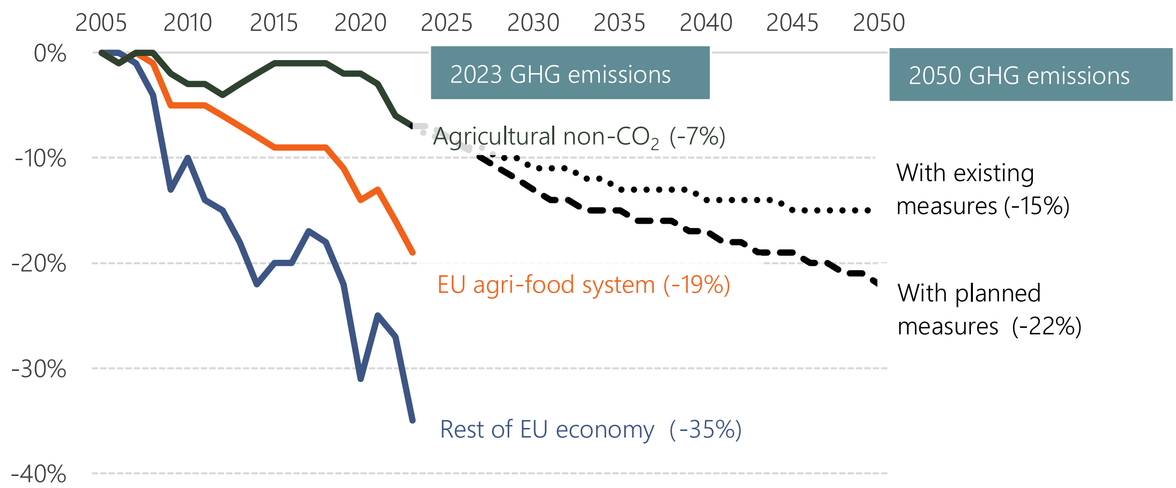
Delays in either strategy would increase long-term costs, further constrain future policy choices, and compound risks: inadequate adaptation can undermine mitigation, for example by degrading land-based carbon sinks or increasing input use to counter declining yields. Conversely, insufficient mitigation at the global level increases the risk that climate impacts exceed the agri-food system's capacity to adapt, locking in higher long-term costs and losses. As a major emitter, the agri-food system needs to help avoid this outcome.

Current progress on both climate adaptation and mitigation is insufficient and must accelerate

The overall direction of travel for both adaptation and mitigation is set out by the European Climate Law, which commits the EU to climate neutrality by 2050, with interim targets of at least 55% net reductions by 2030 and 90% by 2040 compared to 1990, while also strengthening climate resilience. A cost-effective achievement of these objectives relies on ambitious and sustained efforts by all parts of the economy, while acknowledging the specificities of different sectors and allowing for flexibilities between them.

Progress to date has been uneven. Evidence on adaptation progress suggests that current efforts are not keeping pace with accelerating climate impacts. Emission reductions in the EU agri-food system have lagged behind those in other sectors in the last two decades, as shown in Figure 1.

Figure 1 Evolution of greenhouse gas emissions compared to 2005 levels



Sources: EEA (2025c) and JRC (2024d).

[2] These six guiding principles are: lead with a vision, anticipate and act, learn and improve, promote just and fair resilience, strengthen private adaptation, and integrate policies.

Progress has been particularly slow in mitigating agricultural non-CO_2 emissions, which reduced by only 7% since 2005. Looking ahead, current and planned policies are projected to reduce these non-CO_2 emissions by only 15–22% by 2050 compared to 2005. To keep overall EU climate neutrality within reach, such limited mitigation outcomes in the agricultural sector would need to be compensated by either more ambitious reductions in other sectors or by further increasing carbon dioxide removals, which would increase overall costs and risks.

The EU agri-food system has untapped potential to deliver climate action, but this potential remains constrained by existing incentives and market structures

While no single measure offers a simple or immediate solution, there is substantial potential to reduce climate risks and net emissions in the EU agri-food system at manageable cost and with co-benefits. Enhanced climate adaptation can help to sustain yields, stabilise farm incomes and safeguard food security. While it may not be possible to eliminate all agricultural emissions, significant reductions and increased carbon dioxide removals are feasible, many of which are achievable at relatively low marginal abatement costs. For instance, recent modelling indicates possible reductions in agricultural non-CO_2 emissions by a third by 2050 (relative to 2005) at a marginal abatement cost of EUR 100 per tonne of CO_2e.

Many mitigation options can deliver additional benefits for farmers, such as higher input efficiency and income diversification. Importantly, many solutions, such as practices that increase soil carbon, dietary shifts, food waste reductions, agroforestry and agrivoltaics, can deliver benefits for both climate adaptation and mitigation, as well as broader environmental and socio-economic goals.

Unlocking this potential in the EU agri-food system would require behavioural changes, targeted policy support and substantial investments, with the latter outweighed by the avoided costs of climate damages. However, as discussed further below, the current EU policy framework cannot be expected to deliver this.

Upcoming EU policy decisions provide a critical window of opportunity for climate-proofing the EU agri-food system

The next few years will shape the policy framework governing the EU agri-food system over the coming decade. In July 2025, the European Commission proposed the next EU budget and common agricultural policy (CAP) for 2028–2034, which are now under negotiation. It is also considering further steps that build on the Carbon Removals and Carbon Farming (CRCF) Regulation to boost carbon dioxide removals and carbon farming, though their impact might be limited if based solely on voluntary approaches. In parallel, the Commission is expected to present a 2031–2040 climate package and a new framework on climate resilience in 2026. If well designed and complemented by other policies, these initiatives can mutually reinforce each other and unlock much stronger climate action in the agri-food system.

Against this backdrop, this report provides science-based, policy-relevant advice on how to climate-proof the EU agri-food system while supporting broader societal objectives. The analysis focuses on agricultural production, the main source of emissions and climate risks, while recognising that action across the entire value chain is essential to enable more climate-resilient and lower-emission farming practices, dietary shifts and reductions in food waste.

The transition needs to be driven by a coherent set of policies

Climate action in the agri-food system must be aligned with food security, health and environmental objectives and a fair standard of living for the agricultural community

Climate-proofing the EU agri-food system cannot be addressed in isolation. Beyond climate risks and emissions, the system is associated with multiple, interlinked environmental and socio-economic challenges. It both contributes to and is affected by biodiversity loss, soil degradation and water and air pollution. While it effectively ensures the EU's food security, it also generates substantial public-health costs linked to unhealthy diets. In parallel, the agricultural sector faces persistent economic pressures, including high capital-intensity and below-average incomes for many farmers, which constrains investment capacity and hinders generational renewal.

Addressing these challenges jointly can unlock synergies: many options that reduce climate risks can also alleviate environmental pressures, stabilise incomes and improve long-term competitiveness. In turn, improved productivity, healthier soils and richer biodiversity strengthen climate resilience and increase carbon sequestration. Conversely, persistent financial and non-financial barriers may stall climate action if not addressed. This interdependence calls for an integrated approach that advances climate adaptation and mitigation while supporting economic resilience, social cohesion and environmental improvement.

Incremental change is insufficient: a systemic transition of production and consumption is indispensable

Achieving EU climate neutrality by 2050 requires limiting residual greenhouse gas emissions and counterbalancing those that remain with carbon dioxide removals. However, the feasible scale and durability of such removals remain uncertain. Land-based carbon sinks are highly vulnerable to climate impacts, while the deployment of removal technologies depends on a stable regulatory framework and sustained investor confidence. These constraints significantly limit the extent to which residual emissions can be offset and strengthen the case for ambitious emissions reductions across all sectors, including agriculture.

Drawing on multiple studies and scenario analyses, the Advisory Board assessed the mitigation potential of the agri-food system by comparing scenarios that rely solely on technical improvements within existing production systems with pathways that combine such improvements with more structural changes. The latter include shifts in diets and commensurate changes in the value chain,[3] reductions in food waste, more substantial land-use change and transformational adaptation measures. The analysis shows that scenarios limited to technical efficiency gains deliver only modest mitigation, whereas pathways that integrate structural changes achieve substantially higher emissions reductions while strengthening long-term resilience.

Based on this assessment, the Advisory Board concludes that a systemic transition is indispensable to sufficiently increase the EU's ability to achieve climate neutrality by 2050 while delivering important co-benefits, by:

- **enabling substantial reductions** in agricultural non-CO_2 emissions (by approximately half by 2050 compared to 2005) while freeing up land to boost land-based carbon sinks;

[3] Available scenarios compatible with a systemic transition assume that the consumption of livestock products decreases between 15% and 50% compared to today's levels, with a commensurate decrease in production (see Section 4.4.3).

- **increasing climate resilience**, thus lowering vulnerability to climatic risks and enabling long-term, transformational adaptation;
- generating **co-benefits** for public health and other environmental goals, while strengthening the EU's strategic autonomy.

The evidence base of the attainable emission reductions in the agricultural sector by 2040 is limited. Available scenarios suggest that a systemic transition could reduce agricultural non-CO_2 emissions by more than a third by 2040 (compared to 2005), which would deliver an important contribution of the agricultural sector to reach the EU's overall climate target for 2040.

A systemic transition of this scale entails important social and regional implications – notably for livestock systems and regions with a high concentration of drained peatlands – and must therefore be managed in a just and fair way. Furthermore, the breadth of the required changes implies that action cannot be confined to agricultural production alone but must involve coordinated efforts across the entire agri-food value chain. Generational renewal and innovation in the agricultural sector offer a window of opportunity to accelerate change, provided that financial and non-financial barriers are adequately addressed.

The current EU policy framework cannot deliver the required changes

In a next step, the Advisory Board assessed whether the current EU policy framework is capable of delivering the scale and pace of change implied by a systemic transition of the agri-food system. This evaluation finds that, despite recent reforms and initiatives, existing EU policies remain fragmented and insufficient to drive the required transformation, as further discussed below.

The **CAP** is the primary and most well-funded EU-level policy governing agriculture, with a budget of EUR 50 billion per year (equivalent to a third of the total EU budget). It pursues multiple objectives, including a fair standard of living, rural development and climate action. However, its contribution to climate mitigation and long-term adaptation has remained limited. Incentives for climate action are often weak and, in some cases, counterproductive. Whereas a third of its budget is devoted to measures that could benefit the climate, these are estimated to reduce net agricultural emissions by only 35 Mt CO_2e (equivalent to 7% of the sector's 2023 emissions) per year on average. Furthermore, whereas the CAP includes instruments that can support climate adaptation, these have so far primarily focused on short-term robustness rather than long-term, transformational adaptation. Given its design, competing objectives and limited budgetary capacity, the CAP cannot be expected to serve as the sole driver of transition.

Agricultural greenhouse gas emissions are mainly addressed through the **Effort Sharing Regulation** and the **Land Use, Land-Use Change and Forestry (LULUCF) Regulation**, which set binding national targets and rely on Member States to design and implement mitigation policies. To date, these instruments have delivered only limited emission reductions in agriculture. Continued reliance on national targets and measures alone risks producing fragmented and cost-ineffective outcomes, given the diversity of approaches, uneven incentives and limited coordination across Member States.

In parallel, the EU has announced several initiatives aimed at promoting more sustainable production and consumption patterns under the **Farm to Fork strategy**. However, many of these initiatives have not yet been implemented.

More recently, the **CRCF Regulation** has established a first EU-level basis for certifying carbon dioxide removals and soil-based mitigation activities. While this represents an important step towards recognising and rewarding mitigation efforts in agriculture and land use, its scope remains limited and it does not, on its own, provide incentives or obligations commensurate with the scale of climate mitigation and resilience improvements required.

Taken together, the current EU policy framework lacks the coherence, strength of incentives and governance mechanisms needed to steer a systemic transition of the agri-food system. This underscores the need to move beyond a reliance on individual instruments and incremental reforms.

Only a coherent and adaptive policy mix can enable and sustain the transition

No single policy instrument can deliver the required transition, given the diversity of the farming systems, value-chain actors and regional contexts across the EU. The evidence instead points to the need for a coherent and adaptive policy mix that combines mutually reinforcing instruments and evolves over time as knowledge, technologies and conditions change.

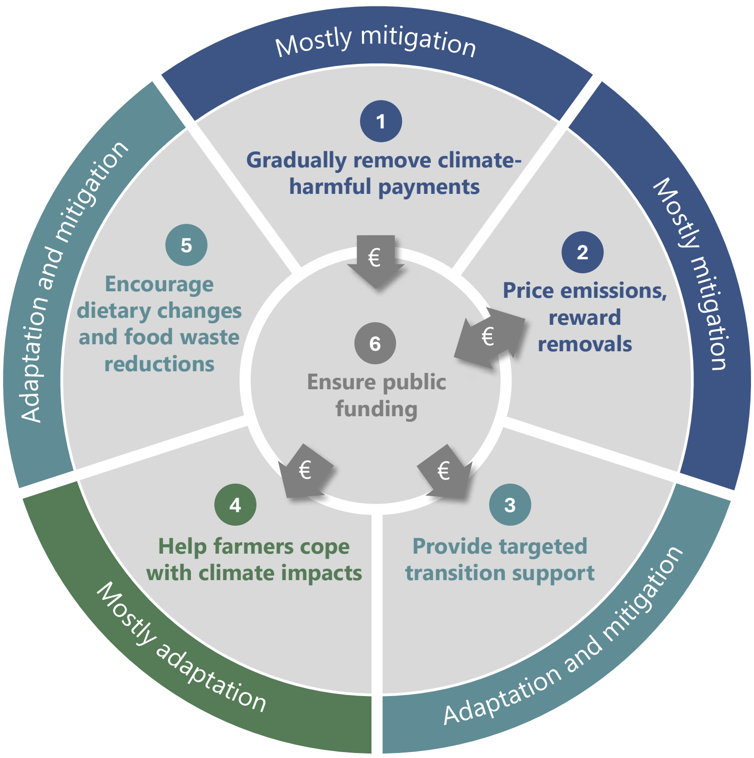
Such a policy mix must align incentives across the agri-food value chain, address both financial and non-financial barriers, and balance effectiveness with fairness. It should support farmers in managing risks and investing in change, while gradually strengthening incentives to reduce emissions and enhance removals and enabling more sustainable consumption patterns. Crucially, the mix must provide a clear long-term direction, while allowing for learning, adjustment and differentiated pathways across regions and production systems.

Together, these insights form the foundation for the policy recommendations presented in the next section.

From analysis to action: the Advisory Board's policy recommendations

Building on the preceding analysis, the following recommendations set out how the EU can translate scientific evidence into concrete policy action that addresses both climate adaptation and mitigation (see Figure 2). Each recommendation specifies the policy changes needed to align the agri-food system with the EU's 2040 and 2050 climate objectives, while ensuring coherence with other environmental, social and economic goals. Together, they form a coherent policy mix and can guide the design of an agricultural and climate policy framework consistent with the EU's long-term climate objectives.

Figure 2 Key policy recommendations for a climate-proof EU agri-food system



Recommendation 1 – Gradually remove climate-harmful payments. The EU should remove CAP payments for the most greenhouse gas-intensive practices already over the next CAP period and explore alternatives to replace the current system of broader income support in the longer term.

Rationale

Despite incremental reforms, key parts of the CAP and related funding streams continue to provide payments that incentivise greenhouse gas-intensive and maladaptive activities or land uses:

- **Coupled payments for animal production** (EUR 16 billion during 2023–2027, 5% of the CAP budget) are largely targeted at ruminant livestock (EUR 15.2 billion), thus favouring the most greenhouse gas-intensive and resource-intensive agricultural systems. Similarly, **decoupled payments for drained peatlands** (estimated at EUR 2.5 billion during 2023–2027, 1% of the CAP budget) also support a practice that is particularly harmful for both mitigation and adaptation.

  Comparable to fossil fuel subsidies, these payments give counterproductive incentives and reduce the budget available for climate-positive measures. Phasing them out could contribute not only to mitigation but also to adaptation by freeing up land that could be used for both mitigation and adaptation purposes. However, such a phase-out could have unintended consequences: for example, removing coupled payments for livestock production may push extensive grazing systems out of the market, which could result in a loss of grasslands with negative impacts on biodiversity and wildfire risks. Furthermore, the phase-out of these payments can adversely affect specific subsectors and regions and result in carbon leakage.

- **Basic decoupled payments** (EUR 120 billion in 2023–2027, 39% of the CAP budget) can be considered as climate-harmful as they incentivise agricultural production over other land use, which results in higher emissions and hinders the repurposing of land for climate adaptation or mitigation. Phasing out these payments would reduce emissions, especially if replaced by other payment schemes that encourage mitigation action in agriculture. However, without well-designed policy alternatives, this would come with a risk of carbon leakage and other unintended socio-economic and environmental impacts.

For these reasons, **the Advisory Board recommends that the EU adopt a phased approach to eliminate climate-harmful payments.**

1. **Phase-out coupled payments for livestock and decoupled payments for drained peatlands over the next CAP period (2028–2034),** as part of a broader approach that supports affected farmers to transition and appropriately rewards ecosystem services (see Recommendation 3). Such support could be financed by redirecting the resources that are freed up by removing harmful payments (see Recommendation 6).

2. **Consider alternatives for all decoupled payments in the longer term.** Explore and thoroughly assess alternative forms of income support that do not conflict with the EU climate objectives, with a view to having them eventually replace current general decoupled payments.

This recommendation and underlying analysis are further elaborated in Chapter 6.

Recommendation 2 – Introduce a greenhouse gas pricing system for agriculture. The EU should introduce a dedicated greenhouse gas pricing system for agriculture, designed to apply the polluter pays principle in a gradual and adaptive manner that encourages the entire agri-food value chain to reduce agricultural emissions and scale up carbon dioxide removals.

Rationale

Agriculture currently accounts for roughly 17% of the EU's net greenhouse gas emissions, yet these emissions are not priced under existing carbon-market mechanisms. Current policies rely primarily on Member State obligations, subsidies and voluntary measures, which have not delivered the pace or scale of mitigation required to meet the EU's 2040 and 2050 climate targets.

Extending EU-wide greenhouse gas pricing to agriculture is therefore essential to create coherent, economy-wide and cost-effective incentives for emission reductions and carbon sequestration, while ensuring credible alignment with the EU's climate objectives. The Advisory Board's analysis shows that a well-designed pricing system can drive both technical and structural mitigation across the heterogeneous agri-food system in a cost-effective and fiscally sustainable way, while also delivering adaptation co-benefits. Furthermore, it can generate revenues to finance transition support and climate-resilience measures within the agricultural sector (see Recommendations 3, 4 and 6).

Introducing such a mechanism poses challenges, as the sector's emissions are diffuse with uneven degrees of measurability, and due to the agri-food system's long investment cycles and limited short-term flexibility. These challenges can be addressed by introducing the system in a gradual and adaptive manner and combining it with complementary instruments.

For these reasons, **the Advisory Board recommends that the EU develop a dedicated framework for pricing greenhouse gas emissions and rewarding carbon dioxide removals for agriculture and land use**, guided by the following design elements.

1. **Pilot and gradual expansion.** Begin with testing monitoring, reporting and verification (MRV) methods and establishing emission baselines before launching a pilot phase covering only large entities that enable learning and provide insights to guide subsequent phases. Over time, the pilot phase should evolve towards a comprehensive system with expanded coverage through lower inclusion thresholds.

2. **Modular architecture**. As the various sources of agricultural emissions have different characteristics, integrating them under the same system could have unintended and unwanted effects. To avoid this, create separate pricing schemes for:

   a) **energy-related emissions**, which could be directly included in existing EU greenhouse gas pricing frameworks;

   b) **non-CO_2 agricultural emissions**, particularly from livestock and nitrogen-fertilised soils;

   c) **land-based agricultural CO_2 emissions and removals,** initially focusing on agricultural land but with the long-term aim of including all land categories.

   To promote economic efficiency, the integration of different pricing schemes should be pursued as a long-term ambition once sufficient robustness and experience are achieved.

3. **Mandatory compliance obligations**. Require obligated entities to submit emission allowances or eligible credits equivalent to the volume of their emissions. Considering administrative feasibility and effectiveness, obligations may apply to farmers or to off-farm entities such as upstream input suppliers, downstream processors and retailers. Regardless

of where the formal point of obligation is designated, it is essential that the scheme accounts for actions across the entire value chain that could reduce emissions or increase removals in agriculture.

4. **Gradually apply the polluter pays principle and reward removals.** Start with free allocation of allowances but transition towards auctioning, which would generate revenues that could be reinvested within the agricultural sector (see Recommendation 6), while maintaining payments for verified removals.

5. **Develop and continuously improve an MRV system.** Initially allow regulated entities to report emissions and removals using default emission factors based on national inventories, with the voluntary option to use more granular approaches building on the CRCF Regulation. To this end, the CRCF Regulation should be expanded in the short term to cover all major emissions sources in agriculture, including livestock. Over time, the MRV system should be regularly assessed and updated, drawing on lessons learned, scientific advances, and new technological opportunities such as remote sensing, satellite data, in situ sensors and other digital tools.

6. **Address carbon leakage**. If the point of obligation of a pricing mechanism is set at the level of food retailers, embedded emissions from food imports are priced while emissions from exported products are not. Under such an approach, the risk of carbon leakage is inherently low, but there would also be little incentive to reduce emissions from products exported out of the EU. If the point of obligation is set further upstream in the value chain (e.g. at the farm level), the risk of carbon leakage becomes significant although the exact magnitude is uncertain. In this case, additional trade measures such as border adjustment mechanisms could be considered as free allocation is phased out, although such measures are challenging in the current international context.

This recommendation and underlying analysis are further elaborated in Chapter 7 (on a greenhouse gas pricing instrument) and Chapter 11 (on trade policies to address carbon leakage risks).

Recommendation 3 – Provide targeted transition support. The EU should provide targeted financial and non-financial support to farmers to tackle key barriers, seize opportunities, and ensure a fair and just transition, with a key focus on the most greenhouse gas-intensive and/or least climate-resilient production systems with limited transition capacity.

Rationale

Climate-proofing the EU agri-food system can boost production efficiency and resilience by stabilising yields and diversifying incomes but often requires substantial upfront investments and in-depth knowledge. However, many farmers (including small farmers) face low and volatile incomes, limited access to finance and knowledge gaps – including how to best adapt to future climate-related risks, and ways to transition to low-emission farming systems. These constraints can act as barriers for climate-proofing the agri-food system.

Strong and well-targeted support is needed to help overcome these barriers, accelerate the adoption of low-emission and climate-resilient practices and technologies, and avoid abrupt economic or social disruption. This support is particularly relevant for the most greenhouse gas-intensive and/or least climate-resilient farms with limited transition capacity, either because they have few transition options or because they face high financial or non-financial barriers to implement such options. It can also underpin fairness by ensuring that the burden of change does not fall disproportionately on those least able to bear it.

For these reasons, **the Advisory Board recommends that the EU develop a comprehensive transition support framework**, combining different types of measures that address both financial and knowledge barriers.

1. **Investment support.** Provide accessible finance to facilitate the adoption of climate-friendly technologies and practices, and the restructuring of the most greenhouse gas-intensive and least climate-resilient farms into climate-proof systems.

2. **Transitional income support.** Offer temporary income compensation to farmers experiencing temporary yield or income losses during the shift to new practices and systems, ensuring continuity of livelihoods while learning-by-doing takes place.

3. **Knowledge and innovation support.** Support projects that foster innovation and experimentation in climate-proof technologies and practices, including by supporting demonstration and early deployment, and strengthen farm advisory services to accelerate the dissemination and scaling up of effective adaptation and mitigation solutions. Support should also target digitalisation and data-driven decision tools, such as farm-level climate stress tests.

4. **Rewards for ecosystem services**. Develop mechanisms that complement a greenhouse gas pricing instrument (see Recommendation 2) by adequately rewarding the provision of meaningful ecosystem services other than climate mitigation or adaptation at the farm level. This is important to support options that contribute to both climate and other environmental objectives, but also to avoid potential environmental trade-offs resulting from climate policies such as the phase-out of climate-harmful subsidies and the introduction of a greenhouse gas pricing instrument (see Recommendations 1 and 2).

5. **Diversification and exit support.** Establish instruments that help the least climate-resilient or most greenhouse gas-intensive farms with limited transition options to diversify their activities or exit the sector. Such mechanisms are essential to uphold the principles of a just and fair transition.

These different types of support could be provided through the CAP, provided that the current CAP instruments are improved. However, it could also be provided through other instruments such as a separate, stand-alone fund (see Recommendation 6).

To avoid long-term subsidy dependencies, limit budgetary pressures, encourage early action and align with the polluter pays principle, transition support should be provided for a limited time period. Support could be sustained in the longer term for the provision of public goods – including ecosystem services, carbon dioxide removals, and adaptation benefits that extend beyond the farm level – due to their broader societal value.

This recommendation and underlying analysis are further elaborated in Chapter 8.

Recommendation 4 – Help farmers cope with unavoidable climate-related impacts. The EU should strengthen the set of instruments that help farmers cope with unavoidable climate-related impacts, such as acute losses from extreme climate-related hazards or gradual productivity losses, while ensuring that such instruments do not undermine the incentive for proactive and transformational adaptation.

Rationale

Proactive adaptation efforts are essential to limit the most severe climate-related impacts, but even with such efforts in place, the residual risk will continue to impose significant costs on European agriculture. Farmers are already experiencing more frequent and severe droughts, floods, heatwaves and cascading climate change impacts. These adverse impacts will intensify in the coming decades, disproportionately affecting farms and regions with high exposure and limited adaptive capacity.

The Advisory Board has previously recommended to promote fairness in adaptation, considering that climate change will disproportionately affect certain communities and regions. In line with this principle, EU policies should help farmers absorb and recover from climate shocks. Yet, the existing risk management toolbox under the CAP remains underfunded and has a limited reach. CAP payment schemes for areas that are less productive due to natural constraints do not yet take into account changing climatic conditions. Strengthening these instruments is crucial but, in line with the Advisory Board's previous recommendations on adaptation, this should be done in a way that anticipates future climate-related risks and incentivises proactive adaptation, and transformational adaptation where necessary.

For these reasons, **the Advisory Board recommends that the EU strengthen its toolbox to help farmers cope with adverse climate-related impacts,** guided by the following principles.

- **Scale up support for overcoming acute climate-related impacts.** Increase and expand the coverage of financial instruments that help farmers cope with and recover from immediate losses from climate-related hazards, including subsidies for agro-insurance schemes, mutual funds, and the agricultural reserve for disaster relief.
- **Account for slow-onset hazards**. Consider changes in climatic conditions when mapping areas with natural constraints that are eligible for additional income support under the CAP.
- **Keep incentives for proactive climate adaptation.** Identify and implement suitable approaches to ensure that compensation payments for climate-related impacts do not undermine the incentive for proactive adaptation efforts nor reward maladaptive actions. To this end, several options should be considered, such as making access to compensation payments conditional on minimum adaptation efforts.
- '**Build back better' and encourage transformational adaptation.** Link publicly funded compensation payments for extreme events to commitments by recipients to undertake efforts that enhance long-term adaptation in line with the 'build back better' principle. Furthermore, consider how payments for areas with climate-related natural constraints could be designed so that they support transformational adaptation when needed, including the diversification or cessation of agricultural activities when risks become too high or when regions become unsuitable for agricultural production.

This recommendation and underlying analysis are further elaborated in Chapter 9.

Recommendation 5 – Encourage healthy, climate-friendly diets and reductions in food waste. The EU should establish an overarching food policy framework that promotes healthy, climate-friendly diets and reduces food waste across the value chain, while safeguarding equitable access to sufficient, nutritious and affordable food for all consumers.

Rationale

Compared to both Member States' and other science-based nutritional guidelines, EU diets are on average too low in healthy, plant-based foods and too high in red meat and ultra-processed foods. This is driving both greenhouse gas emissions and a rise in non-communicable diseases and obesity, with related health costs estimated at EUR 530 billion per year or 3% of the EU gross domestic product. Aligning diets with nutritional guidelines would thus support climate mitigation and reduce public health costs, while enhancing climate resilience as healthy, plant-based foods require fewer inputs per calorie produced. Similarly, a reduction in food waste can contribute to both climate mitigation and climate resilience.

Whereas nutritional guidelines across Member States broadly align, significant discrepancies remain. These partly reflect cultural differences, but also that some guidelines do not reflect the latest scientific findings or do not consider the climate footprint of diets. Updating these national guidelines – based on the latest science on health and climate-related impacts while respecting cultural contexts – would provide more clarity on nutritional goals.

While a greenhouse gas pricing system (see Recommendation 2) can influence food demand, consumption patterns are also shaped by non-financial factors across the food environment. Therefore, an effective policy approach needs to go beyond pricing and target the entire food value chain, including food processors and retailers which strongly shape the food environment.

There is also a strong social dimension to food policies. Food poverty is affecting a small yet increasing share of the EU population. Adverse climate-related impacts, the removal of climate-harmful production subsidies (see Recommendation 1) and pricing of greenhouse gas emissions (see Recommendation 2) may further increase food prices. To ensure a just and fair transition also for consumers, additional measures are needed that ensure that all consumers, including vulnerable households, have sufficient access to healthy and climate-friendly food.

Food policies are a shared competence between the EU and its Member States. While national policies can better reflect local contexts, complementary EU action can add value by levelling the playing field across Member States and creating economies of scale.

For these reasons, **the Advisory Board recommends that the EU adopt an overarching food policy framework** that should do the following.

1. **Encourage the establishment of national guidelines for healthy and climate-friendly diets,** based on a common scientific evidence base, while allowing these guidelines to account for cultural heritage and values.
2. **Promote food environments that enable healthy and climate-friendly food choices**. To this end, the EU should regulate food processors and retailers, by setting mandatory standards for the marketing and labelling of food products, and for public food procurement.

3. **Ensure the provision of robust and consistent data** on food consumption and food waste, based on harmonised methodologies, to enable a transparent progress assessment on the shift towards healthy, climate-friendly diets and the reduction of food waste.
4. **Support Member States** in developing and implementing effective national food policies, including measures to prevent and address food poverty, reduce food waste and inform all consumers about healthy, climate-friendly food choices.
5. **Provide support across the food supply chain**, helping producers, retailers and other stakeholders transition towards climate-proof practices in a coordinated way.

This recommendation and underlying analysis are further elaborated in Chapter 10.

Recommendation 6 – Ensure adequate public funding. The EU should ensure sufficient and well-timed public funding – as a complement to private funding – to finance transition support, risk-management tools and innovation in the agri-food system. To this end, it should explore different options, including the reorientation of existing resources and mobilisation of new revenue streams.

Rationale

Whereas the available estimates on financing needs are fragmented, climate-proofing the EU agri-food system will require tens of billions of euros per year. This will need to be delivered through both private and public funding.

Several of the previous recommendations will already help to mobilise private funding towards more climate-proof production systems. The removal of climate-harmful subsidies (see Recommendation 1) and introduction of a greenhouse gas pricing instrument (see Recommendation 2) do so by directly improving the business case of investments in climate mitigation. Similarly, the provision of transition support (see Recommendation 3) can help mobilise private funds by removing financial and non-financial barriers to mitigation and adaptation options.

Public funding will also be essential, in particular to fund increased transition support (see Recommendation 3) and to help affected stakeholders cope with adverse climate-related impacts (see Recommendation 4). The phase-out of climate-harmful subsidies and introduction of a greenhouse gas pricing instrument will make available public funds that can be recycled to this end, but these funds will only materialise gradually. Meanwhile, there is an urgent need for upfront investment to trigger the transition and build capacity. This means that there is a temporal mismatch between when public funding is most needed (in the short term) and when additional public revenues would become available (in the longer term). If left unaddressed, this mismatch risks stalling climate action.

For these reasons, **the Advisory Board recommends that the EU explore different options to ensure adequate and well-timed public funding** for supporting the transition in the agri-food system (see Recommendation 3) and helping farmers cope with climate-related impacts (see Recommendation 4), including the following.

1. **The reallocation of existing CAP resources towards climate action,** by increasing the share of the CAP budget dedicated to climate action, while ensuring that this budget effectively delivers meaningful mitigation and adaptation outcomes. This would require adjustments to the current legislative proposal for the 2028–2034 CAP, which is expected to decrease rather than increase the budget for climate action.
2. **The frontloading of the auctioning of allowances** under a future greenhouse gas pricing system for the agri-food system (see Recommendation 2), following the precedent of the EU Emissions Trading System for buildings and road transport (EU ETS2). This could be done once there is a clear legal basis for the introduction of such a system and could help to accelerate the generation of public revenues to support adaptation and mitigation measures.
3. **Other EU funds,** either via existing EU instruments or through the creation of a separate, dedicated fund. Additional funding for this could be mobilised via the upcoming EU budget (for example by aligning all EU funding programmes with the EU climate objectives), through the European Investment Bank and through national co-financing.

This recommendation and underlying analysis are further elaborated in Chapter 12.

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Chapter 1

Introduction

1.1 Context and aim of the report

Climate change is accelerating and threatening the EU agri-food system.

The past three years (2023–2025) rank as the warmest ever recorded, with the average global temperature over this three-year period more than 1.5 °C above pre-industrial levels (Copernicus Climate Change Service, 2026). Moreover, the rate of warming is increasing, from on average 0.18 °C per decade in 1979–2008 to 0.25 °C per decade at the end of 2025. This is mainly due to a faster build-up of greenhouse gases (GHGs) in the atmosphere resulting from human activities and a lower net-uptake of CO_2 by natural land and oceans. Europe remains the fastest-warming region, warming at approximately twice the global average.

The first European Climate Risk Assessment (EEA, 2024b) confirmed that this human-induced climate change is posing severe risks for the EU, both directly and by exacerbating existing risks and crises. It further identified food production as one of the main areas where such risks are becoming increasingly severe.

The European Climate Law sets out the EU's overall response to the climate crisis.

The European Climate Law (Regulation (EU) 2021/1119) sets out the overall direction of travel on climate action with objectives on both climate mitigation and adaptation.

- On **mitigation**, it mandates the EU to be climate neutral by 2050, with interim targets of 55% net reductions by 2030 and 90% by 2040 compared to 1990. A cost-effective achievement of these objectives relies on ambitious and sustained efforts by all parts of the economy, while acknowledging the specificities of different sectors and allowing for flexibilities between them.
- On **adaptation**, it requires EU institutions and the Member States to ensure continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change. The Advisory Board has previously set out key guiding principles and policy recommendations to guide these efforts

There is substantial potential to strengthen climate mitigation and adaptation in the EU agri-food system.

As discussed in more detail in Chapter 2, the EU agri-food system is not only a victim but also an important contributor to climate change. Its share in total EU net GHG emissions increased from approximately a quarter in 2005 to a third in 2023. The agricultural sector, which accounts for more than half of the EU agri-food system's net GHG emissions, has only achieved limited emission reductions in the last two decades. Whereas the picture of adaptation progress is less complete, available evidence also indicates a need for enhanced efforts on this front in anticipation of accelerating climate-related impacts.

As discussed in more detail in Chapters 3 and 4, while it might not be possible to eliminate all gross GHG emissions from agriculture, there is substantial potential to reduce emissions and increase carbon dioxide removals, often at a relatively low marginal abatement cost. Similarly, there are many options to strengthen climate resilience in the agri-food system, which can help to safeguard agricultural livelihoods and food security. Importantly, many solutions exist that can contribute to both adaptation and mitigation.

The coming years present a critical window to strengthen climate action within the EU agri-food system.

The Advisory Board has previously attributed the limited GHG reductions in agriculture to weak policy incentives (Advisory Board, 2024). Several ongoing EU policy processes offer opportunities to address this gap while strengthening the EU agri-food system's resilience to current and future climate-related impacts. These processes include:

- the new Multiannual Financial Framework (MFF) and revision of the CAP for the 2028–2034 period, following the European Commission's proposal of July 2025 (EU, 2025b, 2025c);
- the development of the European integrated framework for climate resilience, expected in the second half of 2026;
- the continuing development of the CRCF Regulation (Regulation (EU) 2024/3012) and the European Commission's consideration of additional initiatives to create demand for CRCF credits;
- the Commission's exploration of the post-2030 policy framework to achieve the newly adopted 2040 climate target, for which it is expected to put forward concrete proposals in the second half of 2026.

The Advisory Board aims to raise awareness of the urgent need for a systemic transition of the EU agri-food system and to provide policy recommendations that facilitate this change.

With this report, the Advisory Board aims to provide independent, science-based and policy-relevant advice on strategies to climate-proof the EU agri-food system – that is, to ensure the system is sufficiently adapted to future climate-related risks and makes an adequate contribution to the EU's climate mitigation targets – while minimising trade-offs and fostering synergies with other environmental and societal objectives. This guidance is intended to ensure that policy decisions taken in the coming years place the EU agri-food system on a trajectory consistent with the EU's objectives on climate mitigation and adaptation.

To this end, the report:

1. highlights the **necessity of strengthening climate action in the agri-food system**, while safeguarding other societal objectives such as livelihoods and food security. It does so by demonstrating how the current trajectory jeopardises both climate and broader environmental and socio-economic goals and by identifying options that can deliver synergies and limit trade-offs between climate mitigation, adaptation and these other societal goals;
2. delivers scientifically grounded **recommendations on the design of EU policies** that advance climate mitigation and adaptation in ways that are coherent with other environmental and societal priorities.

1.2 Scope of the report

The report focuses primarily on the agricultural sector, while also considering other parts of the agri-food system.

The agri-food system encompasses all processes and actors involved in the production, processing, distribution, consumption, and disposal of food and agricultural products. It includes primary agricultural production and fisheries, food manufacturing, transportation, retail, and associated services, along with upstream and downstream supply chains such as input industries (e.g. mineral fertilisers) and waste management. This system is embedded within broader economic, social, and environmental contexts, influencing and being influenced by policies, trade, consumer behaviour and resource availability.

Within the agri-food system, the agricultural sector (the part of the economy engaged in agricultural production) is both the main source of GHG emissions and a hotspot of climate-related risks. The report's focus will therefore be primarily on agriculture. However, many on-farm solutions require a concerted effort from the broader agri-food system. Furthermore, demand-side options including dietary shifts and food waste reductions have substantial climate mitigation and adaptation potential, but require action from actors downstream from the farm level. For this reason the report will also consider the role of downstream actors (food processors, distributors, retailers, and consumers) in supporting on-farm climate action along with dietary shifts and reductions in food waste.

Climate mitigation and adaptation serve as the main pillars of the report's assessment of the agri-food system.

As discussed in Chapter 2, the EU agri-food system faces a range of different challenges which are interlinked, meaning that they should not be tackled in isolation but rather require a systemic approach. The focus of this report is primarily on climate mitigation and adaptation, given their strong interlinkages and potential for synergies, and based on the Advisory Board's mandate. It will also – but in less detail – consider to what extent options to enhance climate action in the sector could provide synergies or risk trade-offs with other, non-climate-related challenges.

1.3 Outline of the report

The remainder of the report is structured as follows.

- **Chapter 2** describes a range of interlinked challenges facing the EU agri-food system, including the risks from climate-related hazards and the need to reduce the systems' GHG emissions.
- **Chapter 3** provides a high-level overview of different options to enhance climate adaptation and mitigation in the agri-food system, considering potential synergies and trade-offs between adaptation, mitigation and other relevant dimensions.
- **Chapter 4** defines and assesses various possible futures for the EU agri-food system based on stylised pathways.
- **Chapter 5** identifies existing policy gaps that hinder progress towards the desired transition and outlines a coherent policy mix to address these gaps.
- **Chapter 6** explores to what extent CAP direct payments can be considered as climate-harmful, and how they can be reformed to be aligned with the EU's climate priorities.
- **Chapter 7** considers various options for a GHG pricing mechanism in agriculture, including their benefits and challenges.
- **Chapter 8** examines a range of instruments that can support farmers in the transition towards climate-proof production systems.
- **Chapter 9** investigates how to more effectively support farmers who, despite implementing adaptive measures, continue to experience adverse impacts from climate-related hazards.
- **Chapter 10** explores various options for food policies aimed at promoting healthy and climate-friendly diets and reducing food waste.
- **Chapter 11** focuses on trade policy mechanisms that could serve to reduce the risk of carbon leakage, including their benefits and challenges.
- **Chapter 12** considers options to increase public funding for climate action within agriculture to support several of the policy recommendations in this report.

Chapter 2

State of play and challenges

Key messages

The EU agri-food system faces challenges relating to both climate adaptation and mitigation.

The EU agri-food system is vital for the supply of agricultural products, and an important contributor to the EU economy and source of livelihoods. However, climate change is undermining these services and threatening food production and farmers' livelihoods, especially in southern EU regions. This requires a diligent response on two fronts:

- **climate adaptation** efforts are needed to enhance climate resilience and risk management;
- the agri-food system – and agriculture in particular – needs to accelerate GHG emission reductions and boost carbon dioxide removals to contribute to **climate mitigation** to keep the EU climate targets within reach and help avoid the worst climate change scenarios.

A substantial number of other challenges is threatening the EU's agri-food system.

At the same time, the agri-food system is facing a range of other environmental and socio-economic challenges.

- The system needs to reduce other **environmental pressures** in line with EU environmental objectives to protect vital ecosystem functions such as soil fertility or water retention.
- **Land** for agricultural production is increasingly scarce and expensive due to competing uses.
- **Agricultural incomes** remain below average. Whereas sector consolidation has resulted in fewer and more profitable farms, smaller farm holdings particularly struggle to provide decent incomes. The farming population is declining and ageing, raising concerns about generational renewal and rural vitality.
- More sustainable farming can be profitable but often requires upfront investments, and many farmers have insufficient **access to funding**. Public support to overcome this is faced with competing demands.
- **Productivity** in the agricultural sector is growing slower than the world average, raising concerns about the sector's competitiveness. These concerns are further fuelled by the geopolitical context.
- Higher **food prices** have increased food poverty, with low-income households struggling to afford healthy, nutritious food.
- Ongoing **geopolitical developments** could threaten stability of food supply in the future.
- Current EU **food consumption** patterns – with high consumption levels of red and processed meat – are unsustainable and causing substantial public health costs.

All these challenges are interconnected, positively or negatively. It is therefore important to approach them in a holistic and coherent manner.

2.1 Introduction

This chapter describes a range of interlinked challenges facing the EU agri-food system as a basis for the assessment throughout this report.

The aim of this chapter is to briefly introduce the different climate- and non-climate-related challenges facing the EU agri-food system and highlight their interlinkages. It will form the basis for the assessment of adaptation and mitigation options, pathways and potential policies which are explored throughout the rest of the report.

The remainder of this chapter is structured as follows.

- **Section 2.2** briefly describes the role of the agri-food system and the different services it delivers to the EU. It concludes by outlining a range of challenges which threaten to undermine its ability to continue delivering these services.
- **Section 2.3** elaborates on the risks the system faces from climate-related hazards, and explains why adaptation efforts need to be enhanced to safeguard the future of the system.
- **Section 2.4** elaborates on the GHG emissions and removals in the agri-food system and explains why mitigation efforts need to be increased in the context of the EU climate neutrality objective.
- **Section 2.5** elaborates on a range of other challenges facing the sector, both environmental and socio-economic.
- **Section 2.6** explains how many of the challenges described in this chapter are interlinked. It concludes on the need for both climate adaptation and mitigation as two complementary strategies to climate-proof the agri-food system, while considering other environmental and non-environmental societal objectives.

2.2 The role of the agri-food system

EU agriculture is the primary supplier of agricultural products to EU consumers, and essential for supporting the EU bioeconomy.

The EU's agricultural sector produced approximately 95% of all agricultural biomass[4] supplied to the EU food system in 2019, bringing the Union close to self-sufficiency (EEA, 2023d). The remaining 5% is supplied by imports from non-EU countries, primarily of animal protein feed (see also Section 2.5.5). The sector also contributes to global food security by providing 9% of cereals, 17% of raw milk, 12% of meat, 4% of oil crop and 6% of vegetable and fruit production worldwide (FAOSTAT, 2023).

The EU is also relying on the sector to provide increasing amounts of sustainable biomass to replace fossil fuels and feedstocks in the context of the EU's transition to climate neutrality. Under the European Commission's most recent decarbonisation scenarios, the supply of agricultural biomass for bioenergy purposes more than doubles from 39 Mtoe in 2021 to approximately 100 Mtoe in 2040 and 90 Mtoe in 2050 (EC, 2024f). This may create tension with food security and food exports, unless this increase is supplied through agricultural residues and lignocellulosic crops that do not compete for land with food crops. In addition, biomass demand is also expected to increase to substitute fossil feedstocks, through the production of biochemicals, bioplastics, construction materials, and other renewable bio-based products (Ueckerdt et al., 2021).

For farmers, this creates substantial income opportunities. As biorefineries, biomethane producers and bio-based material industries expand, they will increasingly pay for certified, traceable sustainable feedstocks especially residues, intermediate crops and lignocellulosic perennials. Coupled with carbon farming and sustainability schemes, shifting towards these types of production can diversify farm revenues and improve long-term resilience, provided sustainability standards are met and supply chains are organised (IEA, 2025; EEA, 2025f).

The EU agri-food system is also an important contributor to the EU economy.

The broader agri-food system contributed approximately EUR 1 trillion or 7% to the EU's total Gross Value Added in 2023, of which agricultural production accounted for EUR 222 billion. In the same year, the agri-food system also provided employment to around 30 million people (15% of the EU total), of which 8.4 million were working in agriculture[5] (Eurostat, 2025g).

In terms of trade, the EU has increased its net exports of agricultural products over the last decade, reaching EUR 48 billion in 2024, which is about one third of the EU's total trade balance (Eurostat, 2025f) (see also Section 2.5.5).

Whereas the agri-food system contributes to the EU economy, it is also the largest beneficiary of EU subsidies. As explained in more detail in Chapter 5, the agricultural sector receives on average more than EUR 50 billion per year during 2023–2027 via the CAP (Regulations 2021/2115, 2021/2116, 2021/2117), which accounts for one third of the total EU budget (EC, 2025h).

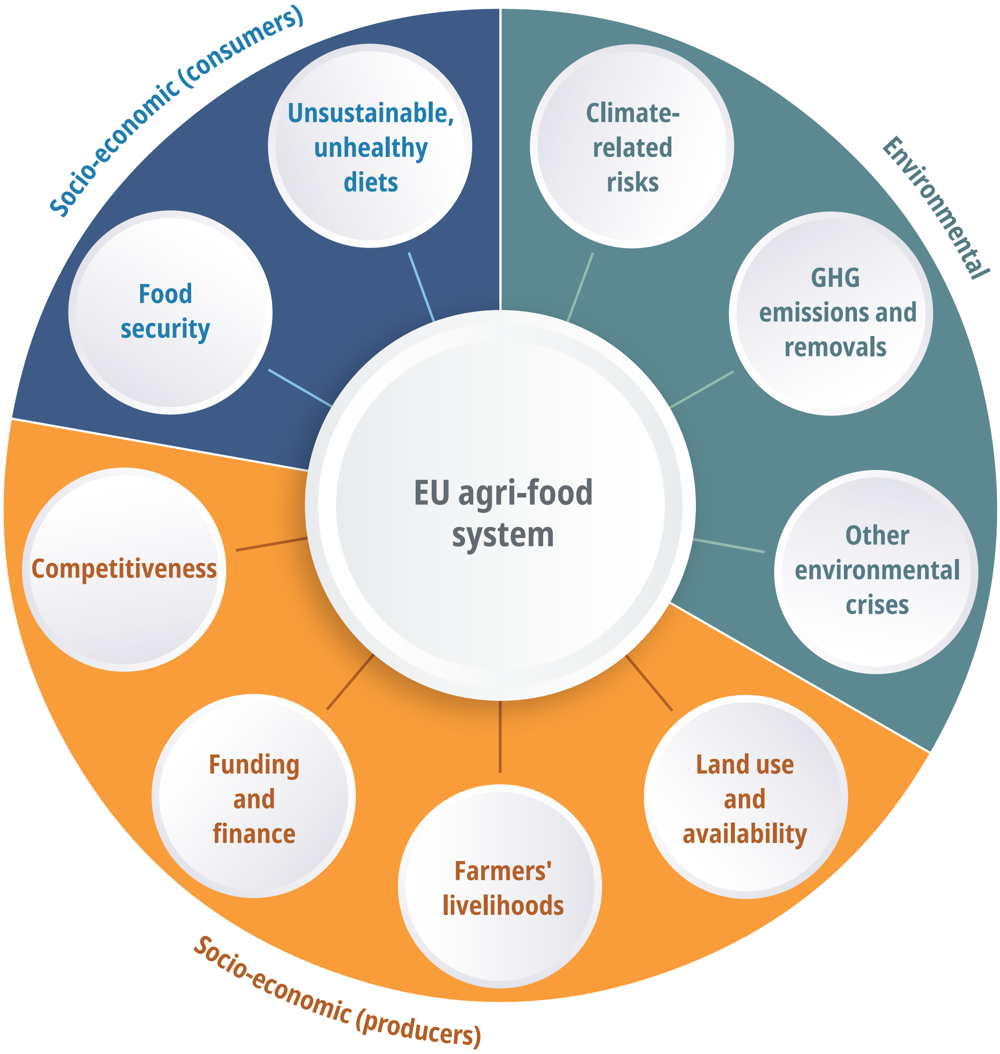
[4] This includes food, feed and feedstocks, measured in dry matter weight and considering net trade.

[5] This includes documented workers only. The total workforce in agriculture is estimated to be at least 10 million when also considering non-documented migrant workers (EFFAT, 2024).

The EU agri-food system is facing several challenges.

The EU agri-food system's ability to continue providing the goods and services described above is facing a range of environmental and socio-economic challenges, as illustrated in Figure 3 and elaborated in more detail in the rest of this chapter.

Figure 3 Overview of the different challenges facing the EU agri-food system



Source: Advisory Board.

2.3 Climate-related risks

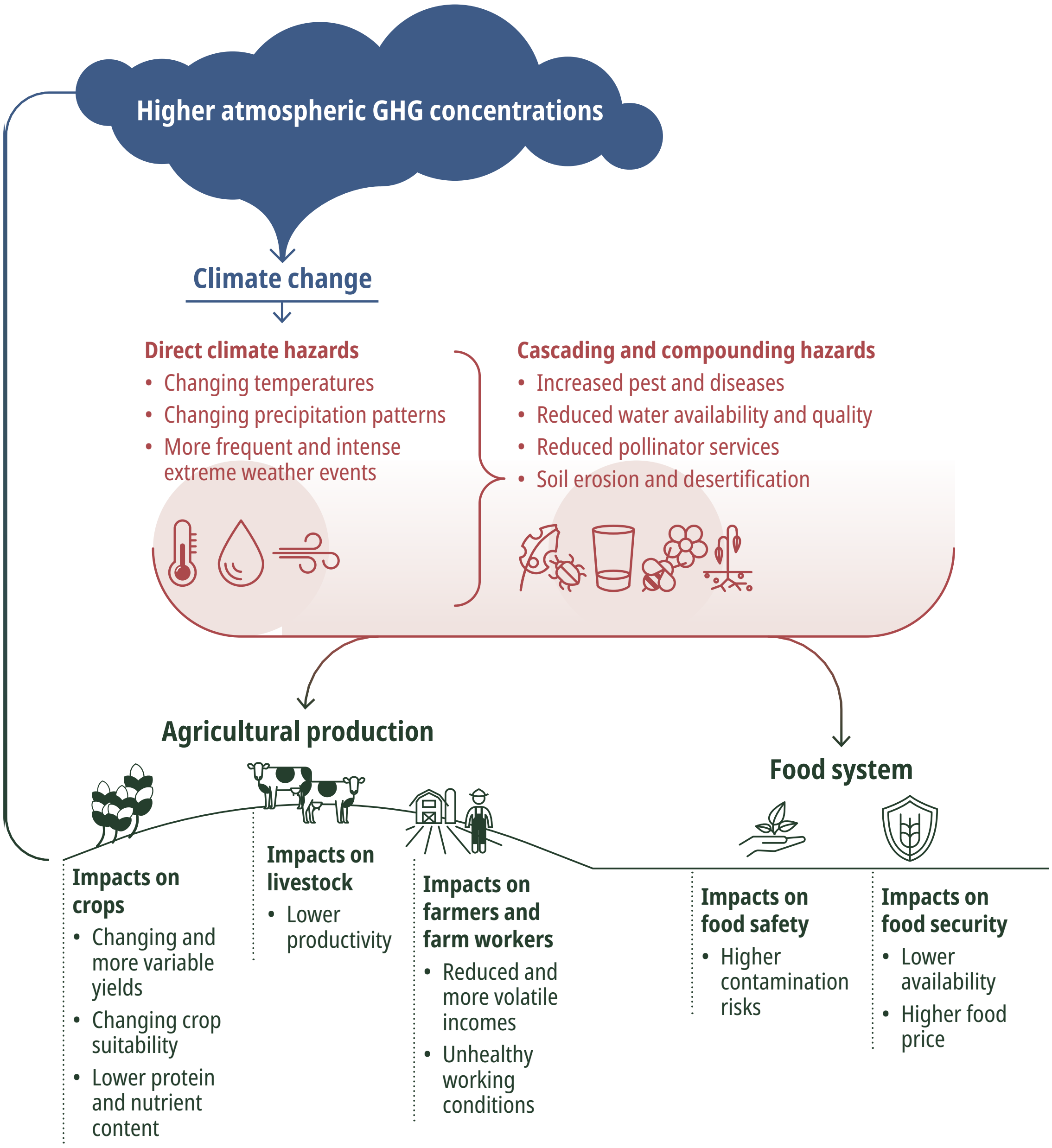
Climate change can affect agri-food systems directly, trigger cascading impacts and compound other risks.

Climate change can impact the agri-food system via different – and often interlinked – multi-risk dynamics, as illustrated in Figure 4. Climate change is projected to increase risks to the agri-food systems through direct climate hazards, which may trigger or amplify other hazards. The term climate-related risks in this report encompasses the risks of:

- **direct climate hazards** which come from changes in temperatures and precipitation patterns such as more frequent, intense, and longer droughts, heatwaves and heavy rainfalls. Such hazards can be either rapid-onset (e.g. storms, hail) or slow-onset hazards (e.g. drought, sea level rise) (FAO, 2022b; EEA, 2024b);
- **cascading hazards** triggered by direct climate hazards, such as mudslides after flooding or soil erosion after prolonged droughts. The chain of impacts often grows to include environmental risks such as pests and diseases, reduced pollinator services, or reduced water availability;
- **compounding hazards** which result from co-occurring climate hazards that magnify each other, or when climate hazards interact with other non-climatic (e.g. financial, geopolitical) risks (EEA, 2024b).

Because these hazards can manifest as discrete events, prolonged stressors or long impact chains of cascading and compounding risks, impacts can be either acute or gradual (FAO, 2022b). Repeated impacts from direct or indirect hazards also amplify climate and other risks by eroding the capacity of soils, farms, and other parts of the agri-food system to cope and recover from subsequent impacts over time.

Figure 4 The different dynamics through which climate change can impact agri-food systems



Sources: Adapted from EEA (2024b) and FAO (2022b).

Climate-related risks for the crop sector differ strongly across regions and crop types and are likely to be underestimated in current projections.

There is strong evidence that climate hazards such as heat stress, droughts and overly wet conditions have already negatively affected crop production both globally (FAO, 2022b) and within the EU (EEA, 2024b). On average, weather-related events are estimated to already cause EUR 17.4 billion of losses per year for crops (Fi-Compass, 2025).

Future climate risks for crop yields vary strongly across regions, crop types and local circumstances, such as water availability for irrigation. As shown in Table 1, crop yields are overall projected to decrease in southern Europe, whereas the impact would be less negative and possibly even positive in northern Europe.

- **Maize crop** yields are projected to decrease across the board, with the size of the decrease largely dependent on latitudes and irrigation availability. The strongest decline is projected for southern Europe, where maize production could collapse with yields projected to decrease by 80% or more in the case of limited irrigation availability (e.g. due to depleted aquifers). The region is currently already heavily reliant on irrigation, with many countries now exceeding thresholds for sustainable water use (EEA, 2024b). Only Hultgren et al. (2025) – which assume more substantial adaptation – project increases in maize yields in northern Europe, while noting that this is theoretical for now as maize is not yet produced at scale in this region.

- **Wheat crop** yields could increase in regions with ample water availability, and no strong water excess, as losses from climate-related events are more than offset by the CO_2 fertilisation effect.[6] Overall, wheat yields are projected to increase in northern Europe and could either increase or decrease in southern Europe, depending on water availability.

- **Vegetables, fruits, nuts and fibre products** are expected to experience negative yield impacts, in particular in southern Europe (Midler, 2022).

Even if the projections of Table 1 suggest that some regions and crops might benefit from climate change, further caution is advised for the reasons below.

- The projections provide average annual values, but climate change is expected to increase in interannual variability, meaning that impacts can be more drastic in individual years (EEA, 2024b, 2019). Whereas weather-related crop losses are expected to increase from EUR 17.4 billion currently to EUR 25–29 billion[7] in 2050 on an average basis, they could reach up to EUR 51–57 billion per year in individual years (Fi-Compass, 2025).

- The modelled projections above are likely to underestimate the adverse effects of climate extremes such as heat stress, drought and extreme rainfall, due to missing information and oversimplification (e.g. insufficient consideration of cascading and compounding risks) in the underlying models (JRC, 2020a). The impact of such extremes could be severe, with drought severity in southern Europe possibly tripling by the end of the century (Devot et al., 2023).

- Even if higher temperatures and atmospheric CO_2 concentrations are projected to increase the yields of certain crop types such as wheat and rice, they would also negatively affect the quality of these crops in terms of protein and nutrient content (IPCC, 2019a).

[6] There is high confidence that fertilisation effect from higher CO_2 concentrations in the atmosphere will more than compensate the negative climate change impacts for C_3 crops such as wheat, at least in regions where there is sufficient water available. This CO_2 fertilisation effect will be much lower for C_4 crops such as maize (Jägermeyr et al., 2021; EEA, 2024b).

[7] The lower end is under a medium global emissions scenario (SSP2–4.5), the higher end under a high global emissions scenario (SSP5–8.5).

Table 1 Projected average yield changes under different scenarios

Assumptions	Crop	Northern Europe	Southern Europe
JRC (2020a)			
Results for 2050, assuming some adaptation	Maize	With irrigation: –1% to –14% Without irrigation: exceeding –23%	With irrigation: –4 to –22% Without irrigation: exceeding –80% in some countries
	Wheat	+5 to +16%	Down to –49%
Jägermeyr et al. (2021)			
Results for 2069–2099, assuming no adaptation	Maize	Down to –20%	Down to –30%
	Wheat	Up to +20%	–10% to +10%
Hultgren et al. (2025)			
Results for 2100, assuming adaptation	Maize	Up to +10%	Down to –40%
	Wheat	–15% to –25%, except for Scandinavia, where yields might increase	

Sources: See table.

Notes: (1) All studies assume high global emissions (RCP8.5), which is projected to result in on average 2 °C global warming by mid-century and 3.7 °C by end of the century. They also include the CO_2 fertilisation effect. (2) The JRC study assumes the uptake of some simplified adaptation options. (3) Hultgren et al. assume more substantial adaptation based on current, observed responses of producers to climate-related changes.

Risks are significant for the livestock sector and could increase in the future, especially due to reliance on feed imports from climate-vulnerable regions.

The livestock sector can be affected by climate change through direct extreme event, lowered productivity due to increased temperatures and humidity, increased presence of parasites and pathogens, and reduced availability and quality of feed and water (Bernabucci, 2019; Hill and Wall, 2015; FAO, 2022b). The livestock sector has already been affected by climate change impacts, with current average annual weather-related losses estimated at EUR 10.9 billion per year, corresponding to 5.1% of EU livestock production (Fi-Compass, 2025).

Risks are estimated to be lower in the livestock sector compared with crop production in the short to medium term, but can become more substantial towards the mid- and later century due to increased heat stress and substantial risks of the spreading of animal diseases (EEA, 2024b; IPCC, 2022e). By 2050, average annual weather-related losses could increase to EUR 15.3 to 17.8 billion per year (Fi-Compass, 2025). Furthermore, the livestock sector's exposure and vulnerability to climate-related risks increases substantially when considering indirect impacts via feed supply chains. The EU livestock sector is highly dependent on feed imports from just a few countries: 70–75% of animal protein feed is currently being imported, and 82% of this comes from Argentina, Brazil and the United States (Ercin et al., 2021). This illustrates the EU's critical dependence on imported soybeans despite its overall self-sufficiency in bulk feed materials. The soybean-producing regions in these countries are vulnerable to climate change (Goulart et al., 2023), and it is projected that by 2050 around 60% of soybean imports into the EU will come from areas with a high or very high vulnerability to drought (Ercin et al., 2021), which also poses substantial climate risks for EU livestock production.

Downstream sectors in the food system also face risks.

Sectors downstream from the farm gate are also expected to be impacted by climate change in various ways:

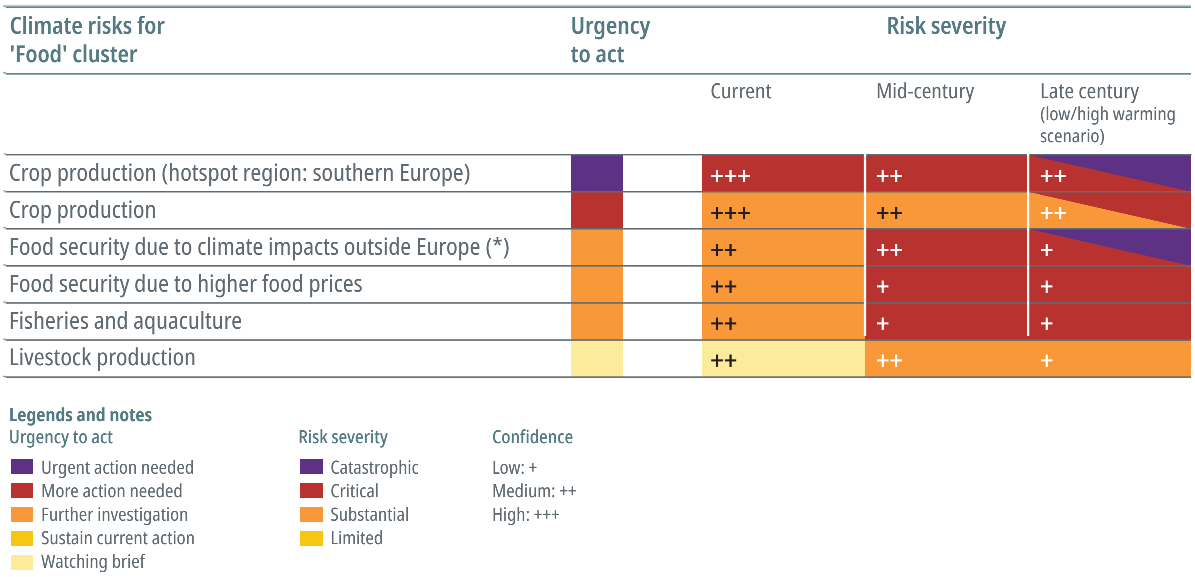
- climate-related hazard can disrupt road, rail, and waterways infrastructure, which can hinder food distribution (EEA, 2024b);
- higher temperatures and humidity rates are expected to increase the risks of food contamination during transport and storage, thereby undermining food safety (FAO, 2022b), while food safety is further threatened by increased risks of zoonotic diseases (Miraglia et al., 2009);
- the shift of climatic zones and changes in crop suitability could result in shifts in production centres, which could necessitate adjustments in downstream logistics and supply chains (EEA, 2024b).

Overall, climate-related risks are substantial in the short term and could become critical over time.

As explained above, climate change can impact agri-food systems through various dynamics, with both negative and positive impacts expected in the future. Whereas this makes it challenging to accurately project future impacts, the overall consensus is that agri-food systems are among the most vulnerable segments of the economy to climate-related risks, both globally (FAO, 2023d; IPCC, 2022d) and in Europe (EEA, 2024b).

As shown in Figure 5, the European Climate Risk Assessment found that for EU crop production, climate-related risks are already substantial in the short (up to 2040) to medium terms (up to 2060) and could become critical towards the end of the century under high-emission scenarios. In line with the projections of Figure 5, crop production in southern Europe is particularly exposed. Impacts on overall EU food security are expected to be substantial in the short and medium terms and could become critical late in the century. Risks could increase further in the event of compound effects between climatic and non-climatic risk drivers.

Figure 5 Climate-related risks for the EU agri-food system



Source: EEA (2024b).

Climate adaptation options exist, but are constrained by uncertainties and limits to adaptation.

There are several possible adaptation options which can reduce climate-related risks (see Section 3.3). However, uncertainties about future climate and socio-economic trends, impacts and solutions make effective adaptation planning particularly challenging. It requires society to prepare for multiple possible climate futures, as waiting for more certainty may not leave sufficient time to take effective action (EEA, 2024b). Such uncertainties arise from uncertainty about future emission trajectories, the inherent chaotic and unpredictable behaviour of the climate system, the potential triggering of tipping points, the evolution of exposure and vulnerabilities from the interaction with other global trends, an uneven distribution of climate-related risks across regions, and the lack of knowledge on long-term and scaled outcomes from implemented adaptation measures.

Some of the projected impacts could exceed the EU's capacity to adapt. Of particular concern is the projected exacerbation of water scarcity in southern Europe, with water availability projected to decrease by up to 40% under a 3 °C global warming scenario. This would exceed the limits of adaptation (see also Box 5) and some of the current agricultural systems in southern Europe (e.g. maize production) risk becoming unviable towards the end of this century (EEA, 2024b; JRC, 2020a).

Shifting agricultural production north could in theory be an effective way to avoid substantial reductions in crop production. However, in practice the actual adaptation potential of such shifts can be constrained by several factors (Franke et al., 2022). Land availability in more northern zones may be limited and increasingly contested, and soil quality may be poorer. Additionally, countries might be reluctant to give up on certain forms of production to maintain jobs and food sovereignty and might therefore provide support to sustain production in less suitable regions. Crop production might also be maintained in zones which are sub-optimal because they are combined with other crop types in synergetic crop rotations or because of the costs of relocating processing factories.

The agricultural sector and broader agri-food system need to enhance their climate adaptation efforts.

The adaptation gap required to avoid increasing losses is difficult to quantify due to the following.

- **Uncertain climate-related risks and impacts.** Projecting climatic, cascading and compounding risks and impacts for the agricultural sector is not straightforward, making it challenging to develop a clear, operational vision of what the sector should adapt to.
- **Lack of indicators.** Until recently, there has been a lack of concrete indicators to measure progress. The Advisory Board has previously recommended to develop such common indicators linked to EU adaptation targets (Advisory Board, 2026).
- **Knowledge and data limitations.** Data limitations and methodological complexity make it challenging to capture all relevant variables to adaptation (Leiter et al., 2019). Knowledge of the effectiveness of adaptation options is limited by the current scarcity of adaptation options implemented at scale (especially more systemic measures beyond the farm) and their interactions (Vermeulen et al., 2018). This results in conceptual and methodological uncertainty for generalising the impact of adaptation options for the long term when building scenarios (Balkovič et al., 2018).

Overall, there is a fragmented and incomplete picture of current progress on adaptation and the typical farmers' responses to climate-related risks in Europe (Thompson et al., 2022). Global studies suggest that farmers tend to adapt after experiencing climate-related impacts rather than anticipating future risks (Berrang-Ford et al., 2021; Chhetri et al., 2019). The current deployment of proactive adaptation options – aiming at increasing both farm and ecological resilience rather than just managing impacts, such as off-farm diversification, soil-improving practices or agroforestry – are low and heterogenous (EEA, 2019; Heller et al., 2024; European Parliamentary Research Service, 2020).

Despite the limitations of the current knowledge base to make quantifiable adaptation pathways, there is a strong consensus in the scientific literature that climate-related risks and impacts for the sector tend to be underestimated, technological potential overestimated, and that the sector needs to substantially enhance its adaptation efforts (Berners-Lee et al., 2018; IPCC, 2022g; EEA, 2024b; Simpson et al., 2023b).

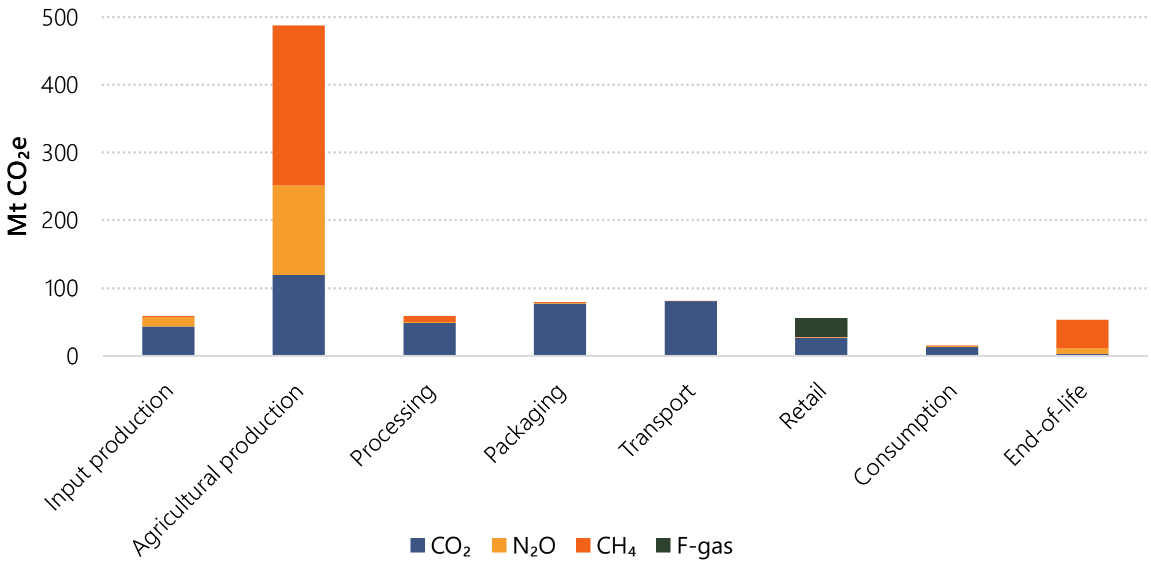
2.4 Greenhouse gas emissions and removals

Agri-food GHG emissions account for almost a third of the EU total and are dominated by emissions from agricultural production.

As shown in Figure 6, net GHG emissions from the entire EU agri-food system were estimated at 889 Mt CO_2e in 2023, accounting for 31% of total EU net emissions. Of these, 55% (487 Mt CO_2e or 17% of total EU net emissions) occurred during agricultural production, including net land-based agricultural CO_2 emissions from cropland and grassland.

Whereas CO_2 emissions are the predominant GHG in other parts of the agri-food system, GHG emissions from agricultural production consist primarily of non-CO_2 gases: approximately half are methane (CH_4)emissions, with CO_2 and N_2O each accounting for approximately one quarter. These shares are based on the IPCC *Fifth Assessment Report* (AR5) global warming potential values over a time frame of 100 years (see also Box 1).

Figure 6 Net GHG emissions of the EU agri-food system in 2023 per sector and greenhouse gas



Sources: EEA (2025c) and JRC (2024d).

Notes: (1) 'Agricultural production' is based on the EU GHG inventory, and includes livestock emissions (CRF categories 3.A and 3.B), emissions relating to the management of agricultural soils (CRF categories 3.C to 3.J), energy use in agriculture, fisheries and forestry (CRF category 1.A.4.c) and net land-based emissions from crop- and grasslands (CRF categories 4.B and 4.C). (2) Other sub-sectors' GHG emissions are based on the Emissions Database for Global Atmospheric Research Food database. (3) 'Consumption' covers emissions relating to energy use in the consumption phase.

Box 1 Different GWP values and their implications

To compare different types of GHGs, they are commonly converted to CO_2 equivalents based on their global warming potential over 100 years.

Whereas CO_2 is the predominant GHG in other major emitting sectors, GHG emissions in the agricultural sector mainly consist of CH_4 and N_2O. To compare different GHGs it is common practice in scientific literature – including in the Intergovernmental Panel on Climate Change (IPCC) assessment reports – and in climate policy to convert CH_4 and N_2O emissions to 'CO_2 equivalents' using conversion factors known as global warming potentials over a timeframe of 100 years (GWP-100). These GWP-100 values compare the heat-trapping effects of different GHGs relative to CO_2 over a century-long time frame, based on their ability to absorb infrared radiation and their atmospheric lifetimes. For example, the AR5 GWP-100 value of 28 for CH_4 represents that the integrated radiative forcing over one century of one tonne of CH_4 is 28 times that of one tonne of CO_2. Biogenic CH_4 has a slightly lower GWP-100 (27) compared to fossil CH_4 (29.8) as it does not affect atmospheric CO_2 concentrations. Parties to the Paris Agreement report emissions of GHGs individually per type but are also required to report aggregated emissions and removals expressed as CO_2 equivalents based on the same GWP-100 metric.

Using a 100-year global warming potential hides important differences between long- and short-lived GHGs.

The GWP-100 metric is useful as it allows for a consistent and transparent comparison of different types of GHGs, which can support choices about priorities, trade-offs and synergies in climate mitigation policies (IPCC, 2022g). Its main drawback, however, is that it hides important differences between long-lived gases such as CO_2 (with an atmospheric lifetime of centuries to millennia) and short-lived climate forcers such as CH_4 (with an atmospheric lifetime of approximately 12 years). CH_4 has a very high warming effect in the short term (80–85 times stronger than CO_2 when measured over 20 years), but a much smaller warming effect thereafter, which results in a GWP of 28 when averaged out over 100 years. Because CH_4 is a short-lived GHG, the relationship between its annual and cumulative emissions, atmospheric concentrations and global temperature increases is different from that of long-lived GHGs such as CO_2.

- If CH_4 emissions remain constant, its concentration in the atmosphere stabilises, leading to only a slight increase in warming over time as the warming effect induced by CH_4 emissions in the recent past is sustained but not substantially increased. A sustained decrease in CH_4 emissions would reduce the overall CH_4-induced warming.
- For long-lived GHGs such as CO_2, stable emissions lead to an accumulation of CO_2 in the atmosphere, thus resulting in higher atmospheric concentrations and increased warming over time. A sustained decrease in the emissions of long-lived GHGs would slow down but not decrease warming. Warming would halt when a net-zero balance between emissions and removals is achieved and would only decrease in case of net-negative emissions thereafter.

As a result, reductions in CH_4 emissions can help slow down warming in the short term, while the world transitions to net-zero emissions of long-lived GHGs to halt overall warming.

The GWP* metric has been proposed as an alternative metric but raises several issues.

Several alternative metrics have been proposed in the scientific literature with the aim to better reflect the different warming characteristics of short- versus long-lived GHGs. Among these, *GWP** ('GWP star') has received particular attention both within scientific literature (Allen et al., 2016; Cain et al., 2019) and in the broader public debate (Changing markets foundation, 2023; Animal Task Force, 2023). This metric assesses the warming effect of short-lived climate forcers such as CH_4 by comparing present-day emissions with emission levels from the recent past.

It is broadly acknowledged that the GWP* metric is better suited than the GWP-100 metric to estimate the cumulative effect of global CH_4 emissions expressed as CO_2-equivalence on global temperature increases (IPCC, 2022g; Rogelj and Schleussner, 2019). However, when the same metric is used to determine reduction pathways at a sub-global level (e.g. for a country or a company), it raises several issues. Because the metric uses emission levels from a recent past as a baseline (referred to as 'grandfathering'), it can de facto give preferential treatment to entities with high historical emissions, at the expense of entities which have lower historical emissions, thereby raising issues about fairness and equity (Duffy et al., 2025). Furthermore, the outcome of the GWP* metric is highly sensitive to arbitrary choices, undermining the comparability of different entities' mitigation efforts. Finally, the entire policy framework, both at the global and EU levels, is currently based on the GWP-100 metric, and changes in the use of metrics without a careful adjustment of accompanying targets can lead to a reinterpretation of policy targets without a clear scientific, political or moral reasoning (Rogelj and Schleussner, 2019). To avoid this, the use of GWP* would require most countries to completely revise their climate targets and policies, which would be politically disruptive (Meinshausen and Nicholls, 2022).

This report uses GWP-100 values.

For these reasons, the approach of the Advisory Board for this report is to maintain the use of the GWP-100 metric, which is consistent with the EU's overall approach and emissions reporting under the Paris Agreement. It uses the GWP-100 values of the IPCC AR5, unless specified otherwise.

Agricultural GHG emissions come from a variety of sources.

Direct GHG emissions from agricultural production can overall be attributed to five main categories, as shown in Figure 7.

- **Livestock** directly accounts for 50% of agricultural emissions and emits GHG emissions via two main sources: CH_4 is emitted by enteric fermentation in ruminants (179 Mt CO_2e), and CH_4 and N_2O are released during manure storage and handling of all livestock types (63 Mt CO_2e). As further explained below, livestock production also contributes to emissions indirectly due to feed production.

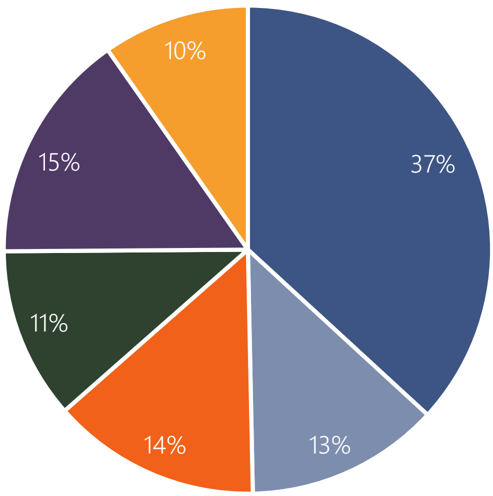
- **Fertiliser use** accounted for 67 Mt CO_2e in 2023, or 14% of the total. This includes direct N_2O emissions from the use of both inorganic (33 Mt CO_2e) and organic fertilisers[8] (25 Mt CO_2e), and CO_2 emissions from liming, urea and other carbon-containing fertilisers (9 Mt CO_2e).

[8] Emissions from organic fertilisers mainly come from manure applied to soils as fertiliser. Dung and urine deposited by grazing animals is reported under a separate category in the GHG inventories but has also been included in organic fertilisers in this report.

- **Other non-CO_2 emissions** refer to a range of other emissions reported under category 3 of the IPCC categorisation, with N_2O emissions from crop residues and the cultivation of organic soils (see below) and indirect N_2O emissions from managed soils as the main sources. Together, these smaller emission sources jointly accounted for 55 Mt CO_2e in 2023 (11% of the total)
- **Energy use** in agriculture (fuel for machinery, heating, irrigation) contributes about 15% of the sector's emissions (75 Mt CO_2e), mainly as CO_2 from on-farm fuel combustion. While often excluded from 'agriculture' in inventories (they are listed under 'energy'), these emissions are essential to consider when looking at a systemic transition of the sector.
- Net **land-based agricultural emissions** account for approximately 10% (47 Mt CO_2e) of total agricultural emissions. However, this is the net balance between gross emissions and removals, and hides substantial GHG emissions (+75 Mt CO_2e) from organic soils (see further below).

For the remainder of this report, emissions from livestock, fertiliser use and other non-CO_2 emissions are jointly referred to as 'agricultural non-CO_2 emissions'.[9]

Figure 7 Breakdown of agricultural GHG emissions in the EU



Source: EEA (2025c).

Note: Based on 2023 data.

Livestock and degraded peatlands are key GHG emission hotspots within agriculture.

As discussed above, livestock directly accounts for half of total agricultural GHG emissions. It also contributes to EU GHG emissions indirectly as approximately two-thirds of EU cereal production (EC, forthcoming) and EU agricultural land (EC, 2023a; Leip et al., 2015) are used to sustain livestock systems. In addition to domestic GHG emissions, the import of protein feed has been linked to substantial emissions resulting from land use change outside the EU, estimated at approximately 100 Mt CO_2e per year (Sandström et al., 2018). This highlights the role of livestock systems as the predominant driver of GHG emissions in EU agriculture. Ruminant meat (beef, lamb, mutton) and dairy products are particularly GHG-intensive, whereas pork and poultry products are less GHG-

[9] Note that this category also includes a limited amount of CO_2 emissions (9 Mt in 2023) from carbon-containing fertilisers.

intensive (Aan Den Toorn et al., 2020; Lesschen et al., 2011; Notarnicola et al., 2017; Weiss and Leip, 2012).

Degraded peatlands (see Box 2 for a definition) are another key GHG emission hotspot, but they are somewhat hidden in the GHG inventories. As mentioned above, agricultural soils are currently a net source of land-based CO_2 emissions reported under the land use sector (+47 Mt CO_2e in 2023). However, this number hides large differences between different soil types and land uses, as shown in Table 2.

Table 2 Net GHG emissions reported under the land use sector per land use and soil type in 2023

Mt CO_2e	Croplands	Grasslands	Total
Mineral soils	+4	–30	–26
Organic soils	+31	+44	+75
Unspecified/other	–1	0	–1

Source: EEA (2025c).

- **Mineral soils** – soils with limited soil carbon content – serve as a net sink, removing approximately 26 Mt CO_2e in 2023. However, there are also differences within this category: current soil management practices result in net emissions from mineral croplands (+4 Mt CO_2e) and net removals (–31 Mt CO_2e) from grasslands. Grasslands both store large amounts of carbon and can continue to sequester more over time; however, much of this carbon is released as CO_2 if the land is ploughed.
- **Organic soils** emit substantial amounts of GHG emissions. Related emissions come primarily from degraded peatlands, which oxidise rapidly, releasing large amounts of carbon in the form of CO_2 (see Box 2). Whereas organic soils make up only 2% of the total agricultural area in the EU (EASAC, 2022), they emitted 86 Mt CO_2e in 2023 (of which 75 Mt CO_2e reported under the land use sector and 11 Mt CO_2e under the agricultural sector), making them a major hotspot of GHG emissions. These soils are concentrated primarily in regions in northern European countries (Ireland, the Netherlands, northern Germany, Scandinavia, Poland and the Baltics).
- The **'unspecified/other'** category in Table 2 is the balance of a small net sink from living and dead biomass on agricultural land, which partially offset by net N_2O emissions from nitrogen mineralisation/mobilisation and limited CH_4 emissions from biomass burning.

Box 2 Organic soils, histosols, wetlands and peatlands

Organic soils refer to soils with a high degree of carbon content (in general a minimum 12% of organic carbon content, see Volume 4, Chapter 3, Annex 3A.5 of the IPCC 2006 guidelines for detailed thresholds (IPCC, 2006)). The World Reference Base for Soil Resources uses the term 'histosols', which refers to soils with thick organic layers (International Union of Soil Sciences, 2022), and can thus be considered a synonym for organic soils.

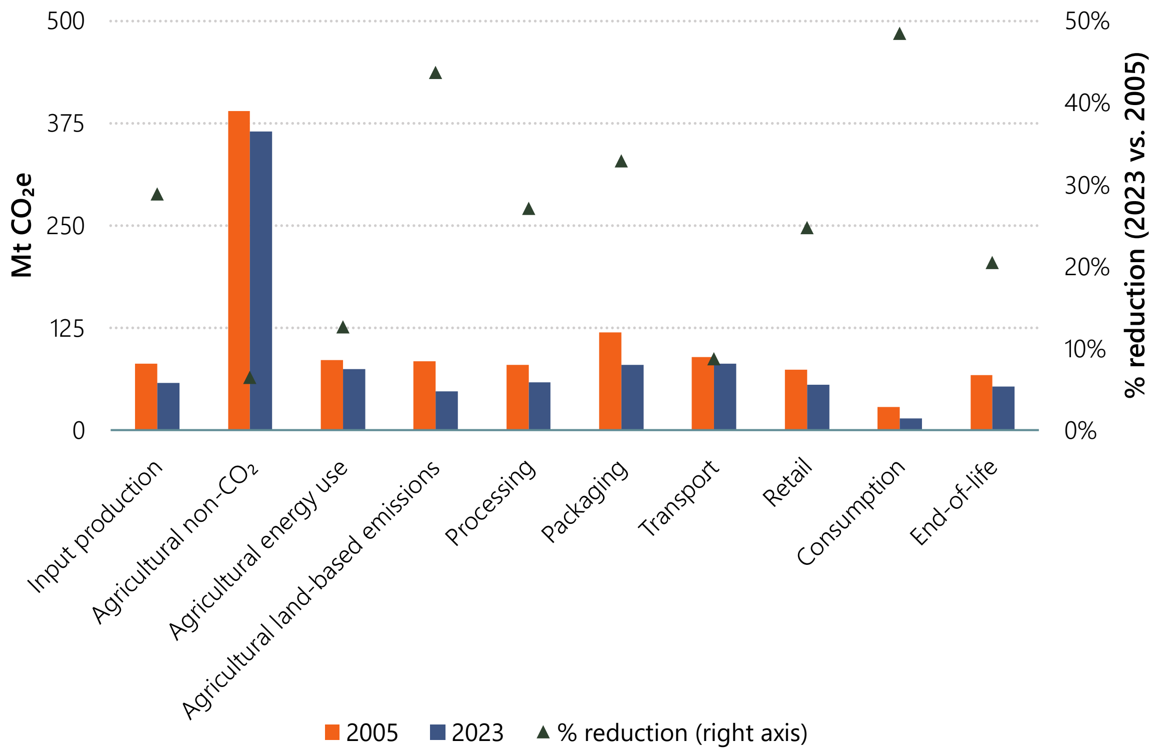
Wetlands are defined by the IPCC as areas of land that are covered by water for all or part of the year (IPCC, 2022h). Peatlands are a specific type of wetland ecosystem, where the soil is dominated by carbon-rich peat. This peat was formed over millennia by the partial decomposition of plant material due to its submergence in water. Degraded peatlands are peatlands characterised by a loss of ecosystem functions due to human activities (e.g. drainage) or natural disturbances (e.g. droughts). When peatlands are degraded, they lose their peat (and thus soil carbon content) through oxidation, resulting in substantial CO_2 emissions.

Climate mitigation progress across the EU agri-food system has been uneven, with only limited reductions in agricultural non-CO_2 emissions since 2005.

The EU agri-food system reduced its GHG emissions by 19% between 2005 and 2023. As this is slower than the rest of the EU economy, its share in total EU GHG emissions increased from 26% in 2005 to 31% in 2023.

As shown in Figure 8, mitigation progress has been uneven across different subsectors. Some smaller emission sources (input and packaging production, consumption and land-based CO_2) made substantial progress on reducing (net) GHG emissions. But the largest emission sources – namely agricultural non-CO_2 emissions – made very limited progress during 2005–2023 after more substantial reductions in the 1990s (Advisory Board, 2024).

Figure 8 Net GHG emissions across the EU agri-food system in 2005 and 2023



Sources: EEA (2025a) and JRC (2024d).

Notes: See notes under Figure 6 for more information on the sectoral splits and methodologies.

The EU agri-food system needs to enhance its contribution to the EU's overall climate targets, by reducing emissions, enhancing removals and supplying sustainable, renewable resources.

To align with the European Climate Law, all major GHG emitting sectors of the economy will have to make a cost-effective contribution to the overall climate neutrality target for 2050 and the intermediate 90% target for 2040. This includes the EU agri-food system and the agricultural sector in particular.

Most of the GHG emissions in agriculture are the result of biological processes, which distinguishes them from energy-related CO_2 emissions in other sectors. There is a general understanding that GHG emissions from biological processes cannot be fully eliminated based on existing technologies, and therefore the agricultural sector is expected to become the main source of residual GHG emissions by 2040 and 2050 (Advisory Board, 2025). These residual emissions should be reduced as much as possible but eventually the remaining emissions would need to be counterbalanced by removals to achieve EU climate neutrality.

Nevertheless, the sector can and must make a substantial contribution to the EU climate targets in three different ways:

- by reducing its own GHG emissions;
- by contributing to the enhancement of land-based removals, both on agricultural land and by freeing up land for other land uses with high sequestration potential such as afforestation and the restoration of degraded peatlands;
- by supporting the decarbonisation of other sectors as key supplier of sustainable biomass and other renewable sources to substitute fossil fuels and feedstocks.

The required role of agriculture in achieving EU climate neutrality is discussed in more detail in Chapter 4.

2.5 Other challenges

2.5.1 Other environmental dimensions

The agri-food system is both a victim and a driver of biodiversity loss, pollution, soil degradation and freshwater resources depletion.

In addition to adverse climate-related impacts, agricultural productivity is also threatened by other environmental crises, with 70% of EU agricultural land suffering from some degree of environmental degradation (Pravalie et al., 2025). Soil degradation and erosion is of particular concern, with 89% of EU agricultural soils showing signs of critical loss of their functions (EC, forthcoming). Over half of arable land is vulnerable to at least one driver of erosion (Borrelli et al., 2022), and an estimated 7% of agricultural land is estimated to suffer from severe erosion resulting in EUR 1.2 billion of productivity losses (EASAC, 2022). The alarming decline in biodiversity also threatens vital ecosystem services such as pollination and biological/natural pest control (Midler, 2022).

As with climate change, the agri-food system is not only a key victim but also an important driver of these other environmental degradations, including biodiversity loss, soil erosion and degradation, and water, air and soil pollution (EEA, 2023c; Galli et al., 2023; Vanham et al., 2023) induced by agricultural practices. The external cost of the EU agri-food system's impact on nitrogen pollution, water use and land use were estimated at USD_{2022} 222 billion per year in 2023 (FAO, 2023b), which also lowers systemic resilience for the agricultural sector itself and increases its long-term vulnerability.

Within the agri-food system, agricultural production exerts most environmental pressures.

As with GHG emissions, agricultural production is the main source of other environmental pressures within the agri-food system (Notarnicola et al., 2017) on four dimensions.

- **Biodiversity.** Agriculture expansion has been shown in several studies to be one of the biggest drivers of biodiversity loss, even though there are management practices with low and in a few cases even positive impacts (Burns et al., 2016; Dudley and Alexander, 2017). In particular, the widespread use of certain practices such as simplified agricultural landscapes, chemical inputs, high grazing intensities and narrow crop rotations have been a main driver of biodiversity loss in the EU and other environmental aspects (INRAE & IDDRI, 2025).
- **Soil quality.** Specific agricultural practices (e.g. the use of heavy machinery and intensive grazing systems) are degrading soil quality through compaction, eliminating soil cover and reducing key soil properties like water storage (Pereira et al., 2020; INRAE & IDDRI, 2025).
- **Water use.** Agriculture is a major water consumer (accounting for over 60% of net water use in the EU) and a key source of freshwater and marine water pollution by chemicals, nitrogen, phosphorus, microplastics, and sediment (EEA, 2021; EASAC, 2022; INRAE & IDDRI, 2024). In particular in southern Europe, agricultural irrigation is putting substantial pressure on water resources (INRAE & IDDRI, 2025) (see also Section 2.3).
- **Air pollution.** The use of chemical inputs and management of animal manure is a main source of air pollutants such as ammonia, sulphur dioxide, heavy metals, fine particles and volatile organic compounds (INRAE & IDDRI, 2025). Their impact on air quality can negatively impact the health of humans, animals and plants, sometimes even over long distances.

Despite its potential to deliver environmental benefits, livestock production is the main cause of environmental degradation in the EU.

Of all agricultural products, meat and dairy exert the greatest pressure on the environment (Leip et al., 2015; Vanham et al., 2023; Notarnicola et al., 2017). When considering also the indirect impacts of feed production, livestock systems account for the majority of the EU agricultural sector's impacts in terms of biodiversity loss (78%), soil acidification (80%), air pollution (80%), water nitrogen and phosphorus pollution (73%) (Leip et al., 2015).

Whereas the aggregate impact of the livestock sector on the EU environment is clearly negative, livestock production can in some cases also have positive impacts on the environment and broader sustainable development goals.

- Livestock can contribute to the circular bioeconomy as waste streams that are unsuitable for other purposes (e.g. direct human consumption) can be used as feed, whereas animal manure can be used as a fertiliser which helps to reduce the need for synthetic fertilisers and to close the nutrient loop (Van Selm et al., 2022; Van Zanten et al., 2023).
- (Silvo)pastoral livestock systems can use marginal land areas suitable only for grass production rather than arable cropping due to biophysical reasons thereby converting non-edible biomass into human-edible protein (FAO, 2023c; Rewilding Europe, 2021).
- Extensive grazing systems can – under certain conditions – contribute to a range of ecosystem services such as biodiversity preservation, soil health, carbon sequestration, and the reduction of the risk of wildfires (Rouet-Leduc et al., 2024; EASAC, 2025).

Similarly to overall agricultural production, the environmental impact of livestock production is therefore not negative by default, but a function of the type and overall management of livestock systems.

2.5.2 Land use and availability

Land availability for food production is under pressure from competing land uses.

Agricultural production requires substantial amounts of land. In 2020, 157 million hectares (Mha) or 38% of the EU land surface was used for agriculture (Eurostat, 2024f). However, this area has been declining slowly but steadily, with limited shifts between 2005 and 2021 from croplands (–6 Mha) and grasslands (–1 Mha) to settlements (+4 Mha) and forest area (+3 Mha) (Advisory Board, 2024).

Looking forward, it is likely that the availability of land for food production will come under further pressure from competing land uses:

- Net land take for **human settlements** continues to occur, even if the trend has been declining since 2005 (Advisory Board, 2024). Between 2012 and 2018, for example, the EU averaged about 450 km^2 per year of net land take in cities and their commuting zones (EEA, 2023b). Even if the EU achieves its non-binding objective to achieve no net land take by 2050 (EC, 2021a; EU, 2013), this would mean that net-land take would continue to occur in the coming 25 years.
- EU objectives and regulations to promote **nature restoration and carbon sequestration** might require further changes from agricultural land to other land uses. For example, the Nature Restoration Law (Regulation (EU) 2024/1991) requires Member States to restore part of their drained peatlands which are currently used for agricultural production. The European

Commission scenarios underpinning a 90% reduction target also show an expansion of wetland and forest areas to enhance carbon dioxide removals, at the expense of grassland areas and – under the LIFE scenario – cropland area (EC, 2024b).

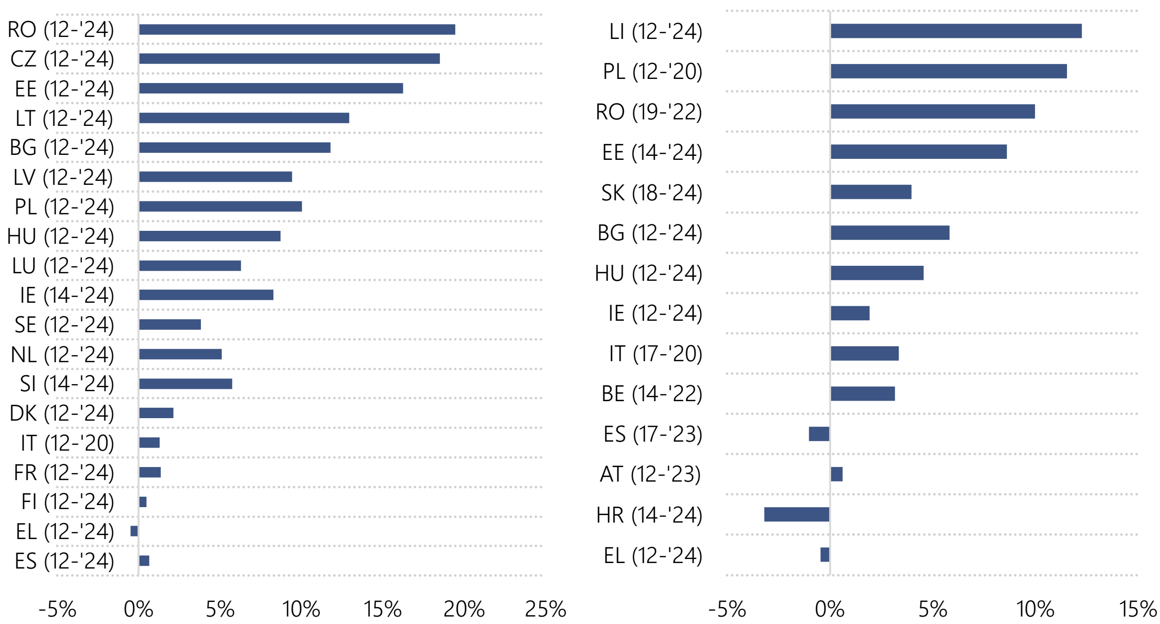
- Within agriculture the land available for food production could face increasing competition from the production of **agricultural biomass for feedstock** purposes (see also Section 2.2).

The required roll-out of renewable energy technologies to achieve the EU climate targets has also been mentioned as a source of competing land demand; however, it would not per se add to competing land demands. A recent study by the Joint Research Centre (JRC, 2024f) found ample potential for the deployment of new solar photovoltaic, onshore wind and hydropower in areas that are less suitable for agricultural production.

Both land prices and land concentration increased substantially over the last decade.

As shown in Figure 9, the increasing pressure from competing land uses has contributed to a sharp increase in land prices in most Member States over the last decade (Eurostat, 2024b). In central and eastern Europe, where prices have risen by an average of 10–20% per year, this trend has also been driven by the capitalisation of CAP payments, as these countries joined the EU later and initially had relatively low land prices. Land rent prices also increased, although at a slower speed.

Figure 9 Average annual change in agricultural land (left chart) and rent prices (right chart)

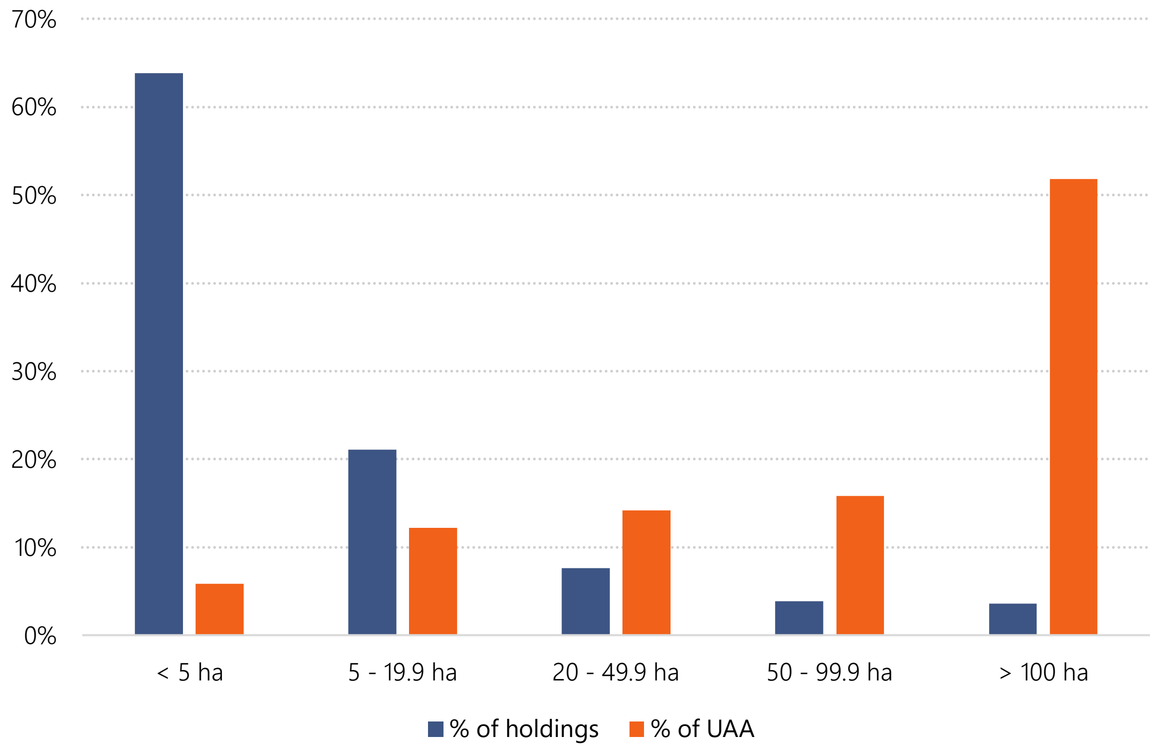


Sources: Eurostat (2024b, 2024c).

Notes: (1) The country code abbreviation can be found in Acronyms and Abbreviations section at the end of the report. (2) Not all Member States have reported data for the same time periods. The figure includes Member States for which data is available. The period for which the average annual change was calculated differs per Member State and is shown in the chart.

At the same time, agricultural land use is becoming increasingly concentrated, with a small number of large farms (approximately 325 000 farm holdings of 100 hectares or more) representing more than 50% of the utilised agricultural area (UAA), whereas very small farms make up the bulk of farm holdings (approximately 5.8 million holdings of maximum 5 ha) but only account for 6% of the UAA (see Figure 10).

Figure 10 Share of farm holdings and UAA per farm holding size category



Source: Eurostat (2024e).

Land prices are increasing production costs and hinder aspirational farmers from entering the sector.

The increase of land prices and land concentration has raised various concerns among stakeholders, policy makers and scientists (European Parliament, 2017, 2015; Plogmann et al., 2022; Van Der Ploeg et al., 2015). Whereas increasing land prices might have benefited farms that own their land, they have substantially increased production costs for farms that rent their land. At the EU level, approximately 50 to 55% of all agricultural area is rented by farmers managing the land (Baldoni and Ciaian, 2023). High prices and land concentration also result in entry barriers for young and aspiring farmers and therefore undermine generational renewal (see also Section 2.5.3).

2.5.3 Agricultural livelihoods and generational renewal

Fair living standards and decent incomes for agricultural workers are a key political priority in the EU.

One of the key objectives of the CAP as established under the Treaty on the Functioning of the European Union (TFEU) is to ensure a fair living standard for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture (EU, 2012). Despite the long existence of the CAP, there are still concerns about low and volatile incomes in the sector, and the economic situation and living standards of EU farmers is high on the political agenda. Indeed, the importance of decent incomes for farmers and other agricultural workers is broadly acknowledged in the Strategic Dialogue on the future of EU agriculture (EC, 2024h) and the European Commission's Vision for Agriculture and Food (EC, 2025i).

Farm income is the most relevant indicator to assess living standards of farm households but is difficult to assess due to a lack of EU-wide data.

It is important to distinguish between farm incomes – which refers to the aggregate income of farming households from a range of activities – and agricultural incomes, which refers to the income from agricultural activities only.

Farm income determines the disposable income of farming households and is therefore the most useful indicator to compare living standards of farming versus non-farming households in the EU (Matthews, 2024). Whereas there is no common statistical database for farm incomes across the EU, a 2015 study for the European Parliament's agricultural committee found that while farm incomes are usually largely coming from agricultural activities (typically about a half to two thirds), they are often complemented by other income streams, with at least a third of farm households receiving incomes from non-farming activities (Hill and Bradley, 2015). Furthermore, data from specific Member States has shown that non-agricultural income increases both the overall level and the stability of farm income when compared with agricultural income. When this non-agricultural income is also considered, the study concluded that farming households in these Member States do not have particularly low incomes compared with the economy-wide average (Hill and Bradley, 2015).

Agricultural incomes remain below the EU-wide average but are highly heterogenous. Smaller farms in particular struggle to earn a decent return on their labour input.

Due to the lack of EU-wide data on farm incomes, livelihoods of the farming community are often assessed based on agricultural income (that is, the net farm incomes from agricultural activities) per agricultural work unit (AWU).

Despite a substantial increase during 2005–2023 (+84%), the average agricultural income per AWU is still at 41% below the average of non-farming sectors (Matthews, 2024). At the same time, agricultural workers are more likely to face occupational safety and health risks and precarious working conditions (DG AGRI, 2025).

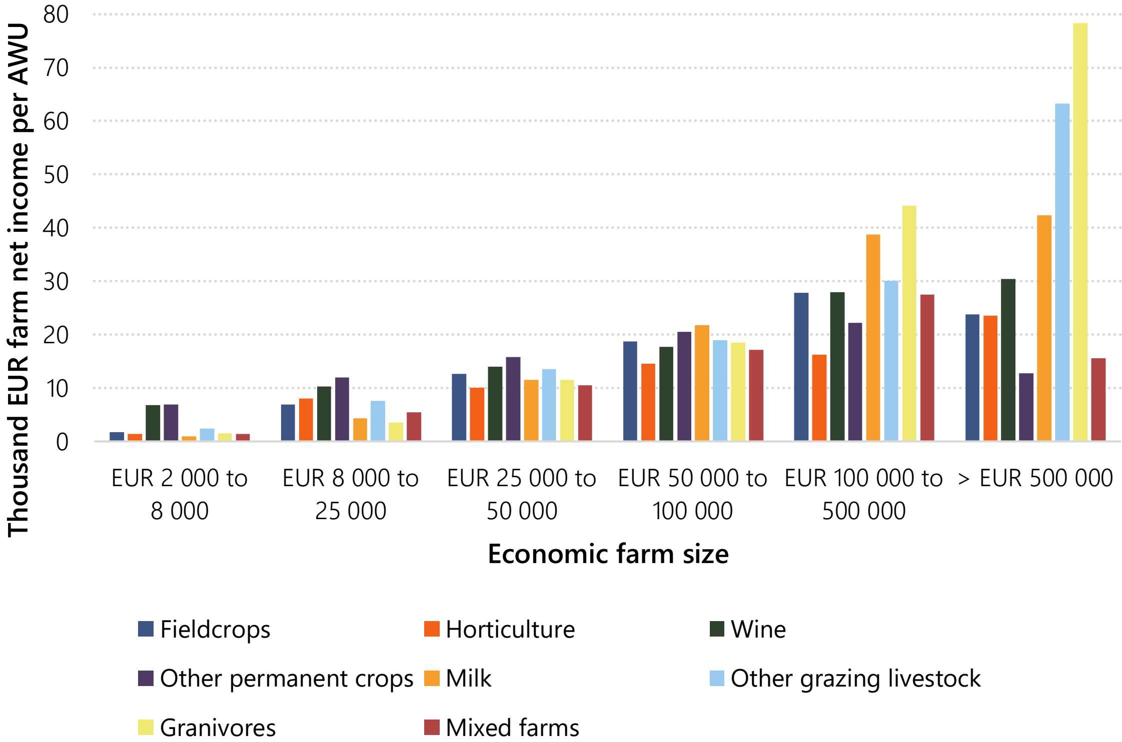
There are however strong disparities within the sector, with an average annual agricultural income per AWU of EUR 61 500 in the top 10% farm holdings compared with less than EUR 800 in the bottom 10% (EC, DG AGRI, 2023).[10] As also illustrated by Figure 11, one of the strongest determinants is farm size, with small farms having on average the lowest income per AWU (Hill and Bradley, 2015; Matthews, 2024). Other factors that are also correlated with income levels include location (lower incomes in less-productive areas), farm type (highest incomes for pig, poultry, dairy, horticulture and wine, and lowest for mixed farms) and farmer age, gender and education (higher incomes for middle-aged men, lower incomes for younger and female farmers) (Hill and Bradley, 2015).

However, some caution is warranted when considering these findings. Whereas small farms generally generate low agricultural incomes per AWU, their managers are more likely to spend a substantial part of their time on non-farming activities. Over 60% of managers of farms below 5 hectares have

[10] These figures are based on data from commercial farms only, which represent a minority (2.6 million registered in 2023) of the 9 million farm holdings identified in the 2020 Agricultural Census.

reported to spend less than 25% of their working time on farming, whereas over 70% of large farm managers (> 100 hectares) reported to work full-time on their farm (Hill and Bradley, 2015).

Figure 11 Average agricultural annual income per farm economic size class and farm type.



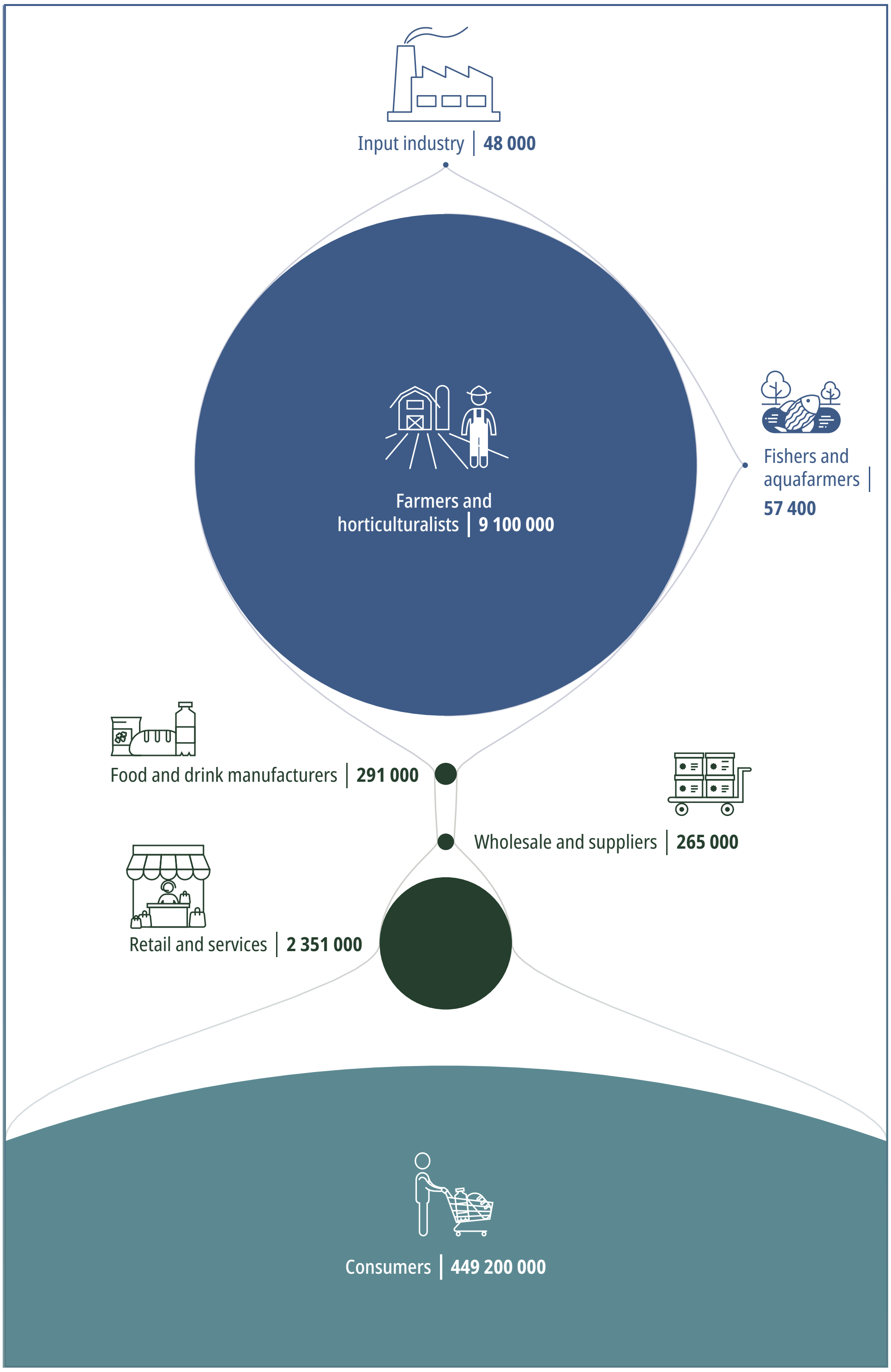
Source: EC (2024d).

Note: The economic size class is based on the standard economic output per farm per year. Farm size could also be expressed in terms of geographical size, but the Farm Accountancy Data Network (FADN) database does not provide a breakdown of this. However, on average farms with a larger economic output are also larger in terms of geographical size.

Low agricultural incomes are often linked to market power imbalances, but scientific evidence is inconclusive.s

As illustrated in Figure 12, the number of enterprises per step in the agri-food value chain is highly skewed, with a high number of farms compared with up- and downstream entities. The high concentration of up- and downstream entities is the result of a consolidation process that has been going on for decades and reached a new scale since 2015 (Clapp, 2021; IPES-Food, 2017; Swinnen et al., 2021).

Figure 12 Number of entities in different parts of the EU's agri-food value chain



Sources: Eurostat (2022a, 2024l, 2018, 2019).

Notes: (1) 'Input industry' covers enterprises manufacturing fertilisers, pesticides, seeds and agricultural machinery. (2) 'Farmers and horticulturalists' refers to agricultural holdings in the EU27). (3) 'Fishers and aquafarmers' includes fishing vessels and aquaculture production units. (4) 'Food and drink manufacturers' are enterprises in food and beverage processing (NACE 10, 11). (5) 'Wholesale and suppliers' covers enterprises in food, beverage and tobacco wholesale (NACE 46.2, 46.3). (6) 'Retail and services' includes specialised food retailers and food service enterprises (restaurants, catering, etc.). (7) 'Consumers' refers to the EU27 population (1 January 2024).

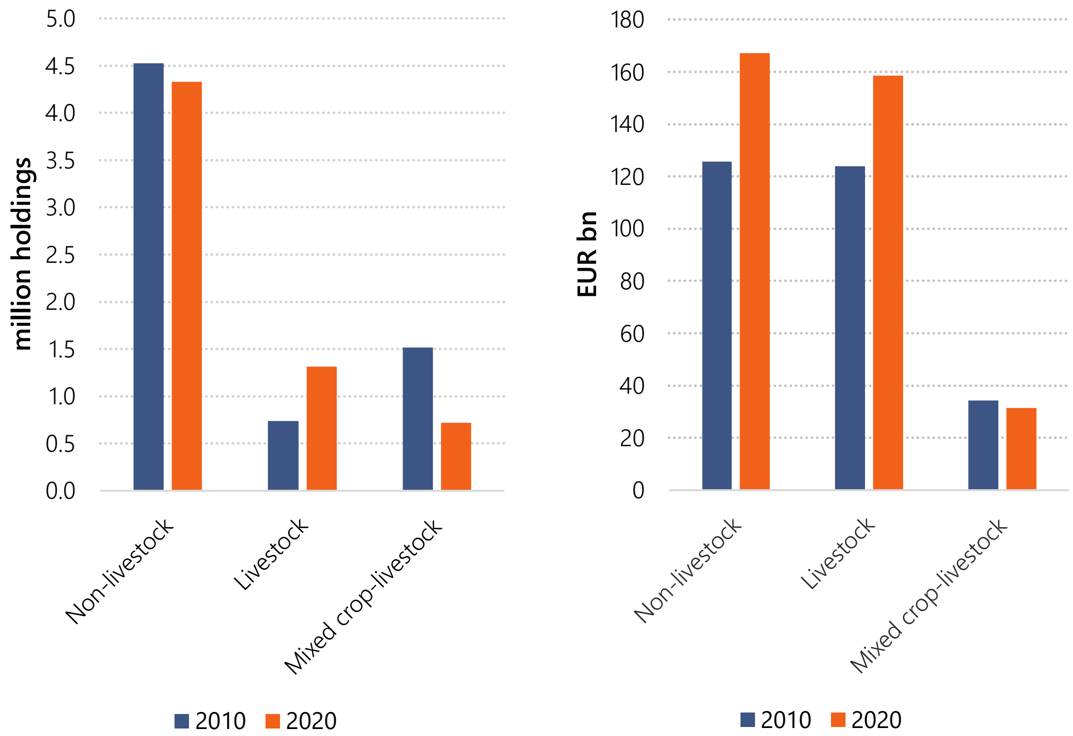
Market consolidation can provide benefits in terms of increased cost-effectiveness through economies of scale. However, it is often seen as a key cause of risk for agricultural incomes, as a large group of smaller farm holdings is increasingly reliant on oligopoly of upstream suppliers and downstream buyers, undermining their market power to negotiate fair prices (EC, 2025i; INRAE & IDDRI, 2025). However, there is also literature that points to mixed empirical evidence on market power. A study by the Organisation for Economic Co-operation and Development (OECD, 2021b) has argued that the low profitability of certain (primarily smaller) farms is due to other structural challenges posed by economies of scale and slow adjustment processes.

Finally, some observers have warned that the oligopoly of powerful food retailers and processors dominating the EU food supply uses pricing strategies, product placement, branding and promotions to push ultra-processed foods. While these products are highly profitable, they are also often considered as unhealthy (The Lancet, 2025). The concentration of market power therefore undermines healthy diets and contributes to substantial public health costs (Monopolkommission, 2024; BEUC, 2021a; WHO, 2021) (see also Section 2.5.7).

Consolidation within agriculture is increasing profitability but reducing jobs in the sector.

The agricultural sector itself is also experiencing a consolidation process towards fewer but larger farms. As shown in Figure 13, the number of farm holdings in the EU decreased by 25% over the last decade, from 12 million in 2010 to 9 million in 2020. This decrease is mainly driven by a reduction in livestock farms (–1.9 million holdings, –46%) and to a lesser extent by fewer mixed crop-livestock farms (–0.5 million holdings, –31%) and non-livestock farms (–0.5 million holdings, –8%). At the same time, the total economic output of the different farm types increased, indicating the trend towards fewer but larger farms.

Figure 13 Evolution in number of farm holdings (left) and economic output (right) per sub-sector



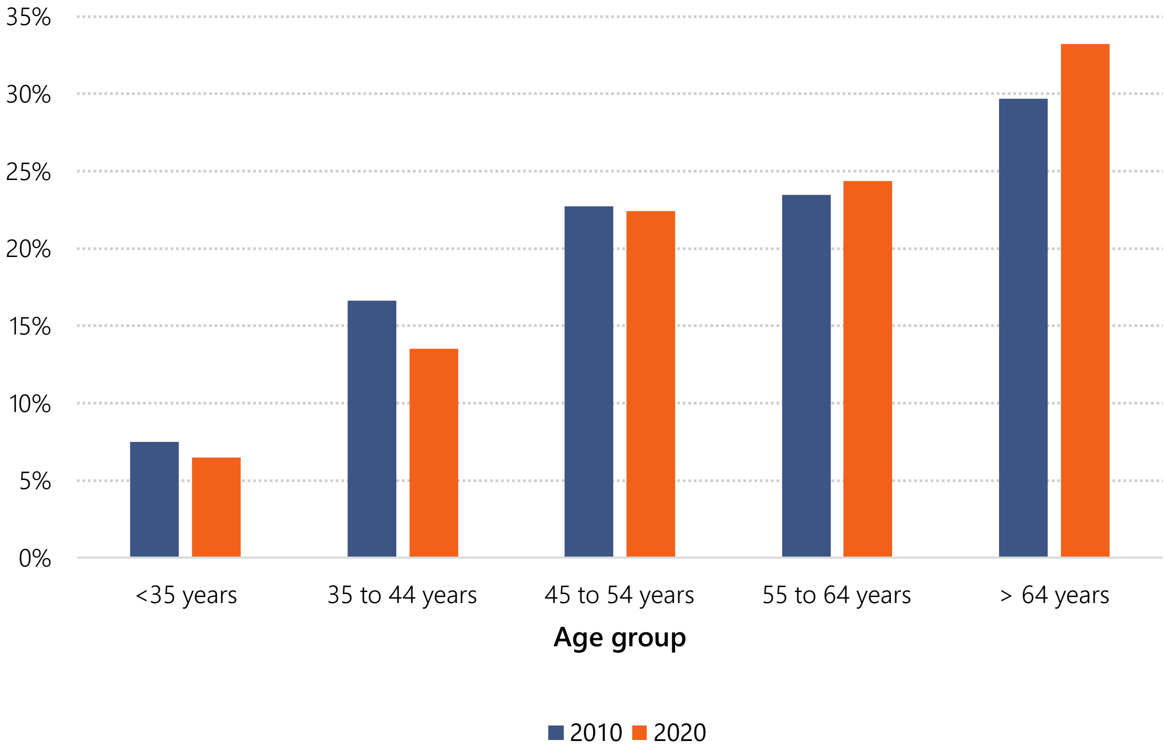
Source: Eurostat (2025c).

On the positive side, the consolidation process has enabled substantial improvements in productivity and farmers' incomes: out of the 84% increase in the average income per AWU during 2005–2023, around three quarters is due to a decrease in the total number of work units (Matthews, 2024), but has also resulted in a loss of agricultural jobs, with the agricultural workforce decreasing from 12.5 million in 2005 to 7.6 million in 2024 (Eurostat, 2024a). This number is expected to continue declining throughout the century (Ormaza Zulueta et al., 2024).

The agricultural sector is facing a lack of generational renewal.

As shown in Figure 14, the EU has an old and ageing farming population. Between 2010 and 2020, the share of farm managers of 55 years or older increased from 53% to 58%, whereas the share of young farmers (below 45 years) decreased from 25% to 20%.

Figure 14 EU farm managers per age category, 2010 vs. 2020



Source: Eurostat (2024d).

This trend has raised concerns about the lack of generational renewal in the sector, which could undermine the sector's capacity to sustain production. Furthermore, it could undermine competitiveness, innovation and sustainability, as younger managers tend to be better educated, more open towards innovations and new business models, and to run more efficient farms compared with their older colleagues (Eistrup et al., 2019; Żmija et al., 2020; Coopmans et al., 2021). It can also lead to land abandonment and further depopulation in remote areas, in case retiring farmers do not find a successor.

2.5.4 Funding and finance for sustainable practices

More sustainable forms of agriculture can be financially beneficial but require upfront investments and can reduce incomes in the first years of their adoption.

Previous sections highlighted the importance of shifting towards a more sustainable agricultural system which is better adapted to climate change, has lower net GHG emissions and overall exerts less environmental pressure. It is widely accepted that at the societal level, the costs of these shifts will be outweighed by the benefits in the form of lower externality costs (FAO, 2024b).

At the farm level, the economics of shifting towards more sustainable and more climate-friendly practices depends on the specific circumstances, and to what extent environmental benefits and other public goods can be monetised. There is evidence that even under current conditions, more sustainable farming can sometimes be profitable and deliver more stable incomes compared with conventional farming, as lower yields and higher labour costs are offset by lower input costs and farms become more resilient to climate-related impacts and input price volatility (IEEP, 2024). Still, at least two barriers may prevent the realisation of these advantages.

- **High up-front investment needs.** In many cases, the shift towards more sustainable practices would require substantial upfront investments (IEEP, 2024). Agriculture, particularly in its modern and mechanised forms, is a highly capital-intensive sector, often comparable to certain branches of industry in terms of equipment, infrastructure and technology requirements. The adoption of sustainable agricultural practices therefore demands not only financial capacity but also long-term access to credit and investment capital. However, access to such financing can be limited, as many farmers rely on short-term or high-interest loans, while affordable credit lines for agricultural investment are often scarce or subject to stringent eligibility criteria (Chen, 2020).
- **Risk of a temporary decrease in yields and incomes.** Whereas more sustainable farming practices can be economically viable once fully implemented, they could increase the risk of lower and more volatile yields (and thus incomes) in the initial years of their implementation as farmers gain experience and learn by doing (IEEP, 2024; Anthesis, 2023).

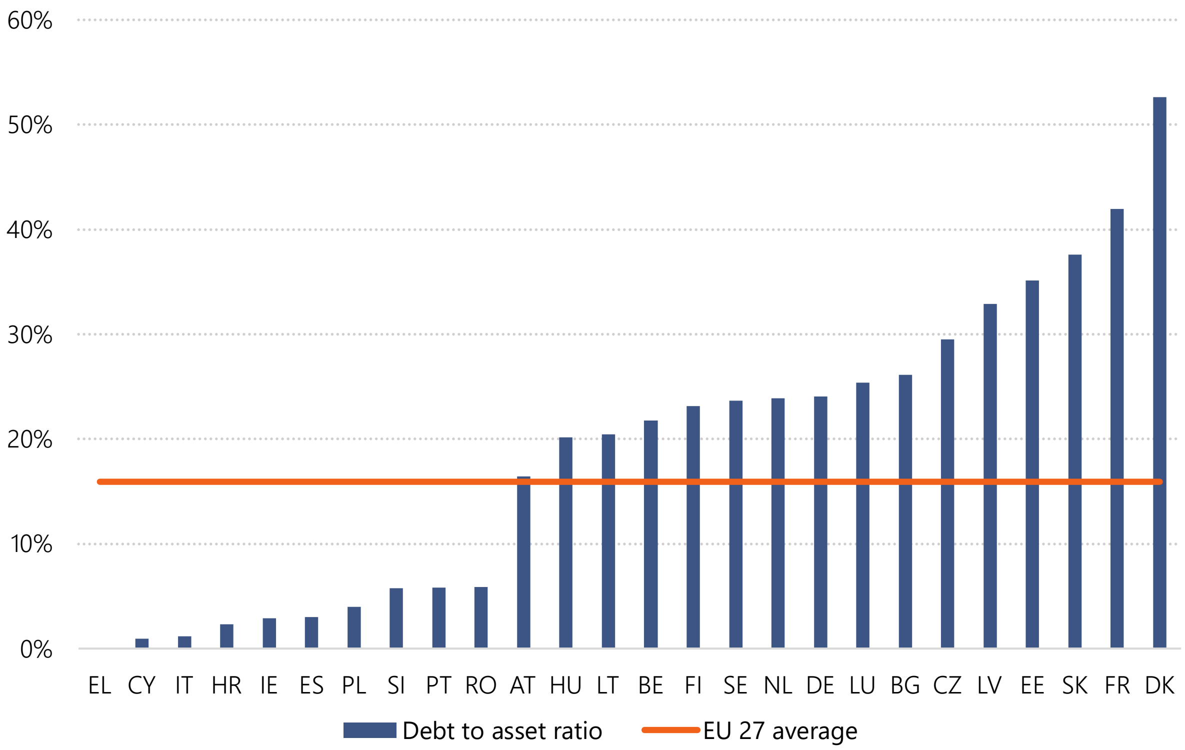
Many farmers are already struggling to access sufficient finance.

Farmers might not be able to finance upfront investments or cope with a temporary reduction in incomes, for the following reasons.

- **Low agricultural incomes.** As discussed in Section 2.5.3, many farms yield low agricultural incomes, which undermines their investment capacity and their ability to cope with a temporary further income reduction when transitioning to new farming practices or systems.
- **High levels of indebtedness.** Whereas there are substantial differences between Member States, farm holdings in some countries are heavily indebted (see
- Figure 15). This limits their capacity to access new loans, and pressures them to continue 'business as usual' until their loans are repaid.
- **Low access to finance.** Even farms which are economically viable often struggle to access finance (e.g. loans). The main reasons cited by farmers include the volatility of farming as a business, uncertainty about the return on investment and the lack of guaranteed compensation for any short-term loss in yield or drop in productivity from changing

practices (Anthesis, 2023). The financing gap[11] for EU agriculture increased from approximately EUR 47 billion in 2017 to EUR 62 billion in 2022 (Fi-Compass, 2023). Over half of this gap (EUR 38 billion) related to small farms, suggesting that they face a particular challenge in getting access to finance. About 30% of the gap related to green investments including climate adaptation and mitigation measures.

Figure 15 Average debt-to-asset ratio of farm holdings per Member State



Source: EC (2024d).

Note: (1) The country codes abbreviation can be found in Acronyms and Abbreviations section at the end of the report. (2) The debt-to-asset ratios are calculated as the sum of short (SE495) and long- and medium-term loans (SE490) divided by the sum of total fixed (SE441) and current (SE465) assets as included in the FADN database.

Whereas estimates are fragmented, transitioning to a more sustainable and climate-friendly agri-food system will likely require investments of tens of billions of euros per year.

The available evidence on the total investment needs and overall costs to align the EU agri-food system with the EU objectives on climate mitigation and adaptation is fragmented, as shown in Table 3. Some estimates only cover a part of the climate-related investment needs, whereas other estimates go beyond climate-related investments (e.g. for biodiversity, which have co-benefits for climate) or beyond the agri-food system (e.g. estimated for the entire land use sector or for the entire economy). A long-standing knowledge gap has been the investment needs for adaptation, which are much more difficult to estimate compared to mitigation-related investment needs (World Bank, 2024). A first estimate was made for the EEA in 2025, but can only be considered as a first, rough approximation as it heavily relies on the extrapolation of data for only three Member States.

[11] The unmet demand for finance by economically viable farms due to loans applied for but rejected by the bank, financing refused by the potential borrower or loans not applied for due to fear of rejection.

Early 2026, the European Commission published another estimate of adaptation investment needs across different sectors and Member States, based on a bottom-up approach (see Table 3).

Table 3 Estimates on investment needs and costs for the transition in the EU agri-food system

Source	Investment and cost estimates
Impact assessment to the EC 2040 Communication, S3 scenario (EC, 2024g)	• Energy-system-related investments (e.g. electrification, energy efficiency or capital cost for machinery) for agriculture: EUR 19 billion per year during 2031–2050. • Mitigation costs for agricultural non-CO_2 emissions: EUR 4 billion per year during 2031–2050. • Mitigation cost for land-based CO_2 emissions (entire land use sector, not only agriculture): EUR 2.7 billion per year (2031–2050).
Study for the sector federation FoodDrinksEurope (Anthesis, 2023)	• Estimated costs of switching to more sustainable agricultural practices (covering more than climate adaptation and mitigation): EUR 29 to EUR 36 billion per year in the first year of implementation, which would then reduce over time. • These costs would be outweighed by avoided costs of inaction (EUR 50 billion per year in the EU for soil degradation alone) and total estimated benefits from improved soil health (EUR 74 billion per year).
IEEP reports (Nadeu et al., 2023; Baldock and Bradley, 2023)	• Overall economy-wide costs to achieve the objectives of the EU's biodiversity strategy (COM(2020) 380): EUR 20-48 billion per year. • Additional costs to achieve the objectives of the Nature Restoration Law: EUR 6 to 8 billion per year. These costs would be far outweighed by the benefits (EUR 8 benefit per EUR 1 invested in nature restoration).
Study for the EEA on costs and benefits of adaptation (Ramboll, 2025)	• The total cost of adaptation for EU agriculture under a moderate emission scenario is estimated at approximately EUR 7 to 7.5 billion per year from now until 2050, increasing up to EUR 9 billion per year from 2050 to 2100. Under a high-emission scenario, these costs increase to EUR 11 to 17 billion per year until 2050 and up to EUR 20 billion per year thereafter. • Costs of inaction are estimated to be higher in most cases, in particular in the second half of the century, where they reach between EUR 28 and 30 billion per year depending on the emissions scenario.
Study for DG CLIMA on adaptation investment needs (EC DG CLIMA et al., 2026).	• Adaptation investment needs in agriculture are estimated at EUR 10 billion per year between now and 2050, of which 7.8 billion in the crop sector and EUR 2.3 billion in the livestock sector. • In addition, the report estimates required adaptation investments for measures in the 'ecosystem sector' which are also relevant for the agri-food system, including investments in soil restoration and management (EUR 8 billion per year), the maintenance and restoration of grasslands and peatlands (EUR 1.1 billion per year), and measures related to pollinators (EUR 1.2 billion per year).

Despite data limitations, the available evidence summarised in Table 3 highlights that a shift towards a more sustainable and climate-resilient agri-food system will require tens of billions of euros per year – especially in the early years of the transition – but several studies conclude that this is by far outweighed by the avoided cost of inaction and other co-benefits.

Public funding will be needed to overcome barriers, but public budgets are increasingly constrained.

Given that many farmers already struggle to access finance, they will need public support to shift towards more sustainable farming practices and systems. However, as highlighted in previous Advisory Board reports the available public budgets of both the EU and its Member States are increasingly constrained due to recent crises including the COVID-19 pandemic, Russia's war of aggression against Ukraine, and the resulting energy crisis (Advisory Board, 2025). Substantial volumes of public money have been spent over the last years to help society – including agriculture – to cope with these crises. For example, national crisis aid for farmers reached EUR 4.6 billion across the EU in 2022 (INRAE & IDDRI, 2025).

Many of these crisis responses have been funded through loans, which public authorities will need to repay in the coming years, putting a substantial burden on the public budget. At the same time, there is growing competition for public funds from political priorities, including defence and industrial competitiveness. The projected increase in climate-related risks can be expected to further weigh on public budgets as authorities will be expected to provide crisis support, including disaster relief, to affected sectors. These combined developments put increasing constraints on the public budget available to support the EU agri-food system.

2.5.5 Competitiveness

Competitiveness is a broad concept which can be measured in different ways.

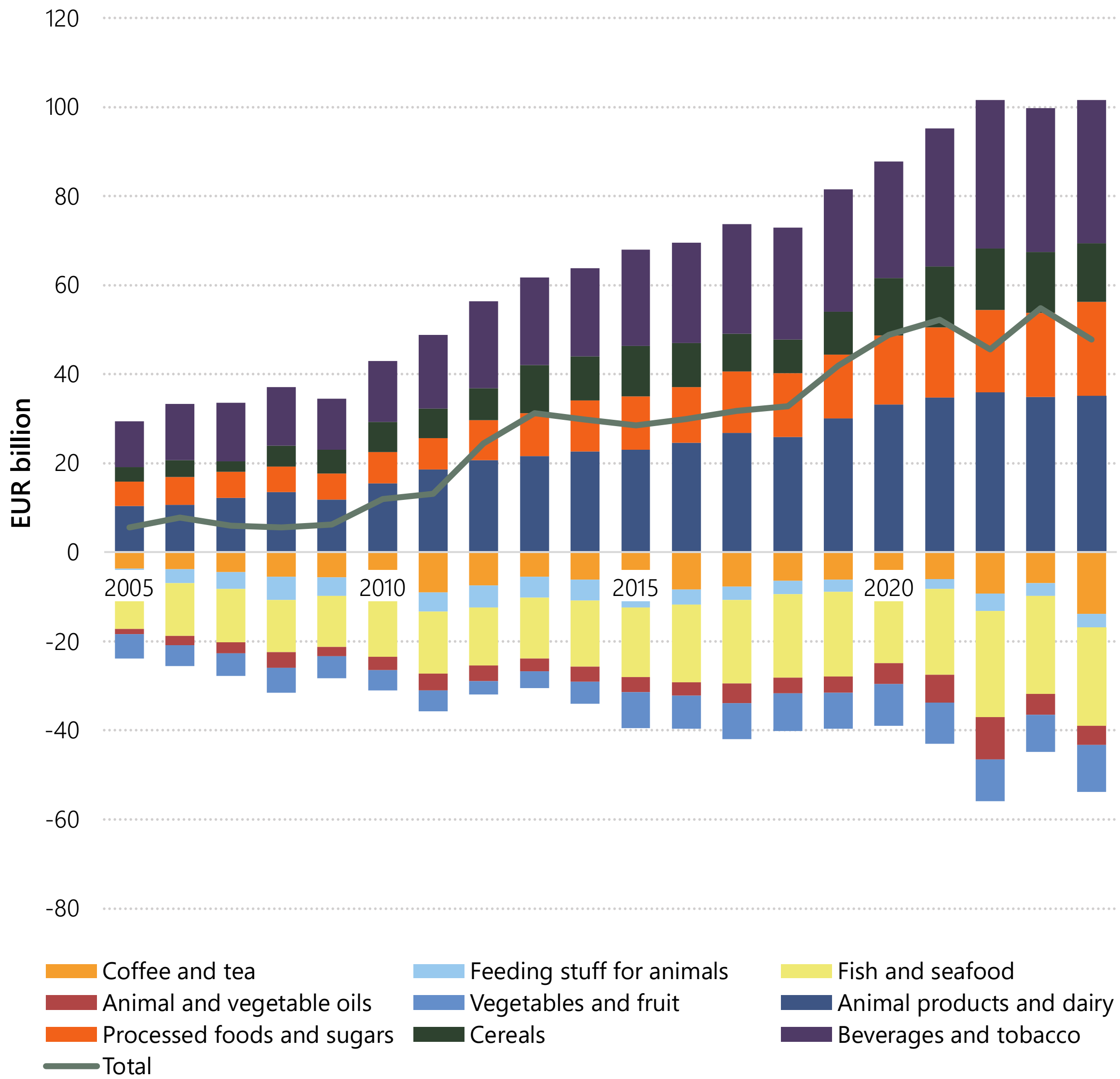
As highlighted by INRAE & IDDRI (2025), competitiveness is a broad and complex concept without a single definition in economic theory. As a result, it can be measured and interpreted in different ways. The common monitoring and evaluation framework under the current CAP sets out two impact indicators to track the competitiveness of the EU agri-food system: trade balances, and total factor productivity (which measures the ratio between total outputs relative to the total inputs used in the production of the output).

The EU agri-food trade balance is positive.

As shown in Figure 16, the EU has increased its net exports of agricultural productions from EUR 8 billion in 2005 to EUR 48 billion in 2024, with an observable increasing trend since 2010. Net exports are primarily driven by high-value-added products, including livestock products.

At the same time, the EU relies heavily on the import of animal protein feed to sustain its livestock production, with imports accounting for 66% of all supply (and even 96% for soybean meal) (JRC, 2024b). Similarly, EU agricultural production is highly dependent on the imports of fertiliser components, including nitrogen (30% dependency), phosphates (68%) and potash nutrients (85%) (DG AGRI, 2024a).

Figure 16 EU net trade balance of agri-food products with non-EU countries



Source: Eurostat (2025f).

Notes: (1) Values in nominal prices. (2) Positive values refer to net exports, while negative values refer to net imports.

The EU is a net land importer, thus exporting certain environmental burdens to non-EU regions.

While the EU is a net exporter of agri-food products in monetary terms, it relies on land resources outside its territory to sustain its food system. In 2018, the EU was estimated to be a net importer of 21 Mha of cropland and 1 Mha of grassland (JRC, 2022b). As a result, the EU exports some of the environmental burdens relating to food production to other regions, often in countries with less stringent environmental regulations. In this way it contributes to deforestation and biodiversity loss in regions supplying the EU with agricultural commodities, particularly in tropical areas where forests are often cleared for soybean, palm oil and cattle production (Ercin et al., 2021).

Farmers are concerned that trade agreements and the geopolitical context will undermine their competitiveness, but the evidence on this is mixed.

The fear of increased competition from cheap agri-food imports from outside the EU is one of the drivers of farmers' protests in recent years. This concern arises particularly in the context of bilateral trade agreements, such as the Mercosur trade agreement (EC, 2025c), which farmers fear would allow a greater influx of agricultural products from South American countries. However, a recent assessment suggests these concerns are largely unjustified, since the import quotas under the agreement would largely prevent any negative impacts on the EU livestock sector, while the EU agri-food system would generally benefit from the agreement (Gohin and Matthews, 2025).

Russia's war of aggression against Ukraine did lead to an increase of imports of Ukrainian agricultural products to the EU, in particular to eastern European countries (UN, 2025)[12]. The potential accession of Ukraine to the EU raised further concerns among European farmers. As one of the world's largest agricultural producers, its integration into the EU would dramatically reshape the agricultural landscape, increasing the EU's total agricultural area by approximately 25% (IEP, 2024). This expansion would have profound implications for EU agricultural policy, particularly the CAP budget, as more land and producers would need to be accommodated within existing subsidy frameworks.

Total factor productivity is growing slower in the EU compared with the world average.

Over the last decade (2011–2019), the total factor productivity in the EU agricultural sector grew by an average 1% per year, which is slightly above the OECD average (0.9%) but below the world average (1.3%) (INRAE & IDDRI, 2025). This suggests that the EU agricultural sector became less competitive compared with other world regions within this period. Furthermore, there are strong differences between Member States, with a decline in productivity in some (Greece, Italy, Cyprus and Malta) and strong growth (>2% per year) in others (Ireland, Croatia, Luxembourg, Portugal and Romania).

2.5.6 Food security

Food security in the EU is facing challenges on some dimensions.

Food security is a function of four different dimensions (FAO, 2013b):

- **food availability**, which is determined by total supply from production, stocks and trade;
- **food accessibility**, in both economic (food and purchasing power) and physical (vicinity of markets) terms;
- **food utilisation**, which refers to the ability of the human body to absorb various nutrients in food;
- **food stability**, which refers to the constancy of the former three dimensions and their resilience to external shocks.

[12] Almost EUR 28 billion in 2022, compared to between EUR 12 and EUR 20 billion per year in the period 2015–2019. Values from the UN Comtrade database have been converted from USD to EUR using the respective year specific average of USD/EUR conversion.

Whereas food availability is not a concern overall, accessibility and stability of supply is an issue for certain commodities.

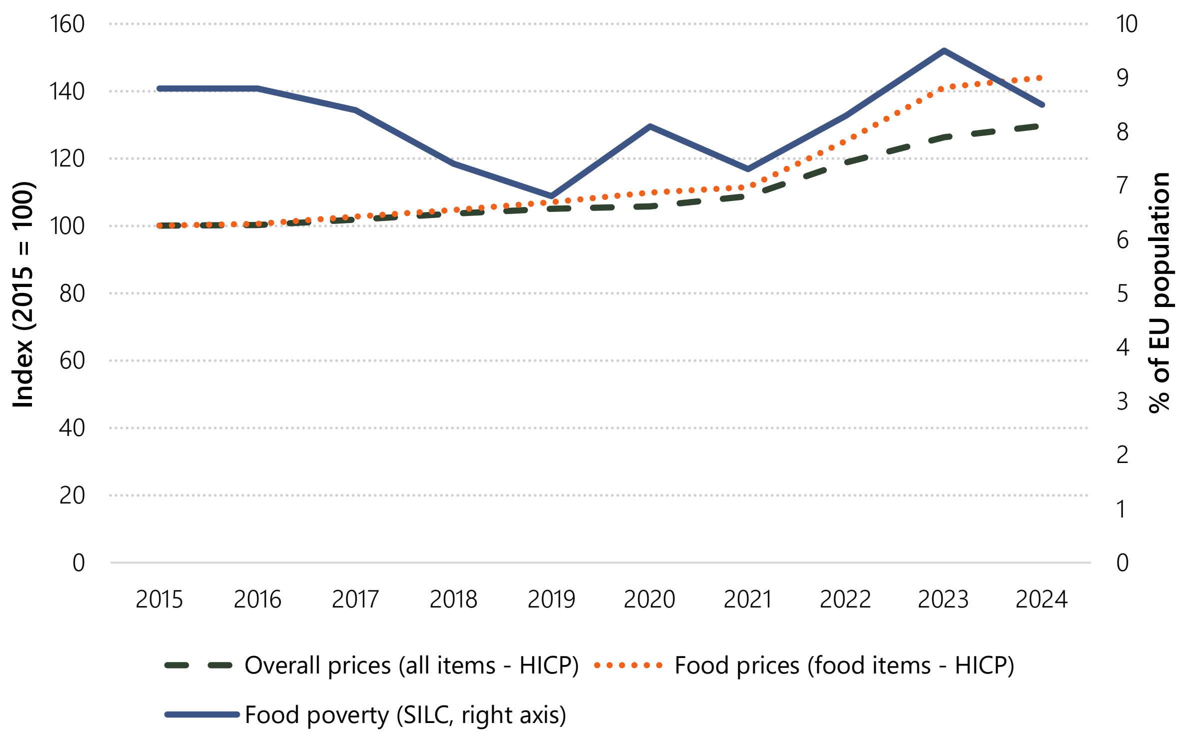
Food availability is currently not a major concern in terms of final products, as the EU is largely self-sufficient for most key agricultural commodities (see also Section 2.2). However, it is dependent on imports for certain commodities such as protein-rich feed crops, vegetable oils and certain tropical products (see Section 2.5.5), raising concerns over the EU's food sovereignty.

Recent disruptions have demonstrated the vulnerability of these supply chains: Russia's war of aggression against Ukraine significantly increased fertiliser prices and affected sunflower oil availability, while soy prices have historically shown considerable volatility linked to climate hazards and policy shifts in major exporting countries like Argentina and Brazil. As global competition for agricultural products intensifies, securing consistent access to these imports may become more challenging, with implications primarily for the cost and stability of livestock production rather than direct food security (Ercin et al., 2021).

Food prices surged since 2022.

As shown in Figure 17, food prices followed general price increases until 2021 but then outpaced them during 2022–2023 because of Russia's war against Ukraine which led to a surge in food, energy and fertiliser prices.

Figure 17 Trends in food prices and food poverty



Sources: Eurostat (2025e, 2024h).

Note: 'SILC' refers to the EU Statistics on Income and Living Conditions indicator on food poverty (see below).

A small but increasing part of the EU population is facing food poverty.

The prevalence of food poverty in the EU is difficult to assess due to varying definitions and indicators. Penne and Goedemé (2021) identified three different indicators, all of which point to an increase in food poverty in the EU in recent years.

- The EU Statistics on Income and Living Conditions indicator measures food poverty as 'the inability to afford a meal with meat, fish or a vegetarian equivalent every second day'. The share of households falling under this definition decreased during 2013–2019 but increased again in recent years to 9.5% of EU households in 2023 (Eurostat, 2024h). Within the group of households at risk of poverty (< 60% of median income), the share of households facing food poverty is above 20%.
- The 'Food Insecurity Experience Scale' indicator from the Food and Agriculture Organization of the United Nations (FAO) also shows an increase, with the share of the European population facing severe food insecurity more than doubling from 0.9% in 2019 to 2% in 2023 (FAO, 2024c).
- A third indicator is the number of people going to foodbanks. In 2023, the European Food Banks Federation (FEBA, 2023) reported that 81.5% of food banks saw an increase in the number of people using their offer in 2022. Notably, a new and growing group of employed people was turning to food banks because they could not make ends meet due to the cost-of-living crisis.

2.5.7 Diets

There are various science-based assessments of what constitutes a sustainable or healthy diet.

There are different types of dietary recommendations available, most of which focus on health and nutritional aspects, with some also incorporating broader sustainability considerations, as shown below.

- **National food-based dietary guidelines.** Each Member State has published food-based dietary guidelines (hereafter referred to as 'national dietary guidelines') grounded in nutritional science and public health evidence (EC, 2025n, 2024e). These guidelines are developed by national health and nutrition authorities and synthesise the best available evidence on balanced diets for disease prevention. Their focus is on promoting health and they generally do not incorporate environmental/climate considerations, although some do (e.g. Denmark, the Netherlands and Germany).
- **Global burden of diseases (GBD) optimal diet.** The Global Burden of Diseases, Injuries, and Risk Factors Study 2017 optimal diet is explicitly focused on human health outcomes, specifically defining the optimal level of intake to minimise the risk of all causes of death (Afshin et al., 2019). Therefore, the GBD optimal diet is fundamentally a health-risk benchmark, even if the study underlines the benefits, in terms of GHG emissions and environmental impacts, of avoiding high intakes of red meat and processed meat products in favour of healthy plant-rich foods.
- **Planetary Health Diet.** The EAT-Lancet Commission's Planetary Health Diet (first published in 2019, with an updated 2025 report (Rockström et al., 2025)) is a scientific effort to define a diet that would allow the world to feed a growing global population in a healthy, environmentally sustainable and just way. It acknowledges that whereas the planetary health diet is adequate for most nutrients, it might not ensure sufficient intake of vitamin B12, calcium, iron, zinc and iodine – especially in populations with low dietary diversity.

The focus of this subsection is on the recommendations these guidelines provide for healthy adults; it does not consider specifics of diets for children, pregnant or lactating women, or the elderly.

Dietary guidelines consistently recommend moderation in the consumption of meat products and promote diets rich in vegetables, fruits, nuts and legumes.

Table 4 provides a summary overview of the weekly recommended intake of different types of food for healthy adults, according to these different dietary guidelines. As discussed in more detail below the table, they consistently recommend moderation in the consumption of meat products (and red and processed meats in particular) and promote the consumption of vegetables, fruits, nuts and legumes.[13] Nevertheless, there are some differences in the specific recommended intake levels, with national dietary guidelines in the EU typically setting less stringent limits for red meat and recommending higher intake of dairy products compared with international studies.

Table 4 Recommended weekly intake of different food types (grams/week per adult)

Category	Subcategory	NDG	GBD	EAT-L
Animal-based	Red meat (maximum)	100–500	155	105 (0–200)
	White meat	100–300	n.a.	210 (0–420)
	Dairy	3 500–5 250	2 900	1 750 (0–3 500)
Plant-based	Fruits & vegetables	2 800–4 800	4 200	3 500
	Legumes	270–700	420	525 (0–1050)
	Nuts	175	147	350 (0–525)

Sources: EC (2025n, 2024e), Rockström et al. (2025) and Afshin et al. (2019).

Notes: (1) Whereas most Member States' national dietary guidelines (NDG) refer to cooked meat, others refer to raw meat and yet others do not specify. Neither the EAT-Lancet Commission (EAT-L) nor the GBD study explicitly specify whether intake values refer to raw or cooked weight. This makes comparison difficult, as meat loses approximately 25% of its weight during cooking. (2) Guidelines for legumes are sometimes expressed for dried weight and in other cases as fresh or prepared. The range for legumes shown in the table above refers to fresh/prepared weight (assuming a conversion rate of 3:1). (3) The EAT-Lancet Planetary Health Diet includes averages and ranges for protein-rich food products (meat, dairy, legumes and nuts), to allow for flexibility within this food group, and separates fruits and vegetables into distinct groups.

- **Red meat.** Most national dietary guidelines advise limiting red meat consumption such as beef, lamb, goat, pork to a maximum of 300–500 grams per week, while some countries (e.g. Germany, Greece, Italy) recommend only 100–150 grams. Similar limits are recommended by the GBD optimal diet (155 grams per week) and the EAT-Lancet Planetary Health Diet (maximum 210 grams per week). Many guidelines also give preference to lean, unprocessed red meat and recommend to limit processed red meat consumption as much as possible as they are generally considered to be worse for health: the WHO classifies processed red meats as a 'Group 1 carcinogen', meaning that there is sufficient evidence that it causes cancer in humans (WHO, 2015). For unprocessed red meats, the evidence is less conclusive: the WHO classifies it as a 'Group 2A carcinogen', meaning that it is probable but less certain to cause cancer in humans. Other studies have also linked the consumption of unprocessed red meats with health risks

[13] Legumes refers to the whole plant from the Fabaceae family, including leaves, stems, and pods. Pulses specifically denote the edible seeds (beans, lentils, peas) of these plants (Harvard - School of public health, 2025).

(Murray et al., 2020; IARC, 2018), even if the debate on the conclusiveness of the underlying evidence is still ongoing (Lescinsky et al., 2022; Glenn et al., 2023; Aravkin et al., 2023).

- **White meat.** Most national dietary guidelines recommend prioritising white meat (poultry) or plant-based proteins over the consumption of red meat, as poultry is leaner, has a healthier fat profile, and carries a lower cancer risk compared with red or processed meats. The recommended amount of white meat to consume is more difficult to compare as different guidelines take different approaches. Bulgaria, Denmark, Germany, Spain and the Netherlands recommend limiting overall meat intake to 300–500 grams per week, with a strong preference for white meat. Greece, Italy and Malta specifically recommend consuming between 100 and 300 grams of white meat per week. Yet other national dietary guidelines (e.g. Belgium and France) do not specify specific consumption levels for white meat. The EAT-Lancet Planetary Health Diet recommends on average 210 grams of white meat per week (with a range between 0 and 420 grams), which is largely consistent with the national dietary guidelines described above. The GBD optimal diet does not include recommendations on white meat.

- **Dairy products.** National dietary guidelines almost universally promote the regular consumption of dairy products for their calcium and protein content, while emphasising low-fat and unsweetened options and recommending to moderate cheese consumption due to its higher fat and salt content. Most guidelines recommend 2–3 servings per day, equivalent to roughly 3 500–5 250 grams per week of milk or yogurt or their equivalents. The two internationally established dietary guidelines recommend levels of consumption in the low end of this range, with the GBD optimal diet and the EAT-Lancet Planetary Health Diet recommending 2 900 grams and 1 750 grams respectively. Whereas national dietary guidelines consider dairy to be a fundamental part of a healthy diet, EAT-Lancet considers it to be optional, allowing plant-rich alternatives to fulfil calcium and protein needs.

- **Vegetables and fruits.** National dietary guidelines consistently recommend eating at least five portions of vegetables and fruit per day, with a preference for more. Many also recommend that within this category, vegetables should account for at least half and up to two-thirds of all vegetables and fruit consumed. In terms of weight, recommendations vary between minimum 2 800 and 4 200 grams of vegetables and fruits per week, depending on the assumed size of a serving. This is very consistent with the intake levels recommended by the EAT-Lancet Planetary Health Diet (3 500 grams per week) and the GBD optimal diet (4 200 grams per week).

- **Nuts and seeds.** Most national dietary guidelines recommend eating nuts and seeds on a regular or even daily basis, with a maximum of 25–30 grams per day. On a weekly basis, most guidelines recommend between 100 and 250 grams, with a strong emphasis on unsalted and uncoated nuts and seeds. Whereas the GBD optimal diet is within this range (150 grams per week), the EAT-Lancet Planetary Health Diet recommends a higher intake of 350 grams per week, while emphasising the importance of variety and nutrient density.

- **Legumes.** Most national guidelines recommend eating legumes multiple times per week, with recommended intake levels for fresh or prepared legumes between 270 and 700 grams of fresh or prepared legumes per week. The EAT-Lancet Planetary Health Diet and GBD optimal diet are somewhere in the middle of this range, with recommended intake levels at 525 grams and 420 grams per week respectively.

Comparing current and recommended dietary patterns faces several methodological challenges.

Comparing current consumption patterns with the dietary guidelines presented above is challenging due to limitations in available data. Eurostat only provides EU-wide data on the consumption of fruits and vegetables (Eurostat, 2022b). The FAO database (FAOSTAT, 2023) provides EU-wide data on the supply of different food types, but this is difficult to convert into consumption as it requires careful adjustments for food waste and non-food uses such as biofuels and seed offtake. There are several sources providing data for specific Member States based on dietary surveys (Darmon et al., 2025; Cocking et al., 2020), but these are prone to misreporting and underestimation of intake levels (Garden et al., 2018; Burrows et al., 2019). Other sources provide data for regions which do not overlap one-to-one with the EU27: the EAT-Lancet study (Rockström et al., 2025) only provides results for a larger Europe and Central Asia region, whereas the GBD study discussed above (Afshin et al., 2019) provides data for western Europe, central Europe and eastern Europe.

To manage these methodological challenges, the Advisory Board compared current consumption patterns with recommended diets using a variety of sources:

- it compared estimated consumption levels in selected Member States from individual studies (Darmon et al. (2025) for France and Rijksoverheid (2022) for the Netherlands) with the national dietary guidelines of those Member States;
- it considered the ratio of current consumption levels in western, central and eastern Europe with the optimal diet as included in the GBD study discussed above (Afshin et al., 2019);
- it considered the ratio of current consumption levels in Europe and central Asia with the Planetary Health Diet as included in the 2025 EAT-Lancet study (Rockström et al., 2025).

Current dietary patterns in the EU are on average unbalanced with excess consumption of red meat.

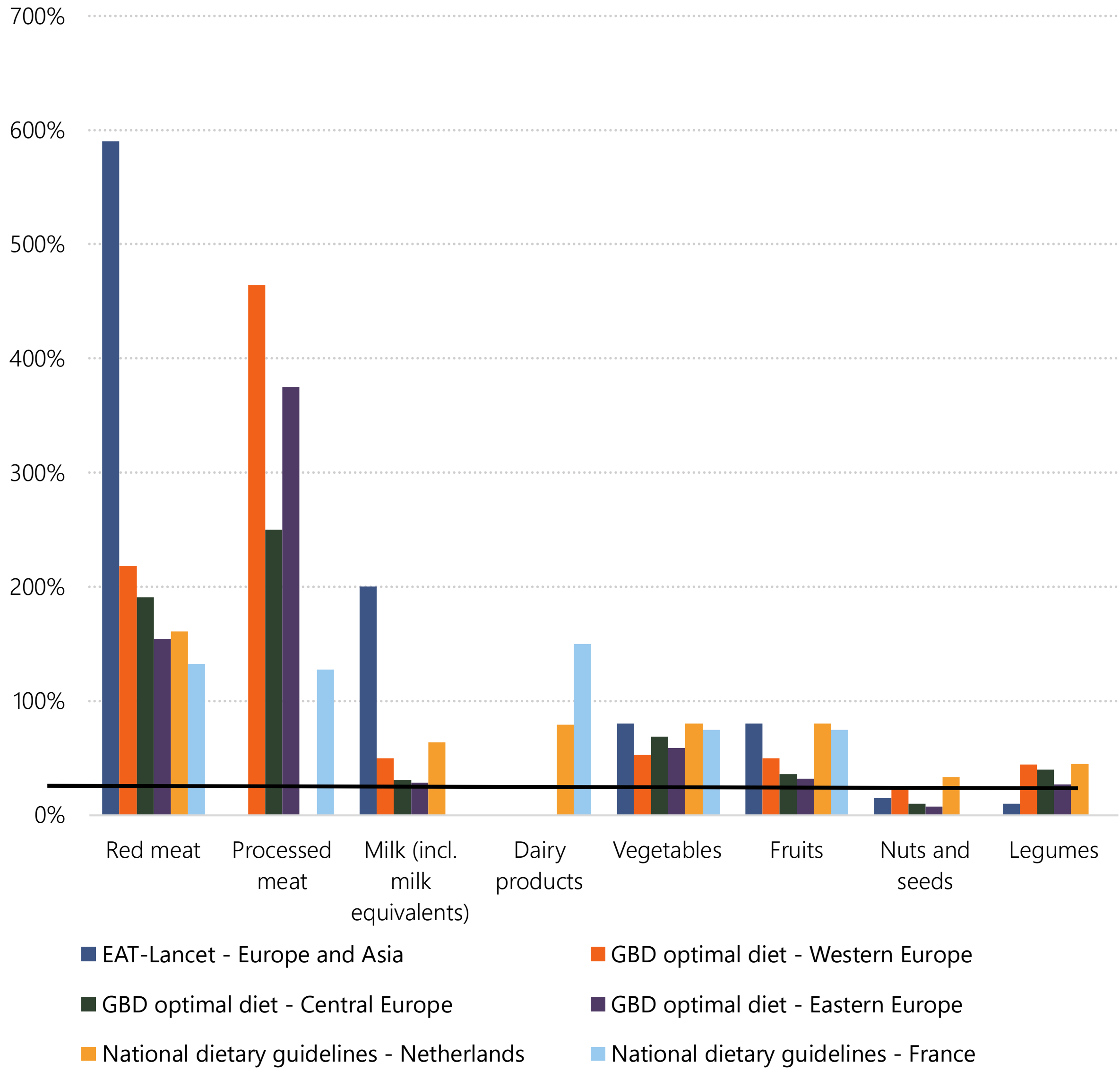
As illustrated in Figure 18, the results of the analysis show that EU diets are on average unbalanced.

- **Processed and red meats.**[14] Whereas some guidelines and data sources provide disaggregated data for processed meats and unprocessed red meat (France and the GBD optimal diet), this is not the case for the sources on the Dutch consumption patterns and the EAT-Lancet planetary health diet. Despite these methodological challenges, most of the considered sources consider that the average intake of processed and red meats substantially exceeds dietary guidelines, even if the magnitude of the excess varies across different sources.
- **Dairy.** Findings on dairy consumption are mixed and difficult to compare, as some guidelines refer to fresh milk or equivalents and others to dairy products in general. Most sources suggest that the consumption of fresh milk or equivalents (e.g. yogurt) should increase to align with health recommendations. However, the EAT-Lancet study – which recommends far lower intake levels of milk (see above) – argues that current intake levels should be reduced by approximately half. When it comes to overall dairy products (including e.g. cheese), average intake levels are close to recommended levels in the Netherlands and exceed them in France.

[14] Only the EAT-Lancet Planetary Health diet includes a recommended maximum intake of white meat, which is about one third below current average diets in Europe and Central Asia.

- **Healthy plant-rich diets.** There is a strong consensus across the different sources that EU citizens on average consume too few vegetables and fruits, with current intake levels 20–65% below recommended minimum levels. The shortfall is even more substantial for legumes (55–75%) and nuts and seeds (65–90%).

Figure 18 Ratio of current vs. recommended intake levels per food type



Sources: EC (2025n, 2024e), Darmon et al. (2025), IHME (2024), Rockström et al. (2025) and Rijksoverheid (2022).

Notes. (1) The figure shows the ratio of current versus recommended intake levels of different food types, according to different sources which use different assumptions about current and recommended intake levels, for different geographical regions (see also above). (2) The 100% dotted line indicates the respective EU consumption estimate from each study shown above. (3) While the specific numerators and denominators used to calculate consumption shares may differ across studies, they remain internally consistent within each study.

These dietary patterns are causing substantial public health externalities, estimated at 5–6% of the EU GDP.

Unhealthy dietary patterns in the EU are driving an increase in overweight and obesity, with over half (52.7%) of the adult population estimated to be overweight and 20% to be obese in 2019 (De

Schutter et al., 2020; Eurostat, 2024k). Diets are also a main driver of non-communicable diseases, causing 49% of the burden of cardiovascular diseases, 80% of type 2 diabetes cases, 55% of hypertensive diseases, and 35% of heart diseases in the EU (De Schutter et al., 2020). For 2020, it has been estimated that unhealthy diets caused 2.5 million premature deaths in Europe, of which approximately 274 000 (11%) due to eating too much red and processed meat, 580 000 (23%) due to eating too few vegetables and fruits, and 516 000 (21%) due to eating too few nuts and legumes (Van Daalen et al., 2024).

These health impacts are causing substantial externality costs. According to the FAO State of Food and Agriculture 2024 (FAO, 2024b), the hidden cost of dietary patterns in the EU are close to EUR 1 trillion[15] per year (see also Box 3). To put this in perspective, this accounts for roughly 5–6% of the EU's GDP, which was approximately EUR 17.9 trillion in 2024 (Eurostat, 2024j). The cost is also equivalent to about 60% of the EU's total annual healthcare expenditure, which stood at EUR 1.65 trillion in 2022 (Eurostat, 2024g).

Even if there are many different drivers of malnutrition, unhealthy eating patterns and diet-related health problems have a clear socio-economic gradient as a healthy diet is often more expensive than calorie-rich but nutrient-poor diets (Penne and Goedemé, 2021).

Box 3 FAO methodology to estimate public health externalities

The calculation of hidden health costs attributed to dietary patterns is derived through a refinement of true cost accounting that estimates the non-fatal and fatal burden of disease using the disability-adjusted life year (DALY) metric. This process relies on data from the GBD 2021 study (Naghavi et al., 2024) to quantify DALYs specifically attributable to individual dietary risk factors (e.g. low legumes or high sodium intake) that cause non-communicable diseases in adults, effectively isolating diet-related impacts from other causes. These quantified DALYs, representing years of healthy life lost, are subsequently monetised by linking them to estimated economic productivity losses, using metrics like GDP per person employed, to arrive at the total social hidden cost.

A better alignment with dietary guidelines could reduce public health externalities while also contributing to climate mitigation.

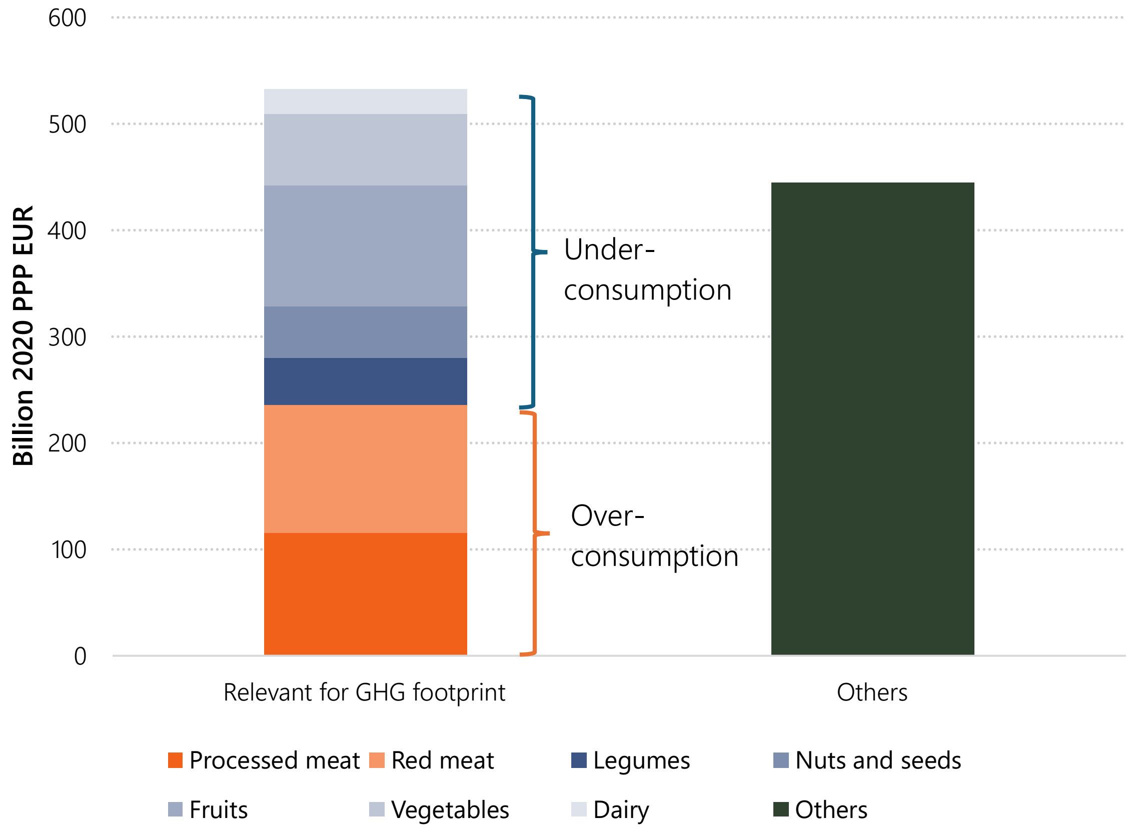
As shown in Figure 19, a substantial share of these public health externalities is linked to the imbalance between the overconsumption of GHG-intensive red meat (both processed and unprocessed) and the underconsumption of low-emission plant derived food (legumes, nuts and seeds, fruits, vegetables) and of dairy products. This imbalance in the EU27 imposes around EUR 530 billion (2020 purchasing power parity (PPP) EUR) in hidden health costs each year (3% of EU GDP), accounting for 55% of the total public health externalities caused by diets. This highlights that a partial shift from red and processed meat to healthy plant-rich diets has a strong potential to both deliver climate mitigation outcomes and reduce negative public health externalities.

It should be noted, however, that not all plant-based food is healthy. Unhealthy plant-based food represents the majority of foods which are high in fat, sugar or salt, with part of these foods being

[15] Converted from USD_{2020} 1.1 trillion, excluding Luxembourg, Malta and Cyprus for which the FAO 2024 report does not include data.

ultra-processed. Such unhealthy plant-based foods have a key role in the development of non-communicable diseases, including diabetes, cardiovascular and chronic respiratory diseases, mental and neurological disorders, and cancer (EC, 2025a).

Figure 19 Hidden health costs from diets in the EU27



Source: FAO (2024b).

Notes: (1) The left column indicates the hidden costs attributable to dietary patterns characterised by high GHG emissions (approximately EUR 530 billion). (2) The right column ('Others') represents remaining hidden costs from dietary patterns not directly linked to high-emission diets, due to excess intake of sodium, trans-fatty acids and too low intake of wholegrains and seafood omega-3 fatty acids. (3) Together, the total hidden health costs associated with current EU dietary patterns exceed EUR 1 trillion per year.

2.6 Need for a systemic approach

The interlinkages between climate adaptation and mitigation warrant the pursuit of both strategies in parallel.

Previous sections of this chapter have outlined the need to strengthen both climate adaptation and mitigation in the agri-food system, and the agricultural sector in particular. Both strategies need to be pursued in parallel to be effective, due to the interlinkages between both.

- **Insufficient adaptation** will undermine mitigation efforts, as climate change can degrade land-based carbon sinks. Climate-related impacts contributed to the recent decline in the Regulation on Land Use, Land Use Change and Forestry (LULUCF) (Regulation (EU) 2018/841) net sink and are projected to further undermine it in the future (Advisory Board, 2024). Furthermore, reduced yields resulting from climate change may result in increased use of land and other inputs to sustain agricultural production, which could further increase net GHG emissions.
- Conversely, **insufficient mitigation** at the global level increases the risk of climate-related impacts exceeding the agri-food system's capacity to adapt. In pursuit of the global temperature goal under the Paris Agreement, the EU has committed itself to ambitious mitigation targets under the European Climate Law. As an important source of GHG emissions, the EU agri-food system has a responsibility and possibility to contribute to this, by reducing its own emissions, enhancing removals and supplying sustainable inputs to help other sectors decarbonise.

Similarly, the link between climate change and other challenges in the agri-food system warrant a systemic approach.

Climate change is projected to compound the other challenges discussed in Section 2.5. In several cases, these other challenges also increase climate-related risks and undermine the adaptive capacity of the agri-food system.

- **Other environmental crises.** Climate change is projected to accelerate biodiversity loss and increase soil erosion (Habibullah et al., 2022; Borrelli et al., 2022). It will reduce available water quantities, whereas nitrogen pollution is projected to reduce water quality, which both contribute to water scarcity in specific regions (Wang et al., 2024). Conversely, the ongoing decline in biodiversity and soil carbon content is making the agricultural sector more vulnerable to climate-related risks (Montanarella and Panagos, 2021).
- **Land use and availability.** As raised above, reduced yields resulting from climate change might further expand the area of land required to sustain agricultural production. Climate change could substantially increase land values in northern Europe and decrease them in southern Europe, in line with projected yield impacts (Van Passel et al., 2017).
- **Farmers' livelihoods.** In a scenario where global warming is limited to 2 °C and assuming endogenous adaptation by farmers, climate change could decrease EU farmers' average incomes by up to 16% by 2050 (EEA, 2019). Incomes could increase in northern and western European regions, but farm profitability in southern Europe could decline to such an extent that it renders agricultural activities in some regions unviable, possibly exacerbating a trend in land abandonment and related job loss. Strong interannual yield variabilities will also strongly impact the stability and predictability of agricultural incomes, which poses a particular challenge (EEA,

2024b). Conversely, low incomes and profitability in parts of the agricultural sector undermine farmers' capacities to invest in adaptation options.

- **Food security.** Climate-related hazards both in and outside Europe could already create critical risks for food security by mid-century, threatening the availability and affordability of nutritious food for parts of the EU population (and low-income households in particular) (EEA, 2024b). Furthermore, as already discussed in Section 2.3, climate change is not only projected to affect the available quantity of food, but also its quality (lower protein and nutrient content) and safety (increased risk of contaminations and zoonotic diseases).
- **Public health.** Climate change is already affecting public health through extreme climate-related hazards and the geographic expansion and increased transmission of infectious diseases (EEA, 2024b). Outdoor workers such as those working in agriculture are particularly exposed to heatwaves, with some deaths already being reported (EEA, 2024b). Conversely, unhealthy dietary patterns are increasing the EU population's vulnerability to climate-related hazards such as heatwaves (Van Daalen et al., 2024). For example, the mortality risk for people suffering from diabetes increases by approximately 18% in case of a heatwave, with such heatwaves projected to become more frequent and more intense due to climate change (Moon, 2021).
- **Trade and competitiveness.** Climate change will alter the comparative advantages for agricultural production in different regions across the world, with overall higher yields expected in higher-latitude regions and lower yields in lower-latitude regions (Bozzola et al., 2023; Magalhães Vital et al., 2022). Changes in trade flows can thus make a substantial contribution to adaptation and limit global welfare losses (Gouel and Laborde, 2021). However, such changes would create winners and losers, and the picture for the EU is mixed. Hristov et al. (2024) found that whereas the EU farming sector as a whole could experience a net benefit, some regions in northern Europe and most southern European regions would face a substantial loss in competitiveness. Gouel and Laborde (2021) found that even if price and trade adjustments can offset some of the expected damages from climate change on agriculture, the EU would still face an overall welfare loss (–0.8% of GDP), even if other world regions are even worse off.
- **Funding and finance.** As already discussed in Section 2.3, climate change impacts are projected to increase annual losses in EU agriculture resulting from extreme weather events from a current average of EUR 28.3 billion to EUR 40 billion by mid-century. For specific years, the maximum estimated losses could increase from EUR 57.5 billion to more than EUR 90 billion per year, which is expected to put pressure on the financial capacities of both farmers, the insurance sector, and the public budget available for disaster relief (Fi-Compass, 2025).

The different challenges described in this chapter are thus interlinked and often risk exacerbating each other's impacts. Furthermore, as further described in Section 3.5, several options to enhance climate adaptation or mitigation can have positive or negative side-effects for the other challenges, creating the potential for synergies but in some cases also risks of trade-offs. Therefore, there is a wide consensus that the different challenges in the agri-food system need to be tackled through a systemic and coherent approach (Soussana et al., 2025; IPES-Food, 2019). Accordingly, while this report primarily focuses on strengthening climate adaptation and mitigation, it also considers how related approaches affect the other challenges outlined in Section 2.5.

Chapter 3

Adaptation and mitigation options

Key messages

There is a wide range of options to enhance climate adaptation and mitigation in EU agriculture and the broader agri-food system.

In the realm of agri-food systems, there are numerous possible options and strategies to enhance adaptation and mitigation. These options can be deployed on various scales and categorised on a spectrum ranging from technical improvements to structural changes:

- **Technical improvements** can be deployed on a small scale, within short time frames and at relatively low costs, and typically aim to improve the existing system without changing the fundamental attributes of that system. Such improvements include improved feeding, herd, manure, nutrient and soil management practices, along with agroforestry and agrivoltaics.
- **Structural changes** are defined as changes on a larger scale and could require more time or upfront investment. They typically aim to address the root causes of vulnerability and enhance climate mitigation and adaptation by changing the fundamental attributes of the system, such as dietary shifts towards more plant-rich consumption patterns and related changes in agricultural production systems.

Each option often addresses various objectives, including both climate mitigation and adaptation.

Several options can enhance both adaptation and mitigation simultaneously. Key examples include soil conservation practices to increase soil organic carbon, agroforestry and agri-photovoltaics, and a shift towards more plant-rich consumption and production patterns.

Furthermore, several options can also deliver substantial synergies with other environmental and socio-economic objectives (e.g. ecosystem restoration). In some cases, however, trade-offs may arise. These include both potential trade-offs between different environmental objectives (e.g. climate mitigation versus biodiversity) and transition challenges for livestock value chains and areas with degraded peatlands. The potentials for synergies and risks of trade-offs are often context-specific, which warrants careful assessments and planning at the local and regional scales.

3.1 Introduction

This chapter provides an overview of options to enhance climate adaptation and mitigation.

Chapter 2 introduced the need to enhance adaptation and mitigation, while highlighting other challenges facing the sector. Based on this, it concluded on the need for a systemic and coherent approach, considering potential synergies and trade-offs with other societal and environmental dimensions.

This chapter provides a high-level overview of different options to enhance adaptation and mitigation in the agri-food system. In the following, the term 'option' is being used to describe either physical or operational/organisational interventions. It does not refer to possible policy interventions which aim to encourage the deployment of these options, which are discussed in Chapter 5 and subsequent chapters of this report.

The objective of this chapter is not to provide a comprehensive overview with a detailed assessment of all possible options, which is available elsewhere (Chiriacò et al., 2025; EC, 2025l; JRC, 2025d). Instead, it aims to provide a high-level overview of what can be done to enhance climate adaptation and mitigation in the agri-food system based on an overall categorisation framework, and to highlight potential synergies and trade-offs based on some illustrative examples. The examples were selected to represent different types of options that have the potential to be relevant in Europe. For some options, more detailed information is provided in the technical annex, which accompanies this report as supplementary material.

Whereas this chapter provides a first assessment for different options in isolation, Chapter 4 will explore different pathways where these various options are combined to different degrees, and the implications of these pathways for the different assessment dimensions.

The rest of this chapter is structured as follows.

- **Section 3.2** provides an overall framework to categorise the different options for enhancing adaptation and mitigation in the agri-food system. It first introduces an overarching framework covering both adaptation and mitigation (Section 3.2.1) and then describes several additional concepts that can help better understand the different characteristics of options to enhance adaptation (Section 3.2.2).
- **Section 3.3** provides a high-level, non-exhaustive overview of options to enhance adaptation.
- **Section 3.4** provides a high-level, non-exhaustive overview of options to enhance mitigation.
- **Section 3.5** discusses potential for synergies and risk of trade-offs between climate mitigation, adaptation and other relevant dimensions.

3.2 Categorisation framework

3.2.1 Overarching categorisation framework for climate adaptation and mitigation

There is a wide range of options to enhance climate adaptation and mitigation in the agri-food system.

In the realm of agri-food systems, there are numerous possible options and strategies to enhance adaptation and mitigation (Chiriacò et al., 2025; EC, 2025l; JRC, 2025d). These options can be categorised in various ways, reflecting the diverse approaches and scales on which they operate.

Options to enhance adaptation can be categorised based on the risk component they aim to reduce, the timescale at which they operate, the hazard that they address, whether the action is taken by public or private actors, etc. As a starting point, this report uses a common categorisation from the climate adaptation literature (IPCC, 2014; Kates et al., 2012; Chhetri et al., 2019; Rickards and Howden, 2012), which distinguishes between the following:

- **Options that deliver incremental adaptation.** These include technological and institutional changes based on existing approaches and technologies, which can be deployed on a smaller spatial scales and shorter timeframes, and which aim to preserve or optimise existing systems without changing the fundamental attributes of that system.
- **Options that deliver transformational adaptation.** These include both existing and novel solutions, which require deployment on larger spatial scales and longer timeframes, and which could change the fundamental attributes of a system, including shifting of systems to different locations, such as moving agricultural production in response to shifting agroclimatic zones. Their objective is to safeguard the core functions of that system (e.g. adequate production of food and sustaining livelihoods) rather than preserving the system in a way that addresses root causes of vulnerability (Gil-Clavel et al., 2025).

Options which enhance climate mitigation can also be categorised in various ways. Common approaches include distinguishing between supply- and demand-side options (Herrero et al., 2016; IPCC, 2023), and to categorise options based on the emission source they target (IPCC, 2023). As a starting point, this report uses the categorisation as developed by Frank et al. (2019), which distinguishes between:

- **Technical supply-side options,** which aim to reduce agricultural emissions through practices and technologies which can be applied at relatively small scale.
- **Structural supply-side options,** which require more fundamental adjustments within agri-food systems to reduce emissions such as large-scale shifts in production systems or the relocation of production.
- **Demand-side options.** These aim to reduce consumption of agricultural GHG-intensive products and waste.

This report categorises different options along a spectrum ranging from technical improvements to structural changes.

In practice, many possible options in the agri-food system can enhance climate adaptation and mitigation in parallel, and it therefore can be difficult to distinguish between adaptation and mitigation options. Taking the different categorisation frameworks above as a starting point, this report uses a common categorisation framework that aims to bridge the conceptual gap between adaptation and mitigation by distinguishing between the following.

- **Technical improvements.** These refer to options which aim to improve the existing system in terms of climate mitigation or adaptation, without changing the fundamental attributes of that system. They can typically be deployed on relatively small spatial scales, within relatively short timeframes and with relatively limited resources. Regarding mitigation, this category of options mainly aims to reduce the GHG intensity of production by changing how products are produced, without changing what is produced or where. Regarding adaptation, they refer to options that can deliver incremental adaptation, mostly aiming to increase the resilience so that crops and livestock cope better during hazard events.
- **Structural changes.** These refer to options which aim to change the fundamental attributes of the existing agri-food system. They require changes on larger spatial scales and sometimes could require more time and upfront investment. This category also covers options that go beyond just agricultural production to include the relevant socio-ecological landscape and change the supply and demand of agricultural products (both regarding the type of products that are produced and consumed, and where they are produced), and to reduce waste.

This common framework deviates somewhat from the categorisation used by Frank et al. (2019), which distinguishes between structural supply-side options and demand-side options. As both types of options are likely to affect each other even if not strictly one-to-one, given the occurrence of trade as a buffer between domestic supply and demand, structural options are considered to include changes at both the supply- and the demand-side.

The distinction between what is a technical improvement versus what is a structural change is not always clear-cut. Instead of two completely separated categories, they should rather be understood as the two ends of a spectrum, with many options fitting somewhere in the middle. In several cases, whether an option should be considered as technical or structural also depends on the scale of its deployment. For example, when applied on a small scale, agroforestry could be considered primarily as a technical improvement that does not substantially alter the overall attributes of the EU agri-food system. However, if applied on a larger scale, it could have a more substantial impact on the type and volume of agricultural production at the EU level and on landscape-level resilience, which could be considered a more structural change.

The spectrum between technical improvements and structural changes can be further broken down along different spatial scales.

An additional dimension in the categorisation framework used in this report is based on the spatial scales at which different options can be deployed. For this report, five distinct spatial scales were identified.

- **Crop and livestock.** This scale focuses on localised impacts at the crop and livestock level. It involves strategies aimed at improving the resilience and productivity of crops and livestock in response to climate-related hazards as well as lowering GHG emission intensity of the respective products, e.g. by switching to more climate-resilient species.
- **Soil and field.** This scale addresses strategies related to the substrate in which crop and grass are grown. It encompasses practices that enhance soil fertility, structure, carbon soil sequestration and overall field productivity to better withstand climate-related impacts along

with reduced fertiliser usage and soil management to enhance mitigation. Some of these practices can overlap with crop and livestock options, for example, in the case of cover crops or changes in fertiliser practices.

- **Farm and livelihood.** This scale focuses on the individual farm level and the livelihoods of farmers. It includes improvements to farm infrastructure (e.g. barns, machinery) and approaches that support farmers in managing climate-related risks, diversifying their income sources, improving their overall resilience and engaging in novel farm-level practices that lower marginal GHG emissions such as low-emission machinery.
- **Land sector.** This scale addresses interventions that operate beyond the individual farm unit, but instead at the scale of the relevant socio-ecological system. For example, restoring peatland hydrology may require coordinated water table management across a landscape. Such interventions may involve multiple stakeholders acting collectively, or a single land manager operating at sufficient scale. What matters is that boundaries for the scope of action are defined at the landscape or ecological system scale, rather than administrative or ownership boundaries.
- **Agri-food system.** This scale focuses on the entire agri-food system from production to consumption. It includes strategies that enhance the overall resilience of the food supply chain and coordinated efforts across food value chains to achieve shifts in supply and demand towards lower-GHG-intensive products, reduced climate-related risks and reductions in food waste.

Generally, options on a larger spatial scale are more structural in nature, while being less technical. As shown in Figure 20, this result in a simplified yet comprehensive framework for identifying and assessing the possible options to enhance climate adaptation and mitigation in the agri-food system.

Figure 20 Overall categorisation framework for climate adaptation and mitigation options

Whereas this provides a common framework to categorise options for both adaptation and mitigation, further distinctions can be made both within adaptation and mitigation respectively. Whereas many options can enhance both mitigation and adaptation in parallel, Section 3.3 focuses on options which mostly enhance adaptation, while Section 3.4 focuses on options which mostly enhance mitigation.

3.2.2 Additional categorisation concepts relevant for climate adaptation

Climate adaptation aims to moderate harm and/or exploit opportunities from a changing climate.

Whereas climate mitigation is a well-understood concept by now, there is less clarity among key stakeholders on what should be understood under climate adaptation. Therefore, this section provides an overview of additional categorisation concepts used in adaptation literature.

To ground the discussion of climate policy in a robust conceptual framework, it is essential to clarify additional key concepts and definitions related to adaptation. Climate adaptation can be defined as 'the process of adjustment [in human systems] to the actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities' (IPCC, 2022a). A related but distinct concept is resilience, which can be defined as 'the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure' (IPCC, 2022a). As a policy goal, resilience is often portrayed as a state to be achieved, while adaptation refers to the process of proactive adjustment (Advisory Board, 2026).

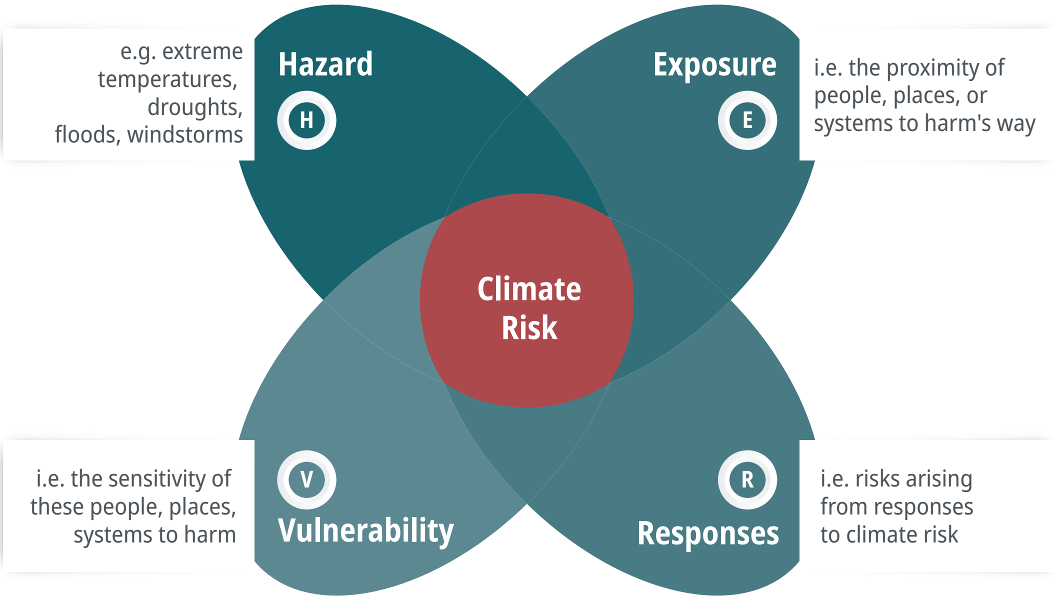
Moderating harm can be achieved by reducing hazards, vulnerability and exposure.

As illustrated in Figure 21, climate risks result from the interaction of hazards, vulnerability and exposure and responses. Adaptation options can reduce these risks by working on each of these four dimensions.

- **Hazards** are potentially damaging physical events, the intensity and frequency of which are expected to increase due to climate change. Whereas climate mitigation aims at reducing the drivers of anthropogenic climate hazards, adaptation options can help reduce the impacts from direct hazards and avoid the progression of cascading and compounding hazards.
- **Exposure** refers to the presence of people, assets or ecosystems in areas that may be affected. Adaptation can reduce exposure on a small scale by providing physical protection (e.g. hail nets) or a buffer between hazard and exposed asset (e.g. firebreaks around fields). On a larger scale, exposure could be reduced by moving agricultural production to regions which are, or are projected to be, less prone to climate-related risks. However, as discussed in Chapter 2, applying such an approach on a large scale could face substantial physical, economic and political barriers.
- **Vulnerability** captures the degree to which people, assets or ecosystems can be harmed due to their sensitivity or lack of adaptive capacity. This can be addressed by reducing the susceptibility to harm of a system's element (e.g. increasing livestock health) or increasing its capacity to cope with and anticipate hazard (e.g. shifting seeding and harvesting dates). These also include options which hedge or transfer the risks associated with any one hazard, for example, by diversifying production or getting climate insurance, which can allow potential yield losses to be spread over a variety of elements with differing levels of exposure and susceptibility, offsetting the risk of simultaneous income loss (Devot et al., 2023) and helping to recover faster (Bucheli et al., 2023).
- **Responses** recognises the modulating effect that actions to reduce climate change and its impacts (i.e. adaptation and mitigation) have on the other components of risk. Responses to

climate change can create new risks or shift vulnerability and exposure on to other people, places or other time horizons. Certain types of responses can also create a false sense of security that leads to underestimating the risk and underpreparing.

Figure 21 The IPCC 'propeller' framework



Source: Adapted from IPCC (2022e).

Climate adaptation may target different outcomes.

As briefly described above, adaptation is a process aimed at achieving resilience to and seizing opportunities from a changing climate. This process can result in different types of adaptation outcomes for agriculture.

- **Yield resilience** denotes the capacity to maintain or rapidly recover crop and livestock productivity under climate stresses - for example, on-farm options such as drip irrigation can stabilise yields during droughts by reducing crop sensitivity to water.
- **Ecological resilience** refers to the ability of agro-ecosystems and landscapes to absorb disturbances (e.g. extreme weather) while retaining essential functions such as soil health, water regulation and biodiversity. For instance, shelterbelts can reduce wind erosion and protect crops during storms, while restored floodplains can absorb excess water during heavy rainfall, buffering downstream areas from flood damage. In both cases, the system absorbs the shock without losing its productive capacity.
- **Social resilience** encompasses the capacity of farming households and communities, along with consumers to cope with, and adapt to, shocks and stresses – supported by measures that increase adaptive capacity and risk management, such as climate information services and index-based insurance schemes that help hedge risks.
- **Transformational adaptation** involves fundamental, systemic changes in the agri-food system that dramatically reduce multi-dimensional risks and open new pathways under a changing climate.

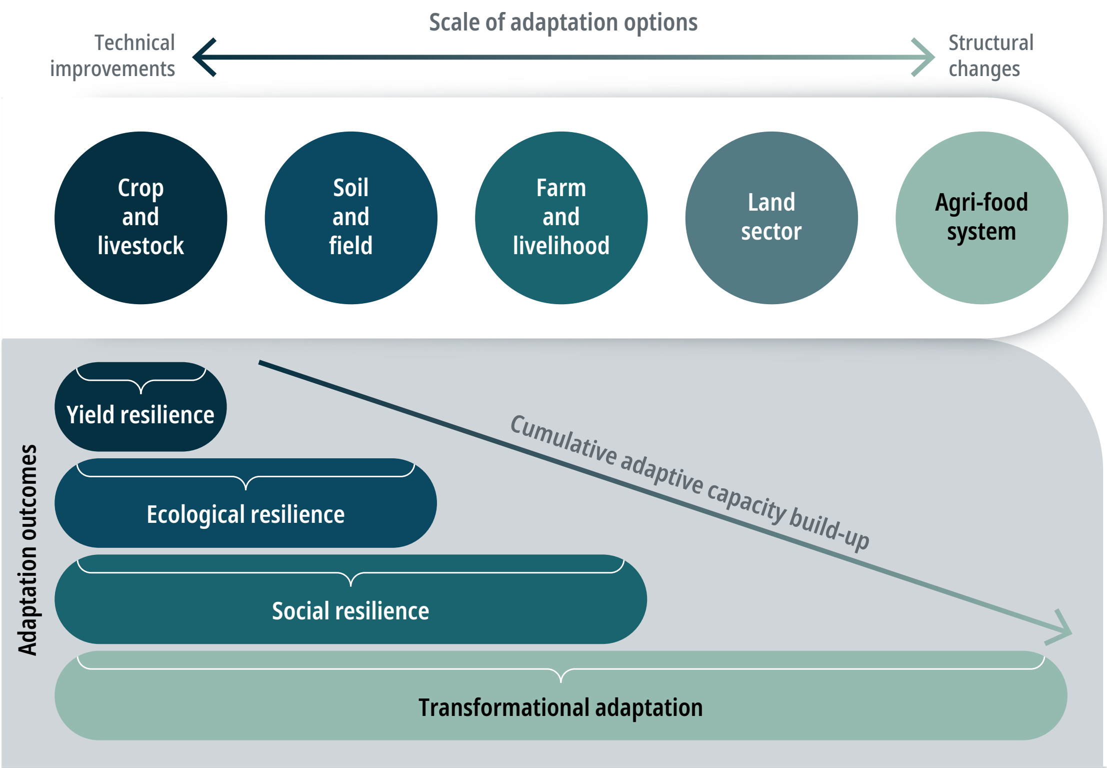
Whereas the first three types of outcomes are primarily focused on moderating harm of a changing climate within existing systems by trying to preserve the status quo, transformational adaptation is about achieving a new state which not only moderates harm but also addresses the root causes of risk and allows for seizing opportunities from a changing climate.

Climate adaptation actions on different spatial scales lead to different adaptation outcomes through a nested approach.

The different types of adaptation outcomes as described above are closely related to the different spatial scales (see Section 3.2.1) at which adaptation options can be taken. Adaptation action at the crop level would primarily contribute to yield resilience, whereas action on the farm level would contribute to social resilience.

However, as illustrated in Figure 22, the relationship is not strictly one-to-one in the sense that different adaptation outcomes cannot be achieved solely by deploying adaptation options on the corresponding spatial scale. Instead, different adaptation outcomes can be achieved through a nested approach where a certain type of adaptation outcome also requires achieving 'lower-level' outcomes (Devot et al., 2023; Leiter et al., 2019; Singh et al., 2022; Massetti and Mendelsohn, 2018; Chhetri et al., 2019). In other words, whereas technical improvements at the crop or field level alone might suffice to secure yield resilience in the short run, achieving social resilience would also require achieving yield and ecological resilience, through a combination of adaptation options ranging from the crop and livestock to the farm and livelihoods level. Achieving the highest possible outcome of transformational adaptation would require a combination of options to reduce exposure and sensitivity at lower spatial scales, boosting adaptive capacities and risk-sharing at intermediate spatial scales, and innovating to hedge risks and seize opportunities at higher spatial scales.

Figure 22 Relationship between scales of options and their climate adaptation outcome



3.3 Overview of climate adaptation-focused options

3.3.1 Overview

Table 5 provides a non-exhaustive overview of different options at different scales to enhance climate adaptation in the agri-food system in Europe. The rest of this section describes these options in more detail.

Table 5 Various climate adaptation options across different scales

Overall categorisation: More technical ← → More structural

Spacial scales	Crop and livestock	Soil and field	Farm and livelihood	Land sector	Agri-food system
	Physical protection	Increased inputs	Adjusted timings	Improved water management	Climate information
	Change in crop or livestock type	Increased input efficiency	Change in what is produced	Integrated landscape planning	Risk transfer and management
		Improved soil management	Farm-level diversification	Regional economic diversification	System-wide land conversion
					Plant-based value chain
					Food waste reductions

3.3.2 Adaptation options at the crop and livestock scale

Adaptation at the crop and livestock level includes mainly technical improvements to stabilise production despite climate-related hazards.

- **Physical protection.** Protecting crops and livestock with physical barriers such as shelters, nets and thermal stress control equipment is an effective form of protection, with typically immediate results, to reduce exposure to hazards such as windthrow, hail and heat. Greenhouses are a longstanding and widespread technical measure for microclimate modification but, in light of the high energy and water costs associated with them, options that provide synergies with other climate goals such as agrivoltaics and agroforestry are garnering more attention. However, while additional ecological benefits can be achieved using nature-based solutions such as buffer strips and hedges for protection or trees for shade, these typically require a longer time to provide the protective benefits. In livestock production, another way to reduce the vulnerability of animals is by generally improving animal health and physical conditions (JRC, 2024a), for example by ventilating of livestock housing.
- **Change in crop or livestock type.** Changing the crop or livestock used in production for less sensitive genotypes is one way to improve yield resilience without changing the existing regime (Manevska-Tasevska et al., 2021). Breeding and genomic selection have been used to improve the tolerance of major crops and animal breeds in Europe to different climate-related hazards such as drought, extreme hot or cold, erratic rainfall and new diseases and pests (Mohammadi,

2018; Henry et al., 2018). Increasing yield resilience does not necessarily entail creating new cultivars; naturally-occurring local varieties that are well-adapted to specific climatic conditions can also be introduced in a different geographic setting if the expectation is that climatic conditions will move towards a similar pattern (Mäkinen et al., 2018).

3.3.3 Adaptation options at the soil and field scale

Adaptation at the soil and field levels include mainly technical improvements to modify production patterns.

- **Increasing input.** This can be seen as a response to increased climatic stress, e.g. expanding irrigation, is an example of an adaptation option that can reduce losses in the short-term but lead to maladaptive outcomes in the future (Albizua et al., 2019).
- **Increased input efficiency.** A potential strategy entails enhancing the efficiency of resource and input utilisation. The employment of techniques such as drip irrigation, effective residue management and the reuse of water resources has been associated with reductions in waste, while often enhancing productivity and conserving natural resources that are becoming scarce due to climate-related risks (Pret et al., 2025).
- **Soil management.** Soil management measures that facilitate the maintenance and restoration of soil health can reduce sensitivity to climate-related hazards. The integration of cover crops (Adetunji et al., 2020), the implementation of crop rotation, the adoption of sustainable tillage practices (Meng et al., 2024) and the application of biochar (Ding et al., 2016) have all been demonstrated to enhance soil structure, water retention, nitrogen fixation, nutrient availability and carbon sequestration. Increasing complexity from a monocrop system, e.g. through mixed-cropping or agroforestry, results in increased soil multifunctionality, microbial species richness and community composition (Li et al., 2021), which in turn support soil health and fertility (Tiemann et al., 2015).

3.3.4 Adaptation options on the farm and livelihoods scale

Adaptation at the farm level involves implementing technical improvements and structural changes to modify production patterns, methods, farm structures and strategies that can be pursued in isolation by a farm business.

- **Adjusted timings.** The strategic timing of agricultural operations, including adjustments to sowing and harvesting periods, or the exploration of counter-seasonal cropping, enables farmers to align their activities with changing weather patterns (e.g. a shorter growing period) and market demands in the future, thereby reducing risk and enhancing flexibility (Minoli et al., 2022). Likewise, adjusting working hours in the fields to avoid the hottest periods is already widely used in southern Europe as a strategy to protect the health of outdoor workers, and is expected to be used more broadly as the window of safe working hours shrinks due to climate change (Zulueta and Mehrabi, 2025).

- **Change in what is produced.** A key adaptation strategy involves shifting the types of crops and livestock farmed to better align with changing environmental conditions and market opportunities. This can take two forms.
    - Transitions to more climate-resilient species such as replacing maize with millet or shifting from cattle to small ruminants. This can provide greater stability under variable climatic conditions. Such changes go beyond simple varietal selection to fundamentally alter what is farmed with larger implications for the farm (e.g. changing equipment, capacity development, seeking new buyers).
    - Shifts towards products that command higher market value can strengthen economic resilience. Where certification schemes and market infrastructure exist, transitions to organic or geographically indicated products can provide access to premium markets, though scalability is limited and trade-offs with other objectives may arise (e.g. water demands in viticulture) (Smith et al., 2020). In Spain, for instance, growing adoption of organic production has supported value-added market differentiation while also delivering ecological co-benefits such as improved soil health, albeit at limited scales (Ochoa-Hueso et al., 2024).
- **Farm-level diversification.** Diversification strategies are a way to hedge risks and can be based on agricultural diversification (e.g. agroforestry, mixed cropping) and on-farm income diversification (e.g. valorisation of farm by-products, agrivoltaics). Agricultural diversification benefits are heavily dependent on the combination and sequencing of crops, perennials and livestock, but generally have been shown to stabilise incomes, disseminate risk spatially and economically (e.g. throughout the income portfolio) and bolster community resilience (Quandt et al., 2023). Landowners and agricultural workers can also diversify their land and activities to include non-agricultural purposes such as ecotourism, payments for ecosystem services, or setting aside land for forestry or renewable energies. These measures can enhance the robustness of the farm in the face of economic and environmental uncertainty, improve ecological local conditions and increase food security, but depend on access to markets for valorisation of secondary crops and additional income-streams (Frelih-Larsen et al., 2022; Meynard et al., 2018).

3.3.5 Adaptation options at the land use sector scale

Adaptation at the land use sector level involves implementing mainly structural changes to modify the inherent system dynamics of agricultural production.

- **Improved water management.** This entails a variety of water management practices, including the development of improved infrastructure for water storage, the regulation of irrigation volumes and timing at the municipal or regional level, the restriction of inefficient irrigation methods and the implementation of systems to capture and utilise rainfall (Masseroni et al., 2018; Angileri et al., 2024; EEA, 2023a; Esteve et al., 2015). Together, these measures help conserve water resources and reduce emissions associated with water use in agriculture. The re-use of wastewater for agricultural purposes is also being increasingly explored as a potential solution (Christou et al., 2024).
- **Integrated landscape planning.** A transformational adaptation strategy can entail the implementation of landscape-level interventions, such as sponge solutions at the water basin scale, which enhance water retention and mitigate flood risk. Zoning, land rehabilitation and the

establishment of conservation corridors are also vital, as they help protect ecosystems, restore degraded areas and improve connectivity across natural habitats (Ma and Jiang, 2023). One specific example is the restoration of wetlands which – in conjunction with the restoration of floodplains – constitutes a valuable nature-based solution that enhances carbon sequestration, fosters biodiversity and mitigates the impact of flooding and protects water reservoirs during droughts, while concurrently contributing to climate regulation and ecosystem resilience (Kreyling et al., 2021).

- **Regional economic diversification.** Another crucial approach is economic diversification within rural areas. This might include the valorisation of agricultural waste into valuable products, investment in renewable energy projects, support for rewilding initiatives or participation in conservation programmes at the regional or sectoral level, rather than the farm level. These alternative revenue streams, when combined with the promotion of environmental stewardship, have the potential to generate significant economic benefits while contributing to the conservation of natural resources.

3.3.6 Adaptation options at the agri-food system scale

Adaptation options at the agri-food scale focus solely on implementing structural changes that transform the whole agri-food system.

- **Climate information.** Access to climate services, including early warning systems, weather forecasts and decision support tools strengthens social resilience by helping farming communities to anticipate and respond to climate-related threats more effectively (Appiah et al., 2025; Islam et al., 2025).
- **Risk transfer and management.** The use of risk management mechanisms, such as multi-peril crop insurance, index-based schemes and revenue insurance, provides crucial financial protection, thereby enabling farmers to recover from economic setbacks in production and sustain their operations (Bucheli et al., 2023). However, while insurance solutions can avoid a spiralling down in vulnerability, they do not necessarily foster long-term adaptive capacity unless the payouts are used for making necessary adjustments that would make the farm more resilient to subsequent hazard events (Jørgensen et al., 2020), and can be maladaptive if they crowd out community-based risk sharing strategies and social networks (Müller et al., 2017). Robust disaster management mechanisms are also essential, including recovery funds, contingency plans, critical infrastructure reinforcement and emergency stockpiles to ensure food security and economic stability during extreme events (Wen et al., 2023; Sandoval et al., 2023). Contract hedging strategies, encompassing the use of future or forward contracts, options contracts and the shortening of supply chains, have been shown to offer farmers and food producers protection against price volatility and market disruptions, thereby providing a buffer against economic uncertainty (Taušer and Čajka, 2014; Tiwari et al., 2021).
- **System-wide land conversion and livelihood expansion.** Land and livelihood conversion is an option to transition out of conventional agriculture, and harness new sources of income. Alternative climate-compatible business models within the land use sector such as forestry, bioeconomy, ecotourism or climate services can boost local economies while reducing pressure on vulnerable farming systems and offering an alternative to out-migration. Successful

transitions require a level of market maturity for the alternative economic activities, and often also policy support for re-skilling and capitalisation, and safeguards for a fair transition.

- **Shift towards more plant-rich food system.** Even though direct climate-related risks are lower for livestock compared with crops, the livestock sector faces substantial indirect risks through feed supply chains (see also Section 2.3). When these are taken into account, plant-based systems are generally more resilient to climate-related risks, ensuring a more stable food supply (IPCC, 2022h; Poore and Nemecek, 2018; Springmann et al., 2018). A shift towards diets with lower levels of livestock consumption can enhance adaptation by reducing pressure on water and land resources, increasing resilience in food supply chains and supporting diversified agricultural systems better suited to changing climate conditions (IPCC, 2022h). By influencing production patterns and policy priorities, dietary shifts become a key component of transformational adaptation strategies. Diversified, climate-resilient plant-rich diets can be supported by the development of novel proteins (see Section 3.4.6).
- **Food waste reduction.** The reduction of food waste across the supply chain from production and processing to the retail and household levels can be a powerful lever to enhance adaptation. Cutting food waste supports climate adaptation by easing pressure on agricultural systems, conserving water and soil resources and improving food availability during times of climate-related stress (FAO, 2013a). Efficient use of food resources can enhance the resilience of food systems, especially in vulnerable regions, and aligns with broader sustainability and policy goals (JRC, 2023a).

3.4 Overview of climate mitigation-focused options

3.4.1 Overview

A wide range of climate mitigation options are available in the agricultural sector and the broader agri-food system, which can be tailored to address specific challenges and opportunities in different agricultural contexts. These include practices and technologies which have the potential to reduce GHG emissions and increase CO_2 removals across all major emission sources and removal hotspots. The options presented in this section are listed as in Table 6.

Table 6 Examples of mitigation options across different scales

Overall categorisation	Technical improvements ←			→ Structural changes
Spacial scales: Crop and livestock	Soil and field	Farm and livelihood	Land sector	Agri-food system
Improved feeding practices Improved herd management Improved manure management	Improved nutrient management Improved soil management Agroforestry Agrivoltaics	Precision agriculture Energy measures	Wetland restoration Biochar	Dietary shifts Food waste reductions Novel proteins

It is important to note that under established GHG inventories, the mitigation effect of some of these options is accounted for under sectors other than agriculture. For example, whereas agrivoltaics provides substantial potential to reduce GHG emissions, these reductions are accounted for under the energy sector rather than the agricultural sector. Similarly, the mitigation impact of anaerobic digestion is partially accounted under the agricultural sector as reduced emissions from manure management, and partially in the end-use sector where the biogas produced during the anaerobic digestion is consumed.

3.4.2 Mitigation options on the crop and livestock scale

Climate mitigation at the crop and livestock level involves mainly technical improvements to lower the GHG intensity of agricultural production.

- **Improved feeding practices.** This category includes a range of options that aim to reduce livestock GHG emissions, primarily methane emissions from enteric fermentation. Many such practices exist and can be grouped into two main strategies: improved feed management (e.g. increasing forage quality, improved feed processing) and diet formulation (e.g. addition of oils, fats and oilseeds, use of feed additives such as 3-Nitrooxypropanol) (Arndt et al., 2022).

- **Improved herd management.** Another option is to reduce livestock GHG intensity, for example through breeding programmes aimed at selecting traits that improve animal efficiency, health and herd productivity. By focusing on both productivity, reproductivity and fertility, these programmes can reduce emissions per unit of livestock output. This is achieved through improved feed conversion and a reduction in the number of non-productive animals in the herd (Eory et al., 2020).
- **Improved manure management.** These practices aim to reduce CH_4 and N_2O emissions from manure storage and disposition. A key option within this category is anaerobic digestion, a biological process in which microorganisms break down organic matter such as animal manure in the absence of oxygen. This process not only produces biogas as a renewable energy source but also significantly reduces methane (CH_4) and nitrous oxide (N_2O) emissions from manure storage and application (Angileri et al., 2024).

3.4.3 Mitigation options for the soil and field scale

Climate mitigation at the soil and field levels involves implementing mainly technical improvements to modify production patterns.

- **Improved nutrient management**. A range of options that aim at reducing N_2O emissions from fertiliser use. Effective practices include optimising the rate, timing and method of fertiliser application (including through precision agriculture techniques, see Section 3.4.4) and the use of products such as controlled-release fertilisers and nitrification inhibitors (JRC, 2020b). Additionally, integrated nutrient management practices such as the integration of legumes into crop rotations can further reduce synthetic fertiliser use and related GHG emissions.
- **Improved soil management.** A variety of practices that aim at maintaining or increasing the organic content in agricultural soils. A key option under this category is the use of cover crops, which provide continuous soil cover between main crop cycles. By doing so, they protect the soil from erosion and contribute to carbon sequestration (Lugato et al., 2020). Other key options include reduced tillage intensity and increased residue retention, which help to preserve soil structure and organic matter (IPCC, 2022f).
- **Agroforestry.** The integration of trees and shrubs with crops or livestock on the same land increases carbon sequestration both in woody vegetation and soils (IPCC, 2022f). This land-use system includes silvopastoral setups (trees in grasslands) and silvoarable systems (trees or hedges with crops).
- **Agrivoltaics**. This option refers to the dual use of land for both solar photovoltaic power generation and agricultural activities (JRC, 2023d). Its mitigation contribution – the substitution of fossil-based electricity generation – is accounted towards the electricity sector in GHG inventories.

3.4.4 Mitigation options for the farm and livelihoods scale

Climate mitigation at the farm level involves implementing technical improvements and structural changes to modify production patterns, methods, farm structures and strategies that can be pursued in isolation by a farmstead.

- **Energy-related options.** Whereas energy use only accounts for 15% of the agricultural sector's total GHG emissions (see Section 2.4), the sector will have to reduce these emissions as part of the broader transition towards zero-emission energy. Options to do this include general energy efficiency improvements, electrification in combination with decarbonised electricity supply and the switch towards zero-emission fuels. A major opportunity lies in the electrification of on-farm machinery, such as tractors, loaders, irrigation pumps and milking systems. Advances in battery technology and charging infrastructure are making electric tractors and autonomous electric field equipment increasingly viable, especially for small to medium-scale farms and activities with predictable duty cycles (Scolaro et al., 2021). Electric machinery can significantly cut on-farm fuel combustion emissions, lower noise and maintenance costs and integrate with on-site renewables like solar panels or biogas-powered generators.
- **Precision agriculture and AI.** These include a range of new technologies such as satellite imagery, AI and smart sensors to optimise crop yield, improve quality and reduce input use (IPCC, 2022i). These technologies, particularly geographic information systems (GIS), remote sensing, livestock and soil and crop monitoring sensors, enable farmers to make data-driven decisions that enhance efficiency while minimising environmental footprints (EEA, 2023a).

3.4.5 Mitigation options for the land use sector scale

Climate mitigation at the land use sector level involves implementing mainly structural changes to modify the inherent system dynamics of agricultural production.

- **Restoration of peatlands.** Peatlands play a crucial role in maintaining biodiversity and natural ecological functions while acting as important carbon sinks. As already discussed in Section 2.4, degraded peatlands are a major source of soil-based GHG emissions. Protecting and restoring peatlands helps prevent the release of stored carbon and supports long-term climate mitigation goals (Molina-Herrera et al., 2016). Whereas rewetting would have a slight warming impact in the short term due to a temporary spike in CH_4 emissions, it would also lead to an immediate reduction in CO_2 and N_2O emissions, thereby having a net-cooling effect in the medium- to long-term (Günther et al., 2020; Greifswald Mire Centre, 2023).
- **Biochar.** The application of biochar on soils is emerging as an effective option to improve soil health and enhance carbon sequestration. Agricultural soils are one potential repository for this stored carbon, with some evidence suggesting co-benefits for soil structure and fertility (Wang et al., 2016) though the evidence is not yet conclusive.

3.4.6 Mitigation options for the agri-food system scale

Climate mitigation options at the agri-food scale focus solely on implementing structural changes that transform the whole agri-food system.

- **Dietary shifts.** As described in Section 2.4, livestock production is a major hotspot of GHG emissions and other environmental pressures. Dietary changes which include a partial shift from livestock to plant-rich food productions therefore provide a highly effective option for reducing GHG emissions and other environmental pressures in the agricultural sector (Rockström et al., 2025). Reducing EU animal product consumption and production by 50% could lower agricultural nitrogen emissions by 40% and GHG emissions by 19–42% compared with 2004 levels (Westhoek et al., 2014).

- **Novel proteins.** Dietary shifts can be supported by the deployment of novel proteins, including plant-based alternatives, fermentation, precision fermentation and cultivated meat (see Box 4). Alternatives to animal proteins can help reduce associated GHG emissions. Moreover, lab-grown alternatives can significantly reduce land use and resource consumption (Alexander et al., 2017; Sinke et al., 2023; Smetana et al., 2015), though they come with much higher electricity use. Estimates show that alternative proteins could reach cost parity with processed animal products, and displace two thirds of animal products consumed in Europe by 2050 (Green Alliance, 2024). The cultivation of legumes for novel plant-based alternatives can contribute to other mitigation-focused options, such as improved nutrient management (EC, 2018; JRC, 2016).
- **Food waste reduction.** Reducing food waste offers considerable potential for climate mitigation. By implementing ambitious reduction targets, the EU could decrease GHG emissions by as much as 16.7 Mt CO_2e annually (JRC, 2023). This reduction would primarily be driven by a decrease in emissions from agricultural production and, from the treatment and disposal of waste. Addressing food loss and waste could also have cascading benefits, such as reducing the demand for additional agricultural resources and thus leading to further emission reductions (JRC, 2023). Additionally, reducing food waste aligns with broader sustainability objectives, such as reducing pressure on biodiversity and conserving vital natural resources. Thus, the reduction of food waste presents a win-win scenario, contributing to both environmental protection and food security.

Box 4 Novel proteins

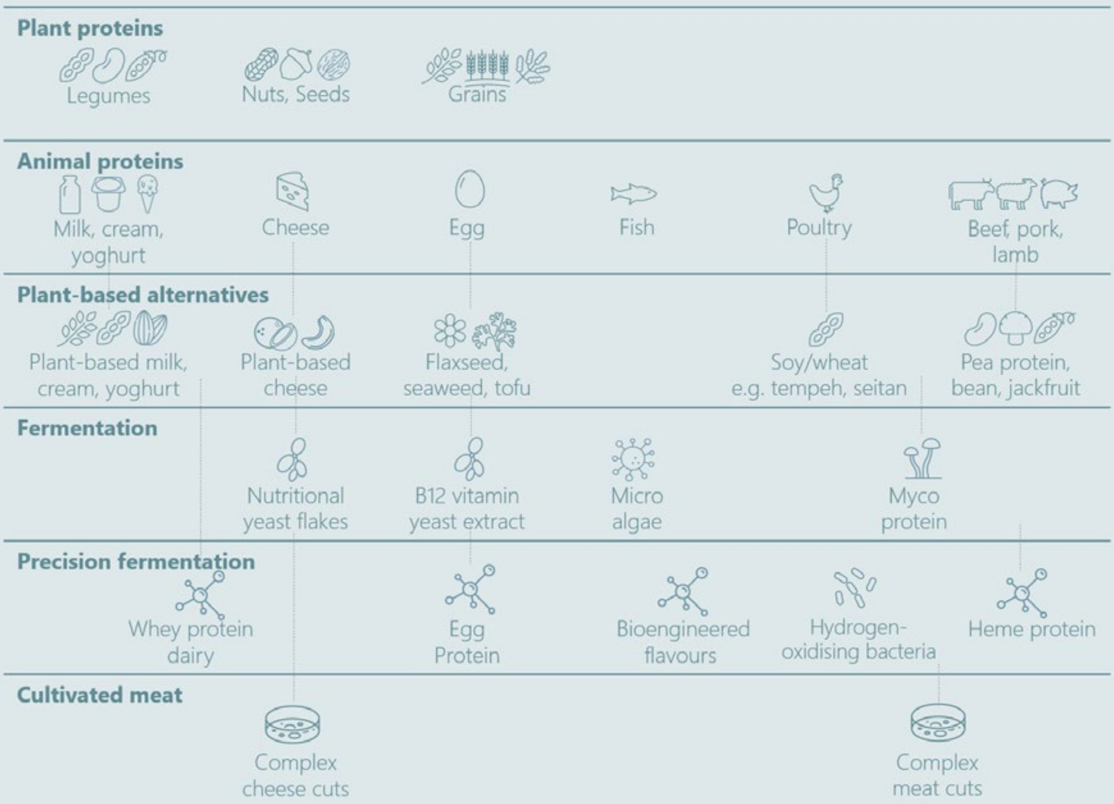
Alternatives to animal-based proteins are diversifying, beyond conventional plant proteins such as legumes, nuts, seeds and grains (see Figure 23). Plant-based and fermentation-based alternatives are widely available on the EU market, whereas products from cellular agriculture have been approved in some countries outside the EU.

- Plant-based alternatives. Plant proteins transformed to mimic the properties of dairy products are widely diversifying in the EU, including vegetal milks, cheeses, yoghurts, creams and ice creams (e.g. from oat, soy, almond, rice, coconut, cashew). Plant-based products mimicking meat have become more sophisticated in terms of taste and texture (e.g. pea protein).
- Fermentation. In addition to plants and animals, proteins can be produced by microorganisms, such as bacteria, fungi and algae. The production process involves cultivating microorganisms in controlled bioreactors, where they convert simple feedstocks into protein. While often referred to as 'fermentation' due to its similarities with food production processes like brewing or yoghurt-making, it is technically a form of microbial cultivation: rather than breaking down sugars into simpler compounds, the microorganisms grow and synthesise proteins as part of their biomass or are engineered to produce specific target proteins. Mycoprotein, produced from fungi to mimic the texture of meat and fish, has been widely commercialised in the United Kingdom and some other countries, for several decades. There are also companies producing edible

proteins from bacteria feeding on light, hydrogen and CO_2, hence relying on less land than plant proteins.

- **Precision fermentation.** With biotechnology, microorganisms can be genetically engineered to produce specific molecules. Such molecules can be chemically identical to those produced by plants and animals, with an indistinguishable taste and equivalent nutritional value. For example, biotech vanilla flavour has been widely commercialised, along with a wide range of other applications, including in the chemical industry. Precision fermentation is now used to produce animal-identical proteins, which are already on the market in the United States and Singapore, including milk proteins (whey, casein) for dairy products, egg proteins and the heme protein, which replicates the taste of blood in meat. This technique can also produce animal fats and enzymes to reproduce the taste of other animal products.
- **Cultivated meat.** In addition to microbial growth, research is underway to grow animal cells in the lab to produce cultivated meat. Sales have been approved in the United States and Singapore, and for pet food in the United Kingdom. With further research, cultivated meat could replicate complex cuts of meat and cheeses (Green Alliance, 2024; Van Der Weele et al., 2019; Santo et al., 2020).

Figure 23 Examples of novel proteins



3.5 Assessment of synergies and trade-offs

3.5.1 Synergies and trade-offs between climate mitigation and adaptation in the agricultural sector

There are multiple options to enhance climate adaptation and mitigation within agriculture.

The EU agricultural sector holds strong potential to contribute to climate change mitigation and enhance resilience through widely recognised, context-specific options, such as improving water retention, soil health and ecosystem functioning. These incremental and technical measures are emphasised here due to their immediate applicability and evidence base, though they represent only part of the broader adaptation and mitigation toolkit. When effectively implemented, these options can reduce emissions and/or increase carbon dioxide removals, while also strengthening the capacity of agricultural systems to cope with and adapt to increasing climate-related risks, for example, by improving water retention, soil health and overall ecosystem functioning (IPCC, 2019b; EEA, 2024a; Chiriacò et al., 2025).

However, as described in more detail in the remainder of this section, the intersection between mitigation and adaptation is not always straightforward: while many practices offer co-benefits, others may entail trade-offs, depending on the implementation context, the spatial and temporal scales involved, and the socio-economic and biophysical conditions (IPCC, 2019b; Chiriacò et al., 2025). Generally, options that result in steep costs to farmers or reduce their income via reductions or more variable yield can leave them economically vulnerable to shocks, with consequences for coping and recovery, but these adaptation trade-offs are addressed in Section 3.5.3. As such, a holistic evaluation of the potential interactions of agricultural practices with climate mitigation and adaptation, considering both synergies and trade-offs, is essential prior to their implementation.

Agricultural practices may generate synergies or trade-offs between climate mitigation and adaptation, whether by design or as unintended side effects.

As outlined by Locatelli et al. (2015), agricultural practices can be explicitly designed with the joint objective of optimising both mitigation and adaptation. However, context-specific planning is essential, as the effects largely depend on local conditions, methodological design and spatial-temporal implementation (Kongsager, 2018). In some cases, agricultural practices may also generate unintended side-effects, when actions designed for one goal (mitigation or adaptation) inadvertently affect the other, either positively or negatively, or when practices primarily aimed at other agronomic or economic objectives unintentionally create synergies or trade-offs between mitigation and adaptation.

Some concrete examples of how agricultural practices may interact with climate mitigation and adaptation, in terms of synergies and trade-offs, are discussed in more detail below. These include soil conservation practices, agroforestry and agrivoltaics, dietary shifts, improving livestock management and the restoration of degraded peatlands.

Soil conservation practices support both climate mitigation and adaptation by enhancing soil carbon content and improving the overall agroecosystem resilience.

Conservation agriculture practices like reduced or no-till farming, cover cropping and crop rotation (Ceaușu et al., 2021) often preserve and increase soil organic carbon by minimising soil disturbance, maintaining continuous cover and including deep-rooted plants or legumes in rotations. The latter also reduces the need for synthetic fertilisers and mitigates associated GHG emissions (Petersson et al., 2025; EEA, 2024a). They also enhance adaptation by preventing soil erosion, improving water retention and increasing drought resilience (García-Tejero et al., 2020), which helps crops to cope with water stress and preserve overall agroecosystem functioning (Baartman et al., 2022). The effects of these practices, both in terms of mitigation and adaptation potential, are amplified when multiple practices are combined (Petersson et al., 2025). However, they can vary significantly depending on the specific context in which they are implemented, with stronger benefits especially in carbon-poor or dry soils typical of Mediterranean regions.

Nevertheless, conservation agriculture practices may sometimes cause trade-offs between mitigation and adaptation. Reduced or no-tillage can increase N_2O emissions from nitrogen fertilisers partly offsetting mitigation benefits, though deep nitrogen placement (≥5 cm) can limit this effect (Van Kessel et al., 2013). Cover cropping may also raise N_2O emissions, particularly with leguminous species and under wet conditions, and in dry environments may compete with the main crop for water, reducing resilience to heat and drought (Francksen et al., 2024; Sharma et al., 2018).

Agroforestry and agrivoltaic systems offer integrated climate solutions by enhancing carbon sequestration and reducing emissions, while simultaneously increasing the resilience of farmers and agroecosystems to climate variability.

By integrating trees and shrubs into agricultural landscapes, agroforestry enhances carbon sequestration in above- and belowground biomass and in soils through root turnover and litter accumulation. In addition, tree shading improves microclimatic conditions reducing temperatures, moderating wind and buffering humidity thus increasing crop and livestock resilience and maintaining productivity under climate stress (Dobhal et al., 2024). Similarly, agrivoltaic systems contribute to reducing emissions from the energy sector through renewable energy generation (JRC, 2023d), while the partial shading from solar panels helps moderate soil moisture loss, alleviating crop stress during heatwaves and provides shelter for livestock in grazed systems, supporting adaptation to climate-related hazards (Soto-Gómez, 2024). Both systems enable farmers to diversify production, reducing dependence on a single crop or activity, spreading and lowering overall risk, which ultimately enhances farmers’ economic resilience to climate shocks (IPCC, 2022d).

However, agroforestry and agrivoltaic systems may also involve trade-offs between climate mitigation and adaptation. In agroforestry, for example, increased tree density enhances carbon sequestration but may lead to competition for light, water, and nutrients with intercrops (Rolo et al., 2021). Similarly, agrivoltaic systems may limit space and light availability for crops (Weselek et al., 2019) but in some cases also lead to increased yields depending on the crop type (Barron-Gafford et al., 2019). In both cases, the crops’ resilience to climate-related hazards may be reduced and site-specific planning, crop and species selection could be essential to minimising negative interactions (Toledo and Scognamiglio, 2021).

Shifting towards plant-rich, locally and seasonally sourced diets, combined with food waste reduction, reduces GHG emissions and enhances food system resilience.

The transition towards more plant-rich diets characterised by reduced consumption of livestock products and increased intake of legumes, whole grains, fruits and vegetables can significantly lower GHG emissions and increase efficiency in land and resource use (Rockström et al., 2025; Poore and Nemecek, 2018; IPCC, 2019b), thus supporting more diversified, locally adapted, and climate-resilient cropping systems (IPCC, 2019b; Chiriacò et al., 2025). Similarly, reducing food loss and waste can lower land and resource use and improve food security, thereby enhancing the resilience of food systems, particularly under increasing climate variability and resource constraints (Cattaneo et al., 2021b).

Only few trade-offs between mitigation and adaptation arise from shifting to more climate-friendly diets or reducing food losses and waste. For example, a shift towards more plant-rich diets could reduce grazing land, which presently contributes to wildfire risk mitigation especially in Mediterranean ecosystems by controlling vegetation fuel loads (Lovreglio et al., 2014; Canals et al., 2024).

Improving livestock management can simultaneously reduce emissions and enhance animal and ecosystem resilience, though trade-offs with electricity consumption and animal health must be considered.

By optimising feed quality and ration formulation for ruminants, such as with concentrates replacing part of the forage, enteric methane emissions can be substantially reduced while enhancing animal health (EEA, 2019; IPCC, 2019b). Efficient manure management through anaerobic digestion reduces methane and nitrous oxide emissions, generates biogas as a renewable energy source, and preserves its value as a soil organic amendment enhancing soil fertility (EEA, 2019).

Extensive livestock grazing management combined with pasture restoration such as reseeding native grasses, implementing rotational grazing, and controlling overgrazing can enhance carbon sequestration and strengthen ecosystem resilience by improving soil health, water retention, and biodiversity, thereby supporting adaptation to climate change. However, potential trade-offs, including a possible increase in GHG intensity per unit of product, should also be considered (Conant et al., 2017). Other trade-offs between mitigation and adaptation include the use of ventilation or cooling systems that help animals adapt to climate change during summer by reducing heat stress and mortality; however these solutions, unless using natural ventilation, can significantly increase electricity consumption, potentially leading to higher GHG emissions (IPCC, 2019b). Moreover, although increasing the proportion of concentrates in ruminant livestock diets can reduce CH_4 emissions, CO_2 emissions may increase from indirect land-use change from grasslands to arable land. Additionally, the implications for animal health must be carefully considered, as excessive or poorly balanced concentrates may lead to digestive disorders and other health issues, ultimately compromising animal welfare and their resilience and adaptive capacity (EEA, 2019).

Restoring hydrological conditions of degraded peatlands preserves carbon sinks, enhances water regulation and strengthens ecosystem resilience, though it may increase CH_4 emissions in the short term.

Restoring the hydrological conditions of degraded peatlands is an effective mitigation solution as it can significantly reduce CO_2 and N_2O emissions (IPCC, 2019b). At the same time, restored wetlands and peatlands improve their water retention capacity – retaining water during heavy rainfall and releasing it slowly during droughts – and buffer against floods and droughts, thus increasing ecosystem resilience. Rewetting could support diversifying agricultural production, for example, as paludiculture (Ferreira et al., 2023).

However, restored waterlogged conditions can enhance anaerobic decomposition, leading to increased CH_4 emissions. This could create a trade-off between adaptation and mitigation, although over the long term the abatement of CO_2 emissions due to restoration generally outweigh the additional CH_4 release, thus still representing a major mitigation benefit (Zou et al., 2022; Günther et al., 2020). Another trade-off is the loss of agricultural production from rewetted soils, which could lead to displacement or even an increase in emissions due to potential indirect land-use change elsewhere (Gerssen-Gondelach et al., 2017).

3.5.2 Synergies and trade-offs with other environmental objectives

The interaction of agricultural practices with the broader environment must be carefully assessed.

Sustainable agricultural practices, while also supporting climate mitigation and/or adaptation, can influence a wide range of other environmental factors, creating both synergies and trade-offs. These interactions may enhance ecosystem functions such as biodiversity, soil health and water and air quality, as further detailed later in this section. At the same time, trade-offs may emerge, requiring careful evaluation to minimise unintended impacts and ensure multifunctionality (EEA, 2019; Chiriacò et al., 2025). Understanding these dynamics is essential for designing agricultural systems that contribute not only to climate action but also to long-term environmental sustainability. The following practices can create co-benefits as compared with conventional agricultural practices.

Soil conservation practices can enhance biodiversity, soil health, water and air quality, though careful management is needed to avoid trade-offs with pests and herbicide use.

Soil conservation options often generate significant environmental co-benefits in addition to climate mitigation and adaptation. One example is reduced or no-tillage combined with permanent soil cover, which improves soil structure and enhances water infiltration and retention (García-Tejero et al., 2020). Other examples are crop rotations and cover crops, which foster greater plant and microbial diversity, contributing to biodiversity both above and below the ground. By limiting soil erosion and nutrient leaching, these practices also reduce water pollution, while lower fuel consumption from reduced or no-tillage can contribute to improved air quality. Nevertheless, some trade-offs may occur. For instance, cover cropping systems may increase pest pressure which, if not adequately managed through crop rotation and biological control, can require higher levels of chemical treatments. Similarly, reduced or no-tillage may increase reliance on herbicides for weed control, with potential negative consequences for biodiversity (Yousefi et al., 2024).

Agroforestry and agrivoltaics can enhance biodiversity and offer soil protection though trade-offs with pest management and habitat fragmentation may occur.

Agroforestry and agrivoltaics systems can also provide multiple environmental co-benefits. In agroforestry, the presence of trees enhances biodiversity by providing habitats for beneficial insects, birds and soil organisms. Trees are effective scavengers of ammonia emissions, reducing ecosystems eutrophication and acidification (Bealey et al., 2014). Moreover, perennial vegetation with permanent root systems helps reduce soil erosion, improves soil health, enhances water infiltration and limits runoff (Ogwu and Kosoe, 2025).

Similarly, agrivoltaic systems provide ground cover supporting soil microbial communities and enhancing soil health, while generating renewable energy and improving air quality compared with fuel-based emissions (JRC, 2023d). However, agroforestry could require additional pest management, whereas agrivoltaics installations can cause habitat fragmentation and disturb wildlife, unless habitat-supporting vegetation such as wildflower strips between panels or hedgerows along site borders is established (EEA, 2019).

Climate-friendly diets and food waste reduction can lower pressure on land and water resources although trade-offs may arise from processed foods, packaging and refrigerated transport.

Shifting towards more climate-friendly diets and reducing food loss and waste generate benefits across multiple environmental dimensions. Diet shifts, particularly towards more plant-rich, local and seasonal foods, lower pressure on land and water resources, reduce pollution, especially nitrogen flows and losses from the livestock sector (Lassaletta et al., 2016), and support biodiversity by reducing habitat losses. Cutting food waste reduces the need for agricultural inputs, decreasing nutrient leaching that affects water quality, and reduces emissions that impact air quality (Rockström et al., 2025). However, trade-offs may arise if dietary shifts increase reliance on processed or imported foods with hidden environmental burdens, or if waste reduction strategies involve energy-intensive measures, such as advanced packaging that generate microplastics or additional waste, water-intensive food processing, or refrigerated transport that increases air pollutant emissions (Rockström et al., 2025; IPCC, 2019a; Poore and Nemecek, 2018).

Improving livestock management can enhance air and water quality, soil health and biodiversity, while excessive manure application may alter soil functioning.

Optimising livestock diets and improving manure management not only reduce CH_4 and N_2O emissions but also curb ammonia volatilisation thereby reducing fine particulate matter detrimental to air quality and human health (EEA, 2019). Extensive grazing combined with pasture restoration promotes plant and microbial diversity and improves soil structure and its water retention capacity.

Restoring wetlands and peatlands can support ecosystem functioning and reduces fire risk, although their management for agricultural purposes may affect soil chemistry and cause localised nutrient runoff.

Restoring wetlands and peatlands enhances biodiversity by re-establishing native habitats. Rewetting improves hydrological conditions, and integrating biodiversity-friendly agricultural activities, such as paludiculture on rewetted wetlands, can create synergies between agricultural production and ecosystem services while reducing nutrient runoff and protecting water quality (EEA, 2019). Furthermore, increased soil moisture in peat, which is highly flammable when dry, lowers the risk of fires and the consequent release of large amounts of air pollutants. However, trade-offs to restoration may arise, as paludiculture management can alter soil chemistry or cause compaction, and nutrient application may lead to localised water pollution (Loisel and Gallego-Sala, 2022).

3.5.3 Synergies and trade-offs with other, non-environmental criteria

Conservation agriculture can sustain yields and reduce costs over time, despite short-term trade-offs.

Conservation agriculture practices such as reduced or no tillage, cover cropping and crop rotation can entail short-term productivity trade-offs, with initial yield reductions (Van Den Putte et al., 2010). However, improvements in soil fertility over time should allow yields to reach levels comparable to conventional systems unaffected by negative climate-related impacts in the medium- to long-term. Crop management can be optimised to mitigate initial yield declines, for example through precision agriculture that tailors input use to plant needs (Krauss et al., 2022). Moreover, these practices often result in lower production costs due to reduced use of inputs and fewer farming operations (Rosa-Schleich et al., 2019). Consequently, short-term yield reductions may be offset by cost savings and, in some cases, by premium prices to the farmers for certified and labelled sustainable production (Olagunju et al., 2025).

Agroforestry and agrivoltaics offer land-use efficiencies but require careful design to manage trade-offs.

Agroforestry and agrivoltaics enable land-use efficiency by combining food and renewable energy production, thus reducing pressure on natural resources. However, they often entail yield reductions of the main crop, especially in water-limited environments (Rolo et al., 2021). Moreover, the presence of trees or photovoltaic infrastructures particularly in poorly designed agroforestry systems or panel arrangements can also interfere with farm operations, requiring farmers to adapt their machinery and agricultural practices (Weselek et al., 2019). In both cases, site-specific planning and careful system design are essential to minimise negative interactions (Toledo and Scognamiglio, 2021). However, both systems allow farmers to diversify production and income sources, thereby enhancing farmers' resilience to market fluctuations (IPCC, 2022c).

Dietary shifts towards plant-rich diets offer substantial health and environmental co-benefits, but may create new dependencies and value chain disruptions.

The transition towards more plant-rich diets improves long-term quality of life, life expectancy and overall human health worldwide (Rockström et al., 2025). Global dietary shift scenarios show that monetised health benefits can even exceed environmental benefits (Springmann et al., 2016), particularly by reducing deaths from coronary heart disease, stroke and cancer (Scarborough et al., 2012). Moreover, many healthy and sustainable diet recommendations are highly cost-effective, especially those promoted for health reasons such as reducing salt and saturated fat intake and increasing fruit and vegetable consumption (Irz et al., 2016).

At the same time, the growing demand for legumes, fruits and oilseeds especially those not commonly produced in Europe may increase import dependence (Murphy-Bokern et al., 2017). Moreover, shifts towards more plant-rich diets may also require a reorganisation of livestock-based value chains, with potential socioeconomic impacts on livestock farming and supply chains across Europe (Genest-Richard et al., 2025). Likewise, reducing food losses and waste, while improving efficiency and food security, may involve high logistical costs, potentially leading to higher food prices (Cattaneo et al., 2021a).

Improved livestock management can enhance long-term productivity but involves upfront costs and potential trade-offs with feed production.

Practices aimed at improving livestock management may require higher upfront investments from farmers, for example in feed optimisation, infrastructure for manure treatment-, or pasture restoration. Especially in extensive systems, limiting grazing pressure can initially reduce meat or milk output. However, over time, healthier pastures and animals tend to enhance productivity, offsetting the initial losses (Schader et al., 2015). At the same time, emissions-reducing strategies such as increasing the proportion of concentrates in livestock diets may generate additional trade-offs by requiring more arable land for feed production, potentially competing with food crops for human consumption and undermining food security (Conant et al., 2017). This underscores the need to balance mitigation benefits with overall resource efficiency, ensuring that emission reductions are not offset by unintended sustainability trade-offs.

Restoring degraded peatlands offers significant climate mitigation potential but entails loss of productive farmland, systemic transitions and coordination challenges.

After restoring degraded peatlands previously used as arable land or grassland, conventional cultivation is no longer possible. Restoring peatlands therefore reduces the agricultural area available for food production, with potential implications for food security. However, they only represent a small share of total agricultural land (approximately 2–3% of UAA (Nordbeck and Hogl, 2024)), limiting the aggregate impact on production capacity. The adoption of paludiculture entails a radical shift in the farming system, with possible legal and economic consequences, and generates uncertainty for farmers. In most cases, rewetting requires collective participation and coordinated action among neighbouring landowners, supported by the consent and cooperation of local authorities. Moreover, permanent waterlogging can create additional challenges, as it may favour the proliferation of disease-vector insects, thereby increasing risks to human health and raising social acceptability concerns among local communities (Loisel and Gallego-Sala, 2022).

Chapter 4

Stylised pathways

Key messages

Business as usual is not a viable path forward.

The EU agriculture's current trajectory does not address the challenges facing the sector from climate change, leading to loss of income for farmers and increasing food prices while continuing the EU's reliance on fertiliser and protein feed imports. Staying the course would also result in too little climate mitigation in the agri-food system and therefore the EU would rely extensively on carbon dioxide removals (CDR) to reach climate neutrality by 2050. As the potential and costs of CDR are uncertain, this would put the achievement of this target at risk.

A focus on technical fixes is essential but not sufficient.

An ambitious deployment of technical and incremental mitigation and adaptation options is essential to achieve the EU climate objectives in an economically and socially coherent manner. Nevertheless, exclusive reliance on such measures would provide only a moderate contribution to climate mitigation efforts, reducing non-CO_2 emissions by no more than one third by 2050 relative to 2005 levels. Consequently, this would imply substantial dependence on CDR to achieve the overall EU climate targets. It is also unlikely to ensure long-term climate resilience and may cause lock-ins and maladaptation. Furthermore, it would generate limited co-benefits for other environmental and public health goals. Such an approach would also need to rely heavily on public funds if structural changes are to be avoided.

Only a more systemic transition of the agri-food system can deliver on multiple objectives, but critical challenges need to be addressed.

Compared with a sole focus on technical fixes, a systemic transition of the agri-food system adds changes in diets and the production mix, reduction in food waste, more substantial land use changes and landscape measures, and more diversified, climate risk-savvy livelihoods. Such a pathway can deliver a more ambitious contribution to the EU's overall climate targets, enabling a reduction in agricultural non-CO_2 emissions by more than a third by 2040 and half by 2050 relative to 2005, while boosting land-based carbon sinks. Furthermore, it can better safeguard European food production against the risks of climate change in the longer term, and result in higher synergies and lower trade-offs with other environmental and public health objectives. Finally, it can reduce the EU's reliance on imports of fertilisers and protein feed and create new opportunities in the bioeconomy and for plant-rich and novel foods.

The transition's main challenges are the expected adverse impact on the livestock sector, and related carbon leakage risks, along with the need to adjust dietary habits which are deeply embedded in culture and territorial identity.

A systemic agricultural transition is largely about physical changes at the farm level, but farmers' choices are heavily constrained by structural lock-ins and supply chain dependencies. Therefore, transforming the whole value chain and fully engaging the food industry and retailers in this transition is essential to support and enable farmers to adopt climate-friendly production systems.

4.1 Introduction

This chapter identifies and assesses different possible futures for the EU agri-food system based on stylised pathways.

Chapter 3 provided a high-level overview of different options to enhance climate adaptation and mitigation in the EU agri-food system and categorised them based on a spectrum ranging from incremental, technical options to structural options. It also identified key areas of potential synergies and trade-offs across non-climate objectives.

This chapter illustrates how the agri-food system might evolve in the future and what different possible futures would mean for the assessment criteria identified in Chapter 2. To facilitate a structured discussion and analysis of the future of the EU agri-food system, it identifies and describes three stylised pathways as illustrative trajectories the system could follow towards 2050. In each pathway, different types of options identified in Chapter 3 are combined and deployed to different degrees. These pathways are not intended to be exhaustive or predictive; rather, they serve as simplified representations that highlight distinct characteristics or strategic orientations. In practice, a wide range of hybrid pathways may emerge, combining elements from the investigated trajectories. Nevertheless, the stylised pathways provide useful conceptual anchors for evaluating future directions and their implications in relation to the criteria outlined in Chapter 2. They allow the analysis to identify the potential for synergies and risk of trade-offs between these different criteria.

The stylised pathways build the foundation for the policy assessment in the subsequent chapters of the report.

The ultimate purpose of this exercise is to derive insights into what policies should aim to achieve to align the agricultural sector and the broader agri-food system with the EU climate objectives, while taking into account other societal objectives. Chapters 5 to 12 of the report build on this analysis by linking the implications of the stylised pathways to policy development.

The rest of this chapter is structured as follows:

- **Section 4.2** introduces and describes the three stylised pathways.
- **Section 4.3** assesses what the three pathways can be expected to deliver in terms of adaptation.
- **Section 4.4** assesses what the three pathways can be expected to deliver in terms of climate mitigation.
- **Section 4.5** explores the implication of the three pathways for the other societal objectives.
- **Section 4.6** provides a summary of potential synergies and risk of trade-offs along the assessment criteria for each of the pathways and concludes on the required way forward.

4.2 Description of three stylised pathways

Three stylised pathways present very different future trajectories of the agri-food system.

The primary typology employed to construct the three stylised pathways is based on the distinction between incremental, technical changes at one end of the spectrum and transformational, structural changes at the other (see also Chapter 3). To serve the purpose of this chapter, the aim of the three stylised pathways is:

- to illustrate the implications of continuing along the current trajectory with limited deployment of both technical improvements and structural changes;
- to evaluate the extent to which a substantial uptake of incremental, technical changes alone can address the key challenges facing the agri-food system;
- to explore the potential benefits and trade-offs of moving beyond incremental, technical options, by complementing these with a substantial uptake of more transformational, structural changes.

To facilitate this analysis, three stylised pathways were developed which correspond to each of the aforementioned aims, as described in Figure 24 below.

Figure 24 Illustration and description of the three stylised pathways

	Limited Effort	Improved Production	Systemic Transition
Main storyline	No or only very marginal new adaptation and mitigation efforts beyond current levels	High deployment of incremental, technical adaptation and mitigation options, but no transformational, structural changes.	High deployment of both incremental, technical and transformational, structural options at both the supply and demand side.
More technical			
Crop and livestock	**Limited uptake** of some options (low-hanging fruit)	**Substantial uptake** of options like feed additives, physical protection, improved herd management.	**Substantial uptake** of options like feed additives, physical protection, improved herd management.
Soil and field	**Limited uptake** of some options (low-hanging fruit)	**Substantial uptake** of options like more efficient irrigation, cover crops, improved crop rotations, nitrification inhibitors and biochar.	**Substantial uptake** of options like more efficient irrigation, cover crops, improved crop rotations, nitrification inhibitors and biochar.
Farm and livelihood	**No uptake**	**Substantial uptake** of options like anaerobic digestion. **Moderate uptake** of agroforestry.	**Substantial uptake** of diversification strategies which cover options like anaerobic digestion, agroforestry, and production of higher quality products.
Land sector	**No uptake**	**Limited uptake** of organic soil rewetting.	**Substantial uptake** of landscape measures including rewetting of organic soils.
Agri-food system	**No uptake**	**No uptake**	**Substantial uptake** of dietary shifts, food waste reductions and other system-level options.
More structural			

The Limited Effort pathway functions as a baseline scenario against which the other pathways are evaluated.

The Limited Effort pathway assumes no or only very marginal additional uptake of new climate adaptation and mitigation efforts. This is consistent with historic trends and long-standing policies, which are not expected to deliver substantial mitigation and adaptation beyond today's levels.

In recent years, however, the EU has adopted some policy measures which might trigger more substantial efforts, such as the Nature Restoration Law which requires the rewetting of a substantial share of degraded peatlands. Such more substantial efforts are not considered in the Limited Effort pathway. Chapter 5 discusses in more detail to what extent existing EU policies could help support mitigation and adaptation efforts.

Deployment of technical options is included in all other pathways.

The Improved Production pathway includes substantial uptake of incremental and technical options, but it has only limited to no uptake of the more transformational and structural options. In contrast, the Systemic Transition pathway makes use of all relevant climate mitigation and adaptation options.

No pathway was considered that is based exclusively on transformational, structural changes without the deployment of more incremental, technical options. This decision reflects the assumption that technical interventions will be an essential component of any plausible transition pathway for the agricultural sector. One rationale for this is the capacity of technical options to deliver immediate benefits, which are critical in the short term. In contrast, structural changes, while potentially offering significant long-term risk reduction and co-benefits, often require more time to materialise and generate measurable impacts and often imply trade-offs. It also corresponds with the fact that transformational adaptation can only be achieved through a nested, multilevel approach, meaning that it requires the deployment of actions from across all levels.

The pathways are storylines, not scenarios.

The pathways presented in this report should be understood as broad narrative frameworks rather than detailed, quantified scenarios. Instead of generating new quantitative projections, the analysis draws on a selection of scenarios and other scientific assessments from existing literature, which are applied in Sections 4.3 to 4.5 to assess the implications of each pathway. However, no scenario from the literature is selected to uniquely represent each of the pathways, as the Advisory Board has not identified scenarios that included all relevant aspects, particularly none that would capture the complexities of adaptation pathways.

The narrative trajectories outlined by the pathways indicate a general direction and (qualitative) magnitude of change but do not define the specific (quantitative) extent of that change. The degree to which technical and structural options are implemented will influence the overall impact in terms of climate mitigation, adaptation potential and the associated synergies and trade-offs. The quantitative scenarios from the literature serve as the analytical foundation for a more detailed evaluation of these potentials and outcomes.

Structural changes are assumed to work on both the supply and demand sides.

In the Systemic Transition pathway, structural and transformational changes are assumed to involve a substantial reduction in livestock production, accompanied by a commensurate decline in the consumption of livestock-derived products. However, given the EU's status as an open economy, production and consumption do not necessarily evolve in parallel, as adjustments in trade flows may act as a buffer. For instance, a decrease in livestock production could manifest primarily as reduced net exports rather than diminished intra-EU consumption.

Nevertheless, for the purposes of this analysis, it is assumed that changes on the supply and demand sides occur in the same direction and with a comparable order of magnitude. This assumption is grounded in two key considerations. First, addressing only the supply side without a corresponding reduction in demand for GHG-intensive products risks shifting production and associated environmental burdens beyond EU borders (Bremmer et al., 2021; Matthews, 2021b; JRC, 2021). Second, implementing supply-side options, such as increasing the cultivation of protein crops for human consumption, is more viable when there is a corresponding consumer-driven demand pull within the EU (IEEP, 2025b).

New and revised policies are needed to implement the pathways.

While the pathways primarily focus on tangible and often physical transformations, their realisation, particularly in the Improved Production and Systemic Transition pathways, requires substantial policy intervention. In contrast, the Limited Effort pathway is based on current levels of climate adaptation and mitigation action, and therefore would not require additional policies.

A variety of policy instruments could be employed to advance each pathway. However, the Improved Production pathway needs most plausibly to be driven by policies that do not substantially increase production costs to farmers (e.g. subsidies, free allocation of emissions allowances or similar support mechanisms), if structural changes are to be kept to a minimum in line with the underlying premise of this pathway. If costs were to increase due to taxes, mandates or similar instruments, production patterns would likely shift to the direction of less-affected types of production. In contrast, the Systemic Transition pathway offers greater flexibility in policy design, allowing for the application of both 'carrot' and 'stick' instruments. The specific policy mix selected will significantly influence the distributional effects and acceptability of each pathway among the different stakeholders in the agri-food system.

4.3 Climate adaptation aspects of the stylised pathways

4.3.1 Limited Effort

Climate adaptation practices within agriculture have so far been limited to the local level.

As briefly discussed in Section 2.3, so far responses to climate-related risks in agriculture have primarily consisted of endogenous, reactive responses to impacts and some limited deployment of incremental, technical adaptation options at lower spatial scales at the crop or livestock level (Berrang-Ford et al., 2021; Chhetri et al., 2019). This can be attributed to different factors relating to farm structure, attitudes and beliefs (e.g. perception of usefulness of the measure), access to credit or subsidies and formal institutional factors, such as prices of inputs and outputs (Swart et al., 2023; Thompson et al., 2024).

The Limited Effort pathway will face limits to climate adaptation and risks leading to maladaptation.

Despite uncertainties in quantifying the magnitude of the effect of individual and combined adaptation options, there is strong scientific consensus that a continuation of such an approach, which often focuses on one specific hazard and one specific crop at a time, will face limits to adaptation as multi-risk scenarios (i.e. cascading and compounding climate and non-climatic hazards, see Box 5) shrink the solution space over time.

A common reaction to address reducing yields caused by climate-related impacts is to increase the use of inputs such as water and pesticides (FAO, 2022b). However, such an approach can result in maladaptive practices by rebounding vulnerability (e.g. depletion of groundwater resources), shifting vulnerability (e.g. reduction of the quantity and quality of water available for other sectors) and eroding sustainability (e.g. degraded biodiversity due to pesticide use), thereby increasing climate vulnerability in the longer term (Bezner Kerr, 2023). Finally, the cascading ecological effects from prevalent agricultural practices in their current form (see Section 2.3) are likely to compound climate-related impacts while diminishing the effectiveness and increasing the costs to deploy adaptation options in the future.

A continuation of a Limited Effort pathway therefore cannot adequately address climate-related impacts in the long-term and even risks resulting in maladaptation and compounding risks.

Box 5 Limits to climate adaptation and risk of maladaptation

The climate change risk profile is expected to change over time.

As briefly discussed in Section 2.3, one of the key challenges in effective adaptation planning is the changing risk profile of climate change. The projected rise in frequency and magnitude of extreme events, such as droughts, heat waves and floods, and the multiple implications of changes in weather patterns for crop development, crop protection, animal husbandry and animal health, lead to increased risks for production at the farm scale and such risks compound with environmental risks from soil degradation, water availability and loss of ecosystem services (EEA, 2024b). Consequently, options that focus on reducing the risks from one hazard and to one crop/species at a time are unlikely to consistently reduce adverse climate-related impacts over time.

Short-term and incremental options face limits to climate adaptation and can lead to maladaptation.

As discussed in Section 3.2.1, incremental, technical adaptation options can generally be implemented within short time frames, whereas more transformational, structural options have longer lead times. For example, physical protection measures (e.g. installing a net to protect against hail) can have immediate effects in reducing exposure of assets, whereas options aimed at restoring degraded ecological processes (e.g. groundwater recharge) often require a longer time and deeper systemic changes, for example to the modes of production, to reduce risks.

Actors might prioritise adaptation options with short implementation times to address the most apparent, short-term climate risks. If the risk profile then changes over time, it might be too late to switch to other, more adequate adaptation options with longer time leads, thereby resulting in limits to adaptation (IPCC, 2022e). For example, changes are expected in the suitability of current wine-growing regions. Expanding upslope, often into previously forested areas, might extend the use of coveted grape varieties but could exacerbate landscape degradation, which in turn might limit the effectiveness of switching to other varieties that tolerate a certain level of warming later on (Van Leeuwen et al., 2024).

Limits to adaptation refer to the points at which actors' and systems' needs can no longer be secured from intolerable risks. Such limits can be either soft in the sense that they can be overcome through targeted interventions and appropriate enabling conditions, even if not currently available, or hard when they cannot be overcome even with unlimited resources due to e.g. physical constraints such as ecosystem collapse or water scarcity. The risk of hard limits increases at higher levels of warming (IPCC, 2022c). The residual risk that cannot be reduced timely through mitigation or adaptation needs to be addressed through disaster risk management and risk transfer options (e.g. insurance) to limit losses and damages (Advisory Board, 2026).

Even if there is limited systematic empirical evidence about the efficacy of different adaptation options over time, it is expected that some adaptation options will become completely ineffective or too costly at certain hazard magnitudes and frequencies. On the other hand, the long implementation time of some of the adaptation options until maturity (e.g. agroforestry) limits the option value of the land[16] and reduces the flexibility of farmers to adjust through short-term strategies.

The choice and timing of adaptation options may also result in maladaptation, leaving a system worse off than before the adaptation option was implemented. Maladaptation refers to 'actions or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future' (IPCC, 2014). Maladaptive outcomes may arise from different failures in the proper risk assessment and planning of appropriate measures, leading to:

- **Rebounding vulnerability.** Short-term actions which decrease the adaptive capacity and shrink the solution space for adaptation over time, for example, by infrastructure lock-ins.
- **Shifting vulnerability.** Large-scale actions where increased vulnerability has a spillover effect in other locations, or new risks are created elsewhere.

- **Eroding sustainable development.** Adaptations that negatively impact environmental, social or economic outcomes, exacerbate vulnerability or climate change and increase adaptation needs. This also includes solutions that exacerbate use or dependence on GHG-intensive practices or technologies.

One example of maladaptation highlighted by Bezner Kerr (2023) is the use of large-scale, groundwater-fed irrigation systems to cope with increasing droughts. Over time such an approach risks leading to reduced groundwater levels, thereby reducing water availability, not only for agriculture but also for other economic sectors and households, while increasing costs and debt loads for farmers. Another example is the use of improved crop cultivars which are better adapted to a changed climate (e.g. more drought-resilient). However, when too much emphasis is placed on only a few varieties, such an approach can reduce agrobiodiversity, thereby increasing the risk of crop loss and the vulnerability of farmers to price volatility.

4.3.2 Improved Production

Incremental, technical options on their own are insufficient to achieve long-term climate adaptation.

The Improved Production pathway assumes a substantial uptake of technical and incremental options at the crop/species and field levels, but only a modest to limited uptake of options at the farm to landscape level and no changes at the highest system level.

As discussed above, when pursued in isolation, crop- and field-level options are only temporary patches and risk presenting trade-offs over time. This remains valid even when these incremental options are deployed to a substantial degree, for the reasons shown below:

- **Limited efficacy.** Options deployed in this pathway have limited windows of effectiveness, especially under scenarios with higher levels of global warming. For example, the IPCC *Sixth Assessment Report* (AR6) indicates that options such as switching to different cultivars and adjusting sowing dates are insufficient to compensate for yield losses projected for Europe in scenarios exceeding 3 °C of warming (IPCC, 2022e). This illustrates that incremental adjustments cannot keep pace with the magnitude and speed of climatic change beyond certain thresholds (IPCC, 2022e).
- **Risk of maladaptation.** Some options may exacerbate vulnerability or exposure in the long term, leading to maladaptation. For example, efficiency gains from improved irrigation measures in drought-prone areas may encourage farmers to pursue expansionist strategies (e.g. more than one crop per year or changing to permanent crops) that ultimately increase pressure on water bodies and create technological lock-ins (Zagaria et al., 2021).

The range of incremental, technical options under the Improved Production pathway can at least temporarily reduce climate-related risks compared with Limited Effort. However, because these measures do not reduce the root causes of vulnerability and exposure nor do they address underlying structural, institutional and physical constraints to large-scale implementation (Brown et al., 2018), they will not be able to sustain adaptation outcomes in the long term particularly under

[16] The 'option value of the land' refers to the value derived from preserving the flexibility of using land for different possible purposes rather than committing to a specific use right now.

higher-warming scenarios. Achieving durable resilience will therefore require transformative changes at the farm, landscape, and system levels, rather than sole reliance on incremental improvements.

4.3.3 Systemic Transition

Transformational adaptation is necessary for a climate-resilient agri-food system.

The Systemic Transition pathway assumes a substantial deployment of adaptation options across all spatial scales, from the crop/livestock level to the whole agri-food system. Such a wide-ranging deployment is generally referred to as 'transformational adaptation' (see also Section 3.2.1). With this approach, a system can as a whole become more resilient to climate-related risks, adaptive to changing risk profiles and provide co-benefits (Chhetri et al., 2019). Key challenges of this approach are higher required initial investment and transition costs in an environment characterised by uncertainty about the specifics of future climate change risks and corresponding adaptation benefits. Furthermore, since the approach requires substantive changes, it could face opposition from sectors that might lose from these structural changes. Finally, it faces institutional and behavioural barriers that tend to perpetuate the status quo (Kates et al., 2012).

Long-term climate adaptation requires pursuing transformational options beyond the farm level.

The deployment of a wide range of adaptation options across multiple scales under the Systemic Transition pathway enables the EU agri-food system to adapt to multiple risks, accounting for the nature of potentially complex and compounded risks, rather than to one hazard at a time. Adaptation options in this pathway reduce overall risk 1) by diversifying the kind of produced goods (e.g. crops, varieties and breeds) and their spatial and temporal arrangements (e.g. agroforestry, cover crops), 2) by diversifying the landscape (e.g. wetland restoration, rewilding for conservation), and 3) by diversifying income streams through both on-farm and off-farm activities. As a result, the system is better able to ensure long-term adaptation under a changing climate with uncertain impacts.

The Systemic Transition pathway also assumes a substantial reduction in the production and consumption of livestock products and food waste. As described in detail in Chapter 3, these options can make a substantial contribution to adaptation, by substantially reducing the amount of land required to sustain food production (IPCC, 2019a). This reduction in land demand can then in turn be used to allow for more diverse landscapes that increase ecological and ecosystem services, along with social resilience when combined with income diversification measures.

As discussed in Section 2.3, the exact required degree of adaptation is uncertain and depends among others on future emission pathways and corresponding levels of global warming. Nevertheless, there is a consensus within scientific literature that whereas incremental adaptation can address adaptation needs in the short to medium term, only transformational adaptation including landscape-wide approaches, dietary shifts and food waste reductions as in the Systemic Transition pathway can deliver long-term adaptation (Challinor et al., 2014; Berners-Lee et al., 2018; WRI, 2021).

4.4 Climate mitigation aspects of the stylised pathways

Agriculture has a crucial role to play in achieving the EU net-zero target by 2050.

The EU has set a net-zero emissions target for 2050, which entails that any remaining GHG emissions must be balanced by equivalent carbon dioxide removals (CDR). Reaching this objective necessitates contributions from all sectors, including agriculture and the broader agri-food system.

To reach the net-zero target, the following three components must, in combination, reduce current emissions to zero.

1. **Emission reductions in agriculture (including land use).** As further discussed below, substantial reductions can be achieved through the deployment of climate mitigation options but, even under the most ambitious scenarios, agriculture is expected to be the main source of residual emissions by mid-century (Advisory Board, 2023; EC, 2024f).
2. **Reductions in other sectors.** It is expected that despite potential for very deep GHG reductions, some level of residual emissions will remain also outside of agriculture, for example from the industry and transport sectors.
3. **Upscaling of CDR.** This could be achieved by both temporary removals in the land use sector or permanent removals through novel approaches (Advisory Board, 2025).

Agriculture can contribute to EU climate neutrality in multiple ways.

The agricultural sector can contribute to the achievement of the EU net-zero target through each of the three components introduced above:

1. it can reduce its own, direct GHG emissions;
2. it can help other sectors to decarbonise by supplying sustainable biomass and other renewable resources as substitute for fossil fuels and feedstocks;
3. it can contribute to enhancing the net sink in the land use sector, by preserving existing carbon sinks, enhancing CDR on agricultural land and freeing up land that can be used for activities with even higher carbon sequestration potential, such as afforestation and wetland rewetting.

The sector's ability to contribute to mitigation in these different ways differs strongly across the three different stylised pathways assessed, as further described below.

4.4.1 Limited Effort

The Limited Effort pathway would deliver only a very modest (or even negative) climate mitigation contribution.

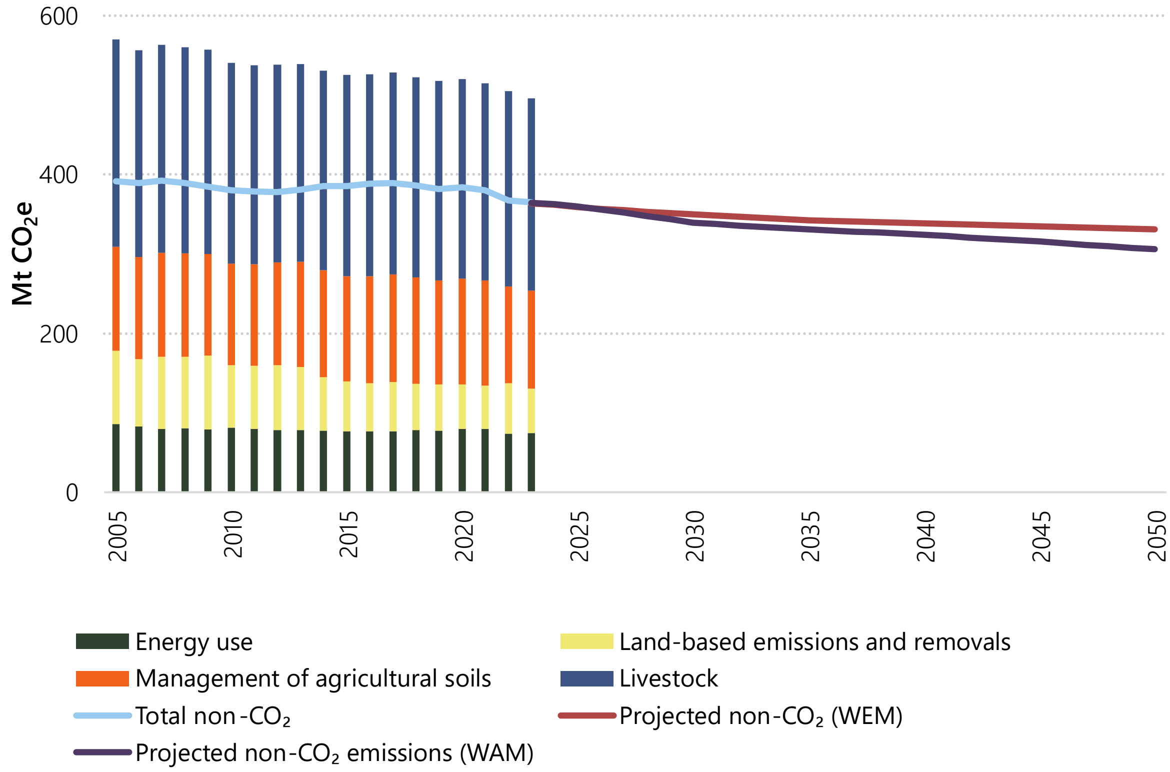
Continuing current policies and trends would deliver only very limited additional reductions in agricultural non-CO_2 emissions. The European Commission's official outlook for agriculture (EC, DG AGRI, 2024) projects only a very modest reduction (approximately 1%) from 2023 to 2035, when considering the CAP strategic plans of EU Member States and other policies in place by the end of September 2024. The main driver for decline is the projected decrease in animal numbers by 2035, which is slightly counterbalanced by increased milk yield. Apart from this, the outlook projects stable conditions on both supply and demand, as efficiency gains are expected to cover the increasing impacts of climate change on yields in the short to medium terms. The latest scenarios from the Commission estimate that without further mitigation action, agricultural non-CO_2 emissions would still be at 347 Mt CO_2e by 2050 which corresponds to a 5% reduction compared to 2023 (EC, 2025i).

The official projections by Member States show moderately steeper reductions up to 2050, as shown in Figure 25. With existing measures (WEM), non-CO_2 emissions are projected to be at 331 Mt CO_2e by 2050 (-9% reduction compared to 2023). Those emissions are reduced to 306 Mt CO_2e (-22% reduction compared to 2005) if additional measures (WAM) are included.

Other studies project increasing emissions in their reference scenarios. For example, Röös et al. (2022) include a business-as-usual scenario which would see an increase of 13% by 2050 compared to 2012. Frank et al. (2019) considered a baseline scenario which would include an increase of between 2% and 15% by 2050 compared to 2010, depending on the model used. In both studies, these changes mainly result from expected increases in production for exports of beef and dairy products. The results emphasise that very little improvement in GHG intensity is expected under Limited Effort. The emission levels under this pathway would therefore largely depend on activity levels, which are largely a function of the competitiveness of EU producers on global markets.

Similarly, Limited Effort could see a modest increase in land-based net CO_2 emissions from croplands and grasslands. Member State projections would see those emissions increase by 1% by 2050 compared to 2023 under existing policy measures (WEM) (EEA, 2025e).

Figure 25 Historic and projected agricultural GHG emissions



Sources: EEA (2025a, 2025e).

Notes: (1) The projections cover emissions from livestock and crop production, not energy consumption and land use. (2) Member States' projections data for energy-related emissions or some land-related emissions in agriculture are not available at sufficiently granularity to allow for a comparison with historical emissions.

The opportunities for dedicating more agricultural resources to biomass production are limited in a Limited Effort setting.

The potential for additional biomass production in agriculture under the Limited Effort pathway remains limited due to mounting pressures on land use. Climate change exacerbates the stress on arable land through increased frequency of climate-related hazards, reduced water availability and soil degradation. Thus, multiple studies and scenarios indicate that the EU's agricultural sector has little room for additional biomass production under business-as-usual trends, especially looking towards 2030 and 2050. For example, an assessment from the European Environmental Agency (EEA) highlights that EU policy objectives create competing demands for biomass from agriculture and forestry for food, materials, energy, etc., yet the supply is fundamentally constrained by finite land area, slow vegetation growth and climate-related impacts (EEA, 2023d). At the same time, agriculture must meet a growing range of demands such as food production for a rising global population, feed for livestock and land for urban expansion and conservation efforts. These competing priorities leave little room for allocating more land to energy crops or other biomass sources.

As a result, no significant increase in biomass availability is projected, constraining the bioeconomy's expansion and reinforcing the need for more efficient use of existing resources. This reality underlines the importance of efficiency, innovation and sustainable resource management in achieving Europe's bioeconomy and climate objectives, rather than expecting a vast new supply of agricultural biomass under current trends (EEA, 2023d).

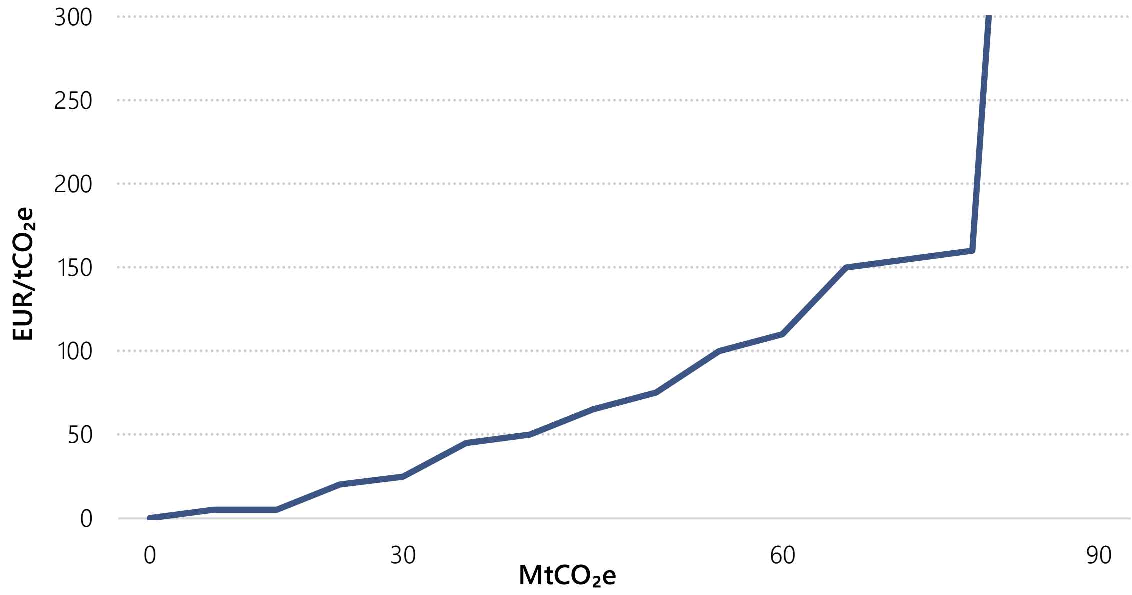
4.4.2 Improved Production

Focusing exclusively on incremental, technical options has a limited climate mitigation potential.

Currently, there are no technical options that can fully eliminate non-CO_2 emissions from sources such as livestock and fertilisers completely or even close to it, nor is any such technology expected to emerge. Available evidence from marginal abatement cost curves illustrates these limitations while also identifying cost-effective opportunities.

As shown in Figure 26, the marginal abatement cost for technological measures as used in the Commission's impact assessment to its 2040 communication exceeds EUR 300 per tonne of CO_2e for an emission reduction of 81 Mt CO_2e, which represents roughly 22% of today's emissions (EC, 2024f). Marginal abatement costs up to EUR 100 per tonne of CO_2e yield a reduction of 62 Mt CO_2e. Another example of a marginal abatement cost curve is presented in the JRC 2025 study based on the curves developed in the previous version of the *Economic assessment of GHG mitigation policy options for EU agriculture* (JRC, 2020b, 2025a); the overall range of marginal abatement costs here broadly aligns with the estimates presented in the impact assessment. In general, these studies highlight the limitations of relying solely on technical mitigation

Figure 26 Marginal abatement cost of technical options



Source: EC (2024f).

Note: The figure shows the marginal abatement cost relating to agricultural non-CO_2 emissions from the S1, S2, and S3 scenarios of the European Commission's 2040 impact assessment.

The Commission's impact assessment includes three main scenarios, S1, S2 and S3, that all reach overall net-zero emissions by 2050 but differ in terms of 2040 emissions. By 2050, all three scenarios assume full deployment of mitigation technologies that reduce agricultural CH_4 emissions (feed additives, farm-scale anaerobic digestion with biogas recovery and breeding through selection to enhance productivity, fertility and longevity) and N_2O emissions (nitrification inhibitors and precision application of fertiliser). They do not assume lifestyle changes that would lead to a substantial reduction in livestock numbers or food waste, and they therefore closely correspond with the Improved Production pathway. The scenarios reach agricultural non-CO_2 emissions of 249 Mt CO_2e by 2050, a 36% decrease compared to 2005 (EC, 2024f). Reductions by 2040 are 21% in S2 and 32% in S3, which are the only scenarios of the three that can be said to be consistent with the EU's 2040 target.

Technical climate mitigation provides some opportunities to improve carbon sequestration on agricultural lands.

Some of the options deployed under the Improved Production pathway would also enhance the land sink, such as cover crops, agroforestry and wetland restoration. The S3 scenario assumes mitigation action targeted at soil carbon – including the restoration of some degraded peatlands – which would turn croplands and grasslands into a net sink (–29 Mt CO_2) by 2050. Some additional potential options to enhance agriculture's contribution to the land sink (e.g. cover crops and biochar) were not considered in the scenarios (Concito, 2024). Moreover, the S3 scenario sees only very limited land-use changes which could contribute to the land sink, with a small shift from grasslands to forests (+4.9 Mha), wetlands (+1.4 Mha) but also croplands (+1.2 Mha).

Options such as anaerobic digestion and cover crops may increase the supply of bioenergy, while agrivoltaics is another source of renewable energy.

The substantial uptake of some of the incremental, technical options under the Improved Production pathway can also be expected to increase the supply of agricultural biomass and other renewable resources to support the decarbonisation of other sectors in the economy. Main options include the increased uptake of anaerobic digestion, deployment of cover crops and agrivoltaics.

Under the S3 scenario, the supply of bioenergy from agriculture in the form of food crops, agricultural residues and lignocellulosic crops more than doubles between 2021 and 2050, but with strong changes within this group: the use of food crops for bioenergy would be largely phased out, whereas the supply from agricultural residues would increase substantially (+83% in 2040 compared to 2021) and lignocellulosic crops would emerge as a major source of bioenergy (EC, 2024f).

Whereas the Commission scenarios do not provide further information on the potential increase in agrivoltaics, other studies have estimated the potential capacity for agrivoltaics in Europe to be very high, ranging between 1.5 and 14 TW for a moderate deployment (between 1 and 10% of the EU agricultural area) (JRC, 2023d), with the most ambitious estimates suggesting up to 51 TW of potential, but without estimating the impact on overall agricultural output (Ali Khan Niazi and Victoria, 2023).

4.4.3 Systemic Transition

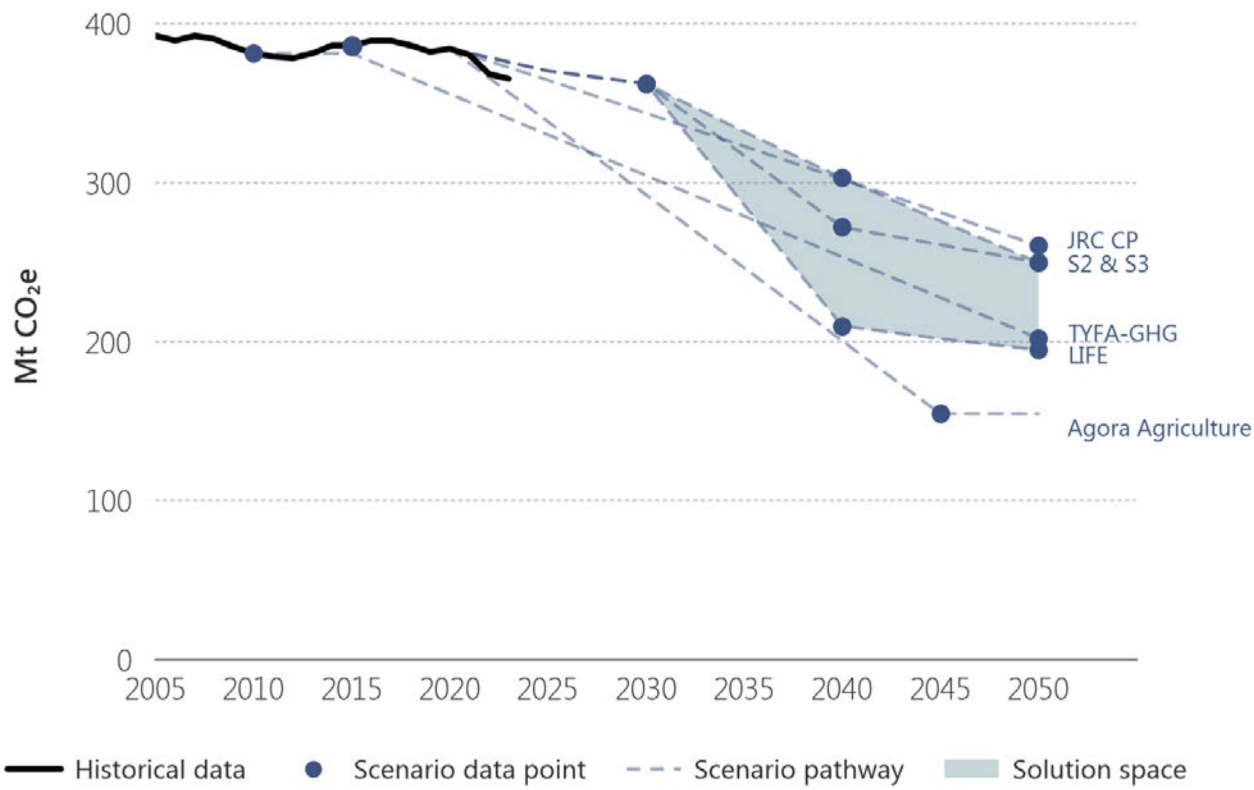
Adding transformational, structural options can deliver substantially more mitigation.

In addition to the technical mitigation scenarios from the European Commission's impact assessment outlined in Section 4.4.2, the existing literature presents a range of scenarios that incorporate structural transformations alongside technical measures, in line with the Systemic Transition pathway. A selection of these scenarios is listed below and illustrated in Figure 27:

- a recent JRC study (JRC, 2025a) estimates a 34% emission reduction by 2050 compared to 2005 under a scenario assuming a carbon price of EUR 100 per tonne of CO_2e (the CP scenario), highlighting that almost the same reduction as in the S1, S2 and S3 scenarios can be achieved at a much lower marginal price by allowing for structural changes;
- the Ten Years For Agroecology (TYFA)-GHG scenario, focusing on agroecological practices and healthy diets, projects a 48% reduction by 2050 compared to 2005 (Aubert et al., 2019);
- the LIFE scenario from the Commission's impact assessment extends the S3 scenario and its full deployment of all additional mitigation technologies by 2040 by incorporating food system adjustments, such as dietary shifts and reductions in food waste, to achieve a 50% reduction by 2050 relative to 2005 (EC, 2024f) with a 47% reduction by 2040 as an intermediate steppingstone.
- Agora Agriculture advances even further, reaching a 61% reduction by 2045 compared to the 2005 GHG inventory value (Agora Agriculture, 2024).

The scenarios collectively suggest that combining technical mitigation measures with structural changes could achieve emission reductions of approximately one half by 2050 relative to 2005 levels. The evidence base for 2040 is comparatively weaker, and the reductions projected under the LIFE scenario may be overly optimistic, as it presupposes near-complete deployment of all available technical potential by that time. Nevertheless, drawing on the current evidence, the Advisory Board considers reductions exceeding one third to be attainable.

Figure 27 Reduction of agricultural non-CO_2 emissions in selected scenarios



Sources: EC (2024f), JRC (2025a), Agora Agriculture (2024) and Aubert et al. (2019).

Notes: (1) Historical emissions up to 2023 are taken directly from the EU agricultural GHG inventory. (2) Scenario trajectories beyond 2023 are shown in absolute emissions by scaling each scenario's indexed values to the corresponding historical inventory level of its base year. This harmonisation ensures that all scenarios are comparable in absolute terms, even though they originate from different baseline years and values. S2, S3 and LIFE are scaled to the 2015 historical value. TYFA-GHG is scaled to the 2010 historical value. The Agora and JRC scenarios are scaled to the 2020 historical value. (3) The shaded band represents the range between the S2 and LIFE scenarios. (4) Marker points indicate original scenario data points or enforced historical anchors (e.g. 2010 for TYFA-GHG, 2020 for Agora and JRC). (5) Where scenarios do not provide annual values, linear interpolation is applied between marker years.

Lower consumption and production of livestock products are key to reach significant emission reductions.

A central driver of the substantial emission reductions projected in the most ambitious structural and technical mitigation scenarios is the decline in livestock production, particularly ruminants, which is intrinsically linked to shifts in dietary patterns. A critical question, therefore, concerns the feasibility of these dietary transitions. Table 7 outlines the key assumptions underpinning the mitigation scenarios illustrated in Figure 27.

The LIFE scenario demonstrates that a moderate dietary adjustment across the EU – represented by a 25% adoption of the EAT-Lancet planetary healthy diet (see Section 2.5.7) – could halve current emissions. This shift in diets corresponds to a relatively modest reduction in meat consumption of about 16% compared with today's levels. However, achieving this level of emission reduction is contingent upon the concurrent, ambitious deployment of mitigation technologies. In contrast, scenarios characterised by lower technological uptake, such as TYFA-GHG and Agora Agriculture, necessitate more pronounced dietary shifts, particularly a significant reduction in the consumption of animal-based products.

Table 7 Overview of changes in diets, livestock numbers and food waste across the structural and technical mitigation scenarios

Scenario	Livestock consumption	Livestock production	Food waste
JRC (CP)	–3% beef consumption	–8% meat production +1% milk production	*n.a.*
TYFA-GHG	–53% meat consumption –50% dairy consumption	–34% meat production –45% milk production	–10% food waste
LIFE	25% shift to EAT-Lancet diet: –16% meat consumption	–25% meat production –10% milk production	*n.a.*
Agora Agriculture	80% shift to EAT-Lancet diet: –51% meat consumption –43% dairy consumption	–49% meat production –27% milk production	–50% food waste

Sources: EC (2024f), JRC (2025a), Agora Agriculture (2024) and Aubert et al. (2019).

Notes: (1) The changes are by 2050 (2045 for Agora Agriculture) compared with the baseline year of each scenario. (2) In the JRC study, no dietary shifts are exogenously assumed; instead, they are a consequence of the price increase of GHG-intensive food products. (3) Some of the numbers from TYFA-GHG are based on chart readings.

The restoration of peatlands can significantly contribute to the net LULUCF sink with only minor reductions in agricultural capacity.

As explained in Chapter 2, degraded peatlands are a main source of land-based emissions, and their restoration would contribute significantly to the EU's long-term climate targets. Under the Systemic Transition pathway, a substantial uptake of this measure to enhance the net land sink is assumed. In the Agora Agriculture scenario (Agora Agriculture, 2024), a rewetting of 80% of all degraded peatlands would reduce emissions by 72 Mt CO_2, while reducing the total agricultural area by less than 2%. Going even further, the CP scenario of JRC (2025a) includes an emission reduction from peatlands of 91 Mt CO_2 which almost fully exploits the total restoration potential in the EU. In contrast, the European Commission's scenarios assume a substantially lower potential of 48 Mt CO_2 by 2050 (Carbon Gap, 2025).

The effects on bioenergy production from a Systemic Transition are mixed.

When compared with Improved Production, the Systemic Transition pathway can affect the potential supply of biomass to the bioeconomy in both directions. On the one hand, reductions in livestock numbers and food waste would decrease the amount of biogenic waste (manure, food waste) available for bioenergy production. On the other hand, as described above, the reductions would also reduce the land area needed to sustain food production, freeing up land which could be used for biomass production for non-food purposes.

The net impact on the supply of agricultural biomass for non-food purposes will likely depend on what the freed-up land would be used for and whether biomass would be harvested on it. As discussed above, the LIFE scenario sees the freed-up area of reduced croplands mainly used for afforestation, more grasslands and slightly more wetland rewetting compared with the S3 scenarios.

At the same time, it only considers marginal changes in agricultural biomass supply for energy between both scenarios (EC, 2025i).

The reliance on CDR to achieve overall net-zero is reduced in the Systemic Transition pathway.

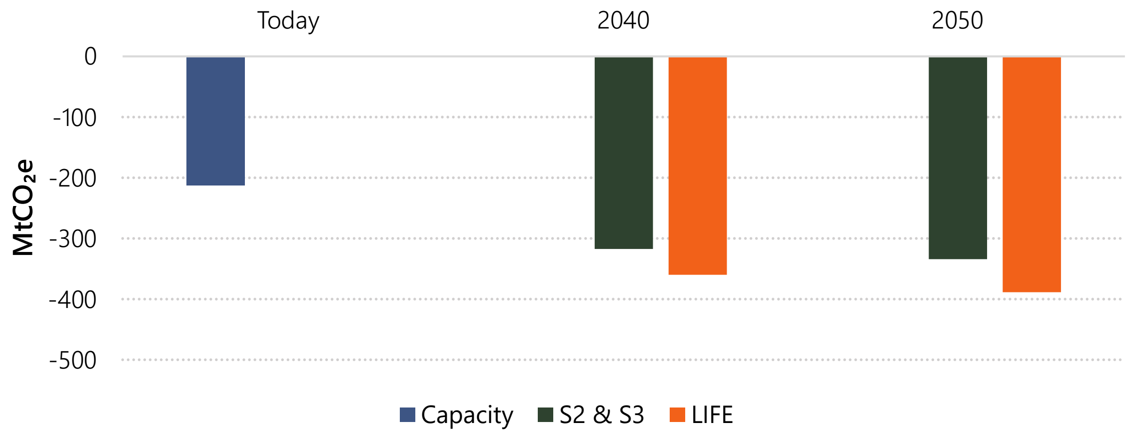
As described in this section, the three stylised pathways have very different implications for climate mitigation both within agriculture and the rest of the economy. As shown in Table 8, Limited Effort would result in the highest reliance on additional CDR to get to net zero, Improved Production would already reduce this reliance to a certain degree, but the lowest reliance is achieved under Systemic Transition.

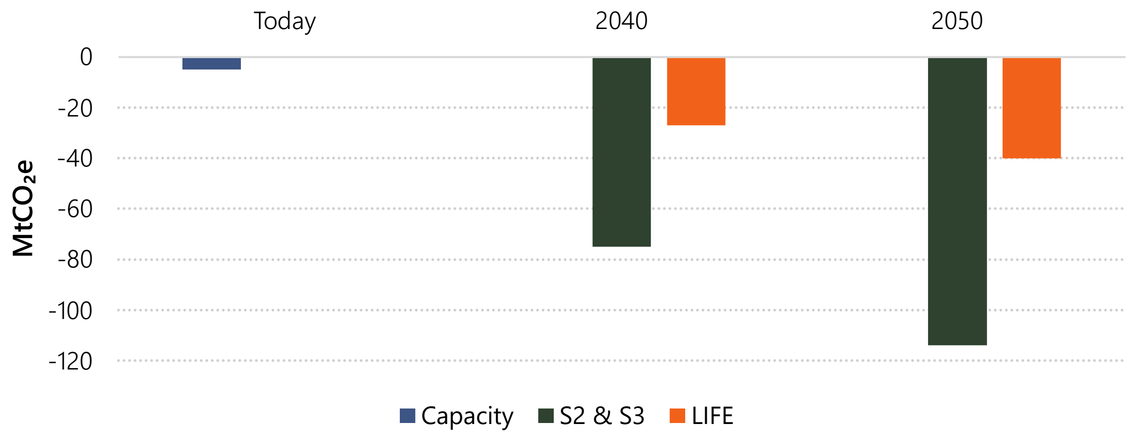
Table 8 Implications of the three stylised pathways on climate mitigation

	Limited Effort	Improved Production	Systemic Transition
Agricultural GHG reductions	Limited	Moderate	Substantial
Contribution to the net land sink	Limited	Moderate	Substantial
Contribution to reductions in other sectors	Limited	Moderate	Moderate
	↓	↓	↓
Reliance on additional CDR	Substantial	Moderate	Limited

This finding is confirmed when comparing the climate mitigation contribution of different sectors and types of removals in the Commission's impact assessment scenarios which deliver EU climate neutrality by 2050, as shown in Figure 28. Scenarios consistent with the Improved Production pathway (S2 and S3) show a heavy reliance on permanent technical CDR by 2040 (around –60 Mt CO_2e) and even more so by 2050 (beyond –100 Mt CO_2e). In contrast, the scenario aligned with the Systemic Transition pathway (the LIFE scenario) projects only around –50 Mt CO_2e of technical removals in 2050. This is a significant difference and increases overall feasibility of the LIFE scenario, given the high uncertainty surrounding the development and availability of CDR solutions. Furthermore, when examining temporal removals in the land sink, one can observe that the primarily technical-mitigation scenario results in a substantially lower land sink compared with the LIFE scenario.

Figure 28 Temporary removals (upper chart) and technical removals (lower chart) in various Commission scenarios





Sources: EEA (2025d), ECNO (2025) and EC (2024f).

Notes: (1) Today's temporary removal values are based on 2023 data from EEA. (2) Today's permanent removal values are based on 2024 data from ECNO.

Uncertainty about the physical and economic potential of removals highlights the need for substantial climate mitigation in agriculture.

In a previous report, the Advisory Board highlighted some key challenges associated with CDR deployment (Advisory Board, 2025).

- **Temporary removals.** Whereas the land use sector in the EU currently delivers a substantial amount of temporary removal, the overall net sink is in decline and decreased to below 200 Mt CO_2e in recent years. Furthermore, their long-term viability is highly uncertain due to potential reversals, whereby stored carbon may be re-emitted into the atmosphere because of environmental disturbances or management failures. The observed decline in sink, together with current and projected climate-related impacts, challenge the prospect of substantially increasing the sink without an ambitious uptake of carbon sequestration practices and structural land use changes (EEA, 2025d). To manage these uncertainties, the Advisory Board has previously recommended that the EU develop a contingency strategy, including further reductions of residual emissions (Advisory Board, 2024).

- **Permanent removals.** Technologies designed to achieve permanent removals, such as direct air carbon capture and storage (DACCS), remain at a nascent stage and are currently associated with high costs. Unlocking the techno-economic potential of these technologies is contingent on a stable and supportive regulatory framework to build strong investor confidence. More mature options such as bioenergy with carbon capture and storage (BECCS) pose challenges to sustainability, as they may conflict with land use priorities and potentially undermine existing carbon sinks in Europe.

Furthermore, a significant portion of the removal potential will be needed to achieve net-negative emissions after 2050. This implies that the full removal potential cannot be allocated to offset emissions in the lead-up to 2050.

In the context of these challenges, the Advisory Board has previously emphasised the need for a dual strategy: provide a clear and supportive regulatory framework for boosting both temporary and permanent removals, while in parallel pursuing ambitious emission reductions across all parts of the economy to minimise residual emissions.

4.5 Impacts on non-climate objectives

In addition to the climate mitigation and adaptation aspects of the introduced stylised scenarios, it is essential to consider the broader impacts on other societal and environmental objectives. Understanding these interconnected outcomes is crucial for designing policies and interventions that deliver not only climate benefits, but also advance wider sustainability and societal goals.

Following the analysis in Chapter 2, the objectives considered in relation to the pathways are:

- other environmental dimensions (e.g. biodiversity, soil health, water availability and quality, air quality);
- land demand and land use;
- livelihoods of farm workers and others in the food supply chain;
- food security;
- public health;
- international competitiveness (including carbon leakage);
- public funding requirements.

This section first assesses whether there is cause for long-term concern relating to each of these objectives in a Limited Effort pathway. Secondly, it assesses whether the state of each objective will improve or deteriorate if either the Improved Production or Systemic Transition pathways are followed instead.

4.5.1 Limited Effort

As explained in Chapter 2, substantial challenges exist in today's agri-food system. Moving towards 2050 along a Limited Effort pathway will most likely not solve these challenges. Table 9 classifies the non-climate objectives based on the level of concern warranted for each, while differentiating between livestock and non-livestock sectors where relevant. The classification of each objective is further explained in the text below.

Table 9 Degree of concern about non-climate objectives in 2050 in the Limited Effort pathway

Major concern	Some concern	No or little concern
Other environmental dimensions Public health Livelihoods of farm workers and others in the food supply chain (non-livestock sectors)	Livelihoods of farm workers and others in the food supply chain (livestock sectors) Land demand and land use Food security Public funding requirements International competitiveness (livestock sectors)	International competitiveness (non-livestock sectors)

Note: In addition to indicating a moderate level of concern, 'Some concern' may also reflect mixed evidence, substantial uncertainty or heterogeneous impact with both winners and losers.

Other environmental dimensions (major concern)

Agriculture is a major driver of other forms of environmental degradation besides climate change, including biodiversity loss, water pollution and soil health degradation (see Section 2.5.1).

As the Limited Effort pathway assumes only a very limited uptake of new farming practices and technologies compared with today, there is little indication that environmental pressures from agriculture would decline under business as usual. On the contrary, it could be expected that farmers' unguided reactions to climate change impacts would be to increase the use of chemical inputs and irrigation systems to sustain production, which would further increase those pressures (FAO, 2022b).

Public health (major concern)

Food is produced to provide nutrition and health to consumers. But the last decades have seen increasing levels of malnutrition and obesity. As discussed in Section 2.5.7, unhealthy dietary patterns in the EU are driving high rates of overweight, obesity and diet-related non-communicable diseases, causing millions of premature deaths and substantial economic losses. The resulting hidden health costs are estimated at 5–6% of the EU GDP equivalent to about 60% of annual healthcare spending based on monetised disease burdens calculated using FAO's DALY-based True Cost Accounting methodology (FAO, 2024b).

Dietary guidelines consistently recommend moderation in the consumption of meat products. Average meat consumption per capita in the EU has actually declined slowly but steadily since 1990, together with a partial shift from red to white meats. Looking ahead, it is uncertain to what extent this trend will continue. Most reference scenarios for the European agri-food system assume that current diets are maintained. However, some surveys indicate that more and more people are consciously attempting to reduce their meat intake (Smart Protein, 2023). The European Commission's most recent agricultural outlook projects only a marginal further reduction in meat consumption towards 2035, although it does expect a further shift from beef and pork to poultry (EC, DG AGRI, 2024). Despite these uncertainties, even if the rate of change observed since 1990 is maintained, meat consumption will still exceed the recommendations of the EAT-Lancet Planetary Health Diet by 2050 (see Section 2.5.7).

Livelihoods of farm workers and others in the food supply chain (some to major concern)

The continuation of the consolidation trend in the sector would deliver further economies of scale and result in fewer but also more profitable farm holdings (INRAE & IDDRI, 2025). But whereas overall income and profitability increase, many smaller farmers would be pushed out of the sector (Ormaza-Zulueta et al., 2024). This adds to the general trend of improved productivity in the sector leading to a decrease in agricultural employment which is projected to decline by more than 20% by 2050 compared with 2011 (JRC, 2022a).

As discussed in more detail in sections 2.3 and 2.6.3, climate change will increasingly challenge the farmers' incomes, especially in Southern Europe. In northern European regions, some studies expect that the net impact on incomes might be positive, but these might underestimate adverse impacts as they do not fully take into account the impact of extreme climate-related hazards and income volatility (Hristov et al., 2024). Recently, average annual climate-related income losses in EU agriculture are projected to increase from EUR 28 billion currently to EUR 40 billion by 2050, which corresponds to approximately 8.5% of all crop and livestock output (Fi-Compass, 2025). In specific years, climate-related losses might increase beyond EUR 90 billion per year.

Land demand and land use (some concern)

Land use is increasingly under pressure, as both human settlements and natural ecosystems compete for space and resources. At the same time, climate change adds another layer of challenge, affecting efforts such as vegetation regrowth and the restoration of degraded peatlands (EC, 2023d). Together, these pressures demand careful management to balance development, conservation and climate adaptation goals (Feng et al., 2025).

If current trends continue, the effect on land use and land demand is not clear-cut. Some observers expect that, at least in the short to medium term, increased productivity gains can fully compensate or even outpace yield reductions from climate-change impacts, so there is no need to increase agricultural land use to sustain production (EC, 2023d). However, it is uncertain to what extent productivity can improve. EU agriculture is already very productive, meaning that room for further improvements is limited compared with other world regions (INRAE & IDDRI, 2025).

In the longer term, productivity gains might not be able to fully compensate adverse yield impacts of climate change, biodiversity loss, etc., meaning that more land would be needed to sustain EU production. Worsening climate conditions, including rising temperatures, droughts and extreme weather, will significantly challenge agricultural productivity. As yields stagnate or fall, the demand for agricultural land will intensify, potentially leading to land-use conflicts, environmental degradation and heightened food security risks across the EU (EEA, 2024b).

Finally, the EU's ambitions for nature restoration and the projected increase in demand for sustainable biomass to decarbonise other parts of the economy might require a net reduction in the land area needed to sustain food production, rather than maintaining it fully stable. Such a reduction is unlikely to occur under a Limited Effort pathway.

Food security (some concern)

As described in Section 2.5.6, food security consists of the four elements: food availability, food accessibility, food utilisation and food stability (FAO, 2013b). Food prices can be seen as an indicator for several of these elements and will be affected by various factors such as climate change impacts, changes in EU diets, changes in global demand, technological development and policies relating to production, consumption and trade. Novel foods and alternative proteins can potentially be a game changer that lowers food prices substantially, but the current outlook is highly uncertain.

Without environmental and adaptation constraints the sector can maximise production in the short term. And provided that increased productivity gains at the farm level are passed on to final consumers, overall food prices can be expected to decrease, at least in the short term (INRAE & IDDRI, 2025).

But in the longer term, food security could be undermined by increasing impacts of climate change in combination with lack of adaptation and further environmental degradation. Reduced yields and more volatile yields could strongly undermine both food availability and affordability. By 2035, projected warming is expected to push global food inflation up by 0.92–3.23 percentage points per year, and overall inflation (also non-food related) by 0.32–1.18 points annually, depending on the climate and emissions scenario (Kotz et al., 2024).

A Limited Effort pathway would also imply a continuation of the sector's high reliance on imports of fertilisers and protein feed, making it very vulnerable to supply and price shocks (INRAE & IDDRI, 2025).

Public funding requirements (some concern)

There is no need for funding (either public or private) to finance the deployment of climate adaptation and mitigation options in the Limited Effort pathway as no additional uptake of such options are assumed. However, adverse climate-related impacts on farmers' incomes would increase pressure on public budgets to provide compensations (e.g. disaster relief) (INRAE & IDDRI, 2025).

International competitiveness (no or little to some concern)

In the absence of climate measures, as in the Limited Effort pathway, predictions about the EU's competitiveness in the future world market for agricultural products are difficult to make in the current geopolitical situation, where tariffs and trade are thrown into the air. Nevertheless, increasing world demand for ruminant meat boosts European production and exports in some scenarios (Frank et al., 2021).

Climate change will change the suitability and comparative advantages for agricultural production of different regions across the world, with some regions becoming more and others less suitable for agricultural production. Some studies suggest that the EU could improve its competitiveness, as Europe is likely to be among the least negatively affected continents globally when it comes to crop yields (Jägermeyr et al., 2021), partly due to the continent's emphasis on wheat production over maize. On the other hand, the EU is highly dependent on soy imports from countries such as Brazil and the United States where soy yields could decline, although projections are uncertain (Li et al., 2025). Low soy yields can damage the EU's production and export of livestock products.

4.5.2 Improved Production

To strengthen climate mitigation and adaptation efforts and potentially also address concerns relating to non-climate objectives, the Improved Production pathway suggests a way forward. Table 10 categorises each of the non-climate objectives according to whether the pathway improves (synergies) or deteriorates (trade-offs) the objective relative to the Limited Effort pathway, with the synergies divided into two levels in order to distinguish between the positive effects of the various pathways. For some objectives, opposing effects, mixed evidence or dependency on policy choices make it difficult to draw clear-cut conclusions, while in one case no change is expected.

Table 10 Effect in 2050 of Improved Production on non-climate objectives relative to Limited Effort

Substantial improvement	Some improvement	Mixed effects	No effect	Deterioration
None	Other environmental dimensions Livelihoods of farm workers and others in the food supply chain	Food security Land demand and land use International competitiveness	Public health	Public funding requirements

Other environmental dimensions (some improvement)

As discussed in Chapter 3, many of the incremental, technical options to enhance climate mitigation and adaptation used under the Improved Production pathway can deliver substantial synergies with other environmental dimensions, including biodiversity, soil quality and nitrogen pollution, but at the same time trade-offs may arise. The aggregate impact will thus depend on the type of options that are deployed, and where and how they are deployed.

There is a general scientific consensus that even when deployed in an ambitious and optimal way, incremental, technical options alone will not suffice to bring agricultural production within planetary boundaries. For example, Springmann et al. (2018) found that when applied in isolation, even a very ambitious degree of technological change would still fall short of bringing the agri-food system to stay within three non-climate-related planetary boundaries (cropland use, blue water use and nitrogen application).

Livelihoods of farm workers and others in the food supply chain (some improvement)

The large-scale deployment of technical adaptation options in the Improved Production pathway can better safeguard incomes against the adverse impact from climate change than the Limited Effort pathway, at least in the short term. For example, sufficient irrigation infrastructure construction and water availability in wheat growing areas could turn yield losses compared with today into yield gains in all of Europe. However, over time, as the effects of climate change increase, it will be difficult to maintain production levels using such a technical and farm-level adaptation approach, but the pathway still holds an advantage compared with Limited Effort.

Under this pathway, the investment and operational costs relating to the deployment of these options would largely be financed through public funding, in order not to increase farmers' cost and to avoid structural adjustments as required by the storyline of the pathway (see Section 4.2). The impact on agricultural incomes and competitiveness can therefore be assumed to be overall positive, at least in the short- to medium term.

Food security (mixed effects)

Improved Production offers the potential for more stable and reliable food supplies due to improved resilience and adaptation capabilities driven by technological progress. Innovations in agricultural practices and digital tools enhance production efficiency and climate responsiveness, reducing exposure to shocks. However, some advanced production methods may initially lead to reduced yields, especially during the transition phase. This temporary dip in production could increase food system vulnerability in the short term, but is expected to mitigate more severe and volatile yield losses in the long run.

Land demand and land use (mixed effects)

Improved Production in agriculture could provide major relief to land-use pressures in Europe, triggered by higher efficiencies and more advanced technological options available at scale. However, several adaptation and mitigation options – and broader sustainability practices such as reduced pesticide use – could reduce yields compared with conventional intensive farming in the short term (Ivezić et al., 2021). When not combined with more structural changes, such as dietary shifts and food waste reductions, the yield reductions could result in either more land being used for agricultural production, decreased overall production or a combination of both (JRC, 2021).

International competitiveness (opposing effects)

In the Improved Production pathway, technical measures can to some extent safeguard agricultural productivity against the threats from climate change, while the application of options such as feed additives will reduce the GHG-intensity of EU exports of dairy products and ruminant meat.

Currently, it is highly uncertain whether there is a willingness to pay for these climate benefits in the global market, but if it is the case, the EU's competitiveness could be enforced.

An implicit assumption of Improved Production is that production costs for farmers remain the same, as the costs relating to deployment of adaptation and mitigation options would be primarily financed through public budget to limit structural changes which is the premise of this pathway. Still, some of the options would reduce average yields. So even if farmers are compensated financially for lower yields through the public budget, overall production levels and thus overall export volumes could be expected to decline.

Public health (no effect)

The Improved Production pathway has little diet-related impact on health, thus maintaining the major health concerns of Limited Effort.

Public funding requirements (deterioration)

A shift towards more sustainable and climate-resilient agricultural practices requires substantial upfront investments and could result in higher operational costs. In the Improved Production pathway, the emphasis must be on public funding in order not to increase farmers' costs and to avoid structural adjustments as required by the storyline of the pathway. Model results from the European Commission's impact assessment points to total annual costs of close to EUR 5 billion to implement the technical changes of the assessment's S3 scenario in 2040 (EC, 2024f).

4.5.3 Systemic Transition

The Systemic Transition pathway supplements Improved Production by adding structural components such as dietary adjustments and food waste reductions and the related change in production patterns. Table 11 classifies each of the non-climate objectives using the same labels as Table 10.

Table 11 Effect in 2050 of Systemic Transition on non-climate objectives relative to Limited Effort

Substantial improvement	Some improvement	Mixed effects	No effect	Deterioration
Land demand and land use Other environmental dimensions Public health	Livelihoods of farm workers and others in the food supply chain (non-livestock sectors) International competitiveness (non-livestock sectors)	Food security Public funding requirements	None	Livelihoods of farm workers and others in the food supply chain (livestock sectors) International competitiveness (livestock sectors)

Land demand and land use (substantial improvement)

The reduction of food waste and lower livestock levels under the Systemic Transition pathway has the potential to more than compensate any yield reductions relating to some of the more technical adaptation and mitigation options. Overall, the pathway could free up substantial amounts of land in the EU, significantly lowering pressure on land use. For example, under the scenario developed by Agora Agriculture (2024), the substantial reduction in livestock production would reduce EU fodder areas by 32 Mha (out of a total of 162 Mha of agricultural land in 2020). In a similar way but to a lesser extent, lower livestock production under the European Commission's LIFE scenario would reduce the area of croplands (–7 Mha) (EC, 2024f). Röös et al. (2022) project even larger gains, with 48% of total agricultural land becoming available for vegetation regrowth, alongside major reductions in grassland (72%) and cropland (28%).

Other environmental dimensions (substantial improvement)

As discussed in more detail in Section 2.5.1, livestock production is a key hotspot within the agri-food system for multiple environmental pressures. Beyond GHG emissions, livestock farming contributes substantially to reactive nitrogen losses to air and water through ammonia volatilisation and nitrate leaching, along with phosphorus runoff, which can drive eutrophication in freshwater and coastal ecosystems. Reducing livestock numbers under the Systemic Transition pathway would therefore not only lower climate-related impacts but also mitigate these nutrient pollution pressures. Additionally, decreased livestock feed production could reduce soil erosion and sediment pollution in rivers, since less cropland would be devoted to intensive feed cultivation.

Lower livestock densities would also diminish the need for antibiotics in animal production, reducing risks of antimicrobial resistance and contamination of soils and water. Similarly, reduced demand for feed crops and a shift towards more sustainable and diversified cropping systems could lead to lower pesticide use, improving soil and water quality and supporting biodiversity recovery.

The overall magnitude of these benefits will, however, depend on where and how livestock production decreases. Extensive, low-intensity grazing systems, for instance, can provide environmental co-benefits such as maintaining semi-natural habitats and supporting carbon sequestration.

An ambitious and integrated combination of incremental, technical improvements and more structural changes could thus bring the EU's agri-food system closer to planetary boundaries including those for nutrient cycles, land use and biodiversity while still ensuring adequate food production to feed the global population (Springmann et al., 2018; Van Vuuren et al., 2025; Rockström et al., 2025; te Wierik et al., 2025).

Public health (substantial improvement)

Impacts towards improved public health could be wide-ranging if diets change in the direction of the EAT-Lancet Planetary Health Diet recommendations which would be consistent with the Systemic Transition pathway (see also Section 2.5.7). As one example, it is estimated that approximately 27% of all premature deaths can be avoided globally (Rockström et al., 2025), although it is uncertain what an equivalent EU estimate would be.

Livelihoods of farm workers and others in the food supply chain (some improvement + deterioration)

Profound structural changes, such as those in the Systemic Transition pathway, will have a substantial impact on farmers' income through the change of prices and the consequences of taxes or similar policy instruments.

When structural changes are driven by shifts of demand to more plant-rich diets, Rieger et al. (2023) find that overall agricultural incomes in the EU increase, mostly due to higher demand for and prices of fruits and vegetables. However, countries that are highly specialised in animal farming, such as Denmark, Germany and Ireland, are likely to lose income due to falling producer prices for animal products. If structural changes are enforced on the production side, for example by a tax or equivalent on farmers' GHG emissions, overall incomes in the livestock sector are likely to decline even more. The European Commission's modelling produced similar results, with agricultural revenues declining by 12–20% in the livestock sector but increasing by 12% in the vegetable and permanent crops sectors (EC, 2024f).

New and diversified income opportunities can arise in certain agricultural production systems, such as horticultural production and energy production such as agrivoltaics and biomass (Agora Agriculture, 2024). Similar opportunities can occur for novel foods, although the outlook of such innovations is currently very uncertain (IPES-Food, 2022).

In terms of agricultural employment, broader structural changes are likely to speed up current trends of agriculture becoming less labour intensive. One study finds that dietary shifts in the EU in line with the EAT-Lancet Planetary Health Diet and 50% reduction of food waste and loss can reduce agricultural employment of both unskilled and skilled workers by more than 10% overall (JRC, 2022a) compared to the 2050 baseline. This number disguises large differences across sectors and regions. In meat production, declines range from 40% to 55%, while in dairy production, labour demand decreases by around 25% compared to the baseline. Also, employment in cereal production declines due to reduced demand for animal feed. In horticulture production, on the other hand, the study shows a slight increase in labour demand. However, it should be noted that such results ignore the labour requirements for management of potential new income streams for farmers relating to activities such as ecosystem services and carbon dioxide removals (EC, 2024f).

International competitiveness (some improvement + deterioration)

The structural changes of the Systemic Transition pathway will often be driven by higher production costs of primarily livestock products, implying a loss of competitiveness in international markets and potentially carbon leakage if demand side changes are not of equal magnitude. There is even a risk of a net-increase in global GHG emissions (leakage rates exceeding 100%) as the EU in general produces with a lower GHG emission intensity than most other countries in world (FAO, 2022a).

Leakage rates in the literature depend on the details of the policy instrument and the underlying model specifications, showing a large variation in the estimates of leakage rates in the literature (Matthews, 2022). Some studies find rather low leakage rates of 15% (Stepanyan et al., 2023) and 7% (JRC, 2025a), while other studies estimate leakage rate as high as 91% (Nordin et al., 2025) and 76% (Jansson et al., 2024). A key reason for the discrepancy is the role of technical mitigation in the studies, as allowing for more and cheaper technical options in the models is consistent with lower leakage rates.

Reducing leakage will require a multi-pronged strategy combining domestic policy coherence, international coordination, and market adaptation (see also Chapter 11):

- demand-side measures (dietary shifts towards plant-rich foods, reduced food waste and losses) can neutralise trade-related leakage by aligning consumption with lower-emission production levels;

- border adjustment mechanisms or carbon footprint standards could help ensure a level playing field for EU producers facing higher climate-related costs, while encouraging emission reductions globally;
- investment in low-emission technologies and support for innovation in plant-rich and novel foods can strengthen the EU's competitiveness in emerging agri-food markets;
- international partnerships and carbon accounting alignment (e.g. through global methane initiatives or carbon farming frameworks) can reduce asymmetric policy effects and avoid displacement of emissions.

Addressing carbon leakage is therefore not only a defensive measure but also a strategic opportunity: the EU's leadership in sustainable production, verification systems and low-emission technologies can ultimately position its agri-food system as a global benchmark for climate-smart competitiveness.

Food security (opposing effects)

By enhancing adaptation and increasing resource efficiency because of less food waste and less production and consumption of very resource-intensive livestock products, the Systemic Transition pathway can be expected to increase the availability and stability of food supply in general, while prices at the consumer level would be more stable. A Systemic Transition would also strengthen Europe's food security more substantially than Improved Production by further reducing reliance on feed and fertiliser imports (Sun et al., 2022).

Transitioning to more climate-friendly diets may raise the level of consumer prices, particularly for fruits and vegetables, due to higher demand (Rieger et al., 2023). Additionally, climate policies that put a price on emissions could drive up the price of GHG-intensive products. For example, a price of EUR 100 per tonne CO_2e is estimated to increase beef prices by 7–8% while the price of milk goes up by 2% (JRC, 2025a; Stepanyan et al., 2023). On the other hand, measures such as initiatives to reduce food waste and subsidies for sustainable products and in particular non-animal-based protein can offset some of these increases.

The mentioned price increases risk being regressive by nature as low-income consumers tend to spend a bigger share of their income on food.

Public funding requirements (opposing effects)

The policy requirements in the Systemic Transition pathway are less strict, for which reason the strain on public funds could be less problematic compared with Improved Production. If for instance an emissions trading system is applied to transform the agricultural sector and incentivise GHG reduction, the system can even be a net source of public revenue under certain system designs. In such a case, the flip side is a negative impact on farmers' income.

4.6 Pathway conclusions

The Limited Effort pathway does not adequately address the climate challenges of agriculture

The point of reference of the assessment in this chapter is the Limited Effort pathway where no or only limited climate adaptation and mitigation efforts are being implemented. Compared with today, this results in a status quo for many of the assessed supplementary societal objectives, while others are deteriorating due to the lack of climate adaptation (as illustrated in Table 12). Farmers' income and wellbeing may be under threat if adequate adaptation is ignored, while consumers may face rising food prices. Moreover, the health issues of current diets are not solved.

In effect, Limited Effort is not a viable path forward. The current trajectory does not address the challenges facing agriculture from climate change, leading to loss of income for farmers and increasing food prices. It would also result in too little mitigation in agri-food and therefore rely on CDR to such an extent that the EU's climate neutrality target would be put into question.

Table 12 Summary of assessment of stylised pathways

		Limited Effort	Improved Production	Systemic Transition
		State in 2050	*Relative to 2050 Limited effort*	
Climate objectives				
Climate adaptation				
Climate mitigation				
Non-climate objectives				
Other environmental dimensions				
Land demand and land use				
Farmers' livelihoods	Livestock			
	Non-livestock			
Food security				
Public health				
International competitiveness	Livestock			
	Non-livestock			
Public funding requirements				

Legend

Limited Effort	Improved Production / Systemic Transition
Major concern	Substantial improvement
Some concern	Some improvement
Little concern	Mixed effects
	No effect
	Deterioration

The pathways addressing climate change have advantages and drawbacks.

The Improved Production and Systemic Transition pathways depart from Limited Effort to reduce GHG emissions and adapt to a changing climate. Table 12 summarises the assessments of the future long-term state in the two pathways relative to the Limited Effort level, which are summarised below.

The **Improved Production** pathway has the following key advantages, shortcomings and risks.

- **Advantages.** It delivers more climate mitigation compared with Limited Effort. The scenarios that are consistent with this pathway project residual agricultural non-CO_2 emissions as low as 250 Mt CO_2e by 2050 (–36% compared to 2005 levels) when assuming a full deployment of all technical mitigation potential, including the potential having high abatement costs. The pathway would also deliver incremental improvements to the sector's climate resilience, which alleviates some of the negative impact from the lack of adaptation in the Limited Effort pathway. This supports economic opportunities in the agricultural sector, while food security in the EU is improved, at least in the short term. It could also reduce the EU's dependence on feed and fertiliser imports somewhat, by enhancing fertiliser efficiency and promoting the cultivation of protein crops in the EU.
- **Risks and shortcomings.** The main drawback of this pathway is that the reduction in non-CO_2 emissions is limited, combined with sparse contributions to land-based removals. To keep the overall EU climate objectives within reach, this would need to be compensated by additional efforts elsewhere, either by achieving even more ambitious reductions in other sectors or by further increasing permanent or forest-based removals. This would in turn increase the risk of the EU not achieving climate neutrality by 2050, as the forest sink is highly uncertain and vulnerable to climate-related impacts, and the technical and economic potential of permanent removal options is uncertain and also needed to deliver net-negative emissions after 2050 (Advisory Board, 2025). The incremental improvements in terms of climate resilience also risk falling short in delivering long-term adaptation. Additionally, the lack of dietary shifts means that public health concerns are not addressed. Furthermore, this pathway would result in a substantial need for public funding, as incentives to a large degree need to be provided by subsidies or similar supporting policies (to avoid the structural shifts of the Systemic Transition pathway).

The **Systemic Transition** pathway has the following key advantages, shortcomings and risks.

- **Advantages.** It can make a far more substantial contribution to climate mitigation, enabling agricultural non-CO_2 emissions to be reduced to 200 Mt CO_2e or less by 2050 (–50% or more compared to 2005), increasing LULUCF removals by an additional 40–50 Mt CO_2e, and freeing up land for the production of sustainable biomass for the bioeconomy (see also Box 6 Box 6for opportunities and risks associated with the bioeconomy). This would reduce the EU's reliance on permanent CDR to achieve climate neutrality by 2050, thereby increasing its ability to achieve net-negative emissions thereafter. In addition, the inherent shift towards reduced livestock consumption provides clear public health benefits and diminishes the externalities that current dietary habits impose on EU society. By implementing adaptation options beyond the farm level, the pathway is also better able to ensure long-term adaptation under a changing climate with uncertain impacts. Moreover, there are substantial co-benefits in other environmental dimensions and public health. A systemic transition would also strengthen Europe's strategic autonomy and food security more substantially than Improved Production, by further reducing reliance on feed and fertiliser imports and increasing the domestic supply for the EU bioeconomy.

- **Risks and shortcomings.** The socio-economic impacts of this pathway are highly dependent on the underlying policy instruments and could be positive for some segments of the sector and negative for others. Overall, it would diversify EU agriculture's income base by reallocating land and residues towards high-value bio-based sectors (IEA, 2025; EEA, 2025f). However, the implied reduction in livestock production would imply a substantial risk of decreasing economic opportunities in the livestock sector. For other sub-sectors, there can be both positive and negative competitiveness impacts. On the one hand, it can enhance competitiveness by enhancing climate resilience and creating new business opportunities for novel foods. On the other hand, if policies apply the polluter pays principle to drive the transition, these policies risk decreasing international competitiveness, which can lead to carbon leakage if domestic demand for GHG-intensive products is not sufficiently curbed, while also increasing food prices for consumers.

Chapters 5 to 12 of this report analyse the effect on different policy designs and discuss how the risks identified in Table 12 can be addressed.

Box 6 Opportunities and risks of intensifying an agriculture-based bioeconomy

Opportunities for EU farmers and rural economies with regard to bioeconomy

- Rising demand and prices. EU decarbonisation goals and a bio-based circular economy are driving up demand for sustainable ecological biomass.
- Valorisation of residues, wastes and new crops. A significant share of agricultural biomass is secondary (stems, leaves, manure). Using residues in biogas plants or industrial bio-refineries turns a disposal cost into revenue. Integrated assessment model (IAM) studies suggest residues could meet a large fraction of future bioenergy demand without expanding cropland (global models find up to 50% of bioenergy by 2050 from residues) (Hanssen et al., 2020). Biogas/biomethane from animal manure or organic waste is also growing (EU policies like REPowerEU explicitly support on-farm digesters). In short, multiple biomass streams, such as straw, manures, agro-industrial waste, become assets rather than burdens.
- Diversification. Participation in the bioeconomy allows farmers to diversify away from reliance on volatile commodity markets and CAP payments. Revenues from biomass contracts, biogas production, carbon farming and supplying bio-based materials can complement or stabilise traditional income streams. This reduces exposure to price shocks in feed, cereals or livestock markets and can make mixed or extensive systems more resilient.

Trade-offs and risks for land use and environment

- Land-use and biodiversity impacts. Expanding energy crops or over-harvesting residues can encroach on nature and agricultural lands. A recent study contrasts a 'high-value' EU climate scenario (emphasising material and circular uses of biomass) with a business-as-usual bioenergy scenario. The high-value case avoids converting some 37 Mha to energy crops, thereby sharply cutting biodiversity pressure. In contrast, the business as usual implies large-scale conversion of forests or marginal land. Clearing soil or trees for biomass also emits CO_2: the analysis estimates approximately 144 Mt CO_2 released under the business-as-usual scenario (up to 370 Mt if unmanaged), offsetting climate gains.

Policymakers must ensure new bioenergy plantations follow strict sustainability criteria (land set-asides, no peat/forest clearance) and prioritise degraded land (Material Economics, 2021).

- Food security and land competition. Diverting crops or arable land to fuels/materials risks pushing up food prices or requiring imports. EU models find that higher prices for crop residues induce farmers to boost food-crop area and yields, leading to higher fertiliser use (Gérard and Jayet, 2023). Policymakers need to balance bioeconomy goals with farm output: for example, by capping first-generation biofuels (food-based) and favouring second-generation feedstocks (residues, wastes, agroforestry).
- Economic and social challenges. Building new bio-based supply chains requires investment and cooperation. Farmers may face high transaction costs collecting low-density biomass. Market prices for novel biomaterials or carbon (e.g. biochar) are still uncertain. Without clear incentives, smallholders might not benefit.

Only a systemic transition of the agricultural sector is sufficiently aligned with the EU's climate, environmental and public health objectives.

A main question investigated in this chapter is whether it could be sufficient to only pursue technical improvements to enhance climate adaptation and mitigation in the agri-food system, in the context of a warming climate and ambitious overall EU climate targets. A comprehensive deployment of such improvements is in fact essential to achieve the EU climate objectives in an economically and socially coherent manner. However, relying on this alone can deliver only a modest mitigation contribution to the overall EU climate targets, could fall short of delivering long-term adaptation and generate only limited synergies with other environmental and public health objectives.

By comparison, a systemic transition of the agri-food system can deliver a more ambitious contribution to the overall EU climate targets, enabling a reduction in agricultural non-CO_2 emissions by more than a third by 2040 and half by 2050 relative to 2005, while boosting land-based carbon sinks. Furthermore, it can better safeguard European food production against the risks of climate change on the longer term, and result in higher synergies and lower trade-offs with other environmental and public health objectives, while strengthening the EU's strategic autonomy. Overall, such a systemic transition is indispensable not only to increase the EU's ability to achieve climate neutrality by 2050, but more generally to secure sufficient food production in the future in a sustainable manner (Soussana et al., 2025; FAO, 2023a).

Key challenges of a systemic transition are that it requires changing current expectations of what the agri-food system should deliver, which may struggle to gain public acceptance, as it can negatively affect incomes and competitiveness in certain sub-sectors and increase the risk of carbon leakage. It also relies on adjustments to current diets, which are deeply rooted in culture and therefore difficult to change in the short term.

A systemic agricultural transition is not only a challenge for farmers but requires coordinated action in all parts of the value chain.

A systemic transition in agriculture is first and foremost about concrete and physical changes at the farm level, as this is where emissions occur and where the adverse impacts of climate change are most acutely felt. However, farmers do not act in a vacuum; they often have little room to manoeuvre, facing structural and systemic barriers when attempting to change production systems (IEEP, 2025b). They cannot always freely choose what farming practices to use, as they are often bound by what is offered by upstream input suppliers in terms of seeds, fertilisers and technology and by contractual requirements from downstream food processors and retailers, where most of the bargaining power is concentrated. These lock-in effects create strong path dependencies that limit diversification and innovation (Koppenberg, 2023).

Moreover, farmers rely on stable consumer demand and support from the entire value chain to build a viable business case for diversifying production towards climate-friendly products. Often, the necessary coordination is lacking (IEEP, 2025b). Structural changes in production and consumption therefore require the transition of entire value chains; for example, it is not feasible for farmers to shift from animal-based to plant-rich products if no processing and marketing infrastructure exists for these alternatives (Amrom Caroline et al., 2021).

This means that the food industry, both upstream and downstream, and retailers must play an active role in facilitating the transition, ensuring that farmers are not isolated, but supported through integrated supply chain strategies and market development.

Current developments in EU agriculture provide a window of opportunity to achieve a systemic transition.

Achieving a systemic transition requires a fundamental restructuring of the most GHG-intensive or least climate-resilient segments of EU agriculture. More concretely, it would require a certain reduction in livestock farms, farms cultivating degraded peatlands and irrigation-based farming systems in regions that are increasingly exposed to water scarcity because of droughts. Whereas several transition strategies exist for such farming systems (see Box 7), deploying them is challenging for the following reasons.

- **Heterogeneity.** The agricultural sector is highly heterogenous, consisting of many different and relatively small holdings. Structurally changing such a sector is more challenging when compared with sectors which are dominated by a relatively limited number of large entities, such as the power or industry sectors.
- **Lack of finance.** As discussed in Section 2.5.4, shifting farming systems is capital-intensive but many farmers lack access to finance. In several Member States they are also heavily indebted, meaning they have little choice but to continue current operations until their debt is paid off and their previous investments amortised.

At the same time, Section 2.5.3 identified two structural trends in the sector which provide a window of opportunity to accelerate the transition towards lower GHG-emitting and better climate-adapted farming systems.

- **Consolidation.** The sector is undergoing a process towards fewer but larger farms, particularly in the livestock sector, where the number of farm holdings decreased by almost half between 2010 and 2020. This reduces the number of entities that need to transform.
- **Generational renewal.** The farming population is ageing, with 57% of farm managers older than 54 and 33% older than 64. A substantial share of farm managers will thus be retiring in the coming two decades. When their holdings are taken over by young farmers, this creates a unique opportunity for fundamentally restructuring farms, as young farmers can more easily commit to investments with long payback periods and are generally more open towards more innovation and sustainable production practices (Coopmans et al., 2021).

As further discussed in Section 5.3, reaping this opportunity would require a comprehensive policy mix that supports the business case of lower-GHG emitting and more climate-adapted farming systems, and that puts in place the required enabling conditions for a successful transition.

Box 7 Examples of transition strategies for the most GHG-intensive and least climate-resilient farming systems

A systemic transition of EU agriculture will require some farmers to adapt their production systems and adopt new business models aligned with climate and environmental goals. A core premise of this transition is that carbon dioxide removals and ecosystem services are financially rewarded, turning them into viable business opportunities.

Transition pathways vary across farm types and regions and may involve changes within farms (e.g. integrating trees, reducing herd size) or across farms (e.g. land-use specialisation, farm exits). While some producers will shift towards more sustainable systems, not all can or need to transition. Exit support and land reallocation mechanisms will be essential to ensure a socially fair process. This box outlines four illustrative farm types and the transition opportunities available from both the sectoral and individual farm perspectives.

- **Grassland-based dairy and beef.** Grassland ruminant systems could shift towards silvopastoral agroforestry and diversified grasslands to enhance sustainability. Integrating trees in pastures improves nutrient cycling, reduces erosion and provides microclimate shelter for livestock (EEA, 2024e). Key environmental goals include lowering methane emissions and protecting permanent grassland carbon sinks. Economically, green biorefinery innovations allow grass protein extraction as a soy substitute, opening new revenue streams (Jørgensen et al., 2022). Silvopastoral agroforestry systems with short rotations can also generate revenues from the sale of woody biomass for bioenergy and biochar production (Frank et al., 2024). Policy measures (e.g. carbon credits for soil carbon and biodiversity payments) and exit support could be considered to help pastoral farmers adapt as EU diets gradually shift towards less beef and dairy (Jørgensen et al., 2022).

- **Grain and crop silage-based dairy and beef.** Intensive dairy and beef systems reliant on maize silage and grain could pursue agroecological cropping transitions. Strategies include diversified rotations with cover crops and legumes to improve soil health and reduce fertiliser needs (EEA, 2024e). Alley cropping and hedgerows (arable agroforestry) can sequester carbon and enhance on-farm habitats, albeit with implementation costs (EEA, 2024e). Environmentally, these changes cut N_2O emissions and nutrient runoff from cropland. Reducing reliance on imported soy feed through EU-grown protein crops or grass protein also curbs deforestation-linked emissions (IDDRI, 2021). While yields per animal may dip under lower input regimes, farmers can benefit from savings on inputs and potential carbon farming incentives. Economic viability can be bolstered by premium markets (e.g. organic) and public support for climate-friendly practices (INRAE, 2025).

- **Pork and poultry.** Monogastric livestock systems could explore circular feeding and housing innovations. Replacing a share of conventional feed with regional legumes, food waste or insect meal can reduce the land footprint and fertiliser use of pig and poultry feed. Improved manure management (e.g. anaerobic digesters) lowers methane and ammonia emissions while generating biogas energy (Frank et al., 2021). Transition strategies also include enhanced animal welfare systems (free-range or silvo-poultry setups) that integrate trees for shade and carbon sequestration. However, these industries operate on thin margins, so changes require careful economic support. Notably, dietary shifts towards plant proteins are projected to significantly cut demand for pork and poultry, helping reduce agricultural GHG emissions and land use. To manage adjustment, policies envisage retraining or exit support for affected producers and incentives for alternative protein enterprises (Frank et al., 2021).

- **Degraded peatlands.** Degraded peatlands represent a small fraction of EU farmland but a disproportionate source of emissions. Restoring them is one of the most effective climate measures, rapidly cutting CO_2 and preventing peat loss (EEA, 2024e). Paludiculture is an emerging solution that enables farmers to continue using rewetted peatlands by cultivating crops such as reeds, cattails or sphagnum moss. This approach preserves the peat, avoiding the roughly 27% of EU agricultural GHG emissions linked to peat oxidation, while generating biomass for insulation materials, horticultural substrates or bioenergy (EEA, 2024e). Beyond its climate benefits, paludiculture supports biodiversity and improves water regulation. However, because it represents a significant shift from conventional farming practices, strong financial incentives and supportive policies are essential (EEA, 2024e). Properly designed, these incentives could reward carbon dioxide removals and ecosystem services, transforming them into viable business opportunities for farmers.

Chapter 5

Towards a coherent policy mix

Key messages

Current EU policies are inadequate to deliver the required changes.

The common agricultural policy aims to pursue a range of policy objectives, including enhancing climate action. However, its effectiveness on the latter has so far been limited due to inadequate – and in some cases counter-productive – incentives. The policy's limited financial resources, allocated across multiple competing objectives, preclude it from serving as the principal instrument for driving both climate adaptation and mitigation in agriculture.

The Effort Sharing Regulation and the LULUCF Regulation are the main tools to drive mitigation in agriculture, but so far they have only had limited success. A continued reliance on these instruments as the primary driver for mitigation risks producing fragmented and cost-ineffective outcomes.

Taken as a whole, the existing EU policy architecture is insufficient to deliver the required systemic transition of the EU agri-food system emphasised in Chapter 4. This underscores the urgent need for both new policy instruments and the reform of existing frameworks.

The Advisory Board recommends that the EU adopt a coherent policy mix.

No single instrument can deliver the transition alone, given the sector's diversity and complexity. The Advisory Board therefore concludes that the EU should adopt a coherent policy mix that introduces targeted and adequately funded **transition and risk-management support** for climate adaptation and mitigation to help farmers adopt new practices and cope with climate-related risks, while **climate-harmful subsidies** are gradually removed.

To ensure a cost-effective transition across the value chain, such reforms need to be complemented by a **greenhouse gas pricing instrument** that gradually applies the polluter pays principle to agricultural GHG emissions while rewarding carbon dioxide removals, the revenues of which can be recycled into the sector. Different policy options – including trade policies – could be considered to address potential carbon leakage risks arising from such an approach.

The policy mix should include **food policies** that target consumers, retailers and downstream food processors, and that address non-economic barriers to healthy, climate-friendly diets, and that reduce food waste.

This policy mix should be implemented without delay yet gradually and adaptively, allowing time for learning, adjustment and capacity-building while providing a clear long-term direction.

5.1 Introduction

New and revised policies are needed to climate-proof the EU's agri-food system.

The preceding chapters of this report established that a comprehensive and systemic transition of the EU's agri-food system is imperative to align with the EU's objectives on climate change mitigation and adaptation, while simultaneously enhancing public health outcomes. Key features of this transition include a widespread adoption of technical improvements, reinforced climate-risk management, diversification of crops, species, livelihoods and the landscape, a certain reduction in livestock numbers (particularly ruminants), a change in dietary patterns towards greater reliance on plant-based foods and an ambitious reduction in food waste.

The remainder of the report examines the policy instruments required to facilitate this transition. While the primary emphasis is on the implications for climate mitigation and adaptation, in accordance with the Advisory Board's mandate, the analysis also considers, where relevant, other environmental and societal challenges such as agri-food industry competitiveness and food security identified in Chapter 2, as well as administrative feasibility.

This chapter identifies policy gaps and outlines the necessary mix of policies.

Chapter 5 identifies existing policy gaps that hinder progress towards the desired transition and outlines a coherent policy mix to address these gaps. For each policy within this mix, Chapters 6 through 12 then explore specific options that may serve as potential solutions.

The remainder of this chapter is structured as follows.

- **Section 5.2** reviews current EU policies and evaluates their adequacy in driving the necessary transition of the agri-food system. This section begins with a summary description and assessment of the CAP, which remains the EU's principal policy instrument for the agricultural sector. It also provides a high-level overview and evaluation of other relevant policies that influence climate mitigation and adaptation in agriculture.
- **Section 5.3** proposes an overall structure of a coherent and integrated policy mix at the EU level that could effectively support the systemic transition required in the agri-food system. The section argues for a gradual and adaptive implementation of these policies to foster learning and improvement.

5.2 Assessment of current policies

5.2.1 Overview of the CAP

The CAP is the EU's primary policy targeting agriculture and has been evolving over time.

Agriculture and fisheries are the only two sectors in the EU with their own, dedicated common policies. The CAP was established in 1962, making it one of the EU's longest-lasting policies. It has been revised regularly, with the current CAP running from 2023 to 2027. Despite a decreasing share over time, it still accounts for 31% of the total EU budget,[17] making it one of the cornerstones of the *acquis* (EC, 2020).

The original objectives of the CAP, as enshrined in Article 39 of the TFEU, are to increase agricultural productivity, thus ensuring a fair standard of living for the agricultural community, to stabilise markets, assure the availability of supplies and ensure that supplies reach consumers at reasonable prices (EU, 2008). Its policy objectives have broadened over time, with the current CAP pursuing 10 different strategic objectives. These include the original objectives and new priorities relating to climate mitigation and adaptation, biodiversity, animal welfare, gender balance, rural development and attracting young farmers (EU, 2021b).

The current CAP contains a range of instruments, structured along two pillars.

The CAP is not a single policy instrument but rather includes a range of incentive schemes and regulatory approaches. Under the current CAP (2023–2027), these instruments are structured along two distinct pillars which are financed by two different funds, as summarised in Box 8Box 8 and Figure 29.

Box 8 Overview of the current CAP's structure and instruments

Pillar 1 is financed by the European Agricultural Guarantee Fund (EAGF). No national co-financing is required. The main instruments are listed below.

- Decoupled income support. Area-based subsidies per hectare (i.e. decoupled from the actual production) provided under the basic income support for sustainability (BISS), the complementary redistributive income support for sustainability (CRISS), and the complementary income support for young farmers (CIS-YF).
- Coupled income support. Subsidies linked with production, based on livestock numbers or production volumes.
- Eco-schemes. Additional subsidies (per hectare or lump sum) for farmers that commit to certain practices aimed at the protection of the environment and the climate.
- Crop-specific payments for cotton. Specific subsidies for cotton production in selected countries (Bulgaria, Greece, Spain and Portugal).

[17] This share relates to the original budget under the MFF. When also considering NextGenEU (the temporary recovery instrument in response to the COVID-19 pandemic), the CAP's share decreases to 25%.

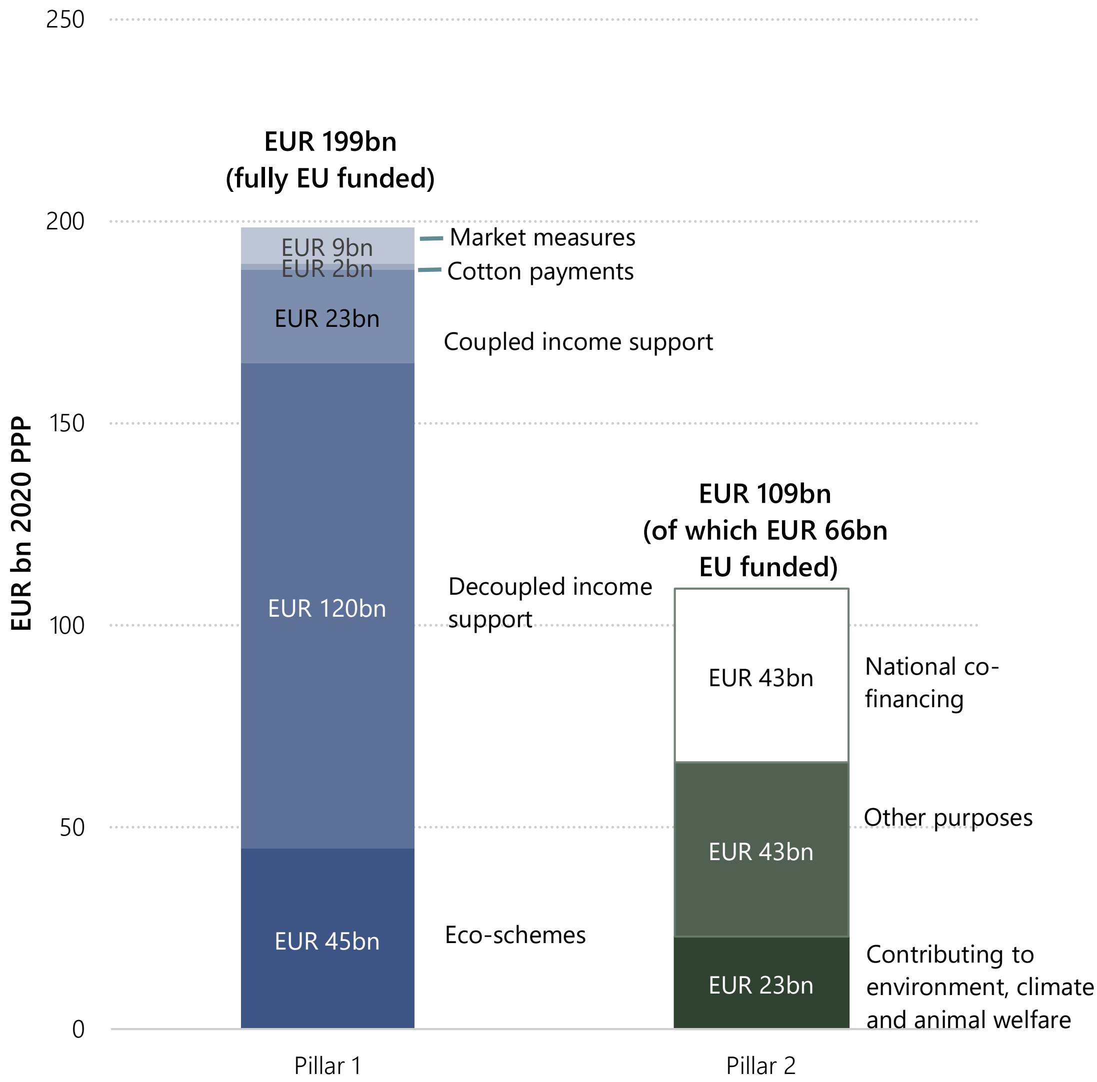
- **Market measures.** A range of interventions that can be used to stabilise agricultural markets, support farmers in times of crisis, and ensure the proper functioning of the food supply chain. These include:
  - mechanisms to buy up and store certain products for which prices fall below a certain reference level, which are then released again when markets stabilise;
  - an Agricultural Reserve of EUR 450 million per year for crisis response to adverse events such as trade disruptions, pest and disease outbreaks;
  - support programmes for specific subsectors, including fruits and vegetables, apiculture, wine, hops, olives;
  - market transparency and monitoring measures;
  - promotion campaigns for certain EU farm products;
  - the EU School Scheme, which provides schools with fresh fruits, vegetables and dairy products, often from local farms.

Decoupled income support, coupled income support and eco-schemes are jointly referred to as 'direct payments' (see Chapter II of the CAP Strategic Plans Regulation).

Pillar 2 is financed by the European Agricultural Fund for Rural Development (EAFRD). National co-financing is required. Under this pillar, Member States can support eight different types of farmers and practices:

- subsidies for farmers that participate in **agri-environmental, climate and other management commitments** (AECMs);
- subsidies for farmers in **areas with natural or other area-specific constraints**;
- subsidies for farmers or other land managers facing **area-specific disadvantages resulting from certain mandatory requirements**;
- support for **investments** which can contribute to the CAP's strategic objectives, with specific provisions on investment support for irrigation;
- support for the **setting up of young farmers and starting up of rural businesses**;
- support for **risk management tools,** including subsidies for insurance premiums and financial contributions to mutual risk funds and income stabilisation tools;
- support for certain forms of **cooperation** within the sector;
- support for **knowledge exchange and information dissemination,** including for the provision of farm advisory services.

Figure 29 Overview of CAP expenditures and its 'green architecture'



Sources: EC (2025h) and JRC (2025c).

Note: The values are cumulative for the 2023–2027 period.

Smaller farms and cattle farms generally rely more on CAP support than other farm types.

Analysis of data from the Farm Accountancy Data Network (FADN) indicates that, on average, direct payments under the CAP accounted for approximately 25% of total agricultural gross income in the EU during the 2020–2023 period. However, this share exhibits substantial variation across farm types and size categories, as illustrated in Table 13. Cattle farms have the highest dependency on CAP support, whereas horticulture, wine and granivore farms display the lowest reliance. Furthermore, farm size appears to be inversely related to dependence on direct payments, with larger farms generally relying less on such support than smaller holdings.

Table 13 CAP direct payments as a share of farm gross income by farm type and economic size

Farm type	
Cereals, oilseeds and protein crops	36%
Other field crops	28%
Horticulture	3%
Wine	7%
Fruits	10%
Olives	17%
Milk	22%
Sheep and goats	34%
Cattle	44%
Granivores	10%

Farm economic size	
EUR 8 000–25 000	27%
EUR 25 000–50 000	26%
EUR 50 000–100 000	25%
EUR 100 000–500 000	19%
Above EUR 500 000	11%

Source: EC (2024d).

Notes: (1) The percentages are averages for the 2020–2023 period. (2) Only specialist farms are included in the left table.

The CAP uses a mix of regulatory approaches and incentive schemes to support climate action.

Since the early 1990's, environmental considerations have become increasingly prominent throughout subsequent revisions of the CAP. The current CAP combines incentive schemes under Pillars 1 and 2 with regulatory approaches to ensure that it contributes to the EU climate and environmental objectives, through a range of instruments commonly referred to as the CAP's 'green architecture'.

- **Incentives schemes.** The CAP can incentivise farmers to engage in climate action both through Pillar 1 (eco-schemes) and Pillar 2 instruments.[18] As shown in Figure 29, out of the total CAP budget of EUR 308 billion in 2023–2027, at least EUR 69 billion is ringfenced for instruments contributing to climate action, other environmental objectives and animal welfare.
- **Regulatory approaches.** The CAP's conditionality framework sets out several minimum requirements relating to climate, biodiversity, the environment and animal welfare. It includes statutory management requirements (obligations from other EU legislation which apply to all farmers) and good agricultural and environmental conditions (GAECs) which set out additional requirements that only apply to CAP beneficiaries.

The CAP's delivery model provides Member States with a large degree of flexibility.

The current CAP, which began in 2023, is implemented through a delivery model under which EU legislation sets out the overall objectives and rules. The CAP budget allocated to each Member State (the national ceiling) is decided upfront based on different criteria including agricultural land area

[18] EU legislation requires 35% of the Pillar 2 budget to be spent on interventions contributing to climate action, other environmental objectives or animal welfare. To this end, 100% of AECMs, 50% of payments for areas with natural and other area-specific constraints and 50% of payments for area-specific disadvantages resulting from certain mandatory requirements can contribute to this objective. Investment support can also contribute 100%, provided there is a link with climate, environment or animal welfare.

and historic reference levels. Whereas the EU legislation provides substantial flexibility to Member States on how to spend this budget, it does set an overall framework with certain requirements. including the following.

- **Payment rates.** Whereas each Member State can to a large degree decide the payment rates per hectare for decoupled payments, they need to ensure that the aggregate required budget does not exceed their national ceiling. Furthermore, some rules apply with the aim to partially converge payment rates per hectare both within and across Member States.
- **Green prioritisation.** Each Member State is required to spend at least 25% of their direct payments on eco-schemes, and 35% of their Pillar 2 budget on purposes that support climate, biodiversity, the environment and animal welfare. Some limited exemptions are provided, for example to allow Member States to shift budgets between eco-schemes and Pillar 2 measures that support environmental objectives.

Each Member State develops a CAP strategic plan (CSP) in which it describes how it will implement the CAP, including how it plans to spend its national CAP budget. The European Commission reviews the draft CSPs during which it can request additional information and make non-binding recommendations. Eventually, the Commission needs to approve the CSPs.

Once the CSPs are approved and implemented, Member States are required to report annually on output, results and impact indicators under the CAP performance, monitoring and evaluation framework (PMEF). The Commission can suspend CAP payments to Member States if annual reports are missing or indicate substantial shortcomings. It is also required to do a biannual performance review, based on which the Commission can request Member States to draw up remediation action plans if necessary.

The CAP's legislation mainly sets out overall objectives, principles and key criteria, so the delivery model provides a large degree of flexibility to Member States, allowing them to customise their CSPs to their specific circumstances and needs (EC, 2023f).

5.2.2 Overall assessment of the CAP

Assessing the CAP's performance regarding climate action is challenging due to its recent, dynamic and diverse nature.

This subsection provides an assessment of the CAP, first in relation to climate mitigation, then adaptation, and finally its other socio-economic objectives. While the CAP's historic performance has been the subject of many studies, assessing its current performance is more challenging because of several reasons (INRAE & IDDRI, 2025).

- The current CAP is relatively new, as its implementation only started in 2023. Moreover, since then it has already been revised several times in response to the COVID-19 pandemic, the war in Ukraine and farmers' protests. As data is reported and published with a certain delay, this makes it challenging to empirically assess the performance of the policy against its stated objectives.
- As discussed above, the CAP sets out an overall framework with a wide diversity in implementation at the national level, making it challenging to assess its performance at an EU-wide level.

This report's assessment of the current CAP's performance is therefore primarily based on literature which provides *ex ante* assessments. Despite this limitation, the available literature points out several important shortcomings which undermine the CAP's performance on climate mitigation and adaptation, but also on its socio-economic objectives. These shortcomings are summarised in the remainder of this section. Subsequent chapters discuss the performance and potential shortcomings of specific CAP instruments in more detail, along with options to address these shortcomings.

The CAP provides good opportunities to support climate mitigation, but its performance on this dimension is hindered by several shortcomings.

The European Court of Auditors concluded that the Member States' plans under the current CAP are greener than in the previous CAP, but do not match the EU's increased ambitions for the climate and the environment (ECA, 2024). Both scientific and grey literature have identified several shortcomings in the current CAP, which undermine its potential contribution to climate mitigation. Overall, these can be summarised as follows.

- **Climate-harmful subsidies.** A key criticism is that a substantial part of the CAP budget is allocated to GHG-intensive forms of agriculture, namely livestock production and the cultivation of degraded peatlands. There are two different underlying causes for this critique. The first is the direct coupled payments for livestock production, which increase total livestock production and related GHG emissions (Jansson et al., 2021). The second cause is the untargeted, non-discriminatory nature of decoupled payments. This means, for example, that such payments are provided to areas used for animal feed production. It has been argued that, accounting also for such indirect support, more than 80% of CAP subsidies in 2013 can be linked to livestock production (Kortleve et al., 2024) and, although the share could be slightly different under the current CAP, the overall magnitude is likely to prevail. Another example is that the non-discriminatory nature of decoupled payments means they are provided for degraded peatlands, which hinders their restoration (see Box 9Box 9). Overall, both the decoupled and coupled CAP payments have been found to be largely ineffective at reducing the climate and environmental externalities of the farming sector, and at improving the sector's capacity to adapt and transform (OECD, 2023).
- **Fragmented and weakened regulatory standards.** The current conditionality framework includes several GAECs which can contribute to the conservation and enhancement of soil carbon stocks, both benefiting climate mitigation and adaptation (e.g. GAECs 1 and 9 on grasslands, and GAEC 2 on wetlands). However, except for the statutory management requirements relating to the Nitrates Directive (Directive 91/676/EEC), the conditionality framework does not target agricultural CH_4, N_2O or energy-related CO_2 emissions, which account for the bulk of the sector's GHG emissions. Furthermore, the effectiveness of the conditionality framework has been criticised for providing too many exemptions and for having a weak compliance regime (Pe'er et al., 2019), with further exemptions added over recent years in response to the war in Ukraine (EU, 2022a) and farmers' protests (EU, 2024a). In May 2025, the European Commission proposed further changes to the CAP, which would further soften its regulatory framework (EC, 2025r), for example, by allowing payments to farmers for complying with GAEC 2 (whereas such payments were previously only allowed for efforts going beyond the GAECs), and to no longer require Member States to update their CSPs in response to new EU climate and environmental legislation.
- **Ineffective incentive schemes.** The aim of the eco-schemes under Pillar 1 and the AECMs under Pillar 2 is to encourage farmers to go beyond the minimum requirements of the

conditionality framework. However, the eco-schemes as developed by Member States are widely criticised for delivering little beyond business as usual, as they tend to reward easy-to-implement measures with limited ecological benefits (Pe'er et al., 2022). A key reason is the high flexibility given to Member States in combination with a lack of incentives for them to prioritise climate and environmental outcomes, which allows a 'race to the bottom' between Member States focusing mainly on the competitiveness of their farmers (INRAE & IDDRI, 2025; Pe'er et al., 2022; Baldock and Bradley, 2023). In designing schemes, Member States have generally prioritised farmer acceptance over ecological ambition, making eco-schemes easily accessible but environmentally modest. By contrast, AECMs under Pillar 2 are generally considered to be more ambitious, but uptake is lower due to their complexity and stricter payment rules (see Box 10).

- **Governance limitations.** While flexibility for Member States is generally considered to be appropriate given the sector's diversity, it has raised concerns as the CAP's governance framework lacks strong incentives for Member States to develop environmentally ambitious CSPs (INRAE & IDDRI, 2025). CAP legislation mainly sets broad, qualitative objectives, limiting the European Commission's legal basis to reject CSPs with limited environmental ambition (ECA, 2024). Further challenges noted in the literature include limited Commission staff capacities and short deadlines, which undermine the robustness of CSP reviews (García Azcárate and Folkeson, 2020).

Box 9 The treatment of wetlands and peatlands under the CAP

The 2014–2020 CAP offered few incentives for wetland preservation and often encouraged drainage. Conservation was not an EU-wide requirement, with only 12 Member States promoting it (ECA, 2021). Restored peatlands, including those under paludiculture, were ineligible for decoupled payments, favouring drained land (Nordbeck et al., 2025). Only six Member States supported rewetting under rural development (ECA, 2021).

The current CAP (2023–2027) rectified these shortcomings to some extent (Nordbeck et al., 2025): protection of wetlands and peatlands is now mandatory under GAEC 2, and paludiculture is in some cases eligible for direct payments. This is the case by default when producing paludiculture products listed in Annex I of the TFEU. In other cases, Member States can still decide to continue decoupled payments if the switch to paludiculture was done under an eco-scheme, AECMs or a similar national scheme.

Despite these improvements, some issues remain (Nordbeck et al., 2025). GAEC 2 is formulated broadly and unevenly implemented across Member States, and only a small minority of Member States have put in place eco-schemes or AECMs to support rewetting and paludiculture. Only six Member States have made all paludiculture systems eligible for decoupled payments, and just two and seven Member States, respectively, offer eco-schemes or AECMs for peatland restoration. Even if addressed, the continued provision of decoupled payments for degraded peatlands remains questionable from a climate perspective, as it sustains drainage incentives alongside restoration rewards.

Box 10 Different commitment periods and payment levels under eco-schemes and AECMs

Under the current CAP, eco-schemes and AECMs are subject to different rules regarding commitment periods and payment levels.

- Commitment periods. Eco-schemes have no prescribed duration (EU, 2021b). Most Member States apply single-year commitments, allowing farmers to opt out annually (Anougmar et al., 2025). AECMs, by contrast, require five- to seven-year commitments, with farmers required to repay their subsidies in case of early withdrawal.
- Payment levels. Member States can decide whether to provide payments under eco-schemes either based on costs incurred and income foregone, or as fixed per-hectare amounts reflecting the ambition level of the eco-scheme.[19] Whereas the first option aims to avoid overcompensating farmers when they implement the eco-scheme, the second option would allow farmers to receive a net-benefit if the fixed payment exceeds costs incurred and income foregone. For AECMs, payments can only be provided based on costs incurred and income foregone resulting from the commitments made, meaning that at best the farmer would not lose out from the commitment (EU, 2021b).

Consequently, eco-schemes tend to be more accessible and may offer higher payments. AECMs are more demanding as they require multi-year commitments but are also subject to stricter limitations on payment levels.

A first estimate suggests that the current CSPs could be effective at driving climate mitigation in the land use sector, but far less so in reducing agricultural non-CO_2 emissions.

The points of criticism above are based on *ex ante* assessments, and additional time is needed to have more clarity on the effectiveness of the current CAP at driving climate mitigation. At this point in time, a first rough estimate of its mitigation potential suggests that the CSPs of all 27 Member States combined could reduce cumulative net emissions during 2023–2027 by 175.4 Mt CO_2e. This corresponds to 35 Mt CO_2e per year, or 7% of total agricultural emissions[20] in 2023 (EU CAP Network, 2025). The large majority of this (85%) would be due to reduced CO_2 emissions and increased removals from agricultural land. Reductions in non-CO_2 emissions would be far more limited (5 Mt CO_2e per year) and achieved almost exclusively through reduced emissions from nitrogen-fertilised soils while leaving livestock emissions untouched. These estimates – even though heavily caveated by the study's authors – suggest the current CAP could be quite effective at supporting emission reductions and temporary carbon dioxide removals in the land use sector, but far less so in reducing non-CO_2 emissions. It would not be effective at reducing livestock emissions, which constitute the largest share of the sector's total GHG emissions (see Section 2.4).

The CAP has so far focused on enhancing the agricultural sector's robustness in the short-term, at the expense of longer-term adaptability and transformability.

As discussed in Chapter 3, climate adaptation can be pursued on different spatial and temporal scales, ranging from incremental to transformational. A comparable framework was used by the

[19] The fixed per-hectare approach is only allowed when the scheme is not linked to specific types of production or land use.
[20] The estimate includes agricultural non-CO_2 emissions, emissions from energy use in agriculture, and net land-based CO_2 emissions on agricultural land.

SURE-farm research project (EC, 2023b) to assess the CAP's performance on enhancing resilience. This framework distinguishes between:

- **robustness**, which refers to a system's ability to maintain its current functions without major changes when faced with sudden shocks in the short term, primarily through the availability of buffer reserves and risk management such as insurance.
- **adaptability**, which refers to a system's ability to adapt its production and business strategies to changing circumstances over the medium term, without changing its operational logic or identity.
- **transformability**, which refers to a system's ability to fundamentally change its operational logic, to cope with severe shocks or enduring stress that would otherwise make the continuation of its current operations untenable.

The overall conclusion of the SURE-farm project's assessment is that CAP instruments focus primarily on boosting robustness in the short-term with mixed effectiveness and at the expense of adaptability and transformability (EC, 2023b).

- **Strong focus on short-term robustness.** The bulk of the CAP budget goes towards robustness-enhancing instruments, by providing buffer resources (income support) and supporting risk management (subsidies for insurances and mutual funds, and disaster relief through the Agricultural Reserve). A short-term focus risks creating an illusion of stability, thereby undermining the incentive for longer-term adaptability and transformability, while also progressively straining public funds as climate-related impacts are expected to increase (see Section 2.3). Furthermore, the effectiveness of some instruments focused on short-term robustness is undermined by several shortcomings (see below).
- **Less support for medium-term adaptability.** Some CAP instruments also support the adaptability of the farming sector. These include eco-schemes and AECMs which provide incentives for more sustainable farming practices (which often deliver ecological resilience co-benefits, see Chapter 3) and investment support. Whereas these instruments can contribute to enhancing medium-term adaptability, they receive substantially less funding compared with other instruments (see Figure 29). Furthermore, the uptake and effectiveness of these schemes at promoting sustainable farming practices have been criticised as explained above.
- **Underdeveloped support for long-term transformability.** A few CAP instruments can contribute to the sector's transformation, including support for organic farming and new rural value chains, and the European Innovation Partnerships for Agricultural Productivity and Sustainability (EIP-AGRI), which aims to drive innovation and knowledge exchange across different actors in the sector. However, the CAP was overall found to fall short in supporting transformability, as it lacks clear long-term goals and a clear vision, provides only little support for transformational innovations and dedicates most of its budget to preserving the status quo.

The CAP's risk management toolbox is the central instrument to boost short-term robustness, but its effectiveness is undermined by several shortcomings.

Farmers face different types of risks: production risks affecting the quality and quantity of products, market risks affecting the price farmers can get for their products and financial risks which can affect farm operations (Fi-Compass, 2025). Climate change can amplify these risks both directly (e.g. crop failures) or via compounded risks (e.g. supply chain disruptions), and through both extreme climate and weather events (e.g. storms) and slow-onset climate-related hazards (e.g. temperature increases and desertification).

The CAP includes several instruments to help farmers manage such risks. Central to this is the CAP's risk management toolbox, which includes the option for Member States to provide support for insurance, mutual funds and income stabilisation tools under Pillar 2 (EU, 2021b), and the Agricultural Reserve under Pillar 1. However, several shortcomings undermine the effectiveness of this toolbox.

- **Limited uptake.** Overall, the CAP's risk and management toolbox has been underused (Arata et al., 2023). The uptake of the risk management tools under Pillar 2 (insurance and mutual fund support) has been highly uneven across Member States, covering in aggregate only 14.5% of EU farmers (INRAE & IDDRI, 2025). Underlying reasons for this limited uptake are a lack of farmers' awareness and knowledge of the tools, a lack of affordability, uncertainty on payouts and administrative complexity (Fi-Compass, 2025; Doherty et al., 2021).
- **Limited budget.** Under the current CAP period (2023–2027), the total budget allocated to risk management tools amounts to EUR 920 million per year, which corresponds to less than 1% of the CAP budget (European Parliament, 2025). The current budget of the Agricultural Reserve is even lower at EUR 450 million per year. By comparison, risk management plays a more important role in the US Farm Bill, with 60% of its budget allocated to insurance (Pieralli et al., 2021).
- **Lack of conditionality on climate adaptation measures.** Access to the risk management tools under Pillar 2 does not require complying with climate adaptation measures. Receiving compensation, for example from insurance coverage, can lead to risky behaviour and disincentivise the deployment of precautionary measures, with potential adverse impacts on the environment (Doherty et al., 2021).

Finally, whereas the overall income support under the CAP could also boost short-term robustness, its largely decoupled nature makes it less effective at enhancing the robustness of small-scale farms and less land-intensive systems such as horticulture (EC, 2023b).

Several concerns about the CAP's socio-economic performance provide additional arguments to revise the policy in a way that better serves both its climate and socio-economic objectives.

Although the current CAP aims to serve multiple strategic objectives, it can be argued that the CAP's primary objective as set out in the TFEU is to increase agricultural productivity, thus supporting a fair standard of living for the agricultural communities. From this perspective, its limited effectiveness in terms of climate mitigation and adaptation could be justified if it performs well on the socio-economic objectives. However, there is broad agreement that the CAP's performance on these objectives could also be further improved, due to the following.

- **Income support not addressing income disparities.** Already since 1991, a main critique of the per-hectare based income support is that 80% of CAP payments are going to the 20% largest farms (EC, 1991), even if such farms are often more productive and economically viable on their own (see Chapter 2). As a result, the decoupled income support does not address income inequalities within the sector (Scown et al., 2020), which are indeed a driver of climate vulnerability (Islam and Winkel, 2017). Despite years of criticism and subsequent

CAP reforms, this 80–20 rule was still valid for CAP income support in 2022. The current CAP (2023–2027) includes some mechanisms to address this imbalance: in addition to the mandatory CRISS and CIS-YF schemes (see Box 8), it allows Member States to make BISS payments degressive or subject to a cap of EUR 100 000 per farm (EU, 2021b). Whereas the CRISS mechanisms could deliver some limited redistribution, the impact of degressivity and capping can be expected to be minimal due to their optional nature for the Member States (INRAE & IDDRI, 2025). Therefore, the high degree of income support towards larger farms is likely to remain under the current CAP.

- **Subsidy leakage outside the agricultural sector.** Another key criticism of the current CAP is that the decoupled payments are at least partially capitalised into land prices (Salhofer and Feichtinger, 2020; Guastella et al., 2018; Baldoni and Ciaian, 2023). This can be beneficial for existing farmers who own their land, but it increases the financial barriers for young farmers and other new entrants. Approximately 50–55% of the agricultural land in the EU is rented out, with most of this land owned by non-farming landowners (Salhofer and Feichtinger, 2020; Baldoni and Ciaian, 2023). As a result, the capitalisation of subsidies into land prices means that a substantial share of CAP subsidies is 'leaked' out of the sector and eventually benefits non-farming landowners. Estimates of capitalisation rates (i.e. the EUR increase in land prices per EUR subsidy) vary widely across literature, but are generally expected to be higher for decoupled payments and land-based subsidies than for coupled payments and non-land-based subsidies (e.g. payments for ecosystem services) (Ciaian et al., 2021). Whereas scientific literature has primarily focused on the capitalisation of CAP subsidies into land prices, it could be expected that these subsidies have put an upward pressure on input prices (e.g. fertilisers) and a downward pressure on output prices, which would further undermine the contribution of CAP payments to support agricultural incomes (INRAE & IDDRI, 2025) although overall food affordability was strengthened.

These points underpin that there are not only strong climate and environmental arguments, but also strong socio-economic arguments to rethink the CAP. Moreover, as already briefly explained above and elaborated in more detail in subsequent chapters, several reform options could provide synergies between climate, environmental and socio-economic objectives. For example, shifting from decoupled payments to agri-climate-environmental subsidies would allow for less-skewed payments, result in less subsidy leakage outside the sector, and may be more effective at supporting productivity in the face of climate-related risks (see Chapter 6).

5.2.3 Overview and assessment of other relevant EU policies

Several EU strategies support the sustainability transition in agriculture but lack concrete implementation.

There are a number of EU-wide strategies under the European Green Deal which are particularly relevant for the agricultural sector and broader agri-food system.

- The **EU Biodiversity Strategy for 2030** sets goals to halt biodiversity loss and restore ecosystems, with direct implications for agricultural landscapes. Among its targets is the legal protection of at least 30% of EU land, including stricter safeguards for the most valuable ecosystems. For agriculture, a key objective is to ensure that at least 10% of farmland contains high-diversity landscape features such as hedgerows, buffer strips, ponds and fallow land. These elements enhance habitat connectivity, support pollinators and natural pest predators, and provide resilience to climate-related risks. For instance, trees and hedgerows reduce wind and water erosion, offer shade and contribute to carbon sequestration, while ponds help retain water during drought. The strategy also calls for planting 3 billion trees by 2030, many of which will be located in rural and agricultural areas, supporting both biodiversity and climate adaptation.

- The **EU27 (F2F) strategy** (COM(2020) 381) outlines a comprehensive plan to transition to sustainable food systems. It explicitly addresses climate mitigation and adaptation, biodiversity preservation, food security and human health. Key targets for 2030 include a 50% reduction in the use and risk of chemical pesticides, a 50% reduction in nutrient losses (which translates to a 20% cut in fertiliser use), a 50% reduction in sales of antimicrobials for farm animals and at least 25% of EU agricultural land under organic farming. In addition to targets for on-farm practices, the strategy aims to reduce food waste, promote healthier diets and use trade and market power to push sustainability in global food supply chains, such as limiting imports linked to deforestation.

Both strategies present strong visions for more sustainable and resilient agriculture in the EU and could thus contribute to the required transition identified in Chapter 4. However, their effectiveness is limited by a lack of funding and binding legal instruments. While targets are clear and scientifically grounded, they remain largely aspirational unless translated into enforceable regulation with robust incentives. Without concrete legal mandates, Member States are free to interpret or delay implementation. As a result, progress across the EU is uneven, and the potential for systemic transition in the agricultural sector remains unrealised (Rinaldi, 2021; IDDRI, 2024).

The Effort Sharing Regulation (ESR) and LULUCF Regulation set binding national climate targets but have so far not delivered substantial mitigation in the agricultural sector.

Within the overall EU climate policy framework, agriculture falls under two central pieces of legislation which set out national mitigation targets.

- The **Effort Sharing Regulation (ESR)** (Regulation (EU) 2018/842) sets binding national GHG reduction targets in sectors not covered by the EU emissions trading system (EU ETS), including transport, buildings, waste, and agricultural non-CO_2 and energy-related emissions. Targets are differentiated by country, based on GDP per capita and cost-effectiveness, aiming for an overall 40% reduction of the ESR-sector emissions by 2030 compared to 2005 levels (EC, 2023g). The national targets for 2030 form the basis for annual emission budgets which Member States need to adhere to, and for which they can use a range of flexibilities.
- The **LULUCF Regulation** integrates the land use sector into the EU climate framework by setting national targets for temporary carbon dioxide removals and emissions from land use by 2030. Relating to agriculture, these targets include land-based CO_2 emissions and removals from croplands and grasslands. The overall EU target is to increase the land use sector's net sink to 310 Mt CO_2e by 2030, which is translated into binding national targets for each Member State, based on factors such as historical removals, land-use patterns and mitigation potential (EC, 2025p). Like with the ESR, these targets form the basis for annual GHG budgets, with certain flexibilities for Member States. (EC, 2025p).

The intervention logic is that the national targets would incentivise Member States to implement ambitious and effective mitigation policies at the national level. However, overall, neither the ESR nor the LULUCF Regulation have so far been able to deliver substantial mitigation or to drive policy change in the agricultural sector with the exception of a few Member States (see Box 11). A lack of strong compliance tools has been identified as the main factor behind the weak influence on the sector (Korosuo et al., 2023; IEEP, 2025a; JRC, 2025c; CAN Europe, 2022; Bruegel, 2023). The Commission audits Member State progress through annual assessments in combination with in-depth compliance checks every five years but the process lacks the stringency that creates a real deterrent against failing to meet national climate targets. Current trends suggest that without stronger sector-specific policies, financial incentives and enforcement tools, agriculture will remain a climate policy gap in the EU (EEA, 2024c).

Box 11 Examples of ambitious national climate policies for the agricultural sector

Only a few Member States have introduced ambitious climate mitigation policies targeting agriculture. Some examples are shown below.

- **Denmark** stands out as the first country in the world to legislate a direct tax on agricultural GHG emissions (Danish Government, 2024). Key features of Denmark's plan include:
    - a livestock emissions levy: starting in 2030, farmers will be charged for emissions above a set threshold per animal;
    - nitrogen and fertiliser measures: the plan will use CAP funds to pay farmers for better nitrogen management;
    - land use changes: Denmark will restore 140 000 hectares of peatlands and plant 250 000 hectares of new forest by 2045, backed by a DKK 40 billion Green Fund.
- **The Netherlands** has initiated a programme to reduce livestock numbers by roughly one third (Rijksoverheid, 2025b). Whereas this is primarily aimed at solving a nitrogen pollution crisis, it is also likely to contribute to climate mitigation. The 13-year strategic framework encompasses measures to financially compensate livestock producers who voluntarily choose to exit the sector or relocate. Additionally, it supports the transition of remaining farmers towards less intensive livestock production systems, characterised by reduced herd sizes and expanded land use per animal.
- **Ireland's** government has set a legally binding target to reduce agricultural emissions by 25% by 2030 (relative to 2018). To achieve the target, the government has launched a portfolio of actions such as support for mitigation technologies and stakeholder engagement (Government of Ireland, 2024).

Certain EU-wide policies could also contribute to the sector's transition but cannot be expected to deliver substantial changes in their current form.

In addition to the ESR and the LULUCF Regulation, which set overall national mitigation objectives, there are several other relevant EU policies which could contribute to climate mitigation and adaptation in agriculture.

- The **Industrial Emissions Directive (IED)** (Directive 2010/75/EU) is the EU's main legal framework to control pollution from large industrial sources. These installations fall under the IED permitting system, which mandates the use of best available techniques to limit emissions to air, water and soil. For agriculture, the IED addresses emissions of ammonia (NH_3), methane (CH_4) and nitrate runoff, all of which contribute to climate change, as well as eutrophication and air pollution. However, the directive's contribution to climate mitigation is limited as it only covers large pig and poultry farms but excludes cattle farms, which are the largest source of agricultural GHG emissions (EC, 2024c).

- The **Nature Restoration Law** (Regulation (EU) 2024/1991) requires Member States to put specific restoration measures in place. Of particular relevance for the agricultural sector is the requirement for Member States to restore degraded peatlands and increase natural landscape features on farmland. Both requirements can contribute substantially to climate mitigation and adaptation (see Chapter 3), but only if implemented effectively by Member States.
- The **Nitrates Directive**, adopted in 1991 (EU, 1991), aims to protect water quality across the EU by reducing nitrate pollution from agricultural sources, primarily from fertiliser and manure application. Member States must identify nitrate-vulnerable zones and establish action programmes with mandatory measures, such as limits on manure application, storage requirements and timing restrictions. While primarily focused on water quality, which would contribute to climate adaptation, these measures can also deliver mitigation benefits by reducing N_2O emissions. Although effective in some regions, implementation of the directive varies widely across the EU. In several countries, water pollution from agriculture remains high and compliance has been lacking (Velthof et al., 2014; D' Haene et al., 2014). The latest Commission report on the implementation of the Nitrates Directive (based on data for 2016–2019) warns that nitrates are still causing harmful pollution to water in the EU (EC, 2021d). In conclusion, the directive's enforcement and scope have not kept pace with current environmental pressures.
- The **CRCF Regulation** is a newer instrument, adopted in 2024. It establishes a voluntary EU-wide system for the high-quality certification of permanent removals, carbon-farming activities and carbon sequestration in long-lasting products. Whereas the regulation sets out the overall framework, more detailed crediting methodologies are still under development, with full implementation expected by 2028. While the regulation represents an important step towards recognising and rewarding mitigation efforts in agriculture and land use, its scope remains limited and it does not, on its own, provide incentives or obligations commensurate with the scale of climate mitigation and resilience improvements required (see also Box 17 in Chapter 7). Thus, mandatory demand for CRCF credits is needed to make the regulation truly effective.

Overall, while these EU-wide instruments can contribute to a wider transition in the agricultural sector aligned with the EU's climate objectives, they cannot be expected on their own to deliver substantial change in their current form, as each only covers a part of the agricultural sector, and some of them lack effective implementation at the national level.

5.3 Overall policy mix to guide the transition

A systemic transition of the agri-food system is best supported through a combination of policy instruments, rather than reliance on a single policy mechanism.

The complexity and scale of the required transition present significant challenges, largely due to the heterogeneous nature of the agri-food system and the multitude of interconnected issues it encompasses (as discussed in Chapter 2). And as concluded in Section 5.2, existing policy frameworks are insufficient to drive the necessary technical improvements and structural changes.

Empirical and theoretical evidence demonstrates that policy mixes comprising multiple, complementary instruments are more effective than singular approaches in facilitating complex transitions (Stechemesser et al., 2024; Rogge and Reichardt, 2016; IPCC, 2022b, Chapter 16). Thus, it is improbable that any single policy could adequately address the diverse and interrelated challenges, market failures and goals facing the agricultural sector (Acemoglu et al., 2024).

This underscores the need for both the development of new policies and the reform of existing ones. Accordingly, this section highlights the following key components of a coherent and integrated policy mix that could be implemented at the EU level to support the transition of the agri-food system:

- avoiding climate-harmful subsidies (Section 5.3.1);
- pricing emissions, rewarding removals (Section 5.3.2);
- transition support for climate-proofing EU agriculture (Section 5.3.3);
- support to overcome adverse climate-related impacts (Section 5.3.4);
- food policies (Section 5.3.5);
- trade policies to address carbon leakage (Section 5.3.6);
- cross-cutting foundations (Section 5.3.7).

The Advisory Board's recommendations regarding the policy mix are summarised in Section 5.3.8, while Section 5.3.9 argues for a gradual implementation of the various components.

5.3.1 Avoiding climate-harmful subsidies

Subsidies that are particularly harmful to the climate should be eliminated to incentivise mitigation and ensure coherence across policy instruments.

The EU agricultural sector receives support through various mechanisms that, while advancing socio-economic objectives, may inadvertently undermine the goals of the European Climate Law. Such policy misalignments must be addressed, within the CAP and related subsidy schemes, to ensure coherence across policy domains, uphold the credibility of the EU's climate policy architecture and facilitate the redirection of private funds towards less GHG-intensive and more climate-resilient activities and practices (Advisory Board, 2024). In many instances, the same socio-economic objectives can be pursued through alternative approaches that do not impede the transition to low-emission and climate-resilient agriculture.

Although maintaining farmers' incomes and supporting rural livelihoods remains a central political priority of the CAP, even considering agriculture as an inherently GHG-emitting sector, the CAP should not actively obstruct the downscaling of the most emission-intensive practices such as livestock production and the cultivation of degraded peatlands.

Chapter 6 explores the rationale for phasing out the most climate-damaging direct payments under the CAP, positioning such a reform as a necessary complement to the GHG pricing framework outlined below.

5.3.2 Pricing emissions, rewarding removals

Current policy frameworks are insufficient to deliver the scale of climate mitigation required in the EU's agri-food system.

Among the various challenges confronting the agricultural sector, the need to substantially reduce GHG emissions and contribute to carbon dioxide removals is particularly critical. However, relying on existing policy frameworks will most likely not deliver substantial mitigation outcomes.

The CAP is unlikely to facilitate large-scale reductions and removals (INRAE & IDDRI, 2025). This limitation stems in part from the CAP's broad mandate, which prioritises multiple objectives, including the enhancement of farmers' productivity and living standards (EU, 2008). As a result, climate objectives often become secondary as explained in Section 5.2.2. Moreover, the coexistence of potentially conflicting goals within the CAP framework may hinder the implementation of effective mitigation strategies. The combination of these competing priorities with a future budget, which cannot be expected to increase substantially, further restricts the capacity to allocate substantial resources towards climate mitigation.

Although the current CAP includes certain climate-related conditionalities, the responsibility for agricultural mitigation largely resides with Member States, incentivised through national targets under the ESR and the LULUCF Regulation. However, the ESR has demonstrated limited effectiveness in reducing agricultural emissions as Member States have prioritised mitigation efforts in other ESR-covered sectors, and its weak compliance mechanisms raise concerns about its continued viability as a primary driver of change (see Section 5.2.3).

Additionally, continued reliance on an ESR-style framework as the main driver of climate mitigation entails a significant risk of generating cost-ineffective outcomes across the EU. Firstly, marginal abatement costs are unlikely to be equalised across Member States if inter-state flexibilities are not adequately used. This misalignment implies that emission reductions may not occur in the most cost-effective locations. Secondly, the decentralised nature of such a framework necessitates that each Member State develop its own regulatory architecture, thereby foregoing the potential efficiencies associated with a harmonised, pan-European approach that leverages economies of scale. Thirdly, intra-EU competitiveness concerns may incentivise Member States to adopt subsidy-based regulatory instruments, undermining the adoption of more economically efficient measures grounded in the polluter pays principle.

Effective climate action in the agricultural sector necessitates the establishment of a dedicated, EU-wide flagship policy with climate mitigation as its primary objective.

Based on the limitations of the current policy framework, this report proposes the development of a dedicated EU-wide mitigation policy to operate alongside the CAP. While the primary responsibility for achieving the EU's 2030 climate target of a 55% reduction in GHG emissions remains with the existing policy framework, the proposed policy could serve as the principal mechanism driving the agricultural sector's contribution to the climate objectives for 2040 and 2050.

As previously recommended by the Advisory Board (Advisory Board, 2024), this new policy should incorporate mechanisms for pricing emissions and rewarding carbon dioxide removals.

Market-based instruments demonstrate greater efficacy than command-and-control regulatory approaches in facilitating agricultural production systems with lower GHG emissions.

By utilising price signals and market-based instruments, the proposed policy would facilitate cost-effective mitigation in a technology-neutral manner, which is of particular importance in a heterogeneous sector like agriculture. This approach enables the prioritisation of economically efficient mitigation strategies across a diverse sector, irrespective of whether these strategies are technical improvements or structural changes (Goulder and Schein, 2013; Grosjean et al., 2018). By internalising the external costs of GHG emissions through pricing, these emissions are converted into operational costs, thereby ensuring that mitigation considerations become an intrinsic part of decision making processes both at the farm level and throughout the value chain (Matthews and O'Neill, 2025).

An alternative policy approach involves the implementation of 'command and control' mechanisms, whereby specific climate-friendly practices are mandated through regulation. While such an architecture offers certain advantages, it is subject to notable limitations. First, it is ill-suited to accommodate the considerable heterogeneity within the agricultural sector, which varies significantly in terms of production systems, regional conditions and mitigation potential. Second, although 'command and control' instruments may facilitate the adoption of technical mitigation measures, they are less effective in incentivising the gradual reduction, rather than complete elimination, of the most emission-intensive production systems, such as those associated with livestock. Third, this regulatory approach diverges from prevailing trends in EU policymaking, which increasingly favour financial incentives over prescriptive regulation (EC, 2025i).

A pricing framework may incorporate both punitive measures and positive incentives and generate revenues which can be reinvested in the sector.

As discussed above, the EU's reliance on subsidies to drive climate mitigation in agriculture faces limits, given the constrained public budget that must serve multiple policy objectives. Importantly, a well-designed pricing scheme may not require substantial public funding. Nevertheless, such a pricing scheme can take various forms.

For instance, some models rely on market-based rewards for farmers who reduce emissions relative to a predefined baseline. This would necessitate public financial support rather than generate revenue, while also deviating from the polluter pays principle. Moreover, although a subsidy-based approach uses price signals to promote cost-effective mitigation, it carries the risk of generating long-term inefficiencies by artificially enhancing the economic attractiveness of agricultural production.

The proposed policy can instead be designed so that emitters need to pay for their GHG emissions, which would be aligned with the polluter pays principle, a foundational tenet of EU environmental law (EU, 2008). In the agricultural context, this principle would need to be complemented by a 'provider gets principle', recognising and rewarding farmers' contributions to carbon sequestration. In contrast to other policy options ('command and control' or a purely subsidy-based approach), such an approach could not only mobilise private funds for mitigation investments but also generate public revenue that could be reinvested to further support the sector's transition.

Chapter 7 provides a detailed assessment of potential approaches to pricing GHG emissions and removals in agriculture, including emissions trading systems and mandatory climate standards.

5.3.3 Transition support for climate-proofing EU agriculture

EU policies should play a role in enhancing climate adaptation in agriculture.

An important component in climate-proofing EU agriculture is the support for adaptation, enabling farmers to transition towards more climate-resilient farming systems and practices. While farmers already have private incentives to adapt their businesses to a changing climate, government interventions also have an important role to play as explained in Box 12. To this end, two types of support can be provided:

- **transition support** to drive the development and deployment of climate-adapted farm practices and systems that can withstand current climate impacts and proactively adjust course to reduce projected climate-related risks and seize opportunities (see further below);
- support for **risk management tools** which help farmers manage the risks of a changing climate (see Section 5.3.4).

Box 12 Why should governments support climate adaptation?

At first sight, it could be assumed that those who are directly exposed to climate risks have an inherent incentive to adapt to a changing climate, as they directly benefit from successful adaptation. From this perspective, farmers should have sufficient economic incentives to undertake adaptation measures when they are profitable, and government intervention may be unnecessary.

However, there are several substantive reasons why such inherent incentives can fall short and why public incentives for climate adaptation in the agri-food system are justified. The main arguments for such an approach are summarised below:

- Alignment with core EU objectives. The TFEU has as core objectives for the CAP to increase agricultural productivity, ensure a fair standard of living for the agricultural community, stabilise markets, assure the availability of supplies and ensure that they reach consumers at reasonable prices. Climate change is a direct threat to each of these objectives. Providing support for adaptation can thus be considered as an essential way to achieve these objectives.
- Food security as a public good. Although food security does not fully meet the classical criteria of a public good, namely non-rivalry and non-excludability (Musgrave, 1959), it can be argued that food security is a public good in a broader definition of the term (Claeys and Steinbach, 2024). Thus, ensuring a stable food supply justifies public intervention to mitigate risks associated with climate-related yield fluctuations and to provide macroeconomic stabilisation (Aakre et al., 2010).
- Provision of co-benefits. Many adaptation strategies yield co-benefits that qualify as genuine public goods. As described in Chapter 3, practices that enhance climate resilience may simultaneously promote biodiversity, reduce nitrogen pollution, and

improve ecosystem health (Chiriacò et al., 2025). Ecosystem-based adaptation measures also may reduce hazard risk of rural communities beyond the farm level, for example, by creating flood plains.

- **Spillover effects.** Inadequate adaptation or maladaptation on individual farms can generate negative externalities, such as increased flood or wildfire risks, degraded soil quality or mismanaged water resources. These spillover effects warrant coordinated public responses.
- **Knowledge gaps.** Adapting the agri-food system to a changing climate is challenging due to uncertainty about future climate-related risks and the complexity of adaptation options. Farmers might thus face important knowledge gaps which hinder effective adaptation.
- **Behavioural barriers.** Farmers, like the rest of society, may face cognitive and behavioural obstacles that hinder timely adaptation. These include short-term decision making, procrastination and denial of climate-related risks, all of which justify targeted public support to overcome such barriers (Grothmann and Patt, 2005).
- **Financial constraints.** Limited access to capital often prevents farmers from investing in necessary adaptation measures (Fi-Compass, 2023). Public funding can play a critical role in bridging this financial gap.
- **Coordination failures.** Effective adaptation frequently requires collaboration among multiple stakeholders, particularly at the landscape level. Government intervention can facilitate coordination and ensure coherent implementation of adaptation strategies and promote economies of scale (Fankhauser, 2017).
- **Insufficient insurance coverage.** While insurance is typically a private product, underinsurance can undermine wider economic stability and impose significant fiscal costs of managing climate-related risks. With a widening climate insurance protection gap, public intervention may be necessary to address common market failures in insurance provision (Jarzabkowski et al., 2019; Lenaerts et al., 2022).
- **Fairness in adaptation.** The Advisory Board has previously recommended to support the most vulnerable regions and communities and promote fairness in adaptation processes and outcomes (Advisory Board, 2026). This includes the agri-food system, and in particular farming communities in Southern Europe, which are particularly vulnerable, as discussed in Section 2.3. The use of robust sectoral risk assessments can help identify and prioritise hotspots of vulnerability and exposure.

A GHG pricing instrument needs to be complemented with policies that deliver enabling conditions for a successful transition.

On the mitigation side, while the removal of harmful subsidies and GHG pricing is generally considered as the most cost-effective policy for reducing emissions and promoting removals, it needs to be complemented with additional policies to address market failures (Stern, 2022; Advisory Board, 2024; Armitage et al., 2023). In particular, while a uniform GHG price may yield static cost-effectiveness, it does not inherently foster innovation, learning, or long-term cost reductions (see Box 13). Furthermore, a GHG price might also not be able to drive the deployment of more mature solutions due to other market failures, including imperfections in risk and capital markets, coordination challenges, lack of information and insufficient remuneration of co-benefits (Stern, 2022).

A GHG pricing instrument for agriculture would therefore need to be complemented with additional policies, for example included under the CAP, that can deliver the enabling conditions for a successful transition towards less climate-harmful production systems. Such additional policies are explored in Chapter 8.

Box 13 Static and dynamic cost-effectiveness

Cost-effectiveness is a central consideration in the design of climate policy, as it enhances the feasibility of achieving ambitious climate objectives (Advisory Board, 2025). Both cost-effectiveness and economic efficiency are explicitly recognised in the European Climate Law (EU, 2021) as key criteria for the development of measures and targets aimed at achieving climate neutrality. From this perspective, it is essential that the agricultural sector contribute to the EU's climate neutrality objectives in a cost-effective manner. In economic terms, cost-effectiveness is generally achieved when the marginal social costs of all mitigation options, both emission reductions and removals, are equalised (Edenhofer et al., 2024a).

Assessments of cost-effectiveness can be approached from either a static or dynamic perspective. Static efficiency refers to the optimal allocation of resources under current technological, cost and market conditions. In contrast, dynamic efficiency also accounts for the evolution of these factors over time. In the context of emerging or uncertain technologies, it is necessary to consider both static and dynamic efficiency when evaluating climate policy instruments and mitigation pathways (Grubb et al., 2021; Gillingham and Stock, 2018). As highlighted in the energy transition literature, the cost trajectories of novel technologies are not fixed but start out high, resulting in a first mover disadvantage. As technologies mature, their costs tend to decline over time due to learning-by-doing and economies of scale. These dynamics are contingent upon sustained public and private support for innovation and early-stage deployment (Anadon et al., 2022; Nemet et al., 2018; Grubb et al., 2021; Acemoglu et al., 2024). Similar patterns are likely to apply to emerging agricultural practices and food technologies.

Incorporating dynamic efficiency into policy design implies that the optimal deployment of new technologies and the selection of incentive instruments may diverge from those suggested by static cost-effectiveness criteria alone. Accordingly, from a dynamic cost-effectiveness standpoint, it is justifiable to support the early deployment of a diverse portfolio of mitigation options, even if they are currently costly, in order to accelerate technological development and cost reductions, rather than relying exclusively on a uniform GHG pricing mechanism.

5.3.4 Support to overcome adverse climate-related impacts

Additional support is needed to help farmers cope with adverse climate-related impacts.

Whereas enhancing climate mitigation and adaptation can reduce climate-related risks, it cannot fully eliminate them. With climatic risk drivers on the rise, farmers will increasingly experience adverse impacts, while many of them face limited financial capacity to absorb and recover from climate shocks or to afford insurance (see Section 2.5.3), and some risks are non-insurable.

Furthermore, some regions in the EU might become less productive altogether due to slow-onset climate-related hazards.

As already discussed in Box 12, there are several reasons to provide public support for adaptation in the agri-food system. This also includes public support to help affected stakeholders overcome adverse climate-related impacts, which is particularly warranted to ensure fairness in adaptation.

Support to overcome adverse climate-related impacts should not undermine the incentive for proactive and transformational adaptation.

Helping farmers overcome adverse climate-related impacts is justified but also includes some risks. It can undermine the incentive for proactive adaptation if farmers expect the public sector to bear the consequences of adverse climate-related impacts. It also risks locking farmers into least climate-resilient practices and systems and preventing transformational adaptation approaches. The provision of support to overcome adverse climate-related impacts should therefore be organised in a way that avoids such perverse incentives and maintains strong incentives for proactive and transformational adaptation (Advisory Board, 2026).

Several approaches to help farmers overcome adverse climate-related impacts, while preserving the incentive for proactive and transformational adaptation, are explored and critically assessed in Chapter 9.

5.3.5 Food policies

Changes to food demand and food waste reduction are essential for climate-proofing EU agriculture.

Adjusting dietary patterns towards more plant-rich diets constitutes a critical element in the transition of the agri-food system. As highlighted in Chapter 4, such an adjustment is needed alongside production-side changes to mitigate the risks of carbon leakage and to create a market pull for plant-based agricultural products. These shifts may to some extent occur endogenously as a consequence of price adjustments, particularly when GHG pricing or reduced CAP support render emission-intensive food products more costly. Additionally, more fundamental changes in food preferences and demand patterns can influence producer prices, thereby encouraging farmers to adopt more sustainable production choices. Beyond their implications for agricultural systems, dietary shifts also yield significant public health benefits (see Section 2.5.7).

Furthermore, reducing food waste is essential for making the EU food system more sustainable. In 2023, around 130 kg of food waste per inhabitant were generated in the EU (EC, 2025m), contributing significantly to GHG emissions, resource depletion and biodiversity loss. By leveraging food policy to minimise waste, the environmental footprint of food production can be reduced, including the energy, water, and land used to grow, process and transport food that ultimately goes uneaten. Reducing the strain on ecological systems supporting farming also reduces climate-related vulnerabilities. This is a practical step towards lowering emissions and building resilience in the agri-food system in the face of challenges such as climate change and resource scarcity.

Expanding food policy instruments beyond pricing could enhance the overall policy effectiveness.

While this report examines pricing as a policy instrument to influence dietary behaviour, food prices represent only one facet of the broader food environment. The reliance on pricing mechanisms presupposes a model of the consumer as a rational, autonomous decision-maker. However, insights from psychological and sociological research challenge the comprehensiveness of this assumption. As various studies emphasise, consumer food choices are shaped by a constellation of factors. In addition to the economic dimension, these include the physical (availability, quality, promotion), cognitive (information, knowledge) and sociocultural (norms, beliefs) surroundings, opportunities and conditions (Glanz et al., 2005; Swinburn et al., 2013; Turner et al., 2018; SAPEA, 2023; Agora Agriculture and IDDRI, 2025). Addressing these additional dimensions through targeted policy interventions could substantially enhance the effectiveness of the overall policy mix.

Consequently, Chapter 10 explores complementary policy approaches that engage with the broader determinants of food choice. In addition, the chapter discusses how food policies and other compensatory measures can protect vulnerable consumers affected by rising food prices due to GHG pricing or equivalent measures.

5.3.6 Trade policies to address carbon leakage

To address concerns of adverse impacts arising from GHG pricing and CAP reform, complementary trade policy measures targeting carbon leakage could be implemented.

Political resistance to climate action in agriculture frequently stems from apprehensions relating to international competitiveness and carbon leakage (Van Hoof, 2023). The proposed policy mix, particularly the introduction of GHG pricing instruments and the reallocation of CAP funds towards climate objectives, may exacerbate these concerns. To mitigate such effects, these two policy interventions should be carefully designed to minimise unintended consequences resulting from loss of competitiveness of EU agricultural producers in both domestic and international markets, potentially resulting in carbon leakage.

However, given the limitations of the modifications to be made within these primary frameworks, complementary policies could be necessary to address the imbalances. Chapter 11 outlines policy options aimed at mitigating the risk of carbon leakage through strategic trade measures, such as carbon border adjustment mechanisms (CBAM) and climate provisions in free trade agreements (FTAs).

5.3.7 Cross-cutting foundations

While private finance is needed to deliver climate mitigation and adaptation in agriculture, adequate public funding remains a cornerstone.

As discussed in Chapter 2, the transition towards a lower GHG-emitting and more climate-resilient agricultural sector will require substantial finance, which cannot be delivered through the public budget alone. The policy mix outlined above would therefore mobilise both private and public money to fund the transition. The respective roles of both instruments can be summarised as follows.

- **Climate adaptation.** Private actors already have an inherent incentive to adapt to a changing climate, as they will benefit directly from their adaptation efforts. EU policies would further support these efforts with public funds, which can be justified based on the arguments described in Box 12.

- **Climate mitigation.** Mitigation efforts could be primarily financed by private actors, driven by a GHG pricing mechanism in line with the polluter pays principle. This should be complemented with public support to address market failures, in particular to support the development and early deployment of mitigation options, to incentivise innovation and to reward environmental co-benefits of mitigation options. Public money would also temporarily finance investment and transitional income support for farms that embark on a more fundamental restructuring of their system (e.g. from livestock to plant-based systems or from drainage-based to paludiculture systems), as such transitions are capital-intensive but can yield substantial mitigation outcomes.

Despite the need to bring in private funds, public funding remains a cornerstone of the transition, and lack of sufficient funds could become a major roadblock. Thus, Chapter 12 explores options for enhancing the public budget for climate-related objectives.

Reliable MRV and MEL systems are essential to overcoming the complexity of agricultural emissions and enabling an effective, coherent EU climate policy.

Accurate monitoring, reporting, and verification (MRV) systems, along with robust data infrastructures, are foundational to the effectiveness of EU climate policy, particularly in the agricultural sector. Unlike the energy sector, where emissions are closely linked to quantifiable fossil fuel inputs, agriculture presents a more diffuse and fugitive emissions profile. This complexity poses significant challenges for the design and implementation of targeted mitigation instruments, especially GHG pricing mechanisms.

The three core components of MRV can be broadly defined as follows (Advisory Board, 2025):

- **monitoring** refers to the systematic collection of data that quantify the impacts of agricultural activities, including GHG emissions, removals, potential future reversals and, in many cases, additional sustainability indicators;
- **reporting** involves organising these data into standardised formats and disseminating them to relevant stakeholders;
- **verification** entails an independent assessment of the reported data to ensure that they accurately reflect actual conditions.

In this context, the availability of reliable and spatially explicit data becomes a critical enabler of effective policy. For instance, comprehensive and high-resolution maps of the EU's organic soils are essential to ensure that policy instruments do not inadvertently incentivise the drainage of carbon-rich peatlands. Similarly, the development of robust indicators for the climate footprint of agricultural products is vital for steering consumer behaviour through mechanisms such as environmental labelling.

In adaptation, robust monitoring, evaluation and learning (MEL) systems are needed to cope with uncertainty, guide proactive decisions, track progress and adjust actions. Monitoring the resilience of EU agriculture to climate-related impacts requires strengthening the knowledge base and adopting consistent and meaningful targets and indicators that can assess progress and outcomes over time and inform adaptive responses. Whereas this report does not further explore this topic, the Advisory Board has previously published recommendations for strengthening MEL systems through improved and harmonised data collection, common reference scenarios for risk assessments and adopting a set of common indicators linked to EU adaptation targets (Advisory Board, 2026).

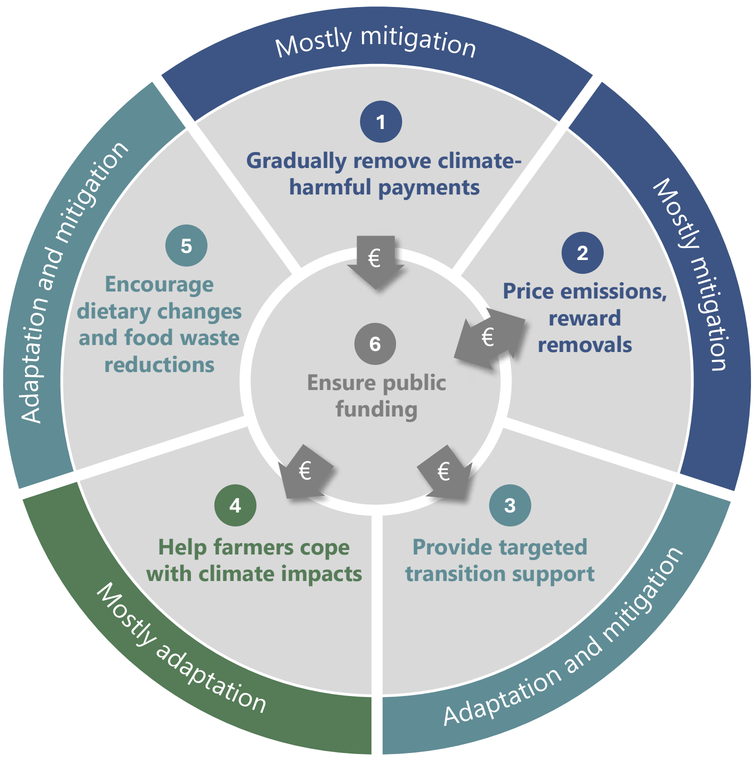
While robust MRV and MEL systems are essential for many of the policies recommended in this report, it is of particular relevance for the implementation of GHG pricing, which is comprehensively discussed in Chapter 7.

5.3.8 Summarising the overall policy mix

The Advisory Board recommends a multifaceted policy mix.

In conclusion, the Advisory Board recommends the implementation of a comprehensive and coherent policy mix aimed at steering the EU's agri-food system towards greater sustainability and climate resilience. The various components of this integrated policy approach are outlined in Figure 30, which also highlights if each policy recommendation mainly targets mitigation, adaptation or both. The exact content of each recommendation can be found in the executive summary.

Figure 30 Components in the policy mix recommended by the Advisory Board



Delivering the necessary policy functions requires new frameworks and an improvement of existing frameworks such as the CAP.

Several components illustrated in Figure 30 require the development of entirely new policy frameworks, most notably the establishment of mechanisms for pricing GHG emissions and removals. Other elements could be addressed through targeted reforms within existing frameworks, such as the CAP, or with new policy frameworks.

As previously discussed, ongoing CAP reform should as a minimum remove the climate-harmful subsidies under the system. In addition, the reform could aim to enhance the instruments' role in fulfilling two other functions of the recommended policy mix, namely providing transition support and support for overcoming adverse climate-related impacts. There are several arguments supporting the CAP's use for these purposes.

- **Close alignment with the CAP's core objectives.** Both types of support aim to enhance climate adaptation and resilience, which is closely aligned with the core objectives of the CAP under the TFEU (see also Box 8). Transition support for climate mitigation could also be considered as necessary to ensure fair living standards, as it reduces the financial impact of GHG pricing and the phase-out of climate-harmful subsidies.
- **Can build on existing CAP instruments.** The CAP already includes several instruments which aim to fulfil these functions, as described in Section 5.2.1. Such instruments include investment support, agricultural knowledge and information services, incentive schemes and risk management tools. However, as discussed in Section 5.2.2, their effectiveness is currently limited and should thus be enhanced if they are to play this role. In particular, it would require a strengthening of the CAP's governance and delivery model to ensure that Member States use the flexibility in the framework to develop climate-ambitious implementation plans tailored to their specific circumstances and needs.

Alternatively, the EU could consider creating new instruments outside the CAP to provide transition support and support to cope with adverse climate-related impacts. For example, the Strategic Dialogue on the future of EU agriculture has called for the creation of a separate temporary Just Transition Fund outside the CAP and for enhancing the role of the European Investment Bank (EIB) to accelerate the sustainability transition in agriculture (EC, 2024h) (see also Section 12.4).

Chapters 8 and 9 primarily examine how existing CAP instruments could be enhanced to better provide transitional support and support for overcoming adverse climate-related impacts. The Advisory Board is however neutral as to whether these functions should be delivered through the CAP or alternative EU instruments. In the latter case, the assessments in Chapters 8 and 9 illustrate how such instruments could be designed to avoid repeating the shortcomings of the current CAP.

Other types of policies are relevant but not covered in this report.

While there are other relevant policies beyond the ones listed in Figure 30 which can further promote climate mitigation and adaptation, their detailed assessment is beyond the scope of this report, as it focuses on the policy components which the Advisory Board finds most relevant from a climate perspective. Additional policies include:

- support for research and development (R&D) for novel foods (see also Box 4);
- policies to foster demand for agricultural biomass and create lead markets for the bioeconomy as a future income stream for the agri-food business;
- disaster management coordination at the EU level;
- policies governing land use;
- support of rural areas beyond the CAP;
- further regulatory approaches to avoid the most harmful environmental practices, for example by strengthening the Industrial Emissions Directive or the Nitrates Directive.

5.3.9 The need for a gradual policy implementation

The underlying data infrastructure and MRV/MEL systems are key enabling factors for the implementation of new policies.

Transforming the EU's agri-food system to become more climate-friendly and climate-resilient is an urgent and complex undertaking. While long-term policy solutions are increasingly well understood, as will be outlined in the following chapters, their immediate implementation may not be feasible or prudent. Thus, a gradual, sequenced approach to policy deployment is appropriate, although legal and administrative preparations should start without delay.

Current limitations in data infrastructure represent a first example of the need for such a gradual approach. Robust and transparent MRV and MEL systems are foundational to the effective implementation of climate policies, particularly those involving pricing instruments. But at present, several critical components of the MRV and MEL infrastructure remain underdeveloped or inconsistent across Member States.

Until adequate systems are fully operational, the implementation of pricing instruments and other regulatory measures must proceed cautiously to avoid undermining trust and effectiveness.

Unlocking the agri-food system's transition potential will take time.

The agri-food system is characterised by long investment cycles and deep entrenchment in existing practices. A sudden shift to a stringent regulatory environment, particularly one involving financial penalties for climate-harmful activities, could impose significant adjustment costs on farmers and food producers. A gradual implementation allows stakeholders time to revise investment plans, adopt new technologies and explore emerging business models aligned with climate objectives. At least four factors emphasise this perspective.

- **Generational renewal** within the farming community is a critical factor. Younger farmers may be more inclined to adopt innovative practices and technologies, but such transitions take time and require supportive policy environments.
- **Development and diffusion of technological solutions**, such as precision agriculture, methane-reducing feed additives or low-emission machinery, is a gradual process. The development of such solutions and the incentives to deploy them must go hand in hand.
- **Ecological restoration** measures aiming to increase the resilience of soils and water systems such as agroforestry and regenerative agriculture involve long maturation processes.
- **Consumer demand** plays a role in shaping the feasibility of climate-friendly transitions, and shifts in dietary preferences, willingness to pay for sustainable products and awareness of environmental impacts are gradual processes. Abrupt policy changes risk creating supply-demand mismatches, leading to price volatility, food insecurity or financial distress within the sector. A phased approach helps mitigate these risks by allowing time for markets and consumers to adjust.

A gradual implementation leaves room for policy learning and iterative improvements.

Climate policy in the agri-food system is still in its formative stages and many instruments, particularly those involving GHG pricing, are novel or untested at scale in agriculture. A gradual rollout enables policymakers to monitor outcomes, identify unintended consequences, understand interactions between the components of the policy mix and refine instruments accordingly. This iterative process of policy learning is essential to avoid ‘childhood diseases’ of new regulatory frameworks, such as administrative overload, loopholes or perverse incentives.

Staged implementation timelines and transitional support schemes can serve as valuable tools for generating empirical evidence and stakeholder feedback. Such mechanisms not only improve policy design but also enhance legitimacy and buy-in from affected communities. In this context, gradualism is not a sign of hesitation but a strategic choice to ensure that policies are both effective and socially acceptable.

The Advisory Board recommends that the EU should start preparing the policy mix now and implement it in a gradual, adaptive way that fosters learning and improvement.

To reconcile urgency and feasibility, it is important to start now but to deploy the policy mix in a gradual, adaptive way. This gives the sector time to adjust, and policymakers time to monitor outcomes, identify unintended consequences and refine the policy mix accordingly.

Chapter 6

Avoiding climate-harmful subsidies

Key messages

Current CAP direct payments can be considered as climate-harmful.

Direct payments under the current CAP, both decoupled and coupled income support, undermine the EU's climate objectives in a way similar to energy subsidies.

- Just as general energy subsidies unintentionally encourage higher energy use, decoupled payments generally encourage agriculture over other land uses, resulting in higher GHG emissions within the EU compared with a baseline with no such payments.
- Coupled payments for livestock and decoupled payments for degraded peatlands are particularly harmful as they actively promote the most GHG-intensive forms of agriculture, making them comparable to fossil fuel subsidies.

Different reform options can support the EU climate objectives, but with potential trade-offs on other policy objectives.

Simply phasing out direct payments could already contribute to EU climate objectives, especially if the budget is reallocated towards incentives for climate action. However, this comes with a substantial risk of carbon leakage, adverse socio-economic impacts and unintended environmental impacts. A more targeted reform of direct payments could reduce these risks but still requires a balancing between climate, other environmental and socio-economic objectives.

The Advisory Board recommends a gradual reform of CAP direct payments.

Given the urgent need to enhance climate action in agriculture while managing the risks of unintended consequences, the Advisory Board makes the following recommendations for the EU.

- **Phase-out coupled payments for livestock** and **decoupled payments for degraded peatlands** over the next CAP period (2028–2034), given the urgency to reduce GHG emissions from the sector. This should be embedded in a broader approach that reduces the risks of unintended social and environmental consequences and helps the affected stakeholders in their transition.
- **Consider alternatives for all direct payments**, with a view to eventually replace them with other forms of income support that do not conflict with the EU climate objectives, while also contributing to the EU's environmental and socio-economic objectives.

6.1 Introduction

This chapter focuses on the parts of the CAP that may drive GHG emissions.

Chapter 5 noted that one of the main issues with the current CAP is that it provides direct coupled and decoupled payments to GHG-intensive farming systems. Section 5.3 concluded that CAP payments should not actively obstruct the transition away from emission-intensive practices in agriculture, to align with the EU climate objectives and ensure consistency with the recommended GHG pricing instrument (see Chapter 7).

This chapter explores to what extent CAP direct payments can be considered as climate-harmful, and how they can be reformed to be aligned with the EU's climate priorities. To this end, it is structured as follows.

- **Section 6.2** assesses to what extent current CAP direct payments could be considered as climate-harmful.
- **Section 6.3** examines the far-reaching policy option of replacing all direct payments to farmers by alternative forms of income support, such as support schemes that more directly target the provision of public goods.
- **Section 6.4** assesses the phase-out or reform of only the most climate-harmful subsidies, namely coupled payments for livestock and decoupled payments for degraded peatlands.
- **Section 6.5** concludes with a recommendation for a phased reform of direct payments, taking into account potential adverse environmental and socio-economic impacts.

6.2 Identifying climate-harmful CAP direct payments

The climate impact of energy subsidies can serve as an analogue for the assessment of CAP direct payments.

To establish to what extent CAP direct payments could be considered as harmful for the climate, it is illustrative to begin with a comparison with energy subsidies. Like CAP direct payments, such subsidies aim to serve socio-economic objectives, but it is widely recognised that they increase GHG emissions (World Bank, 2023).

Overall, a distinction could be made between two types of energy subsidies, which both have counterparts in agriculture.

- **General energy subsidies**, which aim to lower energy costs regardless of the energy source, for example by lowering value added tax (VAT) rates on energy products or providing energy vouchers to vulnerable households. As such measures may inadvertently weaken incentives to reduce energy consumption, the Advisory Board has previously recommended to consider alternative measures such as direct lump-sum transfers to vulnerable households (Advisory Board, 2023).
- **Fossil fuel subsidies** that directly support the use of fossil fuels and which are particularly climate-harmful as they actively counteract the achievement of the EU climate targets by supporting GHG-intensive activities (thus encouraging pollution), hindering a reorientation of private funding towards less GHG-intensive activities and practices, and reducing the public budget available for supporting the climate transition (Advisory Board, 2024). They also hinder economic growth by promoting a sub-optimal allocation of resources and are often insufficiently targeted at the most vulnerable households (IMF, 2025).

In analogy with energy subsidies, CAP direct payments may be considered climate-harmful.

In the agricultural sector, direct payments constitute the primary form of income support under the CAP (see Section 5.2.1 for a brief explanation of how the CAP works). These include untargeted decoupled per-hectare payments and coupled payments linked to specific production activities. While eco-schemes are also formally part of the direct payment's architecture, they are excluded from consideration in this chapter.

Drawing an analogy to the two types of energy subsidies listed above, a distinction could be made between the following.

- **Decoupled payments** overall resemble general energy subsidies in that they broadly incentivise agricultural activity regardless of the specific type of activity. Given that most agricultural practices inherently cause GHG emissions, such payments may be considered climate-harmful as they promote land uses in the EU that are more emission-intensive than alternatives such as forestry or unmanaged nature.[21] This would also be in line with the OECD definition of environmentally harmful subsidies namely 'any subsidy that leads to higher levels of waste and emissions … than what would be the case without the support measure' (OECD, 2005). As discussed in Section 6.3, several modelling studies have shown that EU agricultural GHG emissions would be lower in the absence of decoupled payments.

[21] The current CAP does allow for continuing decoupled payments when agricultural land is afforested or set aside for nature restoration, but only for a limited period.

- **Coupled payments for livestock and decoupled payments for degraded peatlands** specifically support the most GHG-intensive agricultural activities and could therefore be compared with fossil fuel subsidies. Coupled payments for livestock are provided in addition to decoupled payments, thus increasing the subsidy level for livestock production compared with other agricultural activities. Decoupled payments for degraded peatlands promote continued drainage, as rewetted areas are not always eligible for such payments (see Box 9).

Incorporating carbon leakage considerations complicates the assessment of phasing out climate-harmful subsidies.

Discussions on the climate impact of subsidies frequently focus exclusively on intra-EU emissions. However, a comprehensive evaluation requires accounting for global effects, including potential shifts in production and associated emissions to other regions. Since the CAP incentivises agricultural production within the EU, the removal of subsidies could induce carbon leakage, thereby partially offsetting domestic emission reductions. This issue is further considered when exploring different options in Sections 6.3 and 6.4.

6.3 Replacing all direct payments

While direct payments aim to serve the core objectives of the CAP, they risk undermining other EU priorities.

As outlined in Section 5.2.1, a primary objective of direct payments is to support the income of agricultural producers across the EU. But as discussed in more detail in Section 5.2.2 its ability to deliver on this objective has been criticised. The bulk of decoupled payments is currently going to the farms which generate high incomes on their own such as large farms and farms in productive regions, thereby exacerbating rather than reducing income inequality within the sector. Furthermore, at least some part of the decoupled payments is leaked outside the sector through capitalisation into land prices and other inputs, instead of supporting farming incomes.

Additionally, it could be argued that direct payments are needed to assure the availability of supplies and to ensure that these supplies reach consumers at reasonable prices, in line with the formal objectives of the CAP (EU, 2012). However, these objectives could potentially be met in more targeted ways, for example by directly supporting vulnerable consumers.

Together with the potentially climate-harmful impact of direct payments as discussed in Section 6.2, these considerations warrant a critical examination of alternative approaches that could better deliver on socio-economic, environmental and climate objectives, such as directing support towards activities that generate broader societal benefits.

Direct payments could be replaced by more targeted payments, including rewards for climate action and the provision of public goods.

In response to considerations about the effectiveness of the CAP, both academic researchers (Chatellier and Guyomard, 2023; Pe'er et al., 2019; Grethe and Chemnitz, 2023) and environmental think tanks (IEEP, 2025c) have recommended transforming the current direct payments (decoupled and coupled) under the CAP into more targeted payments that support climate and environmental action and the provision of public goods.

In practice, such a transformation of income support could be achieved by phasing out direct payments and reallocating the freed-up budget to other CAP instruments which are more suited to deliver such outcomes, such as incentive schemes for climate and environmental action. Payments from these instruments could also support agricultural incomes, provided they exceed costs incurred and income foregone (see Section 8.5).

Such a shift can be done gradually over time, to smoothen the transition and to give the agricultural sector adequate time to adapt (Chatellier and Guyomard, 2023), as currently done in England (see Box 14). The most straightforward way to achieve this is by setting a maximum payment rate (per hectare or per head, in case of coupled payments for livestock), and to then decrease this maximum payment rate over time.

Box 14 From income support to rewarding public goods under the England Agriculture Act

Following Brexit, the four countries of the United Kingdom have developed alternatives for the CAP (IEEP, 2023). In England, this resulted in the adoption of the Agriculture Act in 2023. One of the core differences compared with the CAP was the shift of the policy's main objectives towards the provision of public goods (together with supporting agricultural productivity).

To pursue this objective, direct income payments in England will be phased out over a seven-year period (2021–2027) with the freed-up budget directed into new 'Environmental Land Management' schemes and grants available to both farmers and other land managers.

These new schemes are organised across three tiers.

- The Sustainable Farming Incentive will support practices that improve the environmental sustainability of farming while maintaining and supporting farm productivity (e.g. actions to improve soil health). They are intended for large-scale take-up and provide relatively modest rewards for modest requirements.
- The Countryside Stewardship scheme provides higher rewards for more targeted farming practices relating to specific locations, environmental features and habitats.
- The Landscape Recovery Scheme supports the delivery of landscapes and ecosystem recovery through long-term, land use change projects, involving groups of several farmers.

These schemes are accompanied by capital grants and specific aid schemes to improve productivity, provide grants for innovation and R&D, provide business support in early stages of transition and support animal welfare measures.

The removal or reorientation of CAP direct payments can provide climate benefits, but at a substantial risk of carbon leakage.

The assessment in the remainder of this section is based on a set of modelling exercises which used different assumptions to explore the impact of reducing or reallocating direct payments under the CAP (see Table 14). Removing or reorienting direct payments is likely to have an impact on GHG emissions and removals both within agriculture and the broader EU agri-food system; however, the scenarios considered for the assessment only provide data for the impact on agricultural non-CO_2 emissions, although their results on land use changes could provide some indication of the implications for land-based agricultural CO_2 emissions.

Simply phasing out CAP direct payments, as in the 'No direct payments' scenario, could deliver only modest reductions in agricultural non-CO_2 emissions (–2.5%), mainly driven by lowered agricultural production (livestock production in particular), and they come with a substantial degree of carbon leakage.

The domestic mitigation benefit could be increased substantially if direct payments are replaced by more targeted payments for GHG reductions, which would also reduce the leakage rate. For example, the 'GHG subsidy' scenario finds substantial emission reductions (–22%), of which 60% would be driven by changes in the production mix and the other 40% delivered through technology effects. As overall production levels would decrease relatively less, the leakage rate would be limited to 20%.

However, the effects critically depend on how the freed-up funds are reoriented. Under the 'Env&Clim' scenario, GHG reductions would be very limited (–1.7%) and mainly driven by production decreases. The limited GHG reductions are due to the scenario reorienting the freed-up budget towards a broad set of environmental incentives and payments for marginal areas, which results in extensification and associated productivity losses. The reduced productivity results in a high leakage rate, as production declines but without a proportional decline in the underlying input factors and associated emissions. In effect, CAP reallocations that do not have a specific climate focus risk delivering only modest domestic emission reductions and even increasing global emissions, although such reforms may be beneficial for other objectives.

Table 14 Modelled impact of reforming CAP direct payments on non-CO_2 emissions

Scenario description	EU *Mt CO_2e (%)*	Non-EU *Mt CO_2e*	Carbon leakage *non-EU / –EU*
No direct payments (Brady et al., 2017) Both coupled and decoupled payments are phased out by 2025, no reallocation towards other CAP instruments.	–9.9 *(–2.5%)*	+4.8	48%
GHG subsidy (Himics et al., 2020) Decoupled payments are replaced by a GHG reduction subsidy (the assessment in this report is based on the variant with a harmonised reduction subsidy across the EU). Coupled payments are maintained.	–95 *(–22%)*	+18	20%
Env&Clim (JRC, 2025b) The bulk of decoupled payments (Basic Income Support for Sustainability) are reduced by 80% and capped at EUR 100 000 per farm and coupled income support is fully phased out. The freed-up budget is reinvested into eco-schemes, AECMs, risk management tools, decoupled payments for young farmers and for areas with natural constraints.	–6.4 *(–1.7%)*	+16.4	256%

Sources: See table.

Notes: (1) The scenarios are all compared with a reference scenario where direct payments are maintained. (2) Brady et al. (2017) model results for 2025, Himics et al. (2020) for 2030 and JRC (2025b) for 2040. (3) The geographical scope is EU27+UK for Brady et al. (2017) and Himics et al. (2020) while EU27 for JRC (2025b). (4) All scenarios kept consumer preferences constant and assumed an unchanged trade regime: in particular, no scenario investigated the introduction of border adjustment mechanisms (see also Chapter 11).

A phase-out of CAP direct payments could lead to both positive and negative environmental impacts.

A complete phase-out of direct payments without the reallocation of budget towards other forms of income support would overall reduce agricultural production, which could ease other environmental pressures than climate. The 'No direct payments' scenario shows a limited decrease in nitrogen surplus (–2.4%) due to lower production levels, while the effect in the 'GHG subsidy' scenario is more substantial (–27%), as this scenario incentivises lower fertiliser application.

Nevertheless, the absence of direct payments or alternative forms of income support risks leading to several unintended negative environmental impacts.

- **Increased production intensification.** Brady et al. (2017) argue that under the 'No direct payments' scenario, the absence of direct payments could raise output prices more than input prices, and as a result, farmers would increase their input use with related negative environmental impacts.
- **Land abandonment in marginal areas.** In the absence of direct payments, agriculture may become economically unviable in less productive regions. Whereas this could create opportunities for nature restoration, it might also result in a loss of grasslands with associated risks for biodiversity, carbon sequestration and wildfires, and undermine rural development (IEEP, 2025c; Brady et al., 2017; DG AGRI, 2020; EASAC, 2025).

A more holistic approach that supports broader environmental action, young farmers and less-productive regions, as assumed in the 'Env&Clim' scenario, would avoid some of the unintended consequences discussed above. Overall, it would result in a decrease in farm input intensity and an increase in crop diversity. Similarly, IEEP (2025c) has suggested a set of measures to address potential adverse impacts of phasing out direct payments, including more targeted income support for those farmers in need, attractive and result-focused environmental schemes and demand-side changes to reduce the risk of carbon leakage.

The phase-out of CAP direct payments would free up land and reduce agricultural land prices.

Phasing out direct payments is expected to reduce overall agricultural land use, which provides opportunities to repurpose the land for carbon sequestration or nature restoration (Wilde, 2025). The modelled decrease in the UAA in the EU ranges from –0.2% (Env&Clim) to –5.6% (GHG subsidy) and –6.5% (No direct payments).

A shift from default per-hectare payments to more targeted payments for public goods would also lower land prices, as it would substantially reduce the capitalisation of subsidies into these land prices (Baldoni and Ciaian, 2023). As such, the modelled CAP reforms would significantly reallocate values within the agricultural sector.

The impact on farmers' livelihoods would depend on how the freed-up budget is used.

As discussed in Section 5.2.1, direct CAP payments contribute substantially to agricultural incomes. Withdrawing these payments thus raises concerns about farmers' livelihoods, and their capacity to invest in more sustainable practices (IEEP, 2025c). However, the impact is not straightforward and depends on if and how the freed-up budget is reallocated.

- **A phase-out of direct payments** would result in a net decrease in agricultural incomes. Under the 'No direct payments' scenario, the phase-out of direct payments without reallocation would decrease agricultural incomes by 21%, as increased producer prices only partially compensate for the loss in direct payments.
- **A reorientation of direct payments** could result in a net increase in agricultural incomes. Under the 'GHG subsidy scenario', agricultural incomes would increase by 6.7%,[22] as the combined effect of climate mitigation subsidies and higher producer prices would outweigh the loss of direct payments.

All scenarios show that impacts would be highly heterogeneous, creating both winners and losers. Brady et al. (2017) found that simply removing direct payments would benefit more productive regions and subsectors less reliant on subsidies, while negatively affecting farmers in less-productive

[22] Assuming a uniform EU reduction subsidy. The increase would only be +5.6% in case of fixed regional budgets.

areas. Similarly, the 'Env&Clim' scenario sees the most negative impact on subsectors that are most reliant on CAP direct payments (specialist crops and specialist cattle) and less severe impacts on subsectors which are least reliant on those subsidies (horticulture, granivores, dairy). Under the 'Env&Clim' scenario, these subsectors might even see a limited net increase in incomes.

Across scenarios, food production would decrease and food prices increase.

Phasing out income support would lead to an overall reduction in agricultural output and increase in prices, although the size of the decrease varies across scenarios and food product types, as shown in Table 15. Overall, the magnitude of the impact is closely linked to the different subsectors' dependencies on direct payments (measured as the share of direct payments in their total income). The impact would be highest for beef production, where production would decrease by 5–10% compared with the baseline, and producer prices could increase by up to 30%. For other subsectors, including other livestock systems, the impact would be more limited with production decreases in most cases limited to less than 5%, and the increase in producer prices limited to between 4% and 10%.

Table 15 Impact on production volumes and producer prices under different scenarios

	No direct payments (Brady et al., 2017)		**GHG subsidy** (Himics et al., 2020)		**Env&Clim** (JRC, 2025b)	
	Production	Price	Production	Price	Production	Price
Dairy	–1%	*n.a.*	–2%	+10%	–2%	+5%
Beef	–5%	*n.a.*	–9%	+30%	–10%	+15%
Pig	–0.2%	*n.a.*	–3%	+9%	–5%	+7%
Poultry	–0.3%	*n.a.*	< –1%	+5%	–3%	+6%
Cereals	*n.a.*	*n.a.*	–8%	+6%	–2%	+4%
Oilseeds	*n.a.*	*n.a.*	–5%	+7%	–3%	+4%
Fruits and vegetables	*n.a.*	*n.a.*	*n.a.*	*n.a.*	–4%	+4%

Sources: See table.

6.4 Reforming the most climate-harmful payments

Reforming the most climate-harmful direct payments can contribute directly to the EU objectives on climate mitigation and adaptation.

Whereas a complete reform of all direct payments under the CAP would fundamentally realign the agricultural sector in the EU, there are less far-reaching options that target only the most climate-harmful payments, namely coupled payments for livestock and decoupled payments for degraded peatlands.

Addressing these payments would not only contribute to mitigation but could also contribute to climate adaptation. As discussed in Chapter 4, a certain reduction in livestock production can contribute substantially to climate adaptation, as plant-rich food systems generally exert lower pressures on water and land resources, increase resilience in the food supply chain and can better support diversified agricultural systems that are better suited to changing climate conditions (see Section 3.3). Similarly, rewetting peatlands can contribute to climate adaptation by serving as a 'sponge' to enhance water retention and mitigate flood risk.

6.4.1 Coupled payments for livestock

Coupled income support under the CAP disproportionately targets livestock production, raising concerns about its alignment with climate policy objectives.

Coupled income support is a CAP instrument which is currently voluntary for Member States to apply, and designed to enhance competitiveness, sustainability, or quality in specific sectors and productions deemed socially, economically, or environmentally significant, yet facing particular challenges. These payments are directly linked to specific outputs, thereby creating targeted incentives.

At the EU level, coupled income support is predominantly directed towards the livestock sector, which receives approximately 70% of the total coupled support budget (EC, 2022). According to the Member States strategic plans, 95% of all coupled support for livestock is provided for ruminants (JRC, 2023c).

This substantial allocation underscores the non-neutral nature of coupled support, in contrast to decoupled hectare-based payments. By disproportionately incentivising GHG-intensive practices, the coupled support actively obstructs the transition towards less GHG-intensive production systems and counteracts the objectives of a GHG pricing mechanism (see Chapter 7).

Phasing out coupled payments for livestock would likely reduce GHG emissions through lowered beef production, with risks of carbon leakage.

While the removal of coupled income support could be expected to reduce GHG-intensive livestock production, the evidence in the literature is limited. In the most relevant study, Jansson et al. (2021) modelled a phase-out of coupled payments for livestock under the CAP, while the released budget was allocated to decoupled payments.

Jansson et al. (2021) found a reduction of overall GHG emissions in the EU of 2.35 Mt CO_2e (–0.5% compared with the reference scenario). This reduction would almost entirely be achieved in the beef subsector (–2 Mt CO_2e), where production decreases by –1.1%, and to a lesser extent dairy subsector (–0.3 Mt CO_2e), reflecting both subsectors' respective reliance on coupled direct payments. Emissions from other agricultural subsectors – including pig and poultry – would increase marginally as consumers shift from beef and dairy to other agricultural products.

The carbon leakage rate in the study is high (75%), which is largely driven by higher emission intensities in the non-EU countries where parts of the lost EU production is reallocated. The authors stress, however, that this leakage estimate is highly dependent on assumptions about price elasticities and emission intensities and should thus be considered with caution.

A phase-out creates other, non-climate-related challenges which need to be managed.

Whereas phasing out coupled income support for livestock under the CAP could deliver benefits for climate objectives, it would also create several challenges, as outlined below.

- **Farmers' livelihoods.** The impact of phasing out coupled income support on livestock farmer incomes differs across the sector and depends on how the freed-up budget is used. The least economically efficient farms would be most adversely affected, and some of them would no longer be economically viable and thus forced to cease operations. However, the overall decrease in production would also result in higher producer prices, thereby having an upward impact on incomes of the rest of the sector. If the freed-up budget is reinvested in the agricultural sector, the net impact on average farmer incomes could even become positive. To illustrate, the simulation in Jansson et al. (2021), where the freed-up budget from coupled payments is reinvested in the overall decoupled payments, would result in a 2.4% increase in producer prices for beef, and total agricultural incomes would increase by EUR 1.4 billion per year.
- **Environmental risks.** The least economically efficient livestock systems are often extensive systems with high biodiversity benefits in low-productive regions which are less favourable for agricultural production (e.g. mountainous regions). Removing coupled income support from these farms could lead to production intensification and land abandonment, with potential adverse environmental impacts, as already discussed in Section 6.2. A particular risk relating to a decrease in grazing systems is the conversion of grasslands into croplands, which would increase land-based agricultural CO_2 emissions and reduce biodiversity.

To avoid such unintended consequences, coupled payments for livestock could be replaced by appropriate rewards for the provision of ecosystem services (carbon sequestration, wildfire prevention and biodiversity conservation). This would provide a more technology-neutral approach that pursues the desired outcomes, which alternatively could be delivered by other land uses and farming systems that are less GHG-intensive than livestock production (IEEP, 2025c). An additional measure to prevent the intensification or conversion of grasslands is through the CAP conditionality framework or through a GHG pricing instrument targeting land-based agricultural CO_2 emissions (see Section 7.5).

The European Commission's proposal for the next CAP maintains, and even allows for an increase in, coupled payments for livestock production.

The European Commission's proposal for the CAP covering the 2028–2034 period, as published in July 2025 (EC, 2025q) makes coupled payments a mandatory intervention for Member States and allows them to spend up to 20% of their income-support envelope to such payments, which is an increase from the 13% limit under the current CAP.[23] This would allow Member States not only to continue but even to increase coupled payments for livestock production. The proposal furthermore requires Member States to support the extensification of the livestock sector, which can be beneficial for other environmental objectives but risks increasing the GHG intensity (measured as emissions per unit of output) of the livestock sector.

6.4.2 Decoupled payments for degraded peatlands

Rewetting agricultural peatlands could unlock substantial emission reductions and deliver other public goods.

As discussed in Chapter 2, degraded agricultural peatlands constitute approximately 2% of the EU's agricultural land area yet are responsible for an estimated 75 Mt CO_2e which is equivalent to 20% of total agricultural emissions. This means that repurposing a minor share of EU agricultural land can deliver substantial mitigation benefits: a recent assessment by the JRC (JRC, 2025a) estimates that the maximum fallowing of degraded peatlands on both agricultural and non-agricultural land could deliver up to 95 Mt CO_2e in emission reductions across the EU.

While restoring degraded agricultural peatlands would decrease agricultural production, the impact would likely be limited given the relatively small land area concerned. Furthermore, restored peatlands could continue to be used for agricultural activity in the form of paludiculture (Wichmann and Nordt, 2024), or for nature restoration purposes. As such, they would offer alternative services by supplying paludiculture products and enhancing biodiversity and nature conservation values, while also contributing to climate resilience by serving as a 'sponge' at the water basin scale.

Decoupled payments for degraded peatlands could be reformed in different ways.

The high concentration of GHG emissions from degraded peatlands suggests that even a limited and strategically targeted reform of certain decoupled payments – namely those given to degraded peatlands – could yield significant emission reductions.

As discussed in Section 5.2.2, the main issue with current decoupled payments for degraded peatlands is that they can actively discourage restoration, as for example not all forms of paludiculture continue to be eligible for direct payments. To address this, two main reform options could be considered.

- **Maintaining decoupled payments for restored peatlands.** Under this option, peatlands that are restored would by default continue to be eligible for decoupled payments, regardless of whether they are thereafter used for paludiculture, or whether the restoration occurred as part of a CAP incentive scheme or equivalent national measure.
- **Phasing out decoupled payments for degraded peatlands.** Under this option, decoupled payments for degraded peatlands would be phased out altogether.

Whereas the two options above would neutralise the incentive for continued drainage, they would not actively incentivise the restoration of peatlands. Achieving this would require additional incentives, such as current CAP eco-schemes and AECMs or a GHG pricing instrument (see Section 7.5). Alternatively, a combination of both options above – namely phasing out decoupled payments

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[23] With an additional 5% to support protein crops, mixed farms or agricultural areas at risk of abandonment of agricultural production.

for degraded peatlands but maintaining them for restored peatlands – could provide a strong incentive for restoration.

The reform options remain relevant, even with the introduction of a GHG pricing instrument.

Section 7.6 recommends introducing GHG pricing for emissions from restored peatlands as soon as the necessary underlying MRV system is in place. This raises the question: to what extent would the reform options discussed above still be necessary? Here, two elements need to be considered.

- **Complementing GHG pricing.** Even if all agricultural GHG emissions are covered by the same GHG price, the current unequal treatment of degraded versus restored peatlands under the CAP would actively work against that price signal, thus lowering the marginal incentive to restore peatlands compared with other mitigation options. This is hard to justify given the high GHG intensity of degraded peatlands. Therefore, even with a well-functioning GHG pricing system in place, there is a strong case for either of the two reform options above to at least ensure an on-par treatment of degraded and restored peatlands.
- **Timing.** As discussed in Section 7.6, the establishment of a comprehensive and effective GHG pricing framework may take considerable time. A reform of decoupled payments for degraded peatlands could serve as a more readily available solution to incentivise their restoration, which could already deliver substantial mitigation outcomes in the short term.

These two elements support the case for reforming decoupled payments for degraded peatlands, even if their related GHG emissions would eventually be covered by a GHG pricing instrument.

Both reform options have their respective advantages and disadvantages.

Considering the recommendation to eventually include all land-based GHG emissions under the same GHG pricing (see Chapter 7), both reform options introduced above have their respective advantages and disadvantages.

- **Maintaining payments for restored peatlands** would best ensure an equal level playing field between different soil types and land uses. Under such an approach, the CAP would provide a uniform, non-discriminatory per-hectare support for mineral soils and degraded and restored peatlands, whereas a uniform GHG price would ensure consistent mitigation incentives across different soil categories. The main downside is that it would require higher levels of public funding and rely on other instruments to provide an active incentive for peatland restoration.
- **Phasing out decoupled payments for degraded peatlands** would reduce the need for public budget and avoid public spending on very GHG-intensive practices, while at least neutralising the effect of the CAP on degraded peatlands. The freed-up budget could then be reoriented to reward schemes for peatland restoration (e.g. via eco-schemes), which could drive early action pending the introduction of a GHG pricing scheme. Its main disadvantage is that once a GHG pricing instrument is implemented, there would be a stronger marginal incentive for peatland restoration compared with other mitigation options, which could result in cost-ineffective outcomes.

6.5 A gradual reform of direct payments

The EU should thoroughly consider alternatives to current direct payments, with the long-term aim of providing income support that is better aligned with EU climate objectives.

As discussed in Section 6.2, all current direct payments could to some extent be considered as climate-harmful, as they incentivise agriculture over other land uses and result in higher GHG emissions within the EU, compared with a baseline where such payments are not provided. However, as discussed in Section 6.3, simply phasing out these payments risks leading to several, unintended consequences, including carbon leakage, a reduction in agricultural incomes and potential adverse environmental consequences in certain regions. These consequences could at least be reduced by using the freed-up budget for other purposes, such as supporting climate mitigation or other environmental objectives. However, the available evidence suggests that such repurposing would need to be considered carefully, as a sole focus on either GHG reductions or other environmental objectives could result in trade-offs between the two. In any case, a reform of direct payments would constitute a significant shift for the agricultural sector. As such, any reform in this area merits thorough analysis and careful planning, and a phased implementation to give time for the sector to adjust and for policy makers to take corrective action along the way.

The Advisory Board therefore recommends that the EU thoroughly consider alternatives for all current direct payments, with the long-term ambition to replace them with alternative forms of income support that are better aligned with the EU climate objectives, while also contributing to the EU's environmental and socio-economic objectives. To this end, several options could be considered, including more targeted payments for ecosystem services (including those that contribute to climate adaptation and carbon sequestration) and the use of alternative criteria as a basis for decoupled payments (Frascarelli et al., 2025).

The most climate-harmful direct payments should already be phased out over the next CAP period (2028–2034), embedded in a broader approach to help affected stakeholders transition.

As discussed in Section 6.2, coupled payments for livestock production and decoupled payments for degraded peatlands can be considered as particularly climate-harmful, comparable to fossil fuel subsidies. As discussed in Section 6.4, phasing out these payments could contribute directly to climate mitigation, while also enhancing the EU's climate resilience. However, as with direct payments in general, such a phase-out could lead to unintended environmental and socio-economic outcomes, particularly in peatland-rich regions or regions where livestock accounts for a substantial proportion of the local economy. Furthermore, transitioning away from these GHG-intensive forms of agriculture would require tackling both financial and non-financial barriers (see Chapter 8). For example, Wichmann and Nordt (2024) identified a range of political, legal, economic, ecological and social aspects that hinder the implementation of peatland restoration, which would all need to be addressed. Similarly, Sommer et al. (2024) have argued that the restoration of peatlands should be considered as a socio-technological transition similar to the German coal phase-out, and thus merits a comparable, comprehensive policy approach. A similar conclusion could be drawn for a decrease in livestock production in regions where this activity plays an important role in the local economy.

Given the urgency to enhance climate action in the agri-food system, the Advisory Board recommends that coupled payments for livestock and decoupled payments for degraded peatlands are already phased out gradually over the next CAP period (2028–2034). These reforms should be embedded in a broader approach that reduces the risks of unintended consequences and helps the affected stakeholders in their transition (see Chapter 8). This includes demand-side food policies (see

Chapter 10) and trade policies (see Chapter 11) to reduce the risk of carbon leakage. Specific options to consider for supporting affected stakeholders include replacing coupled payments by appropriate rewards for public goods provided by extensive livestock systems, providing appropriate rewards for restored peatlands (e.g. continued decoupled payments for paludiculture) and enhancing support for rural development.

Meanwhile, direct payments could remain subject to minimum requirements on climate mitigation pending the implementation of a GHG pricing instrument.

In the interim, as long as direct payments remain in place, it is essential to implement safeguards to prevent these payments from inadvertently supporting GHG-intensive agricultural practices. This could be done through a GHG pricing instrument that internalises the costs of GHG emissions and the benefits of carbon dioxide removals. However, as discussed in Chapter 7, it is unlikely that such a pricing mechanism would encompass all emission sources with a sufficiently high GHG price from the onset. Therefore, as long as direct payments remain in place, emission sources that are not yet covered by a GHG pricing instrument could be kept subject to minimum requirements for climate mitigation.

Chapter 7

Pricing of greenhouse gas emissions in agriculture

Key messages

Designing a GHG pricing scheme for agriculture requires addressing multiple concerns.

GHG pricing is a cost-effective way of reducing emissions in the agri-food system while generating public revenues and opening up market opportunities for farmers engaging in carbon farming activities. Still, any pricing scheme would face practical and distributional challenges. Consequently, when designing a scheme, it is necessary to seek an appropriate balance among cost-effectiveness, administrative feasibility and equity, along with global climate impact and environmental integrity.

The pricing schemes should include mandatory obligations that stimulate both technical improvements and structural changes throughout the agri-food value chain.

Mandatory compliance obligations are essential to ensure the pricing instrument's effectiveness. Where to assign the points of obligation in the value chain should be carefully considered, as it influences the system's scope, administrative feasibility and the nature of climate mitigation actions incentivised. The main options investigated in this chapter include targeting farmers, a combination of fertiliser suppliers, dairies and slaughterhouses, and retailers. Irrespective of the chosen point of obligation, it is essential that the pricing instrument incorporates mechanisms that support both technical advancements at the farm level and broader structural shifts throughout the agricultural value chain.

The Advisory Board recommends that the pricing framework begins with a pilot phase and subsequently evolves gradually into a more comprehensive system.

Due to the novelty and complexity of applying GHG pricing in the agri-food system, the EU should start by testing MRV and establishing emission baselines before implementing a pilot phase that enables learning and provides insights to guide subsequent phases. Over time, the pilot phase should evolve towards a comprehensive system on three dimensions.

- **Separate schemes.** Given the distinct characteristics of various sources of agricultural emissions, they should initially be regulated through separate trading systems to avoid unintended and unwanted effects. Energy-related emissions could be integrated into the existing pricing frameworks covering fossil fuels. In addition, two new systems should be developed: one for agricultural non-CO_2 emissions mainly from fertiliser application and livestock production, and one covering land-based CO_2 fluxes. The integration of these systems should be pursued as a long-term goal.
- **Allowance allocation.** During the pilot phase, emission allowances should be allocated free of charge to alleviate the initial financial impact on the agricultural sector. However, this approach should gradually shift towards auctioning, in alignment with the polluter pays principle, while maintaining rewards for removals. This could also generate substantial auctioning revenues that could potentially be reinvested in the sector.
- **Coverage thresholds.** The pilot phase should only cover large entities to reduce administrative complexity. Over time, inclusion thresholds should be lowered to expand coverage.

7.1 Introduction

This chapter investigates options to price GHG emissions and reward removals.

Chapter 5 made the case for a framework for pricing greenhouse gas (GHG) emissions and rewarding removals in agriculture. To facilitate a cost-effective transition of the agri-food system towards climate sustainability, it is essential to establish a pricing signal that compels the sector to internalise the societal costs associated with its GHG emissions. Thus, Chapter 5 concluded that a flagship mitigation policy in agriculture based on a price on agricultural emissions should be part of the policy mix.

This chapter explores various options for such a pricing mechanism, including their benefits and challenges. To this end, it is structured as follows.

- **Section 7.2** provides a general overview of potential pricing options and variations, what CAP reforms could aim to achieve and the main areas in which those reforms could take place.
- **Section 7.3** identifies the most cost-effective pricing scheme that also aligns with key legal principles in the EU but also highlights major challenges arising from such an approach, along with strategies to mitigate these challenges.
- **Section 7.4** presents three pragmatic variations of an emissions trading system targeting non-CO_2 emissions, mainly from livestock and fertiliser use, that address key complexities.
- **Section 7.5** explores pricing options for land-based agricultural CO_2 emissions and removals.
- **Section 7.6** discusses key MRV requirements needed to support GHG pricing in agriculture.
- **Section 7.7** outlines the Advisory Board's recommendations for a phased implementation of GHG pricing in agriculture to foster policy learning and give stakeholders time to adapt.

7.2 Overview of pricing options

Agricultural emissions come mainly from four sources, which can all be addressed by pricing mechanisms.

This chapter examines how a policy framework can effectively encompass the sources of agricultural emissions by assigning a monetary value to each tonne of CO_2e emitted. These sources and their 2023-values are shown in Table 16.

Table 16 GHG emissions from various agricultural sources

Mt CO_2e (2023)	CRT code	CO_2	CH_4	N_2O	Total
Emissions from fossil fuel combustion					
Agriculture/forestry/fishing	1.A.4.c.	69.8	2.0	3.1	74.9
Agricultural non-CO_2 emissions					
Enteric fermentation	3.A.	0.0	179.5	0.0	179.5
Manure management	3.B.	0.0	44.9	17.6	62.6
Rice cultivation	3.C.	0.0	2.3	0.0	2.3
Agricultural soils	3.D.	0.0	0.0	108.9	108.9
Prescribed burning of savannahs	3.E.	0.0	0.0	0.0	0.0
Field burning of agricultural residues	3.F.	0.0	0.6	0.2	0.8
Liming	3.G.	5.2	0.0	0.0	5.2
Urea application	3.H.	3.5	0.0	0.0	3.5
Other carbon-containing fertilisers	3.I.	0.6	0.0	0.0	0.6
Other	3.J.	0.0	1.5	0.1	1.6
Land-based agricultural emissions and removals					
Cropland	4.B.	31.8	1.3	1.4	34.4
Grassland	4.C.	8.6	3.9	0.5	13.0

Source: EEA (2025a).

Note: Only a part of 1.A.4.c. emissions can be attributed to agriculture.

To facilitate the pricing discussion, this chapter distinguishes between three categories of emissions (see also Section 2.4):

- emissions from on-farm **fossil fuel combustion** for machinery, heating, irrigation etc.;
- **agricultural non-CO_2 emissions**,[24] which consist of:
    - **livestock** emissions in the form of CH_4 from enteric fermentation primarily in ruminants and CH_4 and N_2O released during manure storage and handling,

[24] Although CRT category 3 emissions include a small amount of CO_2 emissions, and while a modest fraction of fossil fuel and land-based emissions are CH_4 and N_2O, this chapter uses non-CO_2 emissions as a non-technical term for category 3 emissions. Likewise, land-based emissions and removals (LULUCF under CRT category 4) will often be referred to as CO_2 emissions, although other GHGs make minor contributions to this category.

- emissions from organic and inorganic **fertiliser application** on agricultural soils (mostly N_2O, but also CO_2 from liming and urea), including livestock excreta deposited while grazing and indirect N_2O emissions from managed soils,
- N_2O and CH_4 emissions from **other field management practices,** which refer to a range of practices (rice cultivation, the treatment of crop residues, N_2O emissions from the cultivation of organic soils);

- net **land-based** agricultural emissions on croplands and grasslands (mostly CO_2 fluxes), which is the net balance between gross emissions and removals. The net figure hides substantial GHG emissions from degraded peatlands (+75 Mt CO_2e), which are drained for cultivation.

Agriculture's emissions from fossil fuels could feasibly be priced within the EU's existing emissions trading systems.

The subsequent analysis in this chapter concentrates on emission sources that are specific to the agricultural sector, namely those arising from livestock, fertiliser application, land use, among others. In contrast, emissions associated with energy use could be easily addressed through existing policy instruments that impose a carbon price on fossil fuel consumption.

Notably, the agri-food system's reliance on electricity and district heating is already regulated under the EU ETS for stationary installations. Additionally, the sector's use of oil and natural gas for agricultural machinery, greenhouses etc. could feasibly be incorporated into the forthcoming EU ETS2, which is designed to cover emissions from buildings, road transport and small-scale industry. Although agriculture (alongside fisheries) has thus far been excluded from EU ETS2, it would make economic sense to have all fuel uses covered under the same pricing scheme.

Extending the price signal of existing policy instruments to fossil fuel use within agriculture could serve as a powerful incentive for the adoption of low-emission technologies and practices. These may include the electrification of machinery, increased utilisation of sustainable, low-carbon fuels and the implementation of energy-conserving techniques such as reduced tillage (see Chapter 3). Nevertheless, the adoption of such technologies may entail substantial additional costs and could justify a gradual integration process should the inclusion of agriculture in the EU ETS2 be pursued, allowing for the natural replacement of machinery and installations at the end of their operational lifespan. On the other hand, it is not straightforward why agriculture would be exceptional in this regard compared with other sectors covered by the system, which may face the same implementation challenges.

There are four principal mechanisms through which remaining GHG emissions from agriculture may be subject to pricing.

The chapter now turns its attention to the remaining GHG emissions, not related to fossil fuels. While various configurations of pricing schemes covering those emissions are possible, four main approaches are predominant in the policy discussions.

1. **Carbon taxation**. The most straightforward method involves levying a tax on agricultural emissions, as exemplified by the forthcoming policy in Denmark (see Box 15). Fixed-price instruments such as taxes offer administrative simplicity and predictability. However, the implementation of an EU-wide emission tax would require unanimous agreement among all 27 Member States (EC, 2019), rendering it politically difficult to implement in practice. Consequently, the EU has so far adopted emissions trading systems to price emissions, and therefore this report does not further examine the option of taxation.

2. **Agricultural emissions trading system (AgETS)**. Under an emissions trading framework, regulated entities are required to surrender allowances corresponding to their verified emissions, similar to the existing EU ETS and EU ETS2. Allowances may be distributed either through auctioning or free allocation, and the ability to trade allowances among participants facilitates the emergence of a market-determined GHG price.

3. **Mandatory climate standards (MCS)**. This approach mandates that regulated entities reduce emissions below a specified threshold (e.g. based on activity or historical emissions), which may be progressively tightened over time (Springer, 2024). The scheme is typically accompanied by a penalty if thresholds are exceeded. Under certain designs, overperformance can be transferred to underperforming entities, which can lead to the development of a market price for GHG emissions. In these cases, MCS effectively mirrors the structure of an AgETS with free allocation.

4. **Voluntary credit schemes**. Emission reduction or carbon dioxide removal projects that demonstrate performance beyond a defined baseline can generate tradable credits. It would be voluntary for farmers to undertake such projects. The credits may be purchased by private companies to comply with their own sustainability targets, but additional sources of demand could be needed, such as through public procurement.

Several hybrid models could be considered. For example, credits generated under a voluntary credit scheme could be used to comply with obligations under an AgETS or MCS framework. This illustrates the potential for combining elements of voluntary and mandatory schemes.

Box 15 The Danish tax on agricultural emissions

In 2024, Denmark adopted a comprehensive policy package based on a tripartite agreement concluded between the Danish government, The Danish Society for Nature Conservation, The Danish Agriculture and Food Council and a number of other organisations (Danish Government, 2024), based on advice from an expert commission (Ekspertgruppen for en grøn skattereform, 2024). As part of the agreement, Denmark is now the first Member State to introduce GHG pricing in the agricultural sector. The main elements of the agreement are:

- a tax on livestock emissions, gradually implemented from 2030, of EUR 40 per tonne of CO_2e, increasing to EUR 100 by 2035, and with a 60% deduction based on average emissions per animal type;
- a tax on degraded peatlands of EUR 5 per tonne of CO_2e emitted, starting from 2028;
- a tax on liming of EUR 100 per tonne of CO_2e emitted, starting from 2028;
- a subsidy for the reduced use of fertilisers equivalent to EUR 100 per tonne of CO_2e, starting from 2028, with the funds being redirected from the direct CAP support (in addition to quotas on nitrogen emissions to address site-specific water quality consequences);
- tax revenues must be recycled to the sector (e.g. as investment support);
- a major public fund is established to support, among other things, afforestation and restoration of wetlands.

The details of how the tax is to be implemented in practice, including MRV, are yet to be developed.

Multiple points of obligation within the agri-food value chain are feasible entry points for a pricing scheme.

A critical design consideration in the implementation of agricultural GHG pricing mechanisms is the determination of the point of obligation, i.e. the entity legally responsible for remitting a tax, surrendering emissions allowances or complying with climate standards. While the principal pricing instruments outlined above can be operationalised in various forms, the selection of the point of obligation significantly influences both administrative complexity and policy effectiveness.

In principle, the point of obligation may be situated at any stage of the agri-food value chain, e.g.:

- **input suppliers**, such as producers of feed and fertilisers;
- **primary producers**, i.e. farmers;
- **food processors**, including dairies and slaughterhouses;
- **wholesalers or retailers.**

The farm level represents the most direct and intuitive point of obligation, given that the vast majority of agricultural emissions originate at this stage. However, from an administrative standpoint, it may be more practical to target upstream or downstream actors, particularly those operating at sectoral bottlenecks where the number of obligated entities is relatively small (Isermeyer et al., 2021). For example, fertiliser manufacturers or meat and dairy processors could be the point at which the pricing of emissions embedded in the products they distribute is applied. In such a system, climate mitigation incentives would need to be relayed to farmers through contracting or market prices.

Still, no matter where the point of obligation is assigned in the value chain, activities and practices need to be monitored and reported at the farm level in order to get estimates of the GHG emissions associated with the farm's produce, including the effect of local mitigation efforts.

The cost of GHG pricing is distributed across the value chain irrespective of the point of obligation.

It is important to distinguish between the point of obligation, also referred to as statutory incidence of the pricing policy (who is formally obligated to pay), and the economic incidence, which refers to how the cost burden is ultimately distributed across the value chain (Metcalf, 2008). According to economic theory, the economic incidence is determined by market conditions, including the elasticities of supply and demand and the distribution of bargaining power, irrespective of the statutory point of obligation (Mankiw, 2012). The reason is that obligated entities will pass on a portion of the cost to upstream suppliers or downstream customers, including end consumers.

In discussions surrounding a GHG pricing mechanism for agriculture, the designation of the point of obligation has been mentioned as a way to shield certain parts of the value chain from the costs from such a mechanism. While being the point of obligation certainly comes with administrative burdens, the economic burden reflecting the GHG price would be shared by the entire value chain, including consumers. Thus, it is questionable whether such a strategy would indeed protect farmers from the costs of emitting GHG.

The European Commission is considering a wide range of pricing options.

The Commission has launched an investigation of the policy options to extend GHG pricing to agriculture. A first report was published in 2023 (Trinomics, 2023), while a follow-up study based on technical workshops with stakeholders is expected in 2026, focusing on both voluntary credit schemes, mandatory climate standards and emissions trading systems (Springer, 2024).

7.3 Exploring fundamental pricing design elements

7.3.1 Identifying the most cost-effective pricing design

A cost-effective GHG pricing scheme in the agricultural sector can be developed by addressing three fundamental design questions.

As outlined in Section 7.2, a diverse range of pricing instruments and design configurations are available, many of which can be combined in various ways. To structure the analysis and facilitate comparison, this section begins by examining three overarching design considerations from the perspective of cost-effectiveness.

1. To what extent should the trading of emission rights be permitted?
2. Should the polluter bear the cost of emissions or, alternatively, be compensated for emission reductions?
3. At which point in the value chain should the obligation to comply be assigned?

Consideration of these questions allows for the identification of policy designs that maximise cost-effectiveness. However, as will be elaborated in Section 7.3.2, the practical implementation of such a model presents considerable challenges. Moreover, it may conflict with other political priorities outlined in the European Climate Law (EU, 2021a), beyond cost-effectiveness. These limitations underscore the need to explore more balanced and pragmatic pricing designs, which are discussed in Section 7.4.

Avoiding emission trade restrictions is essential for maintaining a uniform GHG price across all sources of GHG emissions, thereby enhancing cost-effectiveness.

A well-functioning pricing instrument relies on a consistent and uniform price signal to guide the allocation of emission reductions towards the most economically efficient opportunities. This market-based approach equalises marginal abatement costs across actors, thereby minimising the overall cost of achieving emission reductions.

Consequently, when the trading of emission rights is constrained, the full efficiency potential of the pricing mechanism cannot be realised. Certain models for mandatory climate standards do not permit the trading of surplus reductions (i.e. overperformance) among regulated entities, thereby contravening the principle of unrestricted trading and market-based flexibility.

To uphold overall cost-effectiveness, it is imperative that all agricultural emissions, irrespective of their source, be subject to the same GHG price. This necessitates the inclusion of emissions from both livestock and fertiliser use along with other non-CO_2 sources within the same trading framework, with unrestricted exchange across these categories. The same principle applies to agriculture's land-based emissions and removals under the land use sector, which ideally should also be integrated into the pricing system to ensure uniformity and efficiency, contingent on reversals of temporary carbon dioxide removals and other environmental externalities being properly accounted for (Advisory Board, 2025).

While the polluter pays principle is a foundational normative tenet of EU environmental policy, **it also offers a more cost-effective outcome than a subsidy approach**.

The polluter pays principle stipulates that the polluter should compensate society for the damage caused by its pollution (OECD, 1975). From a purely theoretical perspective, this principle is not a necessary condition for achieving cost-effectiveness. According to the Coase theorem, efficient outcomes can be attained as long as property rights are clearly defined and transaction costs are negligible (Medema, 2020). Applied to the context of agricultural emissions, this implies that granting farmers the right to emit and compensating them for reductions could, in theory, yield an efficient allocation of abatement efforts.

Despite the theoretical appeal of symmetry between 'carrot' and 'stick' instruments in pollution control, the academic literature has identified several conditions under which this symmetry breaks down. While the equivalence may hold in the short term under static conditions, it fails to remain valid in dynamic contexts where market entry and exit are possible. In such cases, only instruments based on the polluter pays principle are considered efficient in the long run (Polinsky, 1979). For instance, a subsidy-based approach would incentivise excessive entry into the sector, thereby resulting in an inefficient allocation of resources and elevated levels of pollution.

Moreover, insights from behavioural economics provide additional support for the polluter pays approach (Matthews and O'Neill, 2025). The concept of loss aversion suggests that individuals respond more strongly to potential losses than to equivalent gains (Kahneman and Tversky, 1979). In the context of this chapter, imposing cost on emissions may elicit a stronger behavioural response than offering subsidies for emission reductions, thereby enhancing the effectiveness of the policy.

Irrespective of economic considerations, an approach of effectively rewarding polluters for ceasing harmful activities is not in accordance with Article 191 of the Treaty on the Functioning of the European Union (TFEU) which stipulates that the polluter should bear the cost of environmental damage (EU, 2012).

Importantly, adherence to the polluter pays principle has implications for the design of policy instruments. It precludes the sole use of voluntary carbon markets, in which farmers are paid to reduce emissions, although such schemes could still be appropriate for incentivising carbon dioxide removals. Similarly, mandatory climate standards and emissions trading systems with free allocation of allowances violate the principle to some extent, as they do not require actual payments for emissions below the regulatory standard or within the allocated quota.

Assigning the point of obligation at the farm level offers the most direct and effective incentives for GHG mitigation.

Farmers possess the greatest technical and practical capacity to influence and manage the emissions generated on their own holdings in an efficient way. This fact supports the view that farmers, rather than upstream actors such as feed and fertiliser suppliers or downstream actors such as meat and dairy processors or retailers, should bear the legal responsibility for GHG pricing (CE Delft, 2023).

Actors who are further removed in the value chain are likely to have less information about which practices are suited for individual farms. While it is possible for upstream and downstream entities to transmit appropriate mitigation incentives to farmers through contractual or market-based mechanisms, doing so in a sufficiently targeted and effective manner, which entails taking the circumstances of the individual farms into account, presents significant practical challenges, and there is a risk that potential channels of mitigation are being overlooked, resulting in a loss of cost-effectiveness. Therefore, placing the obligation directly on farmers is more likely to result in efficient behavioural change and investments delivering emission reductions.

There is also a legal foundation for this policy principle in Article 191 of the TFEU (EU, 2012) stating that environmental damage should as a priority be rectified at the source, which in this case is the farm level.

A farm-level AgETS with full auctioning of allowances and covering all net emissions offers in theory the most cost-effective design.

An on-farm emissions trading system represents a policy design that aligns with all the elements for cost-effective GHG pricing discussed above, while also aligning with fundamental legal principles in the EU. In this model, farmers serve as the point of obligation and are required to acquire emission allowances directly through government auctions or through the secondary market. All allowances are initially auctioned, ensuring that the full cost of emissions is borne by the polluter,[25] in line with EU environmental principles.

Farmers would be obligated to surrender allowances equivalent to the net GHG balance of their operations. This balance accounts both for emissions, such as those from livestock and fertiliser use, and carbon dioxide removal activities, including agroforestry and other land-based removal practices. If a farm achieves a net negative emissions balance, it would generate tradable credits that could be sold to other obligated entities within the AgETS (Burke and Gambhir, 2022). This mechanism not only incentivises climate mitigation at the source but also promotes the adoption of removal practices, thereby enhancing the overall efficiency of the system. Rewarding carbon dioxide removals can be seen as a logical extension of the polluter pays principle (Edenhofer et al., 2024b).

7.3.2 Challenges of a sole focus on cost-effectiveness

An on-farm AgETS faces serious implementation and political challenges.

Although an on-farm AgETS, as described in Section 7.3.1, offers the highest theoretical level of cost-effectiveness – enabling emission reduction targets to be met at the lowest overall societal cost, while also adhering to legal standards like the polluter pays principle – it also faces several significant implementation challenges. These challenges may limit its practical feasibility and public acceptance and must be carefully considered in the design and evaluation of such a scheme. The most prominent issues include:

- high administrative costs,
- risk of reversals for land-based removals and emission reductions,
- risk of carbon leakage,
- adverse distributional impacts.

Implementing a fully comprehensive on-farm AgETS across the EU could entail substantial administrative challenges for authorities and small farms.

With over 9 million farms currently operating within the EU (Eurostat, 2025g), the scale of a pricing system covering all farms would represent an unprecedented expansion in the scope of emissions trading. For comparison, the existing EU ETS encompassed approximately 9 000 installations and aircraft operators in 2023 (EC, 2024i), whereas the EU ETS2 is expected to cover 11 000 regulated

[25] The polluter should be understood as the entire value chain, including consumers, as the cost will distributed across this chain irrespective of the formal point of obligation (see Section 7.2).

entities (HFW, 2025). This underscores the magnitude of the administrative infrastructure that would be required to extend coverage to the agricultural sector.

The complexity of administering a farm-level AgETS would be considerable, involving the registration of a vast number of heterogeneous entities, the collection and verification of emissions data and the facilitation of allowance transactions. From the perspective of individual farmers, particularly those operating small-scale holdings, the administrative burden could be significant (EC, 2024h). These burdens include the need to monitor and report farm-level activity data, and to engage in the purchase and timely surrender of emission allowances. However, developments in automated monitoring technologies using remote sensing, drones or satellite data could be expected to lower MRV costs in the future.

Land-based agricultural CO_2 reductions and removals are inherently non-permanent, which complicates their integration into a unified pricing framework with other emission sources.

Incorporating land-based emissions and removals from agriculture into a generalised pricing scheme entails specific challenges due to the characteristics of this category. While avoided emissions from livestock production or fertiliser application are effectively permanent, enhancements in land-based carbon stocks are reversible and inherently non-permanent due to economically motivated decisions or natural disturbances, many of which are exacerbated by climate change, posing a significant risk to the durability of climate benefits (EEA, 2024a). For instance, trees established under agroforestry systems may later be harvested or destroyed by wildfires, and peatland restoration can be undone through subsequent drainage, ultimately releasing the carbon into the atmosphere. Consequently, land-based mitigation efforts must be maintained over time to deliver enduring climate benefits. This poses particular difficulties when such measures are used to offset emissions in other sectors (Advisory Board, 2025).

Consider the example of an additional tonne of CO_2e emissions in a given year, for instance from livestock production. If this emission is counterbalanced by an equivalent tonne of emission reductions elsewhere, or by carbon dioxide removals that permanently store the captured CO_2, the net emissions balance (measured in CO_2e) of the system is preserved both in the current year and in subsequent years. In contrast, if the offset relies on a temporary removal, the balance may be maintained in the initial year, but the long-term balance becomes uncertain. To ensure integrity, the temporary removal must either be sustained over time or, in the event of reversal, compensated through additional reductions or permanent removals at a later stage. Consequently, the use of temporary removals to offset emissions introduces a future liability. Even when such liability is legally assigned to specific parties, there remains a risk of non-compliance, for example in cases of bankruptcy.

Under an idealised pricing framework, as described in Section 7.3.1, where all net fluxes within the land-based carbon pool are appropriately priced, landowners bear the liabilities for maintaining carbon stocks and preventing reversals. They would incur penalties in the event of a reversal. Nevertheless, the risk persists that landowners may become insolvent and that such liabilities may not be transferable to subsequent owners of the land.

While the precise magnitude remains uncertain, a fully auctioned AgETS is likely to result in a substantial risk of carbon leakage.

Although a pricing system such as the AgETS outlined above is overall cost-effective in achieving a specified level of domestic agricultural emission reductions (excluding administrative costs), it may inadvertently lead to increased emissions outside the EU (Ricci et al., 2024). This occurs as EU producers of GHG-intensive agricultural goods face higher production costs due to the requirement to purchase emissions allowances, thereby reducing their competitiveness in international markets and, most likely, their total production.

As a result, a proportion of production may shift to countries with less stringent climate policies, a phenomenon known as carbon leakage, as explained in Chapter 2. Given that climate change is a global externality, such leakage undermines the environmental effectiveness of the policy by partly offsetting domestic reductions with increases abroad.

This risk is not unique to an on-farm AgETS; any GHG mitigation policy that raises production costs within the EU is susceptible to similar effects, although the risk can be addressed by specific design variations (see Section 7.4 and Chapter 11). As discussed in Chapter 4, estimates of carbon leakage vary widely across studies, depending on the modelling frameworks and assumptions employed. A review of EU-focused *ex ante* analyses reveals leakage estimates ranging from –5% to +111% (Matthews, 2022), highlighting the considerable uncertainty surrounding this issue. Nevertheless, despite this variability, there is broad consensus that pricing agricultural emissions in the EU is likely to induce some degree of emissions displacement to other regions.

An AgETS with full auctioning may give rise to adverse distributional effects for both farmers and consumers.

The requirement to purchase emission allowances imposes a financial burden on farmers. In particular, livestock producers are expected to experience declining profits, as they face increased production costs, whether through direct payment for allowances or through investments in mitigation technologies, while simultaneously contending with reduced demand due to higher consumer prices (Frank et al., 2021). The financial burden is likely to fall disproportionately on smaller or less resource-efficient farms, raising concerns about equity and the socio-economic resilience of the agricultural sector (Ollier and De Cara, 2024). Furthermore, smaller farms tend to have fewer resources to invest in mitigating technologies.

The extent to which farmers are affected depends on their ability to pass these costs along the value chain. Evidence from a Danish study suggests that given the already narrow profit margins in agriculture, a significant portion of the cost burden would be transferred to the food processing industry and consumers. However, landowners may also incur losses due to declining land values (Sørensen et al., 2025).

From a consumer perspective, the introduction of a GHG price on agricultural emissions is expected to lead to increases in food prices. Stepanyan et al. (2023) estimate that a GHG price of EUR 100 per tonne of CO_2-equivalent would raise the consumer price of beef by approximately 8%, while the price of fresh milk products would increase by less than 2%. In contrast, (Frank et al., 2021) project more substantial impacts under a higher GHG price of USD 245 per tonne, estimating price increases of around 40% for ruminant beef and 15–20% for milk. Their analysis also indicates price increases for wheat, coarse grains and oilseeds. While such price effects act as an incentive for dietary shifts, they also affect households financially.

These findings underscore the importance of carefully considering the distributional implications of GHG pricing in agriculture, particularly with respect to vulnerable farmers and low-income consumers. To fully understand these implications, it is important to account for the use of auctioning revenues, whether these are recycled within the agricultural sector or used to support consumers.

7.3.3 Options to address key challenges

Challenges can be overcome by modifying the design of the pricing scheme or by implementing complementary policies.

While a comprehensive on-farm AgETS encompassing all EU farms offers, in principle, the highest degree of cost-effectiveness, the preceding discussion highlights several significant limitations. These challenges underscore the importance of exploring alternative approaches. Potential solutions may involve modifying the design of the proposed pricing scheme, even if such modifications compromise cost-effectiveness, or implementing complementary policy instruments, as introduced in Chapter 5 and further elaborated in subsequent chapters.

Table 17 presents a non-exhaustive set of strategies for addressing the four primary challenges identified. Later in this chapter, three balanced pricing models are proposed, each incorporating selected elements from the table to illustrate how these challenges might be mitigated in practice.

Table 17 Strategies for addressing the challenges of an on-farm AgETS covering all farms

Challenge	Modifications of pricing scheme	Complementary policies
High administrative costs	• Upstream and/or downstream point of obligation • *De minimis* threshold to exclude smaller-scale farms • Exclusion of smaller emission sources	• On-farm MRV support
Reversal risk for land-based reductions and removals	• Land-based emissions and removals from agriculture covered by a stand-alone pricing scheme	
Risk of carbon leakage	• Retailers as point of obligation • Free allocation of allowances	• Trade policies • Incentives towards climate-friendly diets
Adverse distributional effects	• Free allocation of allowances	• Transition support • Incentives towards climate-friendly diets • Reduction of regressive taxes (e.g. food VAT)

Reducing the coverage of the pricing scheme or altering the point of obligation offers a pragmatic approach to alleviating administrative burdens.

One immediate strategy to limit the administrative scope and associated costs is to decrease the number of obligated entities. This can be achieved by shifting the point of obligation away from the farm level and instead targeting bottlenecks within the agri-food value chain, such as input suppliers, output processors or retailers, where the number of entities is significantly lower (Isermeyer et al., 2021).

A key challenge lies in identifying a specific point within the value chain that can be consistently and unambiguously recognised across all cases, thereby ensuring comprehensive emissions coverage while avoiding double counting. For instance, the retail stage, being the final link before products reach consumers, can typically be located with relative ease. Similarly, facilities such as dairies and slaughterhouses serve as the initial point of aggregation once raw milk and livestock exit the farm, making them identifiable reference points within the chain.

This strategy could generate a more manageable scheme seen from the authorities' perspective, while compliance and transactions costs could pose less of a burden, as covered entities would be larger on average, with greater capacity to cope with the extra burden. However, the sector's overall burdens relating to MRV of on-farm mitigation practices would remain the same as obligated entities need to induce farmers to pursue such practices.

Alternatively, the point of obligation may remain at the farm level, but only covering larger-scale farms, thereby relieving those with limited capacity and resources from the administrative demands of reporting, trading and compliance. However, this approach entails a trade-off: it reduces the overall coverage of the scheme and consequently limits its effectiveness in addressing total agricultural emissions. Moreover, there is a risk of threshold speculation where farmers strategically dimension their operations in order to stay just below the threshold (see Section 7.4.1).

A complementary approach to reduce administrative costs involves prioritising major emission sources while excluding minor contributors. Specifically, emphasis could be placed on significant hotspots such as enteric fermentation in ruminants, manure management and the application of organic and inorganic fertilisers. Potential candidates for exclusion include emissions from rice cultivation, poultry production and crop residues. These sources could be progressively integrated into the pricing framework over time.

Establishing a stand-alone pricing mechanism for land-based CO_2 emissions and removals within agriculture could mitigate the risk of reversals affecting other sectors.

As discussed in Section 7.3.2, robustly addressing the non-permanence of land-based agricultural reductions and removals presents considerable challenges. Consequently, the Advisory Board has previously advised against the integration of temporary removals into emissions trading systems as an option to counterbalance emissions from other sectors in the short term (Advisory Board, 2025).

Unlike agricultural non-CO_2 emissions, net CO_2 emissions in the land use sector can be either positive or negative, depending on the balance of carbon fluxes into and out of terrestrial carbon pools (see also Chapter 2). Even an individual plot of land could be a net source in some years and a net sink in other years. That makes it practically infeasible to separate emissions and removals into separate pricing systems.

In light of these considerations, the Advisory Board proposes in this report that all land-based emissions and removals from agriculture be addressed through a stand-alone pricing framework. The advantage of this approach is that it avoids entities constantly moving between different systems. Furthermore, the adverse impacts of reversal risk are contained with the land use sector and will not spill over to other sectors. Integration with broader emissions trading systems, such as an AgETS covering non-CO_2 emissions, should be considered only in the longer term, once measures to address the issue of non-permanence are well-established and robust.

To mitigate carbon leakage and preserve incomes of EU farmers under a GHG pricing regime, a range of policy design options and complementary measures could be considered.

Exposure to a GHG price may erode the competitiveness of EU producers in domestic markets, particularly if imported products are not subject to equivalent carbon constraints, leading to carbon leakage. One potential solution is to shift the point of obligation to the retail level, thereby ensuring that emissions embedded in imported goods are also priced. However, as further described below, such an approach might be challenging in terms of administrative complexity. Alternatively, a CBAM could be applied to imports, as discussed in Chapter 11, to level the playing field.

However, CBAMs are limited in their capacity to mitigate competitiveness losses in export markets, where EU producers may continue to face disadvantages. To address this limitation, several policy options are currently under consideration within the framework of the existing CBAM regulation (Regulation (EU) 2023/956), which presently applies to a select group of industrial goods (EC, 2025e; Marcu et al., 2025). These options may also inform the design of a GHG pricing instrument for the agricultural sector (see Chapter 11).

Another approach to mitigate carbon leakage involves free allocation of emissions allowances to farmers faced with international competition – an approach which has historically been the applied method in the EU ETS. This measure could offer partial financial relief to regulated entities and enhance the competitiveness of European producers in international markets, while still preserving marginal incentives for technological emissions abatement. As explained in Box 16, carbon leakage is best mitigated if allowances are allocated as a proportion of actual production levels (Böhringer et al., 2024), as is the case in the current phase of the EU ETS (EC, 2021c); however, the incentive to reduce the overall production of emission-intensive goods would then be weakened. Consequently, this could undermine the cost-effectiveness of domestic emission reductions (Advisory Board, 2024), highlighting the trade-off with the reduction of carbon leakage. In particular, the need for structural changes as emphasised in Chapter 4 could be left unanswered if too much effort is spent on addressing carbon leakage.

Strategies to protect farmers and consumers from GHG pricing include free allocation, transition support, dietary shifts and fiscal measures.

A range of strategies can be employed to mitigate the financial burden of GHG pricing on vulnerable farmers and consumers. Free allocation of allowances, as previously discussed, may reduce overall costs for producers (see also Box 16), taking regional disparities into account, while targeted transition support can facilitate the adoption of more sustainable production systems (see Chapter 8). Recycling of revenues from GHG pricing could be used to finance such support (see Chapter 12).

On the consumer side, promoting sustainable dietary patterns could help households adapt to higher prices of GHG-intensive products (see Chapter 10). Additionally, fiscal measures such as reducing value-added tax (VAT) on food items could partially offset the price increases resulting from GHG pricing.

Box 16 Free allocation in an AgETS: addressing carbon leakage and supporting farmers

Free allocation of emissions allowances within an AgETS can serve as a mechanism to mitigate carbon leakage and provide support to farmers (for more details see Table 18). Two principal approaches for the distribution of allowances are shown below (Trinomics, 2023).

1. **Grandfathering.** Under this approach, allowances are allocated to agricultural entities based on their individual historical emissions levels. The volume of allowances is typically reduced annually in accordance with the overall emissions cap and may decline more rapidly in case of a transition towards auctioning. In the extreme version of

grandfathering, allocation for individual farms is completely detached from its current output.

2. **Benchmarking.** This method involves establishing GHG intensity benchmarks for each product category, typically aligned with the performance of the top X% most efficient farms that produce the given product. Allowance allocation is then calculated by multiplying the benchmark value by the farm's actual output. Over time, benchmarks could be progressively tightened to reflect a declining cap and to incentivise further emission reductions.

Table 18 Comparison of grandfathering and benchmarking

	Grandfathering	Benchmarks
Alleviation of the financial burden on farmers	Comparison can go either way depending on modalities. Typically, grandfathering is perceived as more generous to farmers.	
Carbon leakage reduction	In the extreme version of grandfathering, there is only very little reduction of the leakage risk, as the farmer still faces the (opportunity) cost of the full allowance price on the margin.	Free allocation acts here as a production subsidy which offsets some of the increase in marginal costs from the GHG price. In effect, farmers are incentivised to produce more than without free allocation, which reduces carbon leakage.
Cost-effective reduction of domestic emissions	Overall cost-effectiveness is largely maintained. The main risk is that inefficient farms stay active.	The split between technical and structural mitigation is distorted by the production subsidy.
Lost auctioning revenue	Comparison can go either way depending on modalities.	
Risk of windfall profits	Farms with historically high-emissions may receive more allowances, even if they are less efficient.	If farms receive more allowances than they need due to generous benchmarks, they can profit by selling excess allowances.
Integration of new farmers into the system	A rule for allocation to entrants without a historical record needs to be invented.	Entrants receive allowances according to benchmarks and their output.
Treatment of farmers existing the system	Farmers (or the landowner) could maintain free allocation for a certain number of years upon exiting.	Exited farmers are no longer eligible for free allowances as their output is zero.

Hybrid models combining elements of both approaches could be implemented. One such variant involves combining grandfathering with an adjustment mechanism, whereby allocations are modified if a farm's output deviates significantly (e.g. by more than 25%) from its historical production level. Another hybrid approach applies benchmarking but uses historical output levels as the basis for the calculation of allocated allowances.

Benchmarks may be regionally differentiated based on climatic and geographical conditions that influence the potential for reducing emission intensity in specific production processes. While such differentiation may be considered equitable, it can constrain the reallocation of production within the EU to areas where GHG emissions would be minimised.

7.4 AgETS covering non-CO_2 emissions from agriculture

This section outlines three alternative pricing options targeting livestock and fertilisers that address major concerns.

Building upon the considerations presented in Section 7.3, the chapter now advances a set of pragmatic policy options designed to address key challenges and concerns associated with the pricing of agricultural emissions. As discussed above, land-based agricultural CO_2 emissions should in the short term be addressed through a stand-alone pricing instrument, while energy emissions could be included into existing pricing frameworks such as the EU ETS2. For this reason, this section concentrates on the development of a pricing framework for non-CO_2 emissions arising from sources such as livestock and fertilisers, introducing three alternative design models. While all three share several core features, they differ in their approach to administrative feasibility, particularly in terms of reducing the number of covered entities. Table 19 summarises the key characteristics of each model.

Table 19 Three distinct pricing models targeting agricultural non-CO_2 emissions

	Option 1 On-farm system	Option 2 ------------------ Off-farm systems	Option 3 ------------------
System design	AgETS	AgETS	AgETS
Point of obligation	Farmers	Fertiliser suppliers, dairies and slaughterhouses	Retailers
Thresholds	*De minimis* threshold to exclude smaller-scale farms	*De minimis* threshold to exclude smaller-scale entities	*De minimis* threshold to exclude smaller-scale retailers

The remainder of the section elaborates on the operational features of the three pricing models. Subsequently, Section 7.7 discusses the potential for a phased implementation of an AgETS, noting that the implementation mechanisms would be common to all pricing options.

7.4.1 Option 1: Targeting larger farms

Exempting smaller-scale farms represents a potential strategy for enhancing the administrative feasibility of agricultural GHG pricing.

The policy options outlined in Table 19 are centred on an AgETS that targets agricultural non-CO_2 emissions, though they differ in the placement of the point of obligation along the value chain. In Option 1, the obligation remains at the farm level but introduces *de minimis* thresholds to exempt smaller farms from compliance requirements.

Determining the appropriate threshold involves a trade-off between administrative efficiency and the comprehensiveness of emissions coverage. Exempting small emitters can significantly reduce the complexity and MRV cost for the regulating authorities and the sector as a whole, while still capturing a substantial share of total emissions. For example, De Cara et al. (2018) demonstrate that such exemptions can yield considerable MRV cost savings relative to full coverage, without undermining the overall cost-effectiveness of the scheme. The cost savings are further enhanced by the tendency of bigger entities to face lower MRV costs per emitted tonne of CO_2e due to economies of scale (Heindl, 2015). These findings underscore the potential value of applying *de minimis* thresholds in the design of agricultural GHG pricing mechanisms.

The number of livestock farms subject to regulation under an AgETS can be significantly reduced without substantially compromising overall emissions coverage.

Table 20 presents the distribution of livestock farms according to the number of livestock units (LSU),[26] highlighting the potential efficiency gains associated with implementing size-based regulatory thresholds, with a particular focus on bovine animals and pigs, which are the main emission sources in the livestock sector. For example, applying a threshold of 50 LSU would reduce the number of regulated cattle and pig farms from over 2.5 million to approximately 400 000, while still encompassing 78% of total cattle and 95% of total pig livestock. Increasing the threshold to 100 LSU, as proposed by Runge-Metzger et al. (2025), would further decrease the number of obligated entities to around 240 000. Under this scenario, coverage of pig production remains high at 93%, whereas coverage of cattle livestock declines to 60%.

The higher concentration of swine production facilitates the use of high thresholds without significantly compromising coverage. For cattle, the decline in coverage kicks in more rapidly when the threshold is elevated, with bigger implications for overall climate integrity, given that GHG emissions from cattle in the EU are several times greater than those from swine (EEA, 2025b).

These examples underscore the potential for substantial administrative simplification through targeted exemptions, while preserving a high degree of emission coverage of the scheme. Nonetheless, even with such thresholds, the number of regulated entities would remain significantly higher than the approximately 9 000 installations and aircraft operators currently covered under the EU ETS, highlighting the scale of the administrative challenge.

Table 20 Coverage of AgETS in terms of holdings and livestock units (LSU) by de minimis threshold

	Bovine animals				Swine			
Threshold	Holdings	Share	LSU	Share	Holdings	Share	LSU	Share
Min. LSUs	thousands	%	millions	%	thousands	%	millions	%
0	1 503	100%	55.4	100%	1 181	100%	33.9	100%
5	981	65%	54.4	98%	285	24%	33.4	98%
10	783	52%	53.2	96%	208	18%	33.2	98%
20	581	39%	50.5	91%	150	13%	32.9	97%
50	324	22%	43.0	78%	93	8%	32.3	95%
100	172	11%	33.0	60%	66	6%	31.4	93%
200	62	4%	18.8	34%	45	4%	29.2	86%
500	11	1%	6.4	12%	19	2%	22.2	65%

Source: Eurostat (2025h).

[26] Livestock units enable the aggregation of livestock from various species based on the nutritional or feed requirement of each type of animal. LSU=1 is the grazing equivalent of one adult dairy cow producing 3 000 kg of milk annually.

Note: The table shows the number of holdings with livestock unit stock for either bovine or swine equal to or above a specified threshold, including the share of all holdings.

For emissions relating to agricultural soils, reducing the number of covered farming entities without significantly compromising overall emissions coverage is less straightforward.

Emissions from the management of agricultural soils come from various sources, including synthetic and organic fertilisers. If data on fertiliser use is not publicly available, farm size could be applied as a proxy metric. In the latter case, Table 21 illustrates the distribution of the EU's 9.1 million farms by hectares of utilised agricultural area (UAA). For example, implementing a 50-hectare threshold, as proposed by Runge-Metzger et al. (2025) would result in fewer than 700 000 farms being subject to regulation, while still encompassing approximately 68% of the total agricultural area. Compared with livestock emissions, these figures suggest that it is more challenging to reduce the number of regulated entities for fertiliser emissions and other soil-related sources without substantially diminishing the overall emissions coverage.

Table 21 Distribution of farms by utilised agricultural area (UAA)

Min. threshold	No. of farms	Share of farms	Share of UAA
hectares of UAA	thousands	%	%
0	9 067	100%	100%
5	3 282	36%	94%
10	2 160	24%	89%
20	1 371	15%	82%
50	676	7%	68%
100	326	4%	52%

Source: Eurostat (2025d).

Threshold levels could be progressively lowered over time as administrative capacity and experience with MRV systems improve.

A key concern associated with the application of thresholds is the potential for strategic behaviour by regulated entities. Farms may deliberately limit their size to remain below the threshold, thereby introducing inefficiencies and potentially hindering the growth of smaller farms (Matthews and O'Neill, 2025). Moreover, larger farms might attempt to circumvent regulation by fragmenting their operations into smaller units. Such practices not only undermine the integrity of the system but also risk creating market distortions, whereby some farms are subject to compliance costs while others are not. These challenges highlight the importance of carefully calibrating threshold levels.

Adopting a dynamic approach that allows for gradual lowering of thresholds over time would reduce the risk of such perverse incentives. As MRV systems become more streamlined and less burdensome, lowering thresholds can reduce opportunities for regulatory avoidance and enhance the overall effectiveness and fairness of the policy framework. Alternatively, threshold levels may be dynamically adjusted to ensure coverage of a predetermined proportion of total emissions. While such an approach may not completely discourage strategic threshold speculation, any attempt to evade regulation would automatically result in a lowering of the applicable threshold.

Consideration must be given to the design of incentive mechanisms for farms operating below the applied thresholds.

Smaller agricultural holdings could be permitted to participate voluntarily, either by generating emission reduction credits related to fertiliser or livestock emissions and certified under an expanded version of the CRCF Regulation or by opting to become obligated entities under the AgETS. In the latter scenario, a generous allocation of free allowances would be necessary to ensure sufficient incentives for voluntary participation.

7.4.2 Option 2: Combining upstream and downstream obligations

Despite omissions, targeting dairies, slaughterhouses and fertiliser suppliers would cover the main emissions sources.

Relocating the obligation of the AgETS from farms to key bottlenecks in the agri-food value chain would significantly reduce the number of regulated entities. Option 2 identifies two such bottlenecks, targeting dairies and slaughterhouses along with suppliers of inorganic fertilisers. Table 22 shows how such an approach would cover the most important emission sources (mostly non-CO_2) grouped under category 3 in the inventories.

Table 22 Coverage of emissions under Option 2

Emission category	Mt CO_2e	Obligated entity
3.A. Enteric fermentation	179.5	Dairies and slaughterhouses
3.B. Manure management	62.6	
3.C. Rice cultivation	2.3	
3.D.1.a. Inorganic N fertilisers	33.0	Fertiliser suppliers
3.D.1.b. Organic N fertilisers	16.3	Dairies and slaughterhouses
3.D.1.c. Urine and dung deposited by grazing animals	8.9	
3.D.1.d. Crop residues	17.4	
3.D.1.e. Mineralisation/immobilisation associated with loss/gain of soil organic matter	0.7	*Could be covered by a LULUCF pricing system*
3.D.1.f. Cultivation of organic soils (i.e. histosols)	10.4	
3.D.2. Indirect N_2O Emissions from managed soils	22.4	Fertiliser suppliers
3.E. Prescribed burning of savannahs	0.0	
3.F. Field burning of agricultural residues	0.8	
3.G. Liming	5.2	
3.H. Urea application	3.5	*Covered by EU ETS*
3.I. Other carbon-containing fertilisers	0.6	
3.J. Other	1.6	

Source: EEA (2025b).

Note: Emission data is 2023 values.

Although Option 2 encompasses the principal emission sources, it exhibits certain omissions, most notably N_2O emissions from crop residues. Similarly, N_2O emissions arising from the cultivation of organic soils (including degraded peatlands) would remain outside the scope of Option 2; however, these could feasibly be incorporated within a LULUCF pricing framework (see Section 7.5). It should be noted that CO_2 emissions from urea application are already attributed to the production installation under the EU ETS (EC, 2025o).

Under Option 1, all emission sources listed in Table 22 could, in principle, be included, although minor sources might be exempted to reduce administrative complexity. In particular, it should be considered to exclude minor sources during the initial implementation phase to facilitate a smoother transition to the pricing system.

Livestock-related emissions may be effectively priced by targeting downstream actors, with dairies and slaughterhouses representing the most appropriate point of obligation.

Livestock emissions lack a clear upstream bottleneck, although the potential role of feed suppliers has been discussed (Trinomics, 2023). But since large shares of livestock feed are produced on-farm and not traded (or traded as grains and thus not necessarily distinguishable from human food), a more feasible alternative is a downstream approach, initially focusing on processors as the most administratively feasible intervention point (Verschuuren et al., 2024).

Within the EU, there are approximately 33 000 meat processing enterprises and 13 000 dairy processors, although it is uncertain how many of these are initial processing facilities once raw milk and livestock exit the farm. Applying a participation threshold based on turnover could significantly reduce the number of regulated entities; however, based on available data, Table 23 presents distribution data based on employee numbers. For example, limiting obligations to enterprises with 50 or more employees would limit the number of regulated entities to just a few thousand, while still capturing the majority of sectoral turnover, which likely correlates with emissions.

This approach offers a pragmatic balance between administrative manageability and emissions coverage, making it a viable strategy for integrating livestock emissions into a broader pricing framework.

Table 23 Distribution of meat and dairy processors by number of employees, 2023

	Processing and preserving of meat and production of meat products		Manufacture of dairy products	
	No. of enterprises	Share of net turnover	No. of enterprises	Share of net turnover
All enterprises	33 013	100%	12 867	100%
10 or more persons employed	10 228	96%	2 967	98%
20 or more persons employed	5 590	92%	1 707	96%
50 or more persons employed	2 420	84%	908	91%
250 or more persons employed	520	63%	260	76%

Source: Eurostat (2025i).

Inorganic fertiliser-related emissions can be addressed by assigning the point of obligation to suppliers of nitrogen-based synthetic fertilisers.

Option 2 places the legal responsibility for inorganic fertiliser emissions on upstream producers and importers of synthetic fertilisers, making them accountable for the emissions associated with the downstream use of their products (Verschuuren et al., 2024; Isermeyer et al., 2021). Under this upstream model, each obligated entity would be liable for the resulting emissions from the total volume of synthetic, nitrogen-based fertilisers introduced to the EU market. Adjustments could be made for products with lower emission profiles, such as those containing nitrification inhibitors, and for documented on-farm practices that reduce N_2O emissions within the value chain of each fertiliser supplier.

Approximately 1 600 companies were engaged in fertiliser manufacturing within the EU as of 2020 (Eurostat, 2025b). No data could be found on the number of fertiliser importers, but even with their inclusion, the number of regulated entities would most likely remain low, particularly when compared with the millions of individual farms that would otherwise fall under a farm-level scheme. This upstream approach thus offers a more streamlined and potentially cost-saving mechanism for regulating fertiliser-related emissions.

Regulating emissions associated with organic fertilisers presents a distinct challenge, although both upstream and downstream approaches offer potential points of obligation.

While the strategy of targeting suppliers of synthetic fertilisers provides a structured framework, it does not inherently account for emissions arising from the application of organic fertilisers, such as manure. In 2023, almost half of total fertiliser-application-related direct emissions were attributable to organic sources when urine and dung deposited by grazing animals are included (see Table 22).

A solution would be to attribute these emissions to livestock. This could be operationalised by applying an emission factor that also incorporates the field emissions from manure when downstream entities such as dairies and slaughterhouses are designated as the actors accountable for livestock emissions. Consequently, liability for these emissions would fall on dairies and slaughterhouses under Option 2.

Even when the point of obligation in an AgETS is placed upstream or downstream, it remains essential that farmers be exposed to effective climate mitigation incentives.

Under an Option 2 system, obligated entities would initially be held accountable for the amounts of fertilisers sold and, at the other end of the value chain, the quantities of milk and meat processed, with emissions calculated using default emission factors. However, this approach effectively imposes a price on production or sales rather than directly on emissions, despite the correlation between these variables (Matthews and O’Neill, 2025).

To enhance the environmental integrity and cost-effectiveness of the scheme, it is necessary to link pricing more closely to actual emissions performance. This requires that upstream and downstream actors incentivise farmers to adopt low-emission practices, and that such improvements are then reflected in the emission factors used to determine the liabilities of obligated entities.

The literature generally identifies two overarching approaches to achieve this alignment (Flatz et al., 2024; Matthews and O’Neill, 2025).

- **Value chain approach.** Obligated upstream and downstream actors engage directly with farmers through contracts or certification schemes.

- **Crediting approach.** Farmers who implement verifiable emission reduction practices generate credits that can be sold to obligated entities.

One potential approach to ensuring on-farm mitigation in an upstream or downstream AgETS is to require obligated entities to incentivise and monitor emission reductions within their own value chains.

Under the value chain approach, fertiliser suppliers would be held accountable for actual emissions associated with fertiliser use by their customers, while dairies and slaughterhouses would be held accountable for emissions associated with livestock production by their suppliers (scope 3).

This model necessitates that obligated entities collect farm-level data on production practices and facilities in order to calculate specific emission factors, which are then aggregated and reported to regulatory authorities. In parallel, these entities would be expected to engage with their customers and suppliers to promote the adoption of mitigation practices, such as the use of feed additives or improved manure management, by offering financial or contractual incentives. Alternatively, obligated entities could choose to use default emission factors that assume no mitigation efforts (see also Section 7.6).

Each obligated actor would be responsible for establishing its own MRV system, along with a payment mechanism to reward emission reductions. While the European Commission could provide methodological guidance and standardised frameworks, delegating the development and implementation of these systems to private actors carries risks. These include the potential for inefficiencies, inconsistent application or a lack of engagement if obligated entities opt to rely on default emission factors, which may be less accurate but administratively simpler.

From a farmer's perspective, the administrative burden of monitoring and reporting activities would not be significantly different from an on-farm AgETS. Farmers just report to their value chain partners rather than to public authorities. But the burdens relating to allowance trading could be lower depending on the specific incentive schemes put in place by these partners.

The value chain approach is likely to reinforce vertical integration within the agri-food system, as primarily downstream actors may seek to establish long-term relationships with suppliers to ensure data reliability and emissions performance. While concerns have been raised by stakeholders that such integration could erode farmers' bargaining power or reduce their market flexibility (EU, 2024b; Flatz et al., 2024), it is not self-evident that these arrangements would be detrimental to farmers. In some cases, closer integration could offer farmers greater stability, access to financing and technical support for implementing mitigation measures. Dairy company Arla's 'Sustainable Incentive Model' is an example of this (Arla, 2025).

An alternative to the value chain approach is the establishment of a market for climate mitigation credits.

Under the crediting approach, there is no direct contractual relationship between farmers and upstream and downstream obligated entities. Instead, farmers can choose to implement approved mitigation practices or projects which would generate emission reduction credits. These credits can then be sold to upstream and downstream actors either within or outside their supply chain, who may use them to offset a portion of their compliance obligations under the AgETS. The generation and certification of credits could be facilitated through the CRCF Regulation as discussed in Section 7.6. Farmers still 'pay' for their emissions in the sense that they face higher fertiliser prices and lower selling prices for livestock compared with a system where farms are directly targeted (Option 1).

From a farmer's perspective, the administrative advantage of this approach compared with the value chain approach is that only farms that engage in mitigation projects would need to monitor and report activities. But on the other hand, trading credits could prove burdensome and complex to farmers.

Two key concerns have been raised about this approach (Flatz et al., 2024). First, there is the risk of double counting if a mitigation outcome is both credited at the farm-level and at the same time reflected in the reported default emissions attributed to the obligated entities. A second key issue is the appropriate calibration of the baseline for crediting to safeguard additionality. For instance, if prevailing agricultural practices result in lower GHG intensities than those assumed by the default emission factors, farmers may receive credits without undertaking additional mitigation efforts.

Both concerns can be addressed by determining the initial liability of obligated entities – whether upstream or downstream – on the same default emission factors that are used as a baseline for the mitigation credits. This would avoid double counting as it ensures that the decrease in net emissions compared with this baseline is only accounted for once, through the credit. It would also keep the climate integrity of the system intact: if the default emission factor is set too high this could indeed result in higher crediting, but this would be offset as it would also require upstream or downstream obligated entities to acquire a greater volume of credits to fulfil their compliance obligations. While this may initially result in a transfer of financial resources from obligated entities to farmers, such effects are likely to be offset by corresponding adjustments in market prices for agricultural products.

The key question under this approach is thus how to set the appropriate default emission factors. In this context, setting emission factors too low poses a more substantial risk than setting them too high. If set too low, genuine mitigation actions undertaken by farmers (those that exceed current practice) may not be adequately recognised and rewarded through credit issuance. Similarly, conversions to higher emission practices will not be captured. This would undermine the incentives intended to promote mitigation efforts at the farm level. Therefore, default emission factors should aim to reflect a reference scenario in which no mitigation has occurred at the farm level. However, they may be subject to adjustment over time to incorporate evolving sectoral practices and technological advancements that result in a new business as usual.

While the crediting approach does not require direct engagement between farmers and downstream actors, such relationships could still emerge. For example, farmers may choose to bundle credits with physical products in transactions with processors, thereby creating a hybrid model that resembles the value chain approach. However, the crediting model also allows for market-based flexibility, enabling farmers to sell credits outside their immediate value chain, potentially securing higher prices and broader market access.

To facilitate participation in the crediting system and reduce administrative burdens, an intermediary institution could be established to mediate credit transactions.

Under the crediting approach, farmers may face challenges in identifying buyers for their emission reduction credits and navigating market volatility. An intermediary could serve as a centralised platform, purchasing credits from farmers and reselling them to obligated downstream entities, thereby streamlining transactions and potentially stabilising prices by acting as a buffer between supply and demand. By consolidating market access, the intermediary would reduce transaction costs and lower entry barriers for smaller producers, enhancing the inclusiveness and efficiency of the crediting system.

The concept of such an intermediary has been explored in the context of agricultural credit markets (Trinomics, 2023) and more broadly in carbon market literature (Edenhofer et al., 2024a; Rickels et al., 2022).

Importantly, even with an intermediary in place, direct transactions between farmers and downstream actors could still be permitted. This flexibility would accommodate the needs of companies seeking to maintain traceability and control over emissions within their own value chains, particularly in the context of sustainability reporting and supply chain certification.

7.4.3 Option 3: Retailer obligations

Assigning the point of obligation to the retail level has been proposed as a means to address carbon leakage in domestic markets.

As an alternative to Option 2, obligations may be moved further down the value chain to the retail level. In such a system, retailers would be responsible for all emissions associated with their product portfolio (scope 3). As also explained in Section 7.4.2, retailers may engage directly with their value chain to reduce emissions or rely on credits generated on-farm.

By pricing emissions at the retail stage, imported products would be included within the scope of the pricing mechanism, thereby helping to level the playing field for EU producers (OECD, 2021a) and reduce the risk of import-related carbon leakage. Nevertheless, this strategy would exempt EU products that are exported from GHG pricing. Whereas this reduces the risks of export-related carbon leakage, it also means that the scheme would omit an important part of EU GHG emissions.

Targeting only a small number of big retailers could provide substantial emission coverage, but wholesalers may have to be included to cover products sold by small retailers and restaurants.

The retail-level approach presents substantial practical challenges. Retailers typically manage a vast and diverse portfolio of products, many of which are composite goods with multiple ingredients, making it challenging to accurately assess the emissions embedded in each item. In addition, the number of potentially obligated entities is considerable. In 2023, almost 900 000 retailers in the EU were engaged in the sale of food, beverages, and tobacco, even though not all of these entities handle products with a substantial GHG footprint such as livestock products (Eurostat, 2025a, 2024i). The inclusion of food service providers such as restaurants would increase the number of entities to approximately 1.6 million.

Applying a *de minimis* threshold, for example limiting coverage to only the biggest retailers with more than 250 employees, would reduce the number of obligated entities to around 1 100, while 61% of total value added would be captured, indicating that the retail sector is highly concentrated (Eurostat, 2025a). This enables coverage of a large share of emissions while only targeting a small number of companies. Food service providers are typically much smaller, and applying the same threshold will only cover 18% of total value added from 1 200 enterprises. However, these numbers are somewhat misleading as some restaurant chains apply a franchise model, where each franchisee counts as a unique enterprise in the statistics.

An alternative would be to shift the point of obligation to the wholesale level, in order to capture the products distributed by small retailers and restaurants. At this level, the number of enterprises involved in the trade of food, beverages and tobacco is approximately 260 000 as of 2023 (Eurostat, 2025a). Imposing a similar threshold of 250 employees would reduce this number to around 900 entities, covering approximately 36% of wholesale turnover. These numbers suggests that the wholesale level is less obvious as the main point of obligation. Moreover, identifying a unique wholesale entity within the value chain as the point of obligation is not straightforward, as vertical integration within the agri-food system can blur the boundaries between different stages of the value chain, complicating the identification of distinct regulatory layers. Still, a combination of wholesale and retail obligations could be considered, targeting the biggest companies at both levels while ensuring that double counting is avoided.

7.5 AgETS covering land-based CO_2 fluxes

The land use sector can be both a sink and a source of CO_2, justifying covering these GHG fluxes by a dedicated pricing instrument.

As discussed in Section 7.3.3, it is appropriate to cover land-based emissions and removals from agriculture under a dedicated stand-alone system (Trinomics, 2023; Advisory Board, 2025).

The principal carbon reservoirs in such a system include above- and below-ground living biomass, which can be enhanced through interventions such as agroforestry and afforestation, along with soil organic carbon, which can be increased through improved soil management practices, including the use of cover crops, crop rotation and reduced tillage (for more details see Chapter 3). Additionally, land-use changes, such as peatland restoration or the conversion of croplands to grasslands, can contribute to soil carbon sequestration, with grasslands often offering a comparative advantage over croplands in terms of carbon retention (EEA, 2025d).

Whereas the initial implementation of the system could focus exclusively on agricultural land, the long-term objective should be its integration with the remaining land use sector.

Agricultural land, comprising grassland and cropland, constitutes a subset of the broader land use sector, within which forestland represents another principal category. In 2023, total net removals across all land categories amounted to 198 million tonnes of CO_2. This figure includes a substantial net sink of 274 million tonnes from forestland, contrasted by net emissions of 47 million tonnes from agricultural soils (EEA, 2025a). These data underscore that agriculture operates within the wider land use sector (LULUCF), which encompasses both carbon emission sources and sinks.

The Advisory Board recommends establishing a pricing system initially limited to agricultural land. Such an approach would mitigate the risk of disturbances, whether natural, economic or methodological, originating from the substantially larger forest carbon pool and spilling over into the agricultural sector, thereby introducing excessive volatility. Increased volatility in the forest sink in the recent decade highlights this risk (Advisory Board, 2024).

Nevertheless, changing agricultural land to other land uses could either increase or decrease net emissions, and a pricing system dedicated only to agricultural land risks ignoring these effects. For this reason, land use changes away from cropland and grassland – to wetlands, forests, but also sealed land – should remain within the system for a defined period to maintain mitigation incentives. This approach aligns with the CAP, which stipulates that eligible land continues to receive decoupled payments under Pillar 1 for the duration of an afforestation commitment by the farmer (EU, 2021b).

A separate regulatory framework would be required to safeguard carbon sinks in managed forests. However, the eventual integration of this framework with the system covering agricultural land should be pursued as a long-term goal. Such integration would reduce the risk that differentiated remuneration rates across land categories create distorted incentives and inefficiencies in land-use management.

A land use sector pricing scheme could be based on the methodologies and certification procedures of the CRCF Regulation.

A pricing system for the agricultural land use sector should be aligned with the polluter pays principle, but in an extended version that takes negative emissions into account. This means that any removals would generate credits, while emissions would generate debits that must be neutralised by surrendering corresponding credits or emission allowances. In such a system, it is essential to establish standardised methodologies that define clear baselines distinguishing emissions from removals. The emerging CRCF framework could be relied upon to provide such methodologies, although continuous and substantial refinement would be necessary to address methodological shortcomings and stakeholder concerns (see Section 7.6).

The CRCF Regulation's carbon farming sequestration units provide a framework for certifying, quantifying and monitoring temporary carbon dioxide removals that would be eligible for offsetting emissions within the proposed system. Such credits linked to temporary removals are themselves temporary, reflecting the inherent risk of carbon reversal. Upon expiration, the original debit could reappear in the account of the emitter who initially used the credit for offsetting, necessitating the surrender of either an emission allowance or a new CRCF credit (which may be a renewed version of the original credit). Consequently, the use of temporary CRCF credits does not permanently eliminate liabilities but rather defers them to a later compliance period. Still, there is much uncertainty about how the approach of temporary credits would work in practice and who would own the liability once a credit expires (IATP, 2024).

Emissions originating from degraded peatlands should be subject to pricing rather than rewarding rewetting projects.

Drainage of peatlands – which constitutes the most significant source of land-based GHG emissions (see Chapter 2) – represents a practice where the Advisory Board recommends deviating from the CRCF Regulation. Under the regulation, the baseline for this land category is defined by current practices, implying that the continuation of existing emissions serves as the reference point. Consequently, any improvement, such as restoration of peatlands, generates credits in the form of soil emission reduction units.

This approach contravenes the polluter pays principle, as peatland owners would receive financial compensation for ceasing emissions rather than being held accountable for them. The Advisory Board therefore proposes adjusting the baseline to align more closely with a zero-emission reference. In practice, degraded peatland owners would be required to surrender allowances or credits unless rewetting occurs. Implementing a direct pricing mechanism for emissions from these soils could achieve two objectives: strengthening incentives for rewetting and ensuring efficient allocation of public funds (Runge-Metzger et al., 2025; Purola and Lehtonen, 2022). To mitigate the financial burden on farmers during the system's initial phase, free allocation of allowances could be considered, particularly given that rewetting projects may necessitate timely coordination among multiple landowners.

Additional emission-intensive management practices should be progressively incorporated into the proposed system as MRV capacities are enhanced.

Practices that diminish land-based carbon stocks, such as grassland-to-cropland conversion and land sealing should also generate debits within the system. However, their inclusion is contingent upon the availability of robust monitoring mechanisms.

Land-use changes can be reliably detected, enabling their immediate integration into the pricing framework, whereas the incorporation of other management practices may need to be deferred until comprehensive MRV systems are established. In the interim, these practices could be regulated through minimum standards under the CAP.

Over time, mechanisms such as public procurement or integration with other compliance schemes will be necessary to ensure adequate demand for removal credits.

In the initial phases of the system, emissions are expected to continue exceeding removals, consistent with current trends. Consequently, tradable emission allowances will need to be issued. However, these allowances should be gradually phased out as the system's overall cap declines in accordance with the EU's increasingly ambitious climate targets.

At a later stage, total net emissions could become negative, as removals will need to surpass residual emissions, including those from peatlands that remain degraded. The European Commission's 2040 Impact Assessment anticipates that net emissions from agriculture within the land use sector could already be negative by 2030 under scenarios aligned with the EU's 2030 LULUCF target (EC, 2024f). All scenarios achieving climate neutrality by 2050 necessitate net-negative emissions from agricultural land use by 2040.

In a net-negative context, demand for removal credits driven solely by the remaining emissions will be insufficient to incentivise the required volume of removals, necessitating additional demand channels. Three complementary approaches merit consideration. First, public procurement could be introduced to purchase and retire credits. Second, land-based removal credits could be fully or partially integrated into other compliance schemes, such as the AgETS for agricultural non-CO_2 emissions, provided that reversal risks are adequately managed. Third, voluntary procurement by private-sector actors seeking to meet internal sustainability objectives could offer supplementary demand, although the effectiveness of this strategy remains uncertain given its reliance on voluntary participation (McDonald et al., 2021).

Public procurement of removal credits could be operationalised through the CAP, a dedicated fund, or as a mechanism for Member States to achieve national LULUCF targets.

One potential avenue for funding public procurement is the redirection of CAP funds towards the purchase of credits relating to land-based agricultural emission reductions or removals. Alternatively, a purpose-built fund, distinct from the CAP, could be established to procure mitigation credits at the EU level. Auctioning revenues from other emission trading schemes could be recycled into such a fund.

Another strategy would be to allow Member States to procure a specified volume of such credits, either as a replacement for or in addition to their existing national LULUCF targets. This approach could serve multiple purposes: it would create predictable demand, signal long-term policy commitment and help establish price benchmarks for carbon farming activities (Mähönen et al., 2023). Moreover, governments could de-risk participation for farmers and incentivise early adoption of high-quality practices that align with EU climate and biodiversity goals.

To prevent double counting of carbon credits, any credit acquired by a public institution must not be simultaneously transferred to a private entity for the purpose of fulfilling internal sustainability objectives. Ensuring the integrity of such transactions necessitates the establishment of a robust and transparent registry system for the issuance and retirement of credits.

7.6 MRV requirements to support GHG pricing

A robust MRV framework forms the backbone of an effective GHG pricing instrument.

As discussed in Section 5.3.7, robust monitoring, reporting and verification (MRV) systems are foundational to the effectiveness of EU climate policy. This also applies to a GHG pricing instrument, whose effectiveness relies on the correct and accurate monitoring, reporting and verification of emission and removal data (Bellassen et al., 2015). Without robust systems to ensure this, GHG pricing instruments risk over- or underestimating emissions and removals, which undermines the instruments' climate integrity and erodes public and investor trust.

Whereas data needs depend on the GHG pricing system's scope and point of regulation, all approaches require farm-level emissions data to be effective.

So far, this chapter has explored several new GHG pricing schemes: one is an AgETS that encompasses non-CO_2 emissions, primarily from livestock and agricultural soils, while the other targets land-based agricultural emissions and removals. The chapter also considered different points of obligation, which could be either on-farm or off-farm.

The data needs for a GHG pricing instrument depend on the instrument's scope and point of obligation. An on-farm system would require robust and verified data on emissions and removals on the farm level. An off-farm system would require data on embedded emissions in the products or activities that are covered by that system. For example, an AgETS for retailers would require data on the embedded emissions in the food products that are sold by those retailers. Similarly, an AgETS on dairies and slaughterhouses would require data on the embedded emissions of the livestock products processed by those entities.

However, as concluded earlier in this chapter, even an off-farm system would need to account for on-farm mitigation action to unlock the sector's full, cost-effective mitigation potential. This means that even under an off-farm system, on-farm emission data would be needed at least for those farms that engage in mitigation activities, so that the mitigation outcomes of these activities are captured by the system.

Estimating emission factors at the individual farm level is essential to accurately capture the impact of farm-specific climate mitigation practices.

The standard approach to emissions calculation involves determining an emission factor for a given activity and multiplying it by the corresponding activity data (IPCC, 2019a). For the individual farm, relevant activity data include variables such as livestock numbers (by type and breed), cultivated land area (per type of land use) and quantities of applied fertilisers. Most of this data is already collected by Member States as part of agricultural regulation and the administration of CAP subsidies (EC, 2025t).

However, determining appropriate emission factors can be considerably more complex, trying to strike a balance between capturing the impact of farm-specific mitigation practices and having a system that is administratively feasible. In practice, the Advisory Board recommends a graduated system that combines different levels of granularity from which the farmer can choose.

- **Simplified approach.** Regulated entities could use the implicit emission factors from their Member State's GHG inventory, which reflect the average management practices used in that Member State. In this case, entities only need to collect activity data and multiply this by the relevant implicit emission factor.

- **Practice-based approach.** Farmers could report on specific management practices (e.g. presence of slurry covers, grazing duration, fertiliser application methods) to select more differentiated emission factors, while still drawing on values established within inventory frameworks.
- **Detailed approach.** For mitigation options not yet reflected in inventories (such as novel feed additives or emerging soil management practices), a more granular system could allow recognition of additional abatement, provided that robust criteria are established for what evidence is required and how it is approved.

Implementing such a system at the EU level would require addressing the considerable methodological variation across Member States. National inventories differ not only because of varying agricultural systems, but also because Member States have developed different calculation approaches. A consolidated EU framework would need to establish standardised calculation methods while allowing sufficient flexibility to reflect genuine differences in farming systems.

Farmers should be able to reliably estimate the emissions impact associated with specific climate mitigation practices.

Transparency is critical to incentivise behavioural change. Farmers must be able to understand how specific practice modifications influence their calculated emissions. This requires the development of an online data management platform enabling farmers to simulate a broad set of management scenarios. To support this system, an EU-wide catalogue of mitigation practices could be established, documenting available techniques and their expected GHG reduction potential, potentially building on existing catalogues such as the JRC Farming Practices Evidence Library (JRC, 2025d) or the new initiative of an EU Carbon Farming Database (EC, 2025b). These estimates would need to account for national or even subnational conditions, and a robust process for incorporating novel practices into the catalogue would need to be implemented, balancing the need for scientific rigour with timely updates.

Downstream obligations would require reporting of embedded emissions based on sales or processed quantities.

If the point of obligation is allocated downstream at the retail level, it becomes essential to quantify sales (the main activity variable) across various food categories, such as meat, cereals and dairy products. This task is inherently complex, given that many retail products comprise multiple ingredients, although a simplified approach could be to start with the most GHG-intensive food categories, for example products with a high content of dairy and beef. Instead, if the point of obligation is positioned further upstream in the value chain, such as at dairies and slaughterhouses, the MRV process becomes comparatively less complex. This is because data on quantities of processed meat and raw milk are more readily available and verifiable.

Emission factors may be based on default values (to be established at the national or EU level) unless processors or retailers can substantiate the application of lower emission factors specific to their supply chains in accordance with the value-chain approach explained in Section 7.4.2. In such cases, processors or retailers would be required to develop and maintain an internal system to monitor emissions in their value chain. Such systems would need to adhere to certified methodologies, to be established by regulatory authorities. Compliance with these methodologies would need to be subject to verification by independent third-party auditors.

The CRSD already requires large companies to report embedded emissions, but its methodological flexibility makes it less suitable for pricing purposes.

The Corporate Sustainability Reporting Directive (CSRD) (Directive (EU) 2022/2464) requires certain companies to annually report the GHG emissions from their own operations (scope 1), emissions linked to electricity and heat imported from outside their company boundaries (scope 2) and emissions throughout their broader value chain (scope 3). More detailed rules on how to report these emissions are included in the European Sustainability Reporting Standards (EU, 2022b) that give an overall description of what type of GHG emissions need to be reported and in which format. However, they do not prescribe a particular monitoring methodology and leave substantial flexibility to reporting companies. Whereas this can be acceptable in the context of general information disclosure, it is more problematic if the reported data is used to determine financial obligations. In such a context, methodological flexibility can lead to uncertainty, undermines consistency and comparability, and can give perverse incentives for regulated entities to use more lenient methodologies.

The CRCF framework could play an important role to facilitate certification of on-farm climate mitigation under a system with off-farm obligations.

Under a crediting approach (see Section 7.4.2), default emission factors aligned with the baseline of the crediting methodology would be used to calculate the emissions that each obligated entity is held accountable for. Credits are employed to acknowledge on-farm mitigation efforts, facilitated by a framework such as the one developed under the CRCF Regulation and its delegated acts. This framework would ensure the demonstration of mitigation beyond baseline levels, incorporating standardised methodologies and certification procedures (see Box 17 for a detailed description of the CRCF Regulation).

If the CRCF Regulation should play a key role in the establishment of GHG pricing in agriculture, the framework would need to be further enhanced. In addition to the possible room for further improvements to the specific methodologies, another key issue is that the framework does not yet cover all main agricultural emission sources. Notably, it does not yet cover GHG emissions from enteric fermentation and manure management, which are two key GHG emission hotspots within agriculture (see Section 7.2). The legislation does mandate the European Commission to review by July 2026 the possibility of extending the CRCF Regulation to these emission sources, and submit a legal proposal to this end if considered appropriate (EU, 2024b).

Box 17 The CRCF Regulation

The CRCF Regulation establishes the foundation for a voluntary carbon credit market.

The EU's CRCF Regulation, adopted in 2024, establishes a voluntary EU-wide system for the high-quality certification of permanent removals, carbon-farming activities and carbon sequestration in long-lasting products, with full implementation expected by 2028. It aims to support the EU's climate neutrality goals by 2050 through high-quality, verifiable carbon dioxide removal activities.

Carbon farming refers to climate-friendly land management practices that enhance carbon sequestration in soils and biomass and reduce emissions of nitrous oxide and other soil-based GHGs. Examples include reduced tillage, crop rotation with legumes, improved forest management, agroforestry, precision farming and peatland rewetting. The inclusion of livestock emission reductions will be considered as of 2026.

The mitigation outcomes of this framework will not only depend on the robustness of the crediting methodology, but also on future demand for CRCF credits. So far, no mandatory instrument that could create demand for CRCF credits has been established. However, the European Commission’s new bioeconomy strategy (COM(2025) 960) creates a voluntary EU Buyer’s Club through which the Commission aims to pool voluntary demand from private companies. Whereas the ability of such voluntary approaches to create sufficient demand remains uncertain, this initiative could encourage the use of the specific methodologies under the CRCF Regulation, which can then provide a basis for further improvements through learning by doing.

The specific CRCF methodologies are still under development.

The CRCF Regulation sets out four overall quality criteria on (i) how to quantify the demonstrated net carbon benefit, (ii) how to establish additionality beyond existing obligations, (iii) how to reflect the storage duration of different types of removals, and (iv) how to ensure adherence to broader sustainability principles. The overall criteria are then operationalised in concrete methodologies for different mitigation practices through delegated regulations, which are particularly important as they establish the technical standards and verification procedures that underpin the credibility of certified carbon dioxide removals, which in turn is a prerequisite for their potential integration into GHG pricing instruments.

The more detailed methodologies are still under development, with the methodologies for a range of practices in the agricultural sector (referred to as ‘carbon farming practices’) expected to be published in 2026. While the Advisory Board has previously assessed that the overall principles of the CRCF Regulation are generally sound (Advisory Board, 2025), the Board has not done a detailed assessment of the draft methodologies. However, some stakeholders have raised several concerns, including the use of baselines that may permit crediting of non-additional activities, the potential for over-crediting due to excessive flexibility in quantification methods and insufficient mechanisms to address the issue of non-permanence (Oeko-Institut e.V., 2025; Günther et al., 2024; IATP, 2024; Ecologic, 2023).

To ensure the credibility and effectiveness of the CRCF Regulation, continuous and substantial refinement is necessary. This includes addressing methodological shortcomings and stakeholder concerns while maintaining a balance between scientific robustness and practical feasibility.

Pricing of emissions from degraded peatlands necessitates the development of comprehensive, high-resolution peat maps.

As a specific but highly important issue, pricing of the emissions from degraded peatlands requires the ability to accurately identify peatland areas at a level of granularity sufficient to link peat areas to landowners. Such maps are also needed for the phase-out of per-hectare subsidies for such peatlands, while maintaining support for other soil types, as recommended in Chapter 6. Consequently, detailed maps of peatlands must be produced for each Member State and integrated with existing agricultural land maps that detail ownership of the land.

At present, Member States report the total area of both degraded and natural or near-natural (undrained) peatlands, but these figures often represent coarse estimates. For instance, Denmark has developed an organic soil map based on an extensive dataset comprising 10 000 sampling points collected during 2009–2010 and 1 000 points revisited in 2022. This sample allowed researchers to train a model with high resolution variables (altitude, land use, geology, climate and groundwater depth), resulting in a 10-metre resolution map of organic soils (EEA, 2024d). While this approach provides a granular map capable of linking peatlands with landowners, it remains a modelled estimate rather than a direct measurement of individual areas.

To enhance accuracy, it has been proposed that landowners be granted the right to contest soil classifications and request verification through impartial, state-authorised third-party sampling, conducted according to standardised technical protocols and analysed by accredited laboratories (Svarer et al., 2024). Furthermore, the integration of ground-based measurements with satellite data has been suggested as a complementary approach (JRC, 2023b).

The current GAEC 2 standard under the CAP establishes requirements for the protection of wetlands and peatlands, relying on the mapping of these areas. Member States have either already implemented GAEC 2 or plan to do so by 2025 (Nordbeck et al., 2025). This indicates that, in principle, the information necessary to phase out payments for degraded peatlands is available. Similarly, the European Peatland Map demonstrates availability of existing data sources (Tegetmeyer et al., 2025). Nevertheless, ongoing refinement of mapping methodologies may be required to ensure sufficient precision for policy implementation.

LULUCF pricing relies on good-quality spatial data and a rigorous crediting framework for removals.

Beyond peatlands, a dedicated system addressing land-based GHG removals and emissions necessitates the use of high-resolution spatial data, including maps that delineate land-use categories and soil types. For accurate accounting, emission factors must be specified for each unique combination of land-use category and soil type, ideally incorporating site-specific conditions and project-level data to enhance precision.

7.7 A phased implementation of GHG pricing

In the initial phases, agricultural emission sources should be addressed through distinct pricing mechanisms.

As elaborated in Section 7.3, the optimal long-term objective for the EU should be the establishment of a comprehensive system that encompasses all categories of emissions and removals from agriculture. However, due to the heterogeneous nature of these emission sources, the Advisory Board recommends a phased approach, beginning with separate trading systems tailored to specific emission types.

Energy-related emissions from agriculture could be incorporated into the EU's existing emissions trading system. In parallel, two new systems should be developed: one targeting non-CO_2 emissions associated with activities such as fertiliser use and livestock production, and another dedicated to regulating land-based agricultural CO_2 fluxes.

The Advisory Boards recommends an approach encompassing multiple phases that gradually introduces the polluter pays principle.

While the inclusion of agriculture into existing policy frameworks such as the EU ETS2 would be fairly straightforward from an administrative perspective, establishing the two new systems requires careful preparation and implementation. To ensure a smooth transition and avoid significant adverse impacts on the competitiveness of EU agricultural products, it is essential to allow sufficient time for stakeholders to adapt (see also Section 5.3.9). This includes fostering the development and adoption of climate-friendly technologies and practices.

Moreover, the administrative and MRV requirements associated with such systems are substantial and must be addressed with care. To build trust and ensure institutional readiness, it is advisable to introduce MRV obligations prior to the imposition of financial liabilities (Runge-Metzger et al., 2025). This phased approach allows for the gradual development of administrative capacity and stakeholder familiarity with reporting requirements.

Accordingly, the Advisory Board recommends a phased implementation approach that allows for testing and piloting of the proposed pricing framework. Table 24 outlines the structure of this gradual rollout, while the rationale and specific elements of each phase are elaborated below. It is important to note that the various pricing schemes may progress through these phases at differing rates.

Table 24 Outline of a phased implementation of a GHG pricing framework

	Preparation		Operation		
	Testing phase	Baseline phase	Pilot phase	Subsequent phases	Long-term ambition
Purpose	To test MRV systems	To establish baselines for the cap and free allocation	To initiate the first mitigation outcomes and foster policy learning	To gradually transition towards the long-term ambition using a phased approach	To have an integrated AgETS with high coverage based on polluter pays and rewarding removals
Reporting requirements?	Yes/No	Yes	Yes	Yes	Yes
Surrendering obligations?	No	No	Yes	Yes	Yes
Coverage (thresholds)	Only large entities	Only large entities	Only large entities	Threshold is progressively lowered	Only small entities excluded
Allowance allocation	N/A	N/A	Free allocation	Increasing proportion of allowances is auctioned	Full auctioning
Separate systems for different emission sources?	Yes	Yes	Yes	Yes	All agricultural emission sources are integrated into one system

- **Testing phase.** A robust MRV system constitutes a foundational element of the GHG pricing framework. Reporting entities require sufficient time to develop internal monitoring capabilities, while external verification and control mechanisms must be established and evaluated. Accordingly, a multi-year testing period is needed to allow stakeholders to familiarise themselves with MRV procedures prior to the imposition of binding commitments based on the reported data. Participation in the testing phase could either be mandatory or voluntary, but financially incentivised.
- **Baseline phase.** Once MRV systems have demonstrated reliability and robustness, the collected data should be employed to calibrate the pricing framework ahead of its operational launch. This includes estimating the aggregate emissions attributable to the entities initially covered by the system, which will inform the emissions cap applied during the pilot phase. Additionally, entity-level data is necessary to establish baselines for the

allocation of free allowances, whether through grandfathering, benchmarking or a hybrid approach (see Box 16).

The baseline phase should be carefully designed to prevent the overreporting of emissions or the creation of perverse incentives that could lead to a temporary increase in emissions. This risk is particularly pronounced when reported emissions by individual entities are directly employed to determine their subsequent free allocations, as in the grandfathering approach. Opting for benchmarking would substantially mitigate this risk. Alternatively, comprehensive verification systems that incorporate historical data could be adopted.

- **Pilot phase.** The initial operational phase serves as a pilot to facilitate institutional learning and suggest adjustments of the pricing system's design in later phases. During the pilot phase, only large-scale entities are required to surrender allowances corresponding to their verified emissions. Consideration should be given to the banking of unused allowances for use in subsequent phases, in order to mitigate excess volatility in allowance prices.[27]
- **Subsequent phases.** In the following phases, the inclusion threshold should be progressively lowered to expand the system's coverage. While this in principle may result in an increase in the absolute emissions cap (measured in tonnes of CO_2e), the cap relative to the initial baseline should follow a declining trajectory. Whereas the pilot phase involves full allocation of allowances free of charge, subsequent phases should gradually transition towards auctioning.
- **Long-term ambition.** The integration of the various pricing systems addressing distinct agricultural emission sources should be pursued as a long-term objective. This integration is contingent upon well-established and robust measures to address the issue of non-permanence for land-based removals and emission reductions.

  Furthermore, the integration of agricultural pricing mechanisms with compliance schemes from other sectors such as the EU ETS should be explored to enhance economy-wide cost-effectiveness (Schellekens, 2025) once environmental risks and governance challenges have been adequately addressed (Sultani et al., 2024; Advisory Board, 2025). The intermediary institution discussed in Section 7.4.2 could play a pivotal role in facilitating this integration by ensuring methodological consistency, market transparency and regulatory alignment. Moreover, a centralised intermediary may be in a better position to manage or take on liability mechanisms for reversal risks (Advisory Board, 2025).

  Finally, a complete shift towards auctioning as the primary allocation method should be implemented, while maintaining incentives for carbon dioxide removals in accordance with the polluter pays principle.

Preparatory efforts should start without delay, reflecting the urgency of the climate crisis and the need for timely policy intervention.

While a phased implementation of agricultural climate policies is necessary, undue delays must be avoided due to the pressing nature of the climate crisis. Immediate preparatory actions are required to enable the timely deployment of the various components of the pricing framework. The Danish

[27] The EU ETS allowance price fell to zero towards the end of its first period in 2007 due to a surplus of allowances combined with banking not being allowed (EC, 2025j).

agricultural taxation scheme, which postpones the taxation of livestock emissions until 2030, exemplifies the extended timelines often associated with full policy implementation (see Box 15).

The scheduled 2026 revision of the EU ETS Directive (as mandated by Article 30 of Directive (EU) 2023/959) presents a critical opportunity to incorporate agricultural fossil fuel emissions into the existing regulatory framework. Concurrently, the CRCF Regulation and its associated methodologies must be further developed and expanded, including the integration of livestock emissions as already envisaged.

To drive the transition towards to 2040 climate targets, the European Commission should initiate a comprehensive 'fit for 2040' legislative package, analogous to the 'fit for 55' initiative. This package should establish the foundations for an AgETS and introduce procurement mechanisms to stimulate climate mitigation efforts within the sector during the interim period until the AgETS is fully functioning.

The pricing schemes should include mandatory obligations that stimulate both technical improvements and structural changes throughout the agri-food value chain.

The establishment of mandatory compliance obligations is critical to ensuring the effectiveness of GHG pricing instruments. Relying solely on voluntary demand for mitigation outcomes is unlikely to generate the scale of transformation required to align the agricultural sector with broader climate objectives.

As discussed in Section 7.4, compliance obligations may be assigned at various points along the agricultural value chain. Each option warrants careful evaluation, particularly with respect to its implications for system coverage, administrative complexity and the nature of mitigation actions it incentivises. Crucially, regardless of the designated point of obligation, the pricing framework must incorporate mechanisms that support both technical improvements at the farm level and structural shifts across the wider value chain.

Chapter 8

Transition support for climate-proofing EU agriculture

Key messages

Public transition support is needed to provide enabling conditions, advance climate adaptation and ensure a just transition.

The effectiveness of policy incentives towards climate mitigation depends on the establishment of enabling conditions that allow the sector to respond appropriately and overcome non-market barriers. This necessitates targeted support to facilitate the transition towards low-emission practices and production systems. An equally critical component of climate-proofing EU agriculture is the promotion of adaptation measures that enable farmers to adopt more climate-resilient practices. Furthermore, farms that face significant difficulties in transitioning may require assistance to exit the sector in a manner that ensures a just transition.

The Advisory Board recommends a comprehensive framework for transition support to tackle different financial and non-financial barriers for the transition, including:

- **investment support** to help farmers overcome limited access to finance;
- **transitional income support** to compensate for a temporary reduction in yields and incomes as farmers switch to new practices and systems and are still learning by doing;
- **support for knowledge development and dissemination** that fosters innovation and experimentation, including by supporting demonstration and early deployment, accelerates the market entrance and scale-up of climate-friendly technologies and ensures farmers have sufficient access to knowledge;
- **incentive schemes that adequately reward the provision of ecosystem services** other than climate mitigation and adaptation at the farm level, to support options that contribute to both climate and other environmental objectives and to avoid potential environmental trade-offs resulting from climate policies;
- **redistribution mechanisms** to help GHG-intensive or least climate-resilient farms that will face the highest pressure to change, but also the highest barriers to achieving this change. The priority should be to help them transition towards less GHG-intensive and better-adapted systems, but additional measures might be needed to help farms with limited transition options exit the sector.

Transition support should be temporary.

As a general principle, support mechanisms should operate on a temporary basis, to avoid subsidy dependence, encourage early action and align with the polluter pays principle. The appropriate duration should be determined and reviewed based on evidence-based needs, while avoiding stop-and-go cycles. As an exception, support should be provided in the longer term for the provision of public goods such as environmental and adaptation benefits that extend beyond the farm.

An improved CAP could deliver such a supportive framework.

The current CAP includes a range of instruments which already aim to provide these different types of support, but their effectiveness can be further improved. This chapter explores areas for improvements and provides a brief assessment as to what extent these are reflected in the European Commission's proposal for the next CAP.

8.1 Introduction

This chapter explores various instrument to support both climate adaptation and mitigation efforts.

As discussed in Section 5.3.3, enhancing both climate adaptation and mitigation in the agri-food system will require transition support.

- **Climate adaptation.** While the increased risk of adverse climate-related impacts inherently incentivises individual adaptation, public policy – including transition support – is required to overcome behavioural barriers, financial constraints and coordination failures, and to remunerate the provision of public goods and positive adaptation spillovers beyond the farm gate.
- **Climate mitigation.** Whereas the removal of climate-harmful subsidies (Chapter 6) and the introduction of a GHG pricing framework (Chapter 7) provide a strong policy foundation for advancing mitigation efforts within the EU's agricultural sector, the effectiveness of such policies depends on the establishment of enabling conditions that allow the sector to respond appropriately (see Section 5.3.3).

This chapter therefore examines a range of instruments that can support the transition. They build primarily on enhancing instruments that already exist under the current CAP, but could also be considered as separate, dedicated instruments. To this end, the chapter is structured as follows.

- **Section 8.2** provides an overview of the types of transition support that the Advisory Board recommends the EU to put in place, for which more detailed options are then explored in subsequent sections.
- **Section 8.3** explores how investment support can address financial constraints, while transitional income support can help farmers adjust to more sustainable production systems.
- **Section 8.4** assesses options to enhance publicly funded initiatives for knowledge development and dissemination relating to climate mitigation and adaptation, including by encouraging innovation and risk-taking.
- **Section 8.5** investigates mechanisms for incentivising the provision of public goods, which are essential for making the transition economically viable for farmers.

8.2 A comprehensive framework for transition support

The Advisory Board recommends that the EU put in place a comprehensive framework for transition support.

As discussed previously (see Sections 4.6 and 5.3.3), the transition towards a climate-proof agri-food system faces a range of financial and non-financial barriers. To overcome these barriers and unlock the potential of generational renewal, the Advisory Board recommends a comprehensive framework that provides different types of transition support.

- **Targeted investment support.** As previously discussed, the introduction of GHG pricing and reduced long-term climate-related risks can improve the business case for climate adaptation and mitigation options. However, as discussed in Section 2.5.3, the deployment of many of these options often requires upfront investments which many farmers are unable to finance, even if they have an economically viable project. Targeted investment support is therefore both necessary and justified, particularly for the most GHG-intensive and least climate-resilient farms that would need to be fundamentally restructured to become climate-proof (see also below under 'redistributive measures'). Additionally, specific support is required for the demonstration and early adoption of new mitigation and adaptation technologies, to foster knowledge development (see also below under 'support for knowledge development and dissemination').
- **Transitional income support.** As also discussed in Section 2.5.3, when farmers shift to more sustainable and resilient farming systems and practices with lower net GHG emissions, they may face temporary yield and income reductions while they learn by doing. Given already low agricultural incomes in parts of the sector, many farmers cannot afford such short-term losses, even if the transition is economically viable in the long run. The support framework should therefore include a mechanism that provides temporary income support as farmers transition.
- **Support for knowledge development and dissemination.** Dedicated support for the development of knowledge is a vital complement to broader incentive schemes like GHG pricing as it can bring down technology and implementation costs, thereby enhancing dynamic cost-effectiveness (see also Box 13). Such support would need to cover both fundamental R&D, its translation into more practical innovations and early-stage deployment, including investment support for the early adoption of new technologies and practices that face a 'first mover disadvantage' but could deliver knowledge and learning-by-doing spillovers. Another crucial element of the support framework are mechanisms to enhance the dissemination of relevant knowledge throughout the sector. This is particularly important as agriculture is a highly heterogenous sector where GHG emissions and removals along with climate-related impacts, are often the result of complex biological and bio-geophysical processes. This raises the importance of enhancing farmers' access to relevant knowledge on the most appropriate mitigation and adaptation options to reduce net emissions and climate-related risks given their specific context.
- **Remuneration of ecosystem services.** As discussed in Section 3.5, many options exist which can deliver both climate mitigation and/or adaptation in combination with other ecosystem services, such as maintaining and improving biodiversity and soil health and reducing nitrogen and phosphorus pollution. A GHG pricing instrument complemented by the private adaptation benefits of such practices alone may not adequately reward these multifaceted contributions. Conversely, policies aimed at driving climate mitigation and

adaptation may inadvertently cause trade-offs with other environmental objectives, such as the loss of extensively grazed grasslands due to the removal of coupled income support (see Chapter 6) or the pricing of GHG emissions from livestock (see Chapter 7). To harness synergies and reduce trade-offs between climate action and other environmental objectives, the EU should provide adequate rewards for the provision of ecosystem services other than GHG emission reductions (which are already incentivised by a GHG pricing instrument) or adaptation benefits at the farm level (where the farmer is the inherent beneficiary of those benefits). Such rewards would further support the business case of options with both climate and other environmental benefits, and help sustain practices and production systems that deliver important ecosystem services, even if they are GHG-intensive and thus disfavoured by climate mitigation policies.

- **Redistributive measures.** As discussed in Chapters 6 and 7, the removal of climate-harmful subsidies and the introduction of a GHG pricing framework would mainly hit the most GHG-intensive farming systems, such as cattle farms and farms on degraded peatlands. Similarly, climate impacts will affect certain regions in the EU (in particular in southern Europe) harder than others. The most GHG-intensive and least climate-resilient farms will thus face the highest pressure to change, but also the highest barriers to achieving this change as it would likely require a full restructuring of their holding. To ensure a just and fair transition that leaves no one behind, these farms merit specific attention under the transition support framework. The priority should be to help them transition towards less GHG-intensive and better adapted systems, using the different types of transition support recommended above. However, some farms might have limited transition potential, for example because their land is becoming increasingly unsuitable for agricultural production due to climate change or because they cannot switch to less GHG-intensive systems due to other constraints. In line with the principle of a just and fair transition, such farms should be helped to exit the sector, for example through voluntary buy-out schemes (see Box 18).

The remainder of this chapter elaborates on how these types of support could be provided, building on and learning from existing CAP instruments and Horizon Europe, the EU's key funding programme for research and innovation.

Box 18 Voluntary buy-out schemes

Voluntary buyout schemes for farmers have gained traction, especially in regions facing acute environmental pressures. Under such programs, governments compensate farmers who agree to permanently shut down or repurpose their farms, thereby achieving environmental targets while providing an exit strategy for farmers. This could become increasingly important as the average age of EU farmers is relatively high with many farmers reaching retirement age soon (EC, 2017).

A notable example of such a voluntary buyout scheme is the Netherlands' buyout plan aimed at curbing nitrogen emissions. In 2023 the European Commission approved EUR 1.47 billion in state aid for the Dutch government to buy out approximately 3 000 livestock farms located near sensitive nature areas (EC, 2023h). This voluntary scheme targets farms with especially high nitrous oxide and ammonia emissions (often intensive dairy and pig farms), offering compensation to those who choose to close their operations.

One potential risk of such buy-out schemes is that they could result in carbon leakage within the EU. For example, the system in the Netherlands does not allow beneficiaries to open new livestock farms elsewhere in the country but does allow them to do so elsewhere in the EU, and they could even receive additional support for this. As a result, the measure supports a displacement rather than a reduction in polluting agricultural systems. This might not be a major issue for local environmental pressures (e.g. nitrogen pollution), but it undermines the climate effectiveness of such buy-out schemes due to carbon leakage. To avoid this, buy-out schemes could be designed to restrict beneficiaries from starting new livestock farms elsewhere within or outside the EU.

As a general principle, support mechanisms should operate on a temporary basis, except for the remuneration of public goods, which warrant long-term financial support.

The policy recommendations outlined above imply an increased demand for public funding, risk reinforcing the agricultural sector's dependence on subsidies, and may conflict with the polluter pays principle. To mitigate these risks, support should primarily serve as a temporary instrument aimed at accelerating the shift towards a climate-proof agricultural sector, while avoiding long-term reliance on public subsidies. The appropriate duration should be determined and reviewed based on evidence-based needs, while avoiding stop-and-go cycles that harm investor certainty and policy credibility.

Nonetheless, sustained support for the provision of public goods, including non-climate ecosystem services, carbon dioxide removals and adaptation benefits that extend beyond the farm level, can be economically justified due to their broader societal value.

8.3 Investment and transitional income support

The current CAP allows Member States to provide investment support for climate adaptation and mitigation with a high degree of flexibility.

As briefly described in Section 5.2.1, Pillar 2 of the current CAP already allows Member States to provide support for investments that contribute to any of the CAP's nine strategic objectives (including climate adaptation and mitigation) subject to certain exceptions[28] (EU, 2021b). However, the support is not mandatory, and EU legislation does not specify how much investment support to provide nor how to prioritise between the different strategic objectives. It only more broadly requires Member States to spend at least 35% of their Pillar 2 budget (which includes investment support) on measures that contribute to either the environment, climate action or the improvement of animal welfare.

Current CAP investment support is primarily targeted at productive investments, with a limited contribution to climate action.

As discussed in Section 5.2.2, when offered flexibility, Member States have generally prioritised boosting productivity and competitiveness over climate and environmental objectives. This also appears to be the case when assessing the planned investment support under the different strategic plans. As shown in Table 25, Member States plan to provide EUR 18.4 billion of investment support, of which about half (EUR 9.6 billion) is claimed to contribute to the enhancement of climate mitigation and adaptation (strategic objective 4 or SO4). However, Member States do not need to specify how substantial this contribution would be. The majority of these 'climate-related' investments (EUR 6.8 billion) would be provided for productive investments which are not per se guaranteed to result in lower GHG emissions or increased climate resilience and could in some cases even be counterproductive, for example investment support for irrigation systems (see Section 5.2.2). Furthermore, part of the investment support is also targeted at forestry instead of agriculture. Out of the total planned investment support, only EUR 2.6 billion (about 15%) would support investments in agriculture that contribute to climate action to a sufficient extent that it is also eligible to contribute to the 35% objective on environment and climate spending under Pillar 2.

Table 25 Planned CAP investment support budgeted for 2023–2029, per type

EUR billion	Productive	Non-productive	Infrastructure	Total
Total	12.1	2.6	3.7	18.4
Contributing to climate action (SO4)	6.8	1.6	1.2	9.6
Contributing to climate (SO4) and the 35% ringfenced objective	1.6	1.6	0.8	3.9
- of which for agriculture	*1.4*	*0.5*	*0.7*	*2.6*
- of which for forestry	*0.2*	*1.1*	*0.1*	*1.4*

Source: (EC, 2025k).

Notes: (1) The data in the table only includes the provided EU budget financed through the EAFRD. (2) The overall public budget for CAP investment support is higher when also considering national co-financing.

[28] See Article 73, paragraph 3 of the Strategic Plans Regulation (EU, 2021b).

Several options could be considered to better target investment support towards climate adaptation and mitigation.

A number of options could be considered to ensure that the CAP's system for investment aid or comparable support instruments provide adequate support for farms embarking on a structural transition towards lower GHG-emitting or better climate-adapted farming systems, while avoiding support for climate-harmful investments. Some examples are listed below.

- **Conditionality.** Some have proposed to strengthen and expand the criteria used to grant CAP investment support, to ensure that supported investments help to reduce GHG emissions (IEEP, 2025c; Guyomard et al., 2023). Similarly, negative lists could be used to avoid support for climate-harmful investments in least climate-resilient or GHG-intensive practices, whereas positive lists could be used to better target investments that enhance climate adaptation and mitigation.
- **Variable support rates.** Another option is to provide more generous support to investments that contribute to climate adaptation and mitigation (IEEP, 2025c). For example, a low support rate could be given for investments where the beneficiary can demonstrate that the investment would at least not increase vulnerability to climate-related hazards or GHG emissions in line with the 'do no significant harm' principle. Higher support rates could be given if beneficiaries can demonstrate the investment would increase resilience or GHG net emissions, with a potential further distinction between incremental improvements and more fundamental restructuring of the most GHG-intensive or least climate-resilient farming systems.
- **Different support types.** Similarly, the form of support could differ according to the climate contribution of different investments. Incremental improvements in climate resilience or GHG intensity could be backed mainly by private finance, with public loans or loan guarantees serving as complementary tools. By contrast, more transformative restructuring of farming systems could warrant stronger public involvement, for example through grants.

The emerging principle of 'resilience by design' – to be further developed in the upcoming integrated framework for European climate resilience and risk management – could be applied when conceiving policies, investments and other measures to ensure the consideration of climate-related risks and prioritisation of transformational measures. The Advisory Board has recommended the scope of its application to be reflective of the whole-of-government, whole-of-society and all-hazards approaches, with direct application to all relevant EU policies and funding, including in agricultural sector (Advisory Board, 2026).

The CAP would need to be complemented with transitional income support.

Whereas the current CAP provides incentives for the uptake of certain sustainable practices (via eco-schemes or AECMs, see Section 5.2.1), it lacks a mechanism to provide transition aid for farms that want to embark on a more holistic transition (Matthews, 2025b). In line with the recommendation to provide temporary income support for such farms, the CAP toolbox could be extended to include additional, temporary transition aid for farmers that want to pursue a more fundamental restructuring of their farming system to enhance climate mitigation and adaptation. The option to provide such support is provided in the European Commission's proposal for the next CAP (see details below).

The different options face challenges in terms of administrative complexity and budget availability, which would need to be addressed.

A key challenge of the options to better target investment support is that they risk increasing administrative requirements for both authorities and farmers: public authorities would need to develop conditionality frameworks and check compliance or decide on triggers for variable support rates and types, while farmers would need to demonstrate compliance with the relevant rules. This risk can be reduced by avoiding unduly complex rules and increasing farmers' access to advisory services (IEEP, 2025c).

Another challenge is that increased investment and transitional income support for climate action require sufficient public budget. This could be ensured by ring-fencing a certain amount of the investment support budget for this purpose. However, this would reduce investment support for other policy objectives (e.g. increasing productivity and competitiveness) which might be particularly problematic for central and eastern European countries who have had less time to modernise since joining the EU (IEEP, 2025c). To counter this, it could be considered to increase the overall public budget for agriculture either within or outside the CAP, but this strategy has its own challenges (see Chapter 12).

The proposal for the next CAP largely continues the current approach on investment support, with some improvements.

The European Commission's proposal for the CAP covering the 2028–2034 period, as published in July 2025 (EC, 2025q), largely maintains the current system for investment support, with a few changes.

- It requires Member States to provide investment support instead of having it only as a voluntary option. In practice this would not change much though, as all 27 Member States already make use of this voluntary option under the current CAP.
- Investments in climate and water resilience are now mentioned as particular focus areas. Whereas the proposal does not specify how much of the investment support should go to these areas, it is a welcome encouragement for Member States to consider them when developing their national plans.
- The investment support would be made subject to the 'do no significant harm' principle under the EU Taxonomy Regulation (Regulation (EU) 2020/852), which should in principle prevent support for investments that would increase GHG emissions or reduce climate resilience. However, the impact of this provision is substantially limited as all support subject to the farm stewardship framework is considered to comply with 'do no significant harm', even if this framework does not cover all major sources of GHG emissions or climate-related risks (see Box 19). It still remains to be seen how the horizontal principle of 'resilience by design' will be operationalised, and whether and how some of these issues could be addressed.
- The proposal allows Member States to pay up to EUR 200 000 to support farmers who choose to transition towards resilient production systems, based on a transition plan drawn up by the farmer and approved by the Member State.

8.4 Support for knowledge development and dissemination

Horizon Europe is the EU's key funding programme for research and innovation but could be better structured to address agriculture and climate change.

Horizon Europe is structured around three pillars where Pillar 2[29] is focused on global challenges and European industrial competitiveness (EC, n.d.). Pillar 2 is further organised in thematic clusters, of which two are relevant for climate action in agriculture.

- **Cluster 5** covers climate, energy and mobility. Whereas it addresses climate science and solutions, energy systems, clean transport and mobility, its areas of intervention do not directly cover agriculture and food.
- **Cluster 6** covers food, bioeconomy, natural resources, agriculture and the environment. However, it does not explicitly address climate change, though the transition to a low-carbon bioeconomy is included among its objectives.

This division means that research explicitly linking climate change mitigation and adaptation with agricultural transformation may need to draw on both clusters or rely on cross-cutting initiatives. The silo structure could lead to gaps and missed opportunities, highlighting the need for continued efforts towards more integrated approaches on agriculture, food and climate change.

Within each cluster, European Partnerships bring together the European Commission and private and/or public partners to address specific challenges by mobilising funding for concerted research and innovation initiatives. These partnerships can help bridge thematic gaps, for instance through initiatives like the European Partnership for Agriculture of Data or the Partnership for a Climate-Neutral, Sustainable and Productive Blue Economy, which integrate climate and sectoral objectives (EC, 2025f). However, there are currently no partnerships dealing specifically with agricultural, food and climate change in Horizon Europe.[30]

Other EU initiatives also aim to promote climate-relevant innovation in the agri-food system.

The Food 2030 innovation strategy sets out 11 pathways to guide future research and innovation policies in the EU (EC, 2023e). Among these are several pathways which are relevant for climate mitigation and adaptation, including pathway 4 on alternative proteins for dietary shifts, pathway 5 for food waste and resource-efficient food systems, and pathway 6 on nutrition and sustainable healthy diets.

The European Institute of Technology has developed Knowledge and Innovation Communities (KIC) with the aim to accelerate innovation and to scale it up. The Climate KIC contributes to projects (e.g. ClieNFarms (2025)) which tests and scales practical solutions for climate-neutral and climate-resilient agriculture in a wide range of farming systems, from arable crops in Mediterranean and continental regions to dairy and beef farms in oceanic and mountainous regions. The project brings together demonstration farms, advisors, researchers, financial actors and supply-chain partners within living labs. Additionally, Climate KIC is following a model of innovation in Ireland that is applied to the entire agri-food and bioeconomy value chain, from soil to farm to fork to society. This involves

[29] Not to be confused with the Pillar 2 under the CAP.

[30] Some partnerships under Cluster 6 could contribute to climate action in agriculture indirectly. These include a network of living labs and research initiatives accelerating the transition to agroecology, a partnership for research and innovation in the Mediterranean area, and a partnership on sustainable food systems. Moreover, 'Mission Soil' is a large-scale initiative focused on protecting and restoring soils, including by increasing their soil carbon stock. This initiative has a goal to create living labs and lighthouses to promote sustainable land and soil management in both rural areas and urban areas.

working with stakeholders from both public and private sectors, including finance and education, as well as civil society, to develop and deploy coordinated innovation actions that work – in practice and at scale – and to obtain insights and lessons about a portfolio of solutions.

The CAP includes additional instruments to boost knowledge development and dissemination.

As briefly introduced in Section 5.2.1, knowledge development and dissemination is one of the interventions eligible for support under the current CAP's Pillar 2. This is delivered through different mechanisms, jointly referred to as Agricultural Knowledge and Innovation Systems (AKIS), consisting of the following.

- The **CAP network** which aims to facilitate innovation and knowledge exchange among key stakeholders such as farmers, researchers, advisors, businesses and policy makers. The network covers both policy-related[31] and more practical topics. On the latter, the European Innovation Partnership for agricultural productivity and sustainability (EIP-Agri) aims to stimulate innovation and knowledge exchange on specific farming practices, bridging the gap between fundamental research and practical innovations. To this end, it brings together farmers, researchers, advisors and businesses in operational groups.
- **Farm advisory services**, which Member States must put in place to provide advice to farmers and other CAP beneficiaries, and which are further discussed below.

While the portfolio of funded projects continues to evolve and covers a broad range of climate-relevant topics, the OECD has noted that resources devoted to AKIS remain limited compared with total agricultural support, and that investment in and adoption of innovation remains a challenge (OECD, 2019).

Only a small share of the EIP-Agri budget contributes to climate adaptation or mitigation.

A recent assessment study by the European Evaluation Helpdesk (DG AGRI, 2024b) found that EIP-Agri has been overall successful in enabling new forms of collaboration between different types of actors, linking science and agricultural practices and spreading innovative solutions. However, climate change is not a main focus of most EIP-Agri operational groups. Only 6.7% of the aggregated public budget for all EIP-Agri projects is expected to contribute to the priority 'Promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sectors'. By contrast, approximately 75% of total public expenditure is dedicated to economic objectives, including improving the economic performance of farms (56%) and improving the competitiveness of primary producers (19%) (DG AGRI, 2024b).

Farm advisory services suffer from limited reach and inconsistent advice.

Recent assessments have concluded that the CAP's farm advisory services are a useful and important tool which has so far delivered a positive impact (Labarthe and Beck, 2022; Kountios et al., 2024; Birke et al., 2022). However, their potential to support the uptake of climate-friendly farming practices is undermined by two main shortcomings.

- **Limited reach.** Currently, independent farm advisory services reach only 5% of EU farms, due to a lack of trained advisors and lack of perceived usefulness. Moreover, these services primarily reach larger farms, whereas smaller farms and younger and female farmers remain

[31] For example, sharing knowledge on how to design and implement CAP strategic plans, or how to monitor and evaluate their impact.

hard-to-reach (Labarthe and Beck, 2022). One option to address this is to provide more funding to ensure a sufficient amount of appropriately skilled independent agricultural advisors (Labarthe and Beck, 2022; Kountios et al., 2024; Baldock and Bradley, 2023). For farmers to participate, independent advisory services must be seen as accessible, useful and credible. Best practices include raising awareness of the services, gathering regular feedback to improve them, ensuring advisors are trusted and versatile, integrating services into existing networks and providing access locally or remotely (Labarthe and Beck, 2022; Kountios et al., 2024). Better data on advisory service users can help identify hard-to-reach groups and design tailored approaches to engage them (Labarthe and Beck, 2022).

- **Inconsistent and non-independent advice.** The fragmentation and lack of coordination of these services have led to duplicate or even contradictory advice. In particular, in several Member States the prime focus of these services has been on enhancing productivity and competitiveness in the short term, at the expense of environmental sustainability (Labarthe and Beck, 2022; Kountios et al., 2024). Furthermore, a significant share of farm advisory services is provided by private companies that simultaneously sell inputs to farmers (fertilisers, pesticides, seeds) or purchase farm outputs. While some of these actors, including cooperatives, may have sustainability commitments, their business models create inherent conflicts of interest that can discourage transitions away from input-intensive practices. This structural lock-in effect undermines the provision of genuinely independent advice oriented towards sustainability (Sutherland and Labarthe, 2022). The Strategic Dialogue on the Future of EU Agriculture (EC, 2024h) explicitly identifies independent advisory services as crucial for the sustainability transition and recommends that parts of the CAP budget be dedicated to strengthening them. It also called for strengthening the implementation of AKIS within independent farm advisory services.

Farm-level assessment tools and transition plans can help enhance climate action.

Due to the sector's heterogeneity and the context-specificity of different mitigation and adaptation options, it is important to tailor advice to individual farms. In this context, user-friendly tools which generate farm-specific recommendations can be powerful instruments. For example, several 'climate stress test' tools have been developed in recent years which allow farmers to identify key climate risks and compare 'possible adaptation options under various climate change scenarios (see for example Zaatra et al. (2025) and Verstand et al. (2020)). Similarly, farm-level transition plans can help guide farmers in moving beyond incremental improvements, and embarking in a more holistic restructuring of their businesses (Baldock and Bradley, 2023).

8.5 Incentives for the provision of ecosystem services

Several options could make the CAP's environmental incentive schemes more effective but would also require higher payment rates.

As discussed in Chapter 5, the CAP includes eco-schemes and AECMs that reward environmental actions, but so far these have delivered limited outcomes. The main reason for this is that Member States have designed them so that they require little additional efforts, to make them easily accessible and to ensure broad farmer participation.

Several options have been explored in the scientific literature which could better ensure that incentive schemes deliver more substantial environmental outcomes. This section focuses on two options in particular:

- shifting from action-based to result-based payments;
- shifting from single-year to multi-year commitment periods.

As further discussed below, both options would better ensure climate outcomes but also increase the administrative efforts and risks for farmers. To ensure sufficient farmer participation under more demanding incentive schemes, they might need to be combined with higher payment rates, which are discussed at the end of this section.

Result-based payments can deliver stronger climate outcomes but add administrative burdens and risks for land managers.

Most environmental schemes under the CAP have so far been action-based, meaning that farmers or landowners receive payments for implementing pre-defined agricultural practices under the assumption that these practices deliver environmental benefits (O'Rourke and Finn, 2025). An alternative approach would be to provide result-based payments, which would link payments directly with the environmental outcomes, regardless of how these are achieved.

Both approaches have advantages and disadvantages, as summarised below (Anougmar et al., 2025; Simpson et al., 2023a; Raina et al., 2024; Umweltbundesamt, 2025; Sidemo-Holm et al., 2018).

- **Action-based payments** are generally simpler and have lower transaction costs, making them more acceptable to farmers due to their predictability. However, they offer limited certainty regarding environmental outcomes, leave little room for innovation as only predefined actions are rewarded, and carry risks of low additionality, perverse incentives, and unintentional non-compliance if eligible actions are defined too strictly.

- **Result-based payments** provide greater assurance of achieving meaningful outcomes, allow flexibility and innovation by land managers, and reduce the likelihood of perverse incentives or rule violations. Furthermore, proving avoided climate-related losses as a result of adaptation measures is technically challenging both if hazard events materialise and if they do not. These benefits come at the cost of higher administrative complexity and transaction costs, along with greater financial risk for land managers due to less predictable payments.

To combine the strengths of both approaches, hybrid schemes could be considered, which first provide an action-based reward to cover upfront costs and encourage farmer participation, followed by follow-up payments conditional on the achievement of certain outcomes (Burton and Schwarz, 2013).

Longer commitment periods can enhance climate outcomes but also increase burdens and risks for land managers.

Incentive schemes with longer commitment periods can generally be considered as more effective at delivering beneficial climate outcomes (Anougmar et al., 2025). This is the case both for schemes covering carbon sequestration practices where the climate benefit builds up over time and is reverted when the practice is discontinued, and for many nature-based adaptation measures that require long time for maturation. For the same reason, schemes with shorter commitment periods can generally be assumed to be less effective.

The main disadvantage of schemes with longer commitment periods is that they are less popular with farmers, who generally prefer the flexibility offered by one-year commitment periods as under the current eco-schemes (Raina et al., 2021), which may result in smaller uptake (Broch and Vedel, 2012).

Higher payment levels might be needed to ensure sufficient farmer participation, for which different options could be considered.

Result-based schemes with multi-annual commitment periods can thus be considered as more effective but would also be more demanding for farmers. Most studies indicate that under more demanding incentive schemes, higher payment rates are needed to secure sufficient farmer adoption (Raina et al., 2021).

The current CAP's approach to set payments is primarily based on the principle of 'costs incurred and income foregone' (see Box 10). The effectiveness of this approach for encouraging farmers' participation in ambitious environmental incentive schemes has been debated. Some argue that it could be effective, as the approach could still generate net-benefits for farmers (Matthews, 2021a; Mögele and Scheele, 2024). This is because the CAP allows for the inclusion of opportunity and transaction costs and payment levels are in practice based on the average costs of certain practices, meaning they yield net benefits for farmers with below-average costs. Additional arguments in favour are that the approach in theory provides the most environmental outcomes for a given public budget and that such payments are allowed without limitation under the Green Box rules of the World Trade Organization (WTO) (Matthews, 2021a). Others have argued however that its central principle to only cover costs incurred and income foregone could still discourage farmers' participation through psychological effects (Röder, 2021) or in case true costs and risk premiums are underestimated. Insufficient differentiation of payment levels by Member States could further discourage farmers' participation in the most productive systems and regions, where opportunity costs are above-average (Agora Agriculture, 2024). Finally, it is inherently difficult to predetermine the payment level needed to achieve the desired participation rate (Mögele and Scheele, 2024).

Two alternative approaches to the current approach of the CAP have been raised.

- **Value-based payments.** Environmental NGOs and others have argued for payments reflecting the value of the ecosystem service provided to society. Such an approach could allow higher payments which can encourage farmers to participate in more ambitious environmental schemes. A drawback to this approach is that it requires regulators to estimate social values of ecosystem services, which is not straightforward. It also carries a risk of overcompensation and thus lower environmental outcomes for a given public budget (Matthews, 2021a). Finally, value-based payments would be subject to limits under the WTO Amber Box rules if targeted at specific types of production or land use, although this might not be as much of a concern as the EU still has ample room to increase payments under this category (Guyomard et al., 2023).

- **Reverse auctioning.** This is an approach where public authorities purchase environmental outcomes based on a bidding process, which has several advantages compared with the previous two approaches. Most importantly, it could set the payment level in a way that maximises environmental outcomes for a given public budget while guaranteeing sufficient farmer participation (Matthews, 2021a). Furthermore, it would not require regulators to calculate costs incurred or income foregone nor the societal value of ecosystem services, which can both be challenging. The main drawbacks of this approach are that it increases transaction costs which could discourage certain farmers (e.g. of smaller farms), is more difficult to implement when environmental outcomes are difficult to quantify and is subject to the same limitations under the WTO as value-based payments.

The proposal for the next CAP shifts the focus from conditionality to incentives, but main concerns remain.

In its Vision for Agriculture and Food, the European Commission stated its intention to orient the future CAP away from conditions to incentives (EC, 2025q). This is also reflected in the proposal for the next CAP (EC, 2025q), which aims to replace the current GAEC framework by a more flexible 'farm stewardship framework' (see Box 19). In addition, it would introduce a new system of 'agri-environmental and climate actions' which would merge the current eco-schemes and AECMs, and which would incentivise farmers to take up more sustainable production practices which go beyond mandatory requirements.

Voluntary incentive schemes could in principle deliver equivalent environmental and climate outcomes compared with regulatory approaches, if such schemes are properly designed and adequately funded. However, when considering other elements of the Commission's proposal, there are several reasons for concern (IEEP, 2025d; Matthews, 2025b).

- **Uncertain budget for climate and environmental action.** To maintain the current environmental and climate ambition while reducing conditionality, the next CAP would need to see an increase in the budget for incentives. However, as discussed in more detail in Chapter 12, the CAP and the MFF proposals would not guarantee such an increase and could actually result in a decrease. Furthermore, the proposal would also allow Member States to pay farmers for adhering with the required protective practices, leaving less budget available for incentive schemes that go beyond the baseline.
- **Uncertain effectiveness of incentive schemes.** This section has described several options to enhance the effectiveness of the CAP's incentive schemes for climate action. The CAP proposal allows Member States to make use of these options: the newly proposed agri-environmental and climate actions may be structured as either action-based or result-based, set for single or multi-year commitments, and designed with more flexible payment rules (including rates that go beyond 'costs incurred, income foregone', providing that WTO compatibility is maintained) (EC, 2025q). In that sense, it is an improvement as the proposal provides more opportunities for Member States to design more effective schemes with appropriate payment rates. However, the actual impact of these measures depends on whether and how Member States choose to apply these options.

Box 19 The proposed 'farm stewardship framework'

As discussed in Section 5.2.1, the current CAP's conditionality framework includes several statutory management requirements (relates to legal obligations from other EU legislation) and GAECs (specific requirements under the CAP). In addition, the legislation includes minimum social requirements.

The European Commission proposes to replace the CAP's conditionality framework by a farm stewardship framework which would maintain the statutory management requirements and social requirements. The nine GAECs would however be replaced by more general, less prescriptive requirements, to be further elaborated by Member States.

Current CAP GAECs	Farm stewardship framework
GAEC 1. Maintenance of permanent grassland (maximum decrease of 5% compared to the reference year) GAEC 2. Protection of wetland and peatland. GAEC 3. Ban on burning arable stubble, except for plant health reasons. GAEC 4. Establishment of buffer strips along water courses. GAEC 5. Tillage management, reducing the risk of soil degradation and erosion. GAEC 6. Minimal soil cover. GAEC 7. Crop rotation in arable land. GAEC 8. Minimum share of agricultural land devoted to non-productive areas or features, including fallow land. GAEC 9. Ban on converting or ploughing permanent grassland in Natura 2000 sites.	Member States shall define minimum requirements to achieve the following objectives: • Protection of carbon-rich soils, landscape features and permanent grasslands on agricultural area. • Protection of soil against erosion, preservation of the soil potential, maintenance of soil organic matter, including through crop rotation or diversification, along with protection against burning of stubble on arable land • Protection of water courses and ground water against pollution and runoff.

Chapter 9

Support to overcome adverse climate-related impacts and risks

Key messages

Several instruments can help farmers overcome adverse climate-related impacts and risks.

The agricultural sector needs public support to overcome unavoidable climate impacts, whether these are sudden due to extreme climate and weather events or gradual from slow-onset hazards. Several policy instruments could address various risk levels, including countercyclical income support, subsidies for insurance premiums and disaster relief for large-scale uninsurable events. The current CAP already includes such instruments; however, their uptake is low due to low awareness, complexity and payout uncertainty. Moreover, the budget for disaster relief appears to be insufficient.

Additional safeguards are needed to maintain incentives for proactive and transformational adaptation.

Enhancing such instruments can increase climate resilience by ensuring more stable incomes and thus improving food security. However, they also risk undermining the incentive for proactive and transformational adaptation. Adequate safeguards are needed to avoid such risks.

The proposals for the next CAP and MFF would strengthen the risk management toolbox but lack safeguards.

Current proposals for the next CAP and MFF include support for risk management and double the size of the EU budget for disaster relief. While these are positive steps considering the increase in climate-related risks, the proposals overall lack safeguards to maintain the incentive for proactive and transformational adaptation.

In the context of increasing climate-related risks, the Advisory Board recommends further improvements to the EU risk management toolbox, guided by the following principles.

- **Scale up support for overcoming acute climate-related impacts.** Increase and expand the coverage of financial instruments that help farmers cope with immediate losses from extreme climate-related events, including subsidies for agro-insurance schemes, mutual funds and the Agricultural Reserve for disaster relief.
- **Address slow-onset impacts.** Consider changes in climatic conditions when mapping areas with natural constraints that are eligible for additional CAP income support.
- **Keep incentives for proactive climate adaptation.** Identify and implement suitable approaches to ensure that compensation payments for climate-related impacts do not undermine the incentive for private adaptation efforts. To this end, several options should be considered, such as making access to such payments conditional on minimum adaptation requirements.
- **'Build back better' and encourage transformational change.** Link publicly funded compensation payments to commitments by recipients to undertake efforts that enhance long-term adaptation. Furthermore, consider how payments for areas with climate-related natural constraints could be designed so that they support transformational adaptation when needed, including the diversification or cessation of agricultural activities when risks become too high or when regions become unsuitable for agricultural production.

9.1 Introduction

Helping farmers overcome adverse climate-related impacts while maintaining incentives for proactive and transformational adaptation.

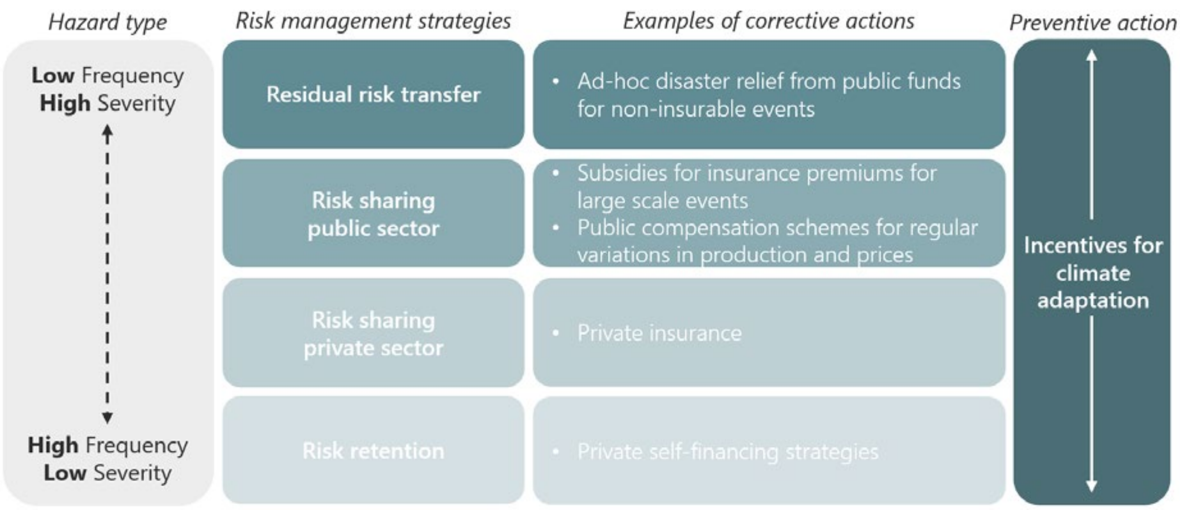
Section 5.3.4 explains that while ambitious climate mitigation and adaptation efforts are essential to limit adverse climate-related impacts, they cannot fully prevent them. It further argues why it is appropriate to provide public support to help farmers overcome climate-related losses. In summary, such support is warranted to address fairness concerns, as some farmers are particularly exposed to climate-related hazards while having limited financial capacities to overcome climate-related losses. At the same time, such support should be designed to maintain a strong incentive for proactive and transformational adaptation.

Different types of hazards warrant distinct risk management strategies.

As illustrated in Figure 31, climate-related risks can differ in terms of frequency and severity, which warrants distinct risk management strategies.

- **Private risk retention.** For hazards with high frequency but low severity, it is expected that farmers manage the risks themselves with self-financing strategies, including building resilience to projected climate-related risks in this category.
- **Risk sharing strategies.** For hazards that are less frequent but more severe, it is appropriate to share risks between different actors. This can be done exclusively within the private sector (e.g. through private insurance products), or the public sector can assume part of the risk (e.g. through compensation schemes) or provide subsidies for insurance premiums.
- **Residual risk transfer.** At the high end of the spectrum are hazards that are low in frequency and high in severity. Such hazards are generally considered non-insurable and require publicly funded disaster relief.

Figure 31 Illustration of different risk levels and potential risk management options.



Source: Adapted from fi-compass (2025).

As discussed in Section 5.2, the current CAP already contains instruments that help farmers cope with climate-related impacts through different strategies. It allows Member States to use CAP Pillar 2 funds to subsidise insurance premiums and mutual funds, and includes an Agricultural Reserve under Pillar 1 that can provide disaster relief. However, the section concluded that the effectiveness of these instruments remains limited due to low uptake, insufficient budgets and the absence of adaptation-related conditionality.

This chapter explores options to improve the CAP's risk management toolbox.

To examine how risk management policies under the CAP can be improved, the chapter is structured as follows.

- **Section 9.2** explores four broad policy approaches that could be considered under the CAP to help farmers cope with adverse climate-related impacts, namely countercyclical payments (9.2.1), strategies to enhance insurance coverage for large-scale climate hazard events (9.2.2), disaster relief and crisis management programmes (9.2.3), and payments for areas with natural constraints, to help regions suffering from slow-onset climate hazards (9.2.4).
- **Section 9.3** explores options to prevent such support mechanisms from undermining the incentive for proactive and transformational adaptation.
- **Section 9.4** explores to what extent the new CAP proposal would improve the CAP's risk management framework and concludes with recommendations for further adjustments.

9.2 Support measures to overcome adverse climate-related impacts

9.2.1 Countercyclical payments

Countercyclical payments can stabilise agricultural incomes and support food security.

As discussed in Section 5.2, the bulk of current CAP income support is provided in the form of decoupled and coupled payments, with pre-defined payment rates per hectare or per head of livestock. A possible alternative is to provide income support in the form of countercyclical payments. Under such an approach, the level of income support would not be pre-defined but would vary in function of certain indicators (see examples below). As such, they can support farmers' income in a variable manner depending on price and production variations.

Countercyclical payments are usually indexed on predefined thresholds based on historical averages and distributed on an annual basis. With this system, similar to contracts for difference for renewable energy, farmers receive higher payments in years with low income due to less favourable climatic conditions. The scientific literature describes several variants to implement countercyclicality (INRAE & IDDRI, 2025; Boysen et al., 2023), which can vary in terms of the following.

- **The base indicator**, which can trigger countercyclical payments that can be either prices, revenues, profits or margins.
- **Reference levels**, which can be based on different geographical scopes, namely at the farm, regional, national or EU level.
- **The thresholds** used for countercyclical payments, which refer both to the thresholds on the losses (compared with the reference level) to trigger payments, and the thresholds on compensation levels (e.g. up to X% of the loss occurred).
- **The link with other support schemes**, as countercyclical payments can be designed as a stand-alone direct payment scheme, integrated as part of a more general direct payment scheme or organised under mutual funds. As such, their funding source could be either existing or new public funds, or public–private funds (at the national, sectoral or cooperative level).

Countercyclical payments can help provide the EU agricultural sector with stable and predictable incomes and protect it from global price volatility (INRAE & IDDRI, 2025; Gohin and Zheng, 2020). This would also contribute to food security by preserving domestic production, reducing dependence on imports and securing the availability of food. Moreover, by subsidising agricultural production losses from climate variations, society would be assuming a shared responsibility in bearing the cost of climate change. Contrary to coupled payments associated with production volumes, countercyclical payments could avoid advantaging farmers in locations with better soil conditions, or disadvantaging farmers in areas with natural constraints, if the reference level is based on a farm or regional scale.

Countercyclical payments are only used to a limited extent under the current CAP.

As discussed in Section 5.2.2, the current CAP already allows Member States to grant support for risk management tools including income stabilisation tools, but so far uptake has remained low. The CAP limits such compensation to farms which have suffered at least 20% losses in production or income (calculated over several years at the farm or sector level), and with a maximum support of 70% of eligible costs.

By contrast, such a form of payments is far more common in other OECD countries. For example, the United States has introduced price-based countercyclical programmes (Agriculture Risk Coverage and Price Loss Coverage) and Canada has introduced a margin-based programme (AgriStability) (Pieralli et al., 2021). These are mostly focused on price variations, as production risks are mostly covered by insurance programmes, as covered in the next section.

Countercyclical payments could support more targeted CAP spending, but their overall budget impact remains uncertain.

Countercyclical payments do not necessarily increase the CAP budget spent on climate action but rather distribute CAP direct payments in a more targeted way. It is unclear how countercyclical payments would impact the overall CAP budget. Some publications argue they could reduce the weight of the budget constraint (INRAE & IDDRI, 2025), whereas others display simulation results highlighting the uncertainty on budgetary consequences, in particular if subsidies are indexed on highly volatile market prices (Pieralli et al., 2021).

Boysen et al. (2023) estimate a budget around 0.4–0.9% of the CAP budget (EUR 0.2–0.6 billion in 2020) by simulating the application of different mechanisms (income-, price- or revenue-based), and up to around 8% of the CAP budget during yield shocks (EUR 5 billion in 2020). Pieralli et al. (2021) estimate a budget around EUR 0.2–15 billion by simulating similar mechanisms, and up to around EUR 23 billion for extreme stochastic simulations.

Countercyclical payments are associated with several challenges, including reduced incentives for adaptation.

One key issue of countercyclical payments is that they can undermine the incentive for proactive adaptation and even drive maladaptation. For example, they can encourage farmers to prefer drought-sensitive crop variations with volatile outputs, as this would allow them to benefit from high outputs (and thus high market incomes) in good years and from higher income support (countercyclical to low outputs) in bad years. Options to minimise such risks are discussed in Section 9.3.

In addition, several other challenges would need to be considered under this approach.

- **Disparities between larger farms and smaller farms.** Similar to other types of direct payments, countercyclical payments are usually area-based, which might provide only limited support to smaller farms which do not benefit from economies of scale (INRAE & IDDRI, 2025).
- **Environmental impacts.** Simulations show that payments based on planted acres (rather than base acres) can affect planting decisions and lead to more specialised crops. Excessive crop specialisation could have negative environmental externalities and create market distortions (Pieralli et al., 2021; Boysen et al., 2023). Furthermore, applying countercyclical payment programmes with indices at different geographical scales and with different rules can create disparities across Member States (Boysen et al., 2023).
- **WTO compatibility.** Price-based countercyclical payments could present a risk of breaking WTO rules, even if estimates from simulations remain below the WTO trade-distorting support ceilings (Pieralli et al., 2021; Boysen et al., 2023).

9.2.2 Support for insurance schemes

Insurance schemes can help farmers manage large-scale climatic risks but are currently underused.

Insurance tools can provide *ex ante* management of production risks and facilitate a quick recovery after losses. They can be organised privately, publicly or through public–private partnerships (Fi-Compass, 2025). Contrary to price and income support programmes, these tools usually provide income support in case of large-scale weather events and can thus help farmers manage the risk of less frequent but more severe climate-related hazards.

However, the current uptake of EU climate risk insurance by farmers is low. As already discussed in Chapter 2, the EU fi-compass (Fi-Compass, 2025) estimates the current annual average loss for the EU27 at EUR 28.3 billion, which corresponds to approximately 6% of annual EU crop and livestock production, with a forecast to increase up to EUR 40 billion per year by 2050 (see Table 26). However, 70–80% of these losses are not currently insured.

Table 26 Estimates of agricultural losses and insurance coverage in the EU

	Current	By 2050
Annual average loss	EUR 28.3 billion	EUR 40 billion
Probable maximum loss on catastrophic years	EUR 57.5 billion	EUR 90 billion
Non-insured climate-related losses	70–80%	—

Source: Based on fi-compass (2025).

Notes: Projections by 2050 are based on a medium global emissions scenario (SSP2–4.5)

Several issues would need to be addressed to enhance the attractiveness of climate risk insurances, including improving their affordability.

Climate risk insurance could be further incentivised by increasing its attractiveness (Arata et al., 2023). For example, an experiment showed that Irish farmers would be more willing to pay for insurance if it was weather-indexed, covered multiple years and was cheaper (Doherty et al., 2021). Other issues that have reduced the attractiveness of European agriculture insurance mechanisms include the long waiting time to receive compensation, uncertainty about claims processing and payouts, and administrative complexity. Moreover, insurance schemes are not available for all climate-related hazards, or are not affordable (Fi-Compass, 2025).

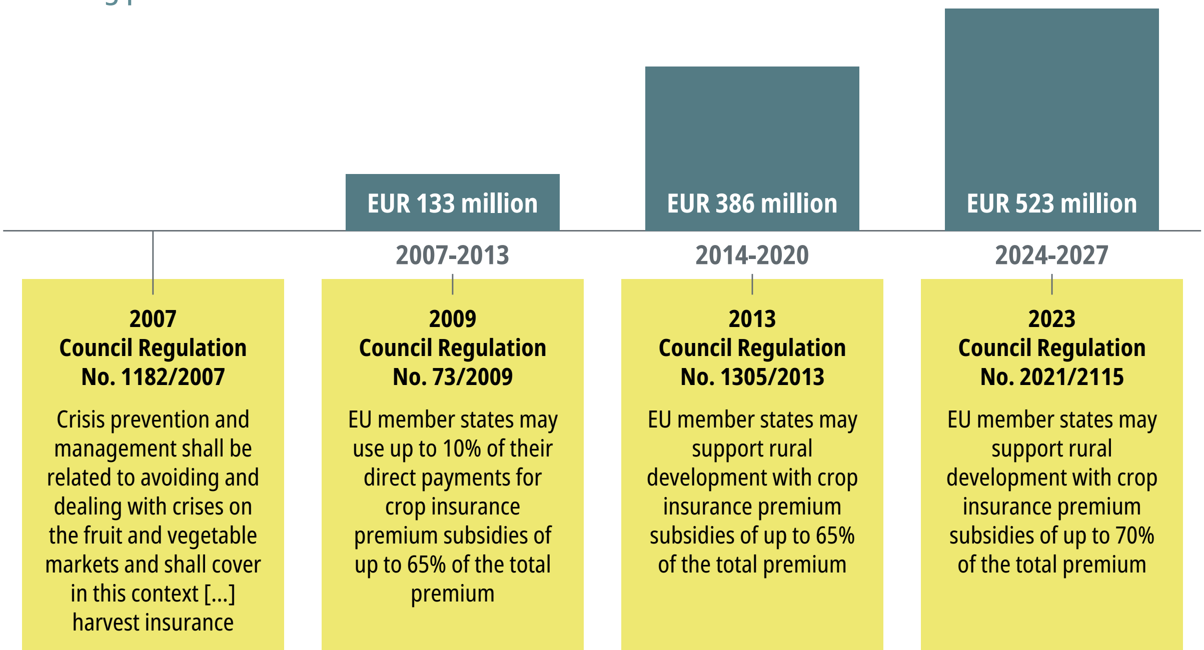
Insurance providers can rely on satellite data to monitor crop activity, droughts and other climate conditions. Moreover, in order to increase the effectiveness of insurance tools with smart contracts, one proposal suggests combining index-based insurance with blockchain technologies (Schwarze and Sushchenko, 2022). The EU fi-compass recommended the creation of an EU agriculture insurance technical assistance platform, providing a focal point for stakeholders to share knowledge and best practices (Fi-Compass, 2025).

Despite increases over time, CAP support for insurance premiums remains very low.

As discussed in Section 5.2.2, the current CAP already allows Member States to subsidise agricultural insurance premiums, but uptake is overall low. As shown in Figure 32, the CAP budget dedicated to this voluntary instrument has been increasing over time, up to about EUR 500 million per year under the current CAP period (2023–2027). Despite this increase, this represents less than 1% of the total

CAP budget. The strategic dialogue on the future of EU agriculture highlighted the need to strengthen insurance tools and to complement them with preventive climate adaptation measures (EC, 2024h).

Figure 32 Actual and planned subsidies per year for risk management instruments in the EU, including premium subsidies



Source: Reproduced from Dalhaus et al. (2023).

Note: The value for the 2014–2020 and 2024–2027 periods indicate planned spending.

Several options could be considered to increase support despite public budget's constraints, with a mix of private funds, public funds and public–private partnerships.

The EU fi-compass recommended that EU institutions and Member States use risk capital markets to increase resources in times of crisis, including with reinsurance and catastrophe bonds. The European Central Bank, the European Insurance and Occupational Pensions Authority and the fi-compass proposed an EU public–private reinsurance scheme to cover catastrophic risks (Fi-Compass, 2025). It has been highlighted that cooperation between the Commission, the EIB and insurance companies could support the development of customised insurance tools for diverse farming activities (EC, 2026).

Additional safeguards would be needed to preserve the incentive for climate adaptation and avoid unintended environmental consequences.

Similar to countercyclical payments, crop insurance subsidies may encourage farmers to adopt higher-risk crops or crowd out community-based risk sharing strategies (Müller et al., 2017), thus undermining proactive and transformational adaptation. Options to minimise such risks are discussed in Section 9.3.

Furthermore, such subsidies may also have a negative impact on GHG emissions and other environmental dimensions. Available literature suggests that overall, crop insurance leads to higher pesticide use and related environmental pressures (Mishra et al., 2005; Möhring et al., 2020). One approach to avoid such adverse impacts is to make insurance subsidies conditional on compliance with more sustainable production practices (Dalhaus et al., 2023).

9.2.3 Disaster relief

With the growing likeliness of climate-related risks turning into crises, crisis management programmes are critical to protect the agri-food sector from non-insurable events.

Crisis management policies, including disaster relief programmes, provide *ex post* management of losses due to disasters (INRAE & IDDRI, 2025). These are applicable to non-insurable events of exceptional magnitude with large-scale impact (see Section 5.2.2). With the increasing frequency and severity of climate hazards and the growing likeliness of risks turning into crises, the role of crisis management mechanisms is becoming more critical. As with other risk management tools, disaster relief funding can be sourced from public or private sources or public–private partnerships. However, given the systemic nature and scale of disaster events, there is a strong argument for a larger share of public funding compared with other mechanisms.

The CAP's Agricultural Reserve remains underused due to limited funding and unclear triggers.

As previously discussed in Section 5.2.2, the CAP's Agricultural Reserve (formerly called Crisis Reserve) has a very limited budget (EUR 450 million per year) compared with the scale of agricultural losses (EUR 28.3–57.5 billion, see Table 26).

In the past 10 years, the CAP's Agricultural Reserve has been mobilised infrequently, with 63 exceptional measures activated, channelling support of over EUR 2.5 billion to farmers (EC, 2024k). The majority of these funds addressed market disturbances and animal and plant health issues rather than climate-related damages (Matthews, 2025a).

Potential explanations for this infrequent mobilisation include the lack of clearly defined triggers (INRAE & IDDRI, 2025). Furthermore, if the reserve is not fully used in one year, the remaining budget is not carried over to the next year but reoriented towards CAP direct payments. This discourages the use of the reserve, as it essentially implies a transfer of funds from one group of farmers to another (INRAE & IDDRI, 2025).

Although climate-related risks' spatial reach is often transboundary and can propagate over integrated systems such as supply chains or the financial system, the CAP's Agricultural Reserve is not designed as a cross-border, jointly managed instrument. It is activated on a per-Member-State basis, and funds are allocated to specific Member States. There is no indication in the official mechanisms that the reserve is structured to promote or require cross-border coordination or pooling of resources among Member States, which is an aspect that could strengthen the EU's role in coordinating transboundary crisis response and incentivising transformational measures in the recovery phase (Advisory Board, 2026).

Disaster relief has been mainly provided by a patchwork of Member State crisis measures.

In addition to the Agricultural Reserve, EU rules allow Member States to provide ad hoc state aid to address disasters from natural hazards. The support provided through this channel is substantially higher compared with the Agricultural Reserve: exceptional national state aid to the agricultural sector in the EU reached EUR 4.6 billion in 2022 under the temporary crisis framework and EUR 11 billion during March 2022–March 2024 under the COVID-19 temporary framework (INRAE & IDDRI, 2025). Between 2021 and 2023, Greece provided EUR 241.7–452.5 million per year of compensation for climate-related damages (Fi-Compass, 2025). In France, a study showed that 40% of the agriculture ministry's budget was allocated to compensation and crisis management in 2022 (I4CE, 2024).

As a result, the Agricultural Reserve has been financially overshadowed by a patchwork of national crisis responses with unclear conditions and triggers. This has created an unlevel playing field and distorted the competition between Member States, while leading to uncertainty for farmers (Boysen et al., 2023; INRAE & IDDRI, 2025). This could be avoided in the future by providing an adequately financed EU crisis reserve with clear rules and triggers, as proposed by the European Central Bank, the European Insurance and Occupational Pensions Authority and fi-compass (Fi-Compass, 2025), while ensuring that support remains well-targeted to those most affected.

Disaster relief can hinder proactive and transformational adaptation.

Just like the other mechanisms described previously, disaster relief risks hindering proactive adaptation and driving maladaptation if not carefully designed. When farmers know that disaster relief will be provided after climate-related losses, they may feel less pressure to invest in proactive or transformational adaptation measures, because the safety net reduces their immediate financial risk. This can in turn lead to a vicious cycle, where insufficient adaptation increases the need for future disaster relief, but once such relief is ensured, this can further undermine adaptation incentives. Given projected increases in climate-related impacts, overreliance on disaster relief without accompanying adaptation measures is likely to strain public budgets. Options to minimise such risks are discussed in Section 9.3.

9.2.4 Payments for areas with natural constraints

Slow-onset climate-related hazards are disproportionately affecting certain EU regions.

Climate impacts are not only the result from extreme weather events such as floods and storms, but can also occur gradually from slow-onset climate-related hazards. This includes phenomena such as declining agricultural yields resulting from progressive climatic shifts (see Section 2.3). These gradual impacts are expected to affect regions across the EU in uneven ways, with certain areas projected to experience disproportionately severe consequences, requiring a need for targeted support.

The current CAP allows top-up payments for less productive areas.

The current CAP allows Member States to provide additional payments under Pillar 2 for farm holdings in areas facing natural or other area-specific constraints (hereafter referred to as 'ANC payments'). The underlying logic is that agricultural production is less productive in such areas and would therefore not be economically viable on its own. By providing additional payments, the CAP can nevertheless sustain agricultural production in these areas, thereby disincentivising land abandonment.

To provide such payments, Member States are required to identify which areas qualify as ANCs, based on the rules established under the CAP 2014–2020 (EU, 2021b). In short, areas can be considered as facing such constraints if they are mountainous, located in regions with low temperatures and short growing periods, vulnerable to dryness or excess soil moisture, characterised by unfavourable texture and stoniness, have shallow rooting depth or poor chemical properties or are on steep slopes.

ANC payments could be used to address slow-onset climate-related hazards, provided that eligible regions are updated regularly.

Climate change is projected to impact several of the parameters used to identify areas with natural or other area-specific constraints, in particular average temperatures, growing periods, dryness and excess soil moisture. As described in more detail in Section 2.3, these impacts are projected to affect agricultural productivity unequally across EU regions: southern Europe is expected to be most adversely affected, while northern Europe could experience a net benefit.

The current CAP rules provide only limited flexibility to adjust the classification of areas that are eligible for ANC payments, reflecting a changing climate. Overall, the current CAP Strategic Plans Regulation (Regulation (EU) 2021/2115) requires Member States to largely maintain the classification from the previous CAP period (2014–2020), but allows them to fine-tune it if previously documented constraints have been overcome. These rules allow (but do not require) Member States to discontinue ANC payments to areas that have become more productive due to climate change. However, they do not allow them to provide ANC payments to areas which used to be productive but have become less productive due to climate change.

A periodical update of areas eligible for ANC payments based on robust and harmonised risk assessments (Advisory Board, 2026) could allow this instrument to better help affected farmers and regions to cope with slow-onset climate-related hazards. However, as further discussed in Section 9.3, additional measures would be needed to prevent such an approach from presenting a moral hazard or locking in least climate-resilient farming systems.

While ANC payments can support agricultural production in marginal areas, they also hinder transformational adaptation.

ANC payments aim to sustain agricultural production in areas by closing the income gap with farms in more productive areas. Whereas this can contribute to food security and rural development, it may also drive maladaptation, by sustaining agricultural production in regions that are becoming increasingly unsuitable for this. ANC payments can also contribute to addressing fairness issues in adaptation, but this requires the identification and prioritisation of vulnerability and exposure hotspots using robust risk assessments (Advisory Board, 2026). Moreover, it reduces pressure on farmers in such areas to shift towards better adapted forms of agriculture, as the payments help them prolong the status quo. Options to minimise such risks are discussed in Section 9.3.

9.3 Maintaining incentives for proactive and transformational adaptation

The expectation of compensation could incentivise risky behaviour, which needs to be avoided.

As highlighted above, the different compensation and support mechanisms to help farmers cope with adverse climate-related impacts must be approached with great caution. The expectation of compensation presents a moral challenge and can incentivise overly risky behaviour. If not carefully regulated, such mechanisms risk undermining the very goal of incentivising timely, proactive and transformational adaptation (Doherty et al., 2021; Boysen et al., 2023). Relying on public support to address climate-related impacts can lead farmers to delay or avoid necessary changes. This would also increase the risk of maladaptation, as it could incentivise the perpetuation of risk-prone farming practices, systems or species in areas where this becomes increasingly unsuitable. The expected availability of government-funded disaster relief also undermines farmers' willingness to pay for insurance tools, which could add further pressures to the public budget (Doherty et al., 2021; Boysen et al., 2023).

Robust rules are thus crucial to avoid the risk of failing to achieve the transformational adaptation needed for long-term resilience. To ensure that support mechanisms do not inadvertently lock in vulnerability or delay essential transitions, it is important to tailor rules, eligibility criteria and adaptation options to specific regional and sectoral conditions. The priority must be for instruments to support, rather than substitute for, proactive adaptation, in order to empower farmers to adapt before they become in need of help to deliver sustainable outcomes for the sector and society.

Several options can maintain the incentive for proactive and transformational adaptation while helping farmers overcome adverse climate-related impacts.

As summarised below, the different support mechanisms discussed in Section 9.2 can include design features that would maintain the incentive for proactive and transformational adaptation. While non-exhaustive, this overview can serve as a starting point for further assessment.

- **Countercyclical payments and subsidies for insurances and mutual funds** could be made subject to minimum requirements on proactive climate adaptation measures (Doherty et al., 2021; Boysen et al., 2023). A key challenge of such an approach is that it requires regulators' knowledge of the best adaptation options, which is challenging as adaptation options are highly dependent on specific contexts. Therefore, if regulators set criteria that are too detailed or strict, it would impose certain options that might not be suitable in all cases. On the other hand, if they only require a very minimum, this would not sufficiently maintain an incentive for ambitious, proactive and transformational adaptation. A sector-based EU-level risk assessment and targets underpinned by a common reference scenario of warming are essential for the identification of risks at multiple time horizons, and the selection of suitable adaptation measures that are robust against multiple plausible futures and a decreasing solutions space.
- **Disaster relief** can be linked to proactive risk management by incentivising farmers to adopt comprehensive adaptation strategies and aim for resilience. For example, access to disaster relief could gradually be made conditional upon farmers' subscribing to insurance schemes, as is currently already the case in the United States (INRAE & IDDRI, 2025), or in Denmark for foresters to access the natural hazard compensation scheme. Compensation payouts could

be made conditional on investments in *ex post* adaptation, in line with the 'build back better' principle. Such an approach would prevent that these payouts are used to sustain risk-prone practices and farming systems.

- **ANC payments** could be made limited in time or subject to minimum adaptation requirements or farm transition plans, based on the identification and prioritisation of vulnerability hotspots (Lenaerts et al., 2022) and fairness checks. In case risk levels in certain areas become too high, they might need to be replaced by support schemes that help affected farms leave the sector and diversify to other land uses and economic activities. Linking payment entitlements to the land rather than the landowners can avoid farmers being compensated to leave the sector and sell their land to a new farmer, who would then again be eligible for ANC payments.

9.4 Improving the EU's risk management toolbox

The proposal for the next CAP maintains and strengthens support for risk management tools and areas with natural constraints, with some additional flexibilities.

The Commission's proposals for the next CAP and MFF largely maintain the overall structure of the current risk management toolbox, with the following changes.

- **Mandatory and higher risk management support.** Whereas support for insurance, mutual funds and income stabilisation tools is a voluntary option for Member States under the current CAP, the provision of such support would become mandatory under the proposal for the next CAP (EC, 2025p). The threshold to trigger such support would remain at a minimum of 20% of the average annual production or income in a previous reference period (see Section 5.2.2) but, once triggered, support would no longer be limited to 70% of eligible costs, thus allowing higher levels of support for affected farmers. Moreover, the proposal introduces some flexibilities on the methods to calculate losses for specific cases.
- **New and stronger Unity Safety Net.** The current Agricultural Reserve is proposed to be replaced with the Unity Safety Net, which has a similar goal of stabilising market disruptions on agricultural production and prices (EC, 2025p). The budget for the Unity Safety Net (EUR 900 million per year) would be double compared with the current Agricultural Reserve, to be funded by the newly proposed EU Facility Fund.
- **National crisis payments.** In addition to the Unity Safety Net, the European Commission proposes to introduce a new possibility for Member States to provide crisis payments to farmers affected by disasters from natural hazards, adverse climatic events and catastrophic events (EC, 2025p). Payments would be allowed provided that the events have directly caused damage resulting in the destruction of at least 30% of the average annual production of the farmer (compared with a historic reference period).
- **Payments for areas with natural constraints.** The current CAP rules only provide limited flexibility to adjust the classification of areas that are eligible for ANC payments. Member States largely need to maintain the classification from the previous CAP period (2014–2020), unless previously documented constraints have been overcome (EU, 2021b). The proposal for the next CAP (EC, 2025p) maintains these rules but also allows Member States to add new areas (limited to 2% of their total agricultural land area) based on newly defined constraints in their national plan. This added flexibility allows Member States to individually remap areas with natural constraints based on the impact from slow-onset climate-related hazards in both directions (adding areas that have become less productive, removing areas that have become more productive). However, it does not provide a harmonised EU framework to ensure a periodical climate risk assessment and mapping of hotspots, with a risk of distorting the intra-EU level playing field.

The proposal includes only few provisions to maintain incentives for proactive and transformational adaptation.

Whereas the proposal overall enhances the EU's risk management toolbox for agriculture (both within the CAP and through the Unity Safety Net), it provides few safeguards to prevent the toolbox from undermining the incentive for proactive adaptation.

On the positive side, the proposal for voluntary national crisis payments does require Member States that make use of this option to provide higher compensation rates to farmers who implement preventive actions to reduce production and income risks (EC, 2025p). However, it also requires such payments to ensure the continuity of the agricultural activity of affected farmers, which could hinder economic diversification and undermine the 'build back better' principle in regions that become increasingly unsuitable for agricultural production.

Furthermore, the CAP proposal replaces the current framework of minimum requirements with a 'farm stewardship' framework, which sets out broader objectives to be further fine-tuned by individual Member States (see Box 19). Several of these broader objectives could also contribute to climate adaptation, such as the protection of carbon-rich soils and landscape features, protection against soil erosion and protection of water courses and ground water against pollution and run-off. However, access to the CAP's support instruments for risk management tools and national crisis payments would be exempted from this farm stewardship framework and thus be largely unconditional. It is also important to note that, by reducing risk for landowners, such support mechanisms can make agricultural land a more attractive investment and potentially increase land prices.

The Advisory Board recommends that the EU enhance its risk management toolbox while maintaining strong incentives for proactive and supporting transformational adaptation.

As discussed in Section 5.3.3, the projected increase in climate-related hazards, exposure and vulnerability of the agricultural sector justifies providing adequate public support to help farmers overcome adverse climate impacts, which should be organised in a way that does not undermine the incentive for farmers to take proactive adaptation action or engage in transformational adaptation including diversification.

To this end the Advisory Board recommends improving the existing risk management tools of the CAP, guided by the following principles.

- **Enhance risk management tools for acute climate-related impacts.** Current instruments that help farmers cope with immediate losses from extreme climate-related hazards – including insurance premium subsidies, support for mutual funds and public disaster relief – should be scaled up and expanded in order to close the insurance-gap. In this regard, the Commission's proposals for a better-funded Unity Safety Net and to make national support for risk management tools mandatory are steps in the right direction, which could be complemented by EU-level reinsurance or public-private partnership mechanisms to enhance risk pooling and diversification (Advisory Board, 2026).
- **Account for slow-onset climate-related hazards.** When updating the mapping of areas with natural constraints that are eligible for additional CAP income support based on robust risk assessments (point above), Member States should consider how changes in climatic conditions affect income, costs and the suitability of agricultural practices at different time horizons. The Commission's proposal provides room for Member States to do this on a voluntary basis, but the proposal would benefit from a clearer EU framework that ensures a harmonised approach.
- **Keep strong incentives for proactive climate adaptation.** To this end, different options should be identified and assessed, including making access to publicly funded risk management tools conditional on minimum adaptation requirements (e.g. the proposed farm stewardship framework). This step could be facilitated by the application of the 'resilience by design' horizontal principle from the inception of investment plans. The proposal to provide higher national crisis payments for farmers who implement preventive

actions could be linked more clearly to climate adaptation measures and extended to insurance premium subsidies, mutual funds and the Unity Safety Net.

- **'Build back better' and support transformational adaptation.** Payouts from insurance schemes, mutual funds and public disaster relief in response to climate-related hazards should, where they relate to recovery or reconstruction, be made conditional on the beneficiary using those funds to rebuild in ways that improve climate resilience. They should also allow farmers to use such payouts to invest in transformational adaptation, such as diversifying their portfolio of activities. Furthermore, it should be considered how payments for areas with natural constraints in response to slow-onset climate-related hazards could be designed so that they support transformational adaptation when needed, including the diversification or cessation of agricultural activities when risks become too high or regions become unsuitable for agricultural production.

As previously recommended by the Advisory Board, these policy improvements should be guided by comprehensive and harmonised sectoral risk assessments and targets, based on a common reference scenario of warming (SSP2-4.5) and stress testing against higher-risk futures (Advisory Board, 2026).

Chapter 10

Food policies

Key messages

Externalities of current food consumption warrant policies targeting food environments.

Current GHG-intensive diets in the EU cause EUR 530 billion of public health costs per year. At the same time around 10% of all food made available to consumers in the EU is being wasted. These externalities and resource inefficiencies justify public intervention. While GHG pricing can already contribute, meaningful dietary shifts and reducing food waste requires action across all four dimensions of food environments: physical, economic, cognitive and socio-cultural.

Policies need to target the full value chain and ensuring a just transition.

Food processors and retailers are surrounding consumers with cleverly marketed, cheap and calorie-dense products that are often neither healthy nor climate-friendly. This warrants policies that target these actors and pursue a shared-responsibility transition across the entire agri-food supply chain.

Encouraging dietary adjustments is politically challenging as food choices are strongly embedded in culture and identity. The least-intrusive instruments (e.g. labelling) are more acceptable but less effective compared with more coercive interventions (e.g. pricing). Policymakers need to balance effectiveness and acceptability by preserving consumer choice and enabling healthy, sustainable choices, clearly communicating societal benefits, and ensuring a fair and inclusive transition.

The Advisory Board recommends an overarching EU-wide food policy framework.

Food policies are a shared competence between the EU and its Member States. While national policies can better reflect local cultural and social contexts, complementary EU action can add value by levelling the playing field and creating economies of scale. The Farm to Fork strategy included several EU initiatives to promote healthier, more sustainable diets and a reduction in food waste, but many of these have not yet been implemented.

The Advisory Board therefore recommends that the EU adopt an overarching food policy framework that should:

- **Set clear objectives for healthy and climate-friendly diets,** by encouraging the establishment of national nutritional guidelines based on a common scientific evidence base, while allowing those guidelines to account for cultural heritage.
- **Promote food environments that enable healthy and climate-friendly food choices**. To this end, the EU should regulate food processors and retailers, by setting mandatory standards for the marketing and labelling of food products, and for public food procurement.
- **Strengthen monitoring and accountability mechanisms,** enabling transparent assessment of progress and ensuring that commitments translate into concrete action.
- **Support Member States** in developing and implementing effective national food policies, including measures to prevent and address food poverty, reduce food waste and inform consumers about healthy, climate-friendly food choices.
- **Provide coordinated support across the food supply chain**, helping producers, retailers and other stakeholders transition towards more sustainable and resilient practices while supporting the principle of a shared responsibility of the entire supply chain.

10.1 Introduction

This chapter investigates food policies to complement the policy interventions outlined in the previous chapters.

Chapter 5 made the case to establish food policies alongside GHG pricing (see Chapter 7) and a reform of agricultural support schemes (see Chapters 6, 8 and 9) to promote healthy and climate-friendly diets, reduce food waste and facilitate a cost-effective transition of the agri-food system.

This chapter explores various options for such food policy mechanisms, including their benefits and challenges. To this end, it is structured as follows.

- **Section 10.2** further elaborates on the rationale to go beyond GHG pricing to promote healthy and climate-friendly diets and food waste reductions and provides overall guidance to achieve this.
- **Section 10.3** discusses various policy options to address each dimension of food environments to promote healthy and climate-friendly diets and lower waste.
- **Section 10.4** discusses the issue of food poverty and policy options across different food environments to address it.
- **Section 10.5** explores the role of the EU in designing an effective food policy mix and concludes on recommendations with regard to food policies.

10.2 The case for policies targeting food environments

Healthier and more sustainable consumption patterns are needed to reduce GHG emissions, public health costs and resource inefficiencies.

As discussed in more detail in Chapter 2, Europe's prevailing dietary patterns are a major driver of GHG emissions, other forms of environmental harm and substantial health risks. Compared with the scientific consensus on what represents sustainable and healthy eating patterns, the average EU diet tends to be too high in animal-based foods and ultra-processed products, while falling short on fruits, vegetables and legumes. This is causing substantial externalities within the EU, including EUR 530 billion (2020 PPP EUR) in hidden health costs each year linked to the overconsumption of GHG-intensive, animal-based foods and the underconsumption of their plant-based alternatives. A comparison with historic trends shows that the high share of animal-based food consumption is a relatively new phenomenon which emerged in the second half of the 20th century.

The extent to which Member States integrate climate considerations into their dietary guidelines varies considerably. Denmark updated its official dietary guidelines in 2021 with the explicit title 'Good for health and climate', becoming one of the first countries globally to fully integrate climate impacts alongside nutritional guidance (Danish Veterinary and Food Administration, 2021). These guidelines advise to eat plant-rich diets, reduce meat consumption (especially beef and lamb), choose seasonal produce and minimise food waste. In contrast, France's dietary guidelines (last comprehensively revised in 2019) contain only occasional references to environmental considerations, primarily encouraging seasonal and local produce without systematically linking recommendations to climate outcomes (Santé publique France, 2019). According to a review of 33 jurisdictions, only seven have dietary guidelines with extensive climate focus (Tregear et al., 2024). Harmonising guidelines to reflect both the latest nutritional science and climate evidence, while respecting national food cultures, could provide clearer signals to consumers.

Further around 10% of food made available to EU consumers is wasted (at the retail, food service and household stages). This accounts for 16% of total GHG emissions from the EU agri-food system (EC, 2025l). Beyond its climate impact, food waste also represents a major loss of natural resources such as land, water and energy, and undermines the overall sustainability and resilience of the EU food system (EC, 2025m).

As concluded in Chapter 4, a change towards healthy and climate-friendly diets and a reduction in food wastes are indispensable to climate-proof the EU agri-food system.

Externalities in the food system justify policy intervention.

The true environmental and public health costs of our food system are not reflected in market prices (FAO, 2024a). This market failure provides a strong rationale for policy action, namely the implementation of a policy mix that internalises and mitigates these externalities (Balmford et al., 2018; Matson, 1997).

Literature highlights that achieving healthy and sustainable diets leading to significant GHG emission reductions will require aligning economic signals with sustainability – effectively tackling those indirect effects – as part of a food transformation (EEA, 2022). This logic was also followed in the F2F strategy which states that 'EU tax systems should aim to ensure that the price of different foods reflects their real costs in terms of finite natural resources, pollution, GHG emissions and other environmental externalities' (EC, 2021b, p. 15). Similarly, the strategic dialogue on the future of EU agriculture stated that 'the true costs of food and feed production are hidden but should be better reflected in market prices.'

Chapter 7 discussed a GHG pricing mechanism that could internalise the climate-related externalities of food products. This would already help to ensure that less GHG-intensive food products would become economically more attractive compared with GHG-intensive ones, which could also provide substantial health co-benefits. However, it would not be able to internalise other hidden costs of the food system, including negative public health externalities which are currently estimated to correspond to 6% of the EU GDP (see Section 2.5.7).

Food consumption patterns are not only determined by rational, economic considerations.

Relying only on price-based policy instruments to address food consumption patterns is rooted in the notion of consumers as rational, self-interested actors who make decisions by weighing costs and benefits to maximise their individual utility. In this view, it is assumed that individuals respond predictably to policy-induced changes in marginal costs, and that they possess both the information and autonomy needed to make optimal choices based on those signals (Becker, 1976).

However, a substantial body of literature from two different scientific fields challenges this rationalist foundation.

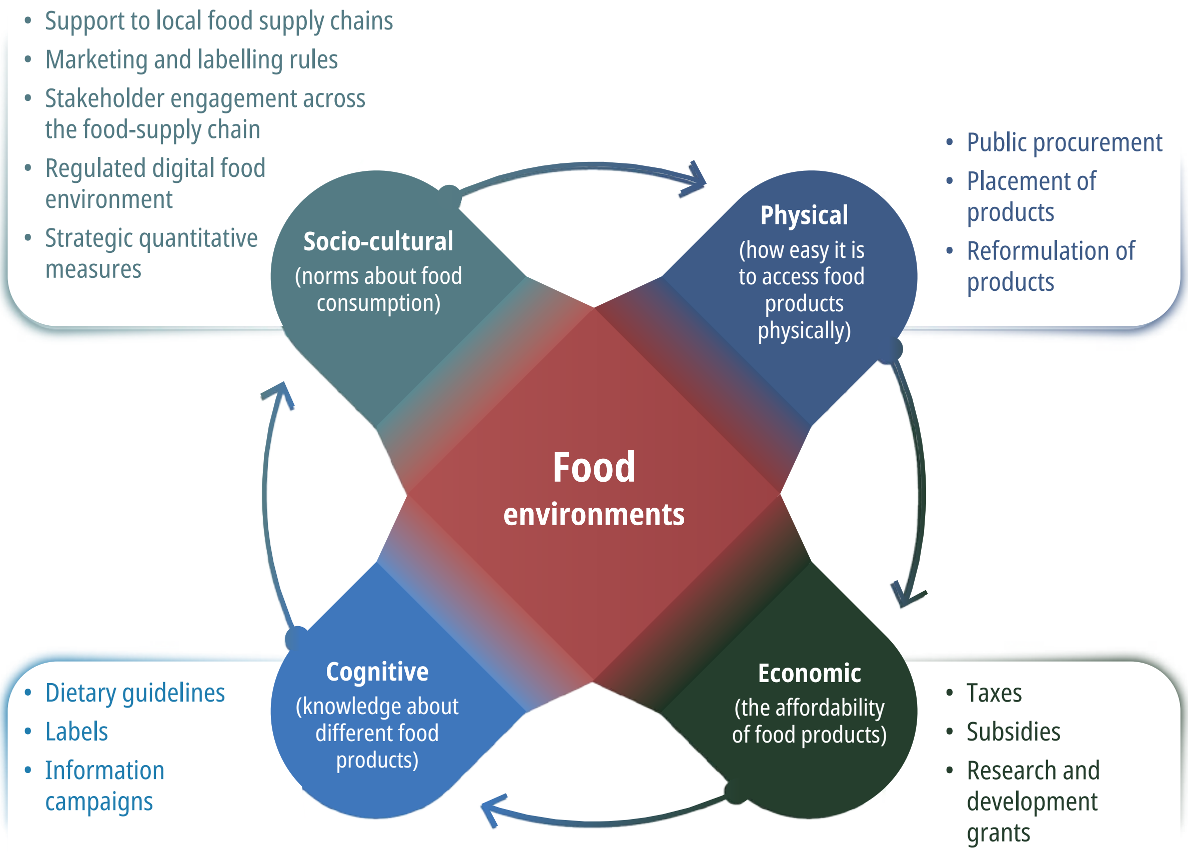
- Building on **behavioural economics**, evidence suggests that food choices are often guided by intuitive, habitual and socially influenced processes rather than deliberate and rational economic reasoning (Tversky and Kahneman, 1974; Kahneman and Tversky, 1979). In practice, food choices often appear to be automatic or habitual, with consumers opting for default options (e.g. eating what those around them eat or choosing the customary dish) instead of optimising based on price, taste or health alone (Vandenbroele et al., 2020).
- Another strand of **sociological research** also critiques the portrayal of consumers as purely rational actors in sustainable consumption as it does not account for social dimensions (Welch and Southerton, 2019; Moloney and Strengers, 2014). Recent research from this stream highlights the importance of collective and sociocultural dynamics shaping consumption, arguing that lasting change occurs when sustainable practices become socially embedded and normalised rather than driven by individual interventions. To this end, it identifies three key levers that can be used to normalise plant-rich diets: (1) more frequent encounters with less resource-intensive consumption, (2) higher exposure to such consumption across diverse social contexts, and (3) greater ease of access to engage in these practices. Together, these elements can enhance the level of normalisation of plant-rich diets, which is already visible in some European countries (e.g. Denmark) (Halkier and Wendler, 2025).

Food choices are taken in contexts shaped by both economic and non-economic factors, commonly referred to as food environments.

As discussed above, food choices are not only determined by price signals but also by habits, cultural and social norms and physical ease of access. Together, they determine the contexts in which consumers make decisions about acquiring and consuming food, which is generally referred to as food environments (Swinburn et al., 2013). These factors can be classified in different ways (Glanz et al., 2005; Swinburn et al., 2013; Turner et al., 2018; SAPEA, 2023; Agora Agriculture and IDDRI, 2025). This report uses a classification that, distinguishes between four different dimensions as illustrated in Figure 33:

- the **physical dimension** determines how easy it is to access different food products physically (e.g. vicinity of supermarkets, product placement, menus in canteens and restaurants);
- the **economic dimension** determines the relative affordability of different food products (e.g. prices, purchasing power);
- the **cognitive dimension** refers to consumers' information and knowledge about the health and sustainability impacts of different food products;
- the **socio-cultural dimension** refers to the cultural and social norms about food which are shaped by social practices and habits, culture, marketing and advertisement.

Figure 33 Illustration of various dimensions of food environments



Food policies are more effective when they target all dimensions of food environments.

So far, public policies to promote healthier, more sustainable food choices have been primarily focused on the cognitive dimension of food environments (e.g. through labelling, awareness campaigns, dietary guidelines) and to a more limited extent on the economic dimensions (e.g. sugar and fat taxes). However, the effectiveness of such policy tools in isolation is likely to be limited (Welch and Southerton, 2019; Moloney and Strengers, 2014). Further such policy tools place disproportionate responsibility on individuals despite their comparatively limited influence relative to institutional and organisational actors (Gram-Hanssen, 2021; Halkier and Wendler, 2025).

The insights from behavioural economics and sociology demonstrate that cognitive biases, social norms and cultural practices often mediate or override responses to information or price incentives. Building on these insights, policymakers can supplement the classical policy instruments with complementary measures that also target other dimensions of the food environment. It is globally acknowledged that such a comprehensive approach could better support consumers in making healthy and sustainable food choices, compared with an approach that solely focuses on individual willpower or consumer awareness (FAOSTAT, 2023; SAPEA, 2023).

Subsequent sections of this chapter provide a more detailed overview of what type of policy instruments could be considered to promote dietary adjustments and food waste reductions (Section 10.3) across the four identified dimensions of food environments.

Food policies would need to target food processors and retailers, which exert substantial control over food environments and thus consumption patterns.

The EU food system is characterised by a limited number of powerful downstream companies such as large processors and supermarket chains which account for the bulk of the food supplied to consumers and thus strongly shape consumer diets. In Germany, for example, four retailers control roughly 85% of grocery sales, raising concerns about lack of competition and excessive market power in the food supply chain (Monopolkommission, 2024).

The market power of EU food giants means they can strongly influence eating patterns through product composition, pricing, placement and promotion. Currently, they use these marketing tools to drive sales of profit-maximising products, which often include calorie dense, salty, fatty, sugary and high-emission food products. Moreover, supermarkets routinely offer multi-buy deals, deep discounts and prominent placement of ultra-processed food that is unhealthy and with a high carbon footprint, while packaging and branding (cartoon mascots, health claims, indulgent messaging) make such products appear attractive or normal (Vandevijvere et al., 2023; BEUC, 2021b). As such, these companies contribute to the negative public health impacts and related externalities as discussed earlier, which has motivated proposals for policy intervention (e.g. nutrient profiling, marketing reforms, healthier retail zoning) to realign retail practices with public health goals (BEUC, 2021b).

Similarly, food processors and retailers are also pivotal to reducing food waste. Their control over product standards, promotions and supply contracts shapes how much food is produced, stocked, and ultimately discarded. Strict cosmetic and quality standards for fruits and vegetables, along with contractual specifications imposed by retailers, often result in the rejection of edible produce before it reaches shelves (Garrone et al., 2014; Priefer et al., 2016). Volatile demand forecasts and marketing driven overstocking further amplify surplus generation and wastage at the retail stage (Schneider and Eriksson, 2020). Promotional practices such as 'buy one, get one free' and bulk discounts have been shown to encourage over purchasing and subsequently higher levels of household food waste. Retail concentration intensifies these dynamics, as a few dominant supermarket chains can externalise waste-related costs across the supply chain, pushing financial and logistical burdens onto suppliers and consumers (Schneider and Eriksson, 2020). Addressing food waste therefore requires not only consumer awareness but also systemic reform in retail practices, including procurement standards, pricing strategies and product presentation, to prevent waste at its source.

Addressing food waste and unhealthy consumption patterns thus demands shared responsibility and coordinated reform across the agri-food system. Systemic change grounded in collective accountability could become essential to preventing food waste and promoting dietary shifts towards more sustainable and healthy food options.

Maintaining freedom of choice is key to enhancing the public support to food policies.

Food consumption is deeply intertwined with cultural identity, traditions and socio-economic heritage (EEA, 2022). Furthermore, plant-rich foods are often perceived as less tasty, unfamiliar, needing more work and time to prepare a meal, or more expensive, though as demand increases, learning effects can improve taste and reduce costs (Arrow, 1962; Wright, 1936; Kozicka et al., 2025). Finally, changes in consumption patterns would also have implications for the supply side and can threaten certain livelihoods, particularly in livestock-dependent regions. As a result, policies aiming to promote healthy and sustainable consumption patterns often face substantial political and cultural challenges.

Analysis on public attitudes towards different food policy instruments found that information-based measures like labelling (48% support) and media campaigns (45%) were the most accepted, followed by reduced availability (40%) and incentives (38%). By contrast, more coercive policies such as price increases (27%) and advertising bans (26%) were the least accepted. Notably, a substantial share of respondents remained neutral across most policies (26–33%), except for price increases, where neutrality dropped to 16%, suggesting stronger polarisation (Pechey et al., 2022). On the other hand, literature shows that the coercive food policies are more effective at shaping consumption patterns compared with less intrusive policies such as information-based approaches (Ammann et al., 2023).

Policymakers will need to find a balance to ensure the food policy mix is sufficiently effective while maintaining broad public support across stakeholders. To this end, they can consider the following.

- **Maintaining freedom of choice.** Food policies can be designed so that they expand options and remove barriers to enable healthier and more sustainable choices, without eliminating or hindering choice or imposing a single diet. For example, providing better food education and clear labels empowers individuals to make informed decisions, while increasing the availability of healthy diets gives citizens more choice than they currently have. Pricing policies can then be framed as a tool to ensure that when consumers still choose to consume less healthy or sustainable food products, the true costs of these products are better reflected in their market prices (Pieper et al., 2020).
- **Communicating societal benefits.** In their communication, policymakers can emphasise the societal benefits that food policies deliver. From this perspective, the substantial public health externalities caused by current diets, which currently account for almost 6% of the EU GDP (see Section 2.5.7), provides a strong argument.
- **Promoting fairness and inclusivity.** Food policies can meet resistance not only from consumers, but also from producers. To address this, policymakers can provide public transition support for affected farmers (see Chapter 8), that could entail combining environmental and social policies (Huttunen et al., 2024). This might include supporting the scale-up of new income opportunities (e.g. growing high-protein legumes as European demand for plant proteins rises, shifting to organic methods that earn premium prices, or focusing on bioeconomy) and backing it up with concrete rural development programmes. Such policy approaches would indicate that it is not about shutting farms down, instead it could be about farming in a more cost-effective way in a changing world and climate.

10.3 Policy options to promote healthy and climate-friendly diets and lower food waste

Section 10.2 emphasised the importance of comprehensive policies targeting all four dimensions of food environments to support healthier, more sustainable consumption patterns. To support such policy efforts, this section provides a brief overview of the types of policy instruments that could be considered for this, starting with the physical dimension.

Policies targeting the physical dimension of food environments.

Enabling healthy and climate-friendly diets can be supported by addressing the physical dimension of food environments by changing the physical availability and convenience of various foods. Even if consumers try to consume the healthy and sustainable choice, they can only do so if healthier, sustainable options are accessible in their daily lives – in grocery stores, restaurants, schools, workplaces and neighbourhoods.

Policymakers can enact a range of measures to ensure that the default food options people encounter is increasingly aligned with dietary recommendations and sustainability goals. These policy measures include the following.

- **Public procurement**. Ensuring the widespread availability of healthy and sustainable food options, including novel foods and alternative protein sources (see Box 4), is essential to enabling better consumer choices. When nutritious, sustainable and easy to prepare products based on fruits, vegetables, plant-based proteins and whole grains are readily accessible across all retail environments, consumers are more likely to incorporate them into their diets (Spoyalo et al., 2024). Large scale availability reduces barriers, particularly for low income and rural communities, and helps normalise these foods as part of everyday eating (Seguin et al., 2014). To drive meaningful change, policies should support the production, distribution, and retail presence of such products at scale. Public procurement can play a central role in this process, for example by ensuring that plant-rich options are consistently offered in public and semi-public canteens, including schools, hospitals and government institutions. In addition, incorporating food waste reduction into EU public procurement through political intervention could further strengthen sustainability goals. The EU Green Public Procurement criteria already recommend measures such as menu planning rules and requirements for caterers to donate surplus food; however, implementation remains voluntary, coverage across Member States is inconsistent, and there is limited monitoring or enforcement to ensure compliance. Strengthening these provisions by making them mandatory and linking them to clear performance indicators would help realise their full potential.
- **Placement of products**. Evidence from systematic literature reviews show that greater availability and prominent placement of healthy options encourages healthier purchasing and consumption habits (Shaw et al., 2020). Similar strategies could be used to shift consumer behaviour towards more sustainable options. Public policies can support this transition by mandating the prominent placement in public canteens of sustainable products. In the EU, the F2F strategy explicitly promotes sustainable public food procurement as a tool to improve the availability and visibility of sustainable food options. A 2024 JRC report highlights that public procurement accounting for 14% of EU GDP has transformative potential in shaping food environments. The report recommends integrating

environmental and nutritional criteria into procurement guidelines to ensure that sustainable products are not only available but also prominently placed in public food settings (JRC, 2024e).

- **Reformulation of products**. Reformulating food products by altering their composition (e.g. reducing excess salt, sugar or saturated fats) or processing methods has been shown to effectively improve public health outcomes (Fanzo et al., 2023). These interventions are most effective when mandated and uniformly applied across entire product categories, ensuring a level playing field for all brands and manufacturers (Packer et al., 2024; WHO, 2023). To maximise its impact, reformulation can be integrated into comprehensive food policy frameworks.

Policies targeting the economic dimension of food environments.

As already discussed in detail in Chapter 7, pricing policies are a powerful lever to influence dietary choices by making sustainable foods more affordable relative to unhealthy and unsustainable ones. At present, many unhealthy or environmentally harmful foods are cheap and abundantly marketed, while healthier, low-impact options (fruits, vegetables, legumes, etc.) can be too expensive for low-income consumers (WWF, 2023). Governments can intervene to correct these imbalances through various economic policy options, where explicit GHG pricing is only one. Alternative options are:

- **Taxes**. Fiscal measures such as taxes on red and processed meats and foods high in unhealthy fats, sugar and salt can effectively shift consumption patterns. Economic modelling has demonstrated that food-group-specific taxes in the EU can significantly contribute to both nutritional and environmental targets, though substantial tax levels are needed to achieve meaningful change (Latka et al., 2021). A recent study by Springmann et al. (2025) has further showed that reforming VAT rates, raising them on meat and dairy while lowering them on fruits and vegetables, could lead to improved health outcomes and reduced environmental impacts across most Member States. When focusing on food waste, expanding economic incentives through political interventions could further support these objectives, for instance by waiving VAT on donated food or subsidising technologies such as dynamic pricing systems.
- **Subsidies**. To make healthy and sustainable food more accessible, policy measures could directly promote the production of sustainable food types in addition to supporting environmentally friendly farming systems. This includes shifting subsidy structures such as those under the CAP to better incentivise fruits and vegetables, as well as the scaling of plant-based proteins for human consumption. Farmers could be actively engaged in this transformation, with continued support for production systems that contribute positively to ecosystems. (SAPEA, 2020, 2023). Subsidies could also be redirected to support the production of plant-rich foods and environmentally friendly farming systems. Denmark provides a strong example: its government launched Plant-Based Food Grant (Plantefonden) worth several million Danish krone and a national action plan for plant-based foods in 2023, which includes education, innovation funding and eco-schemes for diversified plant production (Ministry of Food, Agriculture and Fisheries of Denmark, 2023).
- **R&D grants**. EU investment in alternative protein research has grown rapidly. The European Commission alone has already invested considerably, primarily through Horizon Europe. Denmark and the Netherlands are among the top funders per capita, with fermentation-based protein research showing the highest growth (SAPEA, 2020). Furthermore, the Group of Chief Scientific Advisors assessed the readiness and sustainability of various alternative

protein sources (algae, insects, microbial fermentation and cultured meat) and recommended targeted R&D funding and infrastructure investment to overcome technological and regulatory barriers (SAPEA, 2023). Innovation grants can boost product development at different levels of technological readiness, from early-stage research to pilot and commercialisation, help reduce costs and increase resource efficiency (Green Alliance, 2024). For example the Netherlands allocated EUR 60 million through its National Growth Fund in 2022 to build a cellular agriculture ecosystem, supporting cultivated meat and precision fermentation research, education and publicly accessible scale-up facilities (Rijksoverheid, 2025a). Further R&D support could lower the cost of alternative plant-based proteins which could then directly target the economic food environment. This additional funding could be channelled through the increased budget for clean technologies proposed under the Horizon Europe programme in the Commission's 2028–2034 MFF.

Policies targeting the cognitive dimension of food environments.

Empowering consumers with information about the associated health and sustainability impacts is a policy approach in public health nutrition. For a population wide dietary adjustment to be effective, individuals should understand both the rationale for change and the practical steps required to modify their dietary patterns. Cognitive interventions aimed at promoting climate-friendly diets encompass a broad spectrum of strategies. These can be summarised as follows.

- **Dietary guidelines based on both health and sustainability criteria**. While national dietary guidelines are instrumental in promoting public health and sustainability through the adoption of healthy and sustainable eating patterns, they frequently lack alignment with broader environmental sustainability objectives, such as those outlined in the Paris Climate Agreement or by the EAT-Lancet Commission (Rockström et al., 2025). To address this gap, dietary guidelines can explicitly incorporate sustainability criteria and be regularly updated to reflect the evolving scientific consensus on both the health and environmental impacts of food systems. Such integration can shape consumer demand and influence the supply of healthier, more sustainable food products (James-Martin et al., 2022). Furthermore, developing a methodology to effectively translate science-based findings into national dietary guidelines could become a joint task for the EU and the Member States.
- **Labels**. To support the transition towards healthier and more sustainable food practices, information strategies could leverage a range of tools, front-of-pack labelling, environmental or nutritional scoring systems and digital platforms that provide personalised feedback (SAPEA, 2020, 2023). These instruments can enhance consumer awareness and guide more informed food choices (Ikonen et al., 2020). From a climate perspective, this could include labels showing the GHG footprint of different types of food products, as is currently being piloted in France (ADEME, 2026).
- **Information campaigns**. Public communication strategies could include marketing campaigns and targeted advertisement on sustainable food choices (SAPEA, 2020, 2023). In parallel, communication campaigns and educational programmes could address the issue of food waste by promoting reductions in overconsumption. Such efforts can be reinforced through practical guidance on food planning, shopping habits, preparation, storage and reuse or recycling practices (Reynolds et al., 2019). Training cooks and servers in waste minimisation, and involving consumers in measuring plate waste, have been effective in some pilots. School and community programmes could build skills such as cooking with leftovers, shopping by list and improving date label literacy. Investments in sustained

education and nudge campaigns can further reinforce these behaviours. Although information and education strategies alone are typically insufficient to drive largescale behavioural change, they constitute a critical foundation for broader policy interventions. These measures contribute to raising public awareness and fostering social acceptance, thereby cultivating a cultural context that is more receptive to shifts in dietary practices. When integrated with complementary economic and environmental policies, information-based approaches enhance the likelihood that individuals will translate knowledge into action. The overarching objective is to ensure that citizens across Europe not only understand the principles of a healthy and sustainable diet but also feel empowered, motivated and supported to incorporate these principles into their everyday food choices.

Policies targeting the socio-cultural dimension of food environments.

Media representations and commercial marketing exert a powerful influence on dietary behaviours and societal food norms (Boyland et al., 2025). Consequently, a critical area of policy intervention involves addressing the advertising and promotion of food products. At the same time, communication channels present opportunities to actively promote sustainable and health enhancing dietary patterns. Leveraging social networks, cultural narratives and public messaging can contribute to shifting normative expectations around food consumption, thereby supporting broader efforts to foster sustainable food system transformation. The policy options that effectively address the socio-cultural food environment entail the following.

- **Support to local food supply chains.** Short food supply chains are characterised by reduced geographical distances and fewer intermediaries between producers and consumers. While local food production accounts for only a limited share of total consumption and in some cases may exhibit a higher environmental impact than certain long-distance alternatives (Edwards-Jones, 2010), it offers distinct social and educational benefits. In particular, it fosters stronger consumer engagement with food production practices, enhances awareness of food quality and promotes more informed dietary choices (Benos et al., 2022). Moreover, access to diverse food entitlements beyond conventional market structures, such as community supported agriculture, direct sales and informal exchanges can strengthen food system resilience, support healthier and more sustainable eating patterns and deepen the connection between consumers and producers (Vasquez et al., 2017). Furthermore, chefs are increasingly recognised as key actors in dietary transitions, with the potential to influence both food quality and consumer behaviour through their menu choices, sourcing decisions and public visibility (Bertoldo et al., 2021).
- **Marketing and labelling rules.** Regulatory measures to curb the promotion of foods high in salt, sugar and saturated fats are crucial for reshaping consumption patterns particularly among children and adolescents, who are especially vulnerable to persuasive advertising. Evidence shows that restrictions on marketing across television, digital platforms and retail environments can significantly reduce exposure and influence purchasing behaviours. For example, a WHO Europe report (WHO, 2018) documented that comprehensive marketing policy to support healthy and sustainable diets could lead to measurable declines in the consumption of unhealthy, unsustainable foods and beverages. Similarly, Boyland and Tatlow-Golden (2017) found that children's dietary preferences and intake are directly shaped by exposure to advertising of high fat, salt and sugar products, underscoring the public health case for stricter controls. More recent modelling by Mytton et al. (2020) indicated that banning digital advertising of such foods could substantially reduce their intake at the population level. Policy action could therefore include marketing restrictions,

nutrient-profile-based advertising standards, clear labelling requirements and limits on promotional tactics in retail and online environments. In addition, harmonising date-marking rules across the EU and improving consumer education on the difference between 'use by' and 'best before' labels could further support food waste reduction and sustainable consumption. Simplifying packaging, for example by offering smaller portions or easy-to-reseal packs and standardising labels could also help normalise food waste reduction practices among consumers.

- **Stakeholder engagement across the food-supply chain.** To lower socio-economic and cultural barriers towards transformation of the food system, policymakers could engage all stakeholders in transparent and inclusive dialogue to define the pace and scope of reforms. Such a participatory and inclusive approach can help balance competing interests while ensuring that policy development remains grounded in scientific evidence and aligned with public health and climate objectives (Giesbers et al., 2025).
- **Regulated digital food environment.** The digital transformation of the food environment presents significant opportunities to encourage healthier and more sustainable patterns of food purchasing, storage and consumption. As mentioned in the section on cognitive dimension, digital tools and platforms can support informed decision making, facilitate personalised dietary guidance and enable more efficient food management at the household level (Scapin et al., 2025). However, to fully realise these benefits, it is essential to implement regulatory frameworks that govern digital media, particularly in relation to food-related content. Establishing rules analogous to those applied to traditional advertising can help curb the spread of disinformation and misinformation, thereby protecting consumers and reinforcing public health and sustainability objectives.
- **Strategic quantitative measures.** These measures leverage quantitative methods to enable strategic advantages for climate mitigation of the agri-food system. This can include strategic menu planning to lower the climate impact of public canteens and food waste. Results from Flynn et al. (2025) show that such approaches can lower carbon footprints of public canteens by up to 30%.

10.4 Policy options to address food poverty

Climate change and climate policies enhance the need to address food poverty.

Food poverty refers to the inability of individuals or households to access or afford sufficient, safe and nutritious food that meets their dietary needs and preferences for an active and healthy life. It is driven by economic constraints, but is also linked to social exclusion, unstable food environments and limited access to healthy food outlets (FAO, 2023e).

Food poverty has been on the rise Europe in recent years (see Section 2.5.6). Even if this trend may only be temporary, several of the elements covered in this report could put upward pressure on food prices in the years and decades to come. This includes climate-related shocks and stresses and policy interventions such as pricing GHG emissions from agriculture (see Chapter 7) and phasing out CAP subsidies for particularly climate-harmful practices (see Chapter 6). As lower-income households spend a higher share of their income on food, they are particularly vulnerable to such price increases.

The European Climate Law mandates that EU institutions and Member States should consider food security and affordability and the need to make the transition just and socially fair, when taking measures to achieve EU climate neutrality by 2050 (EU, 2021a). To this end, the policies recommended in other parts of this report should be accompanied by additional measures to tackle food poverty. Such measures should be grounded in a rights-based approach rather than a charitable model, recognising access to adequate food as a fundamental human right enshrined in the EU Treaties and the Universal Declaration of Human Rights (UN, 1948). The right to food is further elaborated in Article 11 of the International Covenant on Economic, Social and Cultural Rights (UN, 1966), which obliges states to ensure access to adequate, nutritious and culturally appropriate food. Within the EU context, this principle is consistent with the European Pillar of Social Rights and the Charter of Fundamental Rights of the European Union (Articles 34 and 35), which emphasise dignity, social inclusion and access to essential services (EU, 2000). A rights-based approach highlights the responsibility of public institutions to guarantee equitable access to healthy, sustainable and affordable diets for all citizens, shifting the narrative from voluntary charity to enforceable social justice (UN Human Rights Council, 2009; FAO, 2020).

Multiple options exist to address food poverty.

In its essence, food poverty is just one aspect of a broader topic relating to welfare policy, inequality and redistribution in society. The ordinary tax system and the welfare state can play a key role in supporting policies that reduce overall poverty.

Beyond general redistributive measures several other options could be implemented to increase the food purchasing power of low-income households while maintaining the incentive for healthier, more sustainable consumption patterns.

- **Sustainable food allowances or vouchers.** These would function similarly to food stamps or coupons that can be redeemed for healthy, sustainable food items. They could be provided to low-income households to top up their food budget specifically for nutritious, climate-friendly foods. This directly addresses equity by helping those who might otherwise struggle with price increases, and it simultaneously creates a market pull that supports farmers transitioning to those products.
- **School and community meal programmes.** This concept aligns well with existing school and community meal procurement strategies in the EU. Programmes like the EU School Scheme (for more details see Chapter 5), already incorporate educational and health

objectives. Expanding these frameworks to include free or subsidised sustainable and healthy meals prioritising plant-rich, organic and locally sourced options would not only ease food insecurity among vulnerable families but also improve child nutrition, reduce environmental impact and foster long-term educational gains.

- **Social Climate Fund.** The EU's forthcoming Social Climate Fund (SCF) is aimed at energy and transport poverty. Under this approach, the SCF takes a portion of the revenues of the EU ETS for buildings and road transport and allocates it to Member States to spend on cushioning vulnerable consumers from carbon cost impacts (e.g. through income support or energy vouchers). The fund's mandate could be extended to address food poverty, potentially by leveraging revenues from the AgETS proposed in Chapter 7.
- **Price monitoring.** To ensure that policy interventions such as GHG pricing do not cause excessive price hikes, governments may need to monitor food prices and address market power throughout the value chain if competition is found to be insufficient.
- **Food waste redistribution**. Redistribution of edible foods that would otherwise be wasted can alleviate hunger and support the most vulnerable groups in society. On the other hand, food waste should generally be reduced to preserve resources as well, thus highlighting a trade-off.

10.5 The case for an overarching EU food policy framework

Food policies are a shared competence between the EU and its Member States.

As discussed above, policies to promote healthier, more sustainable consumption patterns can take many different shapes and forms. In the EU, the legislative competence to put in place such policies is shared between the EU institutions, its Member States and sub-national authorities (Wiebke et al., 2025). For example, labelling and rules on food composition are primarily an EU competence, as they relate to the internal market and consumer protection. On the other hand, taxation measures are primarily a national competence, even if the EU sets out the overall framework for VAT levels. Other initiatives, for example those relating to monitoring and reporting, are shared between the EU and the national levels (Wiebke et al., 2025).

EU action can provide added value by ensuring a level playing field and realising economies of scale.

As previously discussed, food consumption patterns are strongly embedded in social and cultural norms. From this perspective, nationally developed food policies could be more effective as they can cater for specific regional and local context and circumstances (Agora Agriculture and IDDRI, 2025).

Complementary action at the EU level can support and coordinate these national efforts to ensure common progress and a coherent approach. Doing so can deliver the following advantages.

- **Ensure a level playing field.** By coordinating national efforts, action at the EU level can prevent market fragmentation and competitive distortions that may arise from a patchwork of different national approaches. It would also allow for better comparability between Member States.
- **Realise economies of scale.** A coordinated approach can also allow for shared resources and economies of scale while reducing compliance costs for companies operating across multiple Member States.

The F2F strategy provides a basis for further EU action.

The 2020 F2F strategy aimed to reduce the environmental and climate footprint of the EU food system and strengthen its resilience, ensure food security and lead a global transition towards competitive sustainability from F2F (EC, 2021b). To this end, it also included several initiatives to promote healthier and more sustainable diets and a reduction in food waste. However, while the strategy has led to progress on voluntary and non-legislative measures, several of its key regulatory initiatives remain delayed or only partially implemented, as also discussed in more detail in Table 27 (European Parliament, 2024).

The Advisory Board recommends an overarching, EU-wide food policy framework that sets out direction, ensures coherence and comparability and supports the scale-up of solutions.

The analysis in this chapter has highlighted the importance of using a range of different instruments targeting all dimensions of food environments to promote healthy and climate-friendly diets and food waste reductions, while addressing food poverty. It also argued that EU-level action can provide added value, by ensuring a level playing field and delivering economies of scale.

Whereas the F2F strategy included several promising initiatives which could contribute to the required changes, many of these have so far not been put into practice. The Advisory Board therefore recommends that the EU establish and implement an overarching, EU-wide food policy framework that:

1. **Encourage the establishment of national guidelines for healthy and climate-friendly diets,** based on a common scientific evidence base, while allowing those guidelines to account for cultural heritage and values.
2. **Promote food environments that enable healthy and climate-friendly food choices**. To this end, the EU should regulate food processors and retailers, by setting mandatory standards for the marketing and labelling of food products, and for public food procurement.
3. **Ensure the provision of robust and consistent data** on food consumption and food waste, based on harmonised methodologies, to enable a transparent assessment of progress on the shift towards climate-friendly diets and the reduction of food waste.
4. **Support Member States** in developing and implementing effective national food policies, including measures to prevent and address food poverty, reduce food waste and inform all consumers about healthy, climate-friendly food choices.
5. **Provide coordinated support across the food supply chain**, helping producers, retailers and other stakeholders transition towards climate-proof practices while supporting the principle of a shared responsibility of the entire supply chain.

Concrete options that could be considered to operationalise each of these recommendations, some of which were also included under the F2F strategy but have so far not yet been implemented, are provided in Table 27.

Table 27 Concrete options to implement the recommendations for food policies

1. Encourage the establishment of national guidelines for healthy and climate-friendly diets
• Clear, indicative EU-wide targets. Building on the F2F strategy's commitment to halve per capita food waste, the EU has set legally binding food waste reduction targets under the Waste Framework directive (Directive 2008/98/EC), although with a lower ambition level (10% reduction in food waste from processing and manufacturing and a 30% per capita reduction in food waste at retail, restaurants, food services and households by 2030) (EU, 2025a). The EU could also consider introducing an indicative, longer-term target to increase the share of plant-based proteins in diets, set for a horizon beyond 2030 (European Parliament, 2024).
2. Promote food environments that enable healthy and climate-friendly food choices
• Standardised front-of-pack nutrition labels. The F2F strategy committed to proposing harmonised mandatory front-of-pack nutrition labelling across the EU by 2022. However, the Commission has so far not submitted a legislative proposal, and the initiative has effectively stalled. Front-of-pack harmonisation was not taken forward in the Commission's 'Vision for Agriculture and Food' (European Parliament, 2024).
• Standardised sustainability indicators. The F2F strategy announced the development of an EU-wide sustainability labelling scheme to harmonise environmental information across products. The underlying legislative proposal expected as part of the framework for sustainable food systems has not yet been published, leaving harmonised sustainability indicators undelivered (European Parliament, 2024). However, the initiative is still ongoing: under the EU Vision on Agriculture and Food, the Commission

committed to developing a voluntary benchmarking system for on-farm sustainability assessments, which could also be extended to the whole agri-food sector.

- **Restrictions on misleading health or environmental claims.** Under the F2F strategy the Commission committed to establishing harmonised EU rules on environmental claims as part of a broader sustainable labelling framework. This was reflected in the 2023 proposal for a Green Claims Directive, which would require companies to substantiate environmental claims with robust, independently verified evidence. However, negotiations have stalled and the Commission has signalled an intention to withdraw the proposal, leaving the F2F objective of a harmonised EU system for environmental claims still pending (CMS, 2025).
- **Fair, sustainability-based criteria in public sector food procurement.** Under the F2F strategy, the Commission committed to proposing minimum mandatory criteria for sustainable public food procurement and to reviewing the EU school scheme. Whereas the legislative proposal was originally announced for Q3 2021, it has been delayed with the public consultation process launched in early November 2025.

3. Ensure the provision of robust and consistent data

- **Standardised GHG accounting methodologies across all food system sectors.** Literature consistently highlights this gap, with recent analyses calling for harmonised accounting boundaries and emission-factor methodologies across agriculture and diets. The F2F strategy did not envision establishing an EU-wide MRV framework for food-system emissions, and no similar initiatives have been taken at the EU level to date.
- **A central EU body providing harmonised methods to derive emission factors across geospatial and temporal scales.** Literature shows that emission-factor datasets are scattered across national inventories, JRC databases and private life-cycle-assessments highlighting the need for an EU-level authority to support and harmonise the development of such factors (Karl et al., 2025). The F2F strategy did not include any initiatives in this direction, and no other similar initiatives have been taken at the EU level to date.
- **Development of EU wide progress indicators tracking food environment transformation.** This could include annual EU reporting showcasing shifts in availability, affordability and marketing of plant-rich options across all Member States using common metrics.

4. Support Member States

- **EU wide dietary guidelines methodology support.** The EU could provide a comprehensive methodology to guide Member States in developing science-based dietary guidelines for sustainable and healthy eating. In addition, it could set EU-level science-based targets to be embedded within national dietary guidelines.
- **Provide financial support for redistributive policies.** The EU could redistribute available funds to help Member States finance redistributive policies. These could include revenues from a GHG pricing scheme (see Chapter 7) similar to the approach of the Social Climate Fund for the EU ETS2, or an extension of the Just Transition Fund to cover food vulnerability.
- **A rights-based framing of food access.** The EU could embed food security programmes in antipoverty and public health strategies.

5. Provide coordinated support across the food supply chain

- **Innovation support (financial and non-financial).** The EU could provide capacity-building innovation support for all actors along the supply chain, from farmers to retailers and food processors. This support could include financial measures, such as dedicated grants, low-interest loans and innovation prizes for companies developing sustainable and healthy novel foods. In addition, it could involve non-financial support, including training and education programmes for farmers, chefs and public canteens on how to grow, prepare and work with novel, plant-rich foods. Non-financial support could also promote supply-chain development and local sourcing for public kitchens and consumers, for example through innovative digital tools.
- **Remove regulatory barriers.** The EU could provide an accelerated EU authorisation pathway for novel foods, including precision-fermented and cell-based proteins, harmonised hygiene rules for small-scale plant protein processors and reduced administrative burden for cross-border trade in plant-based ingredients.
- **Long-term contracts and risk-sharing mechanisms.** The EU could support and facilitate purchase guarantees or multi-year contracts between farmers, processors and public institutions to stabilise demand for plant protein crops and reduce transition risk.

Chapter 11

Trade policies to address carbon leakage

Key messages

Various trade policies can mitigate carbon leakage risks.

Carbon leakage refers to the phenomenon whereby GHG emissions increase in non-EU countries as an unintended consequence of the EU implementing more stringent climate policies aimed at reducing its own emissions. Such leakage can manifest as shifts in the relative competitiveness of EU producers both in domestic and foreign markets.

To counter the risk of carbon leakage, three main policy pathways can be identified:

1. **Multilateral instruments.** These involve coordinated action among multiple countries to harmonise climate policy frameworks, thereby reducing competitiveness concerns. Examples include international agreements on GHG pricing or the inclusion of climate-related provisions in FTAs.
2. **Unilateral instruments with a focus on trade flows.** These are measures adopted by a single jurisdiction to mitigate leakage by adjusting the treatment of imports and exports. Instruments such as CBAM and mandatory import standards fall within this category.
3. **Unilateral instruments with a focus on domestic policy**. These aim to reduce leakage by alleviating the burden of GHG pricing on emission-intensive, trade-exposed sectors within the domestic economy. An example is the free allocation of emission allowances under an emissions trading system.

As free allowances granted in the early stage of an AgETS are gradually phased out, trade measures such as a CBAM could ease farmers' transition and mitigate carbon leakage.

Chapter 7 outlined a GHG pricing system that evolves towards a polluter pays principle, while the free allocation of allowances is gradually phased out. If the system assigns the point of obligation at the farm or processor level, carbon leakage becomes a concern. To address this, new measures could be introduced in parallel, such as a CBAM that would ensure that emissions embedded in imported agricultural goods are subject to carbon constraints equivalent to those applied to domestic production. However, a CBAM faces distinct challenges and shortcomings.

- Implementing a CBAM in the agricultural sector involves substantial **administrative complexity** that must be carefully managed. A pragmatic approach would involve initiating the mechanism with a limited set of high-emission agricultural products, such as meat and dairy, while leveraging insights from the existing CBAM framework applied to industrial sectors.
- The CBAM concept has drawn severe criticism from multiple countries, outside the EU, and extending the measure to agriculture could lead to substantial **diplomatic backlash** in the current international situation.
- While CBAMs can help level the playing field in domestic markets, addressing **export-related carbon leakage** remains a distinct challenge. Potential solutions in this area are subject to significant limitations, both in terms of feasibility and effectiveness.

11.1 Introduction

Policy recommendations in the preceding chapters may lead to carbon leakage.

Several of the policy instruments examined in this report have the potential to increase production costs and reduce output volumes of GHG-intensive agricultural commodities in the EU. Notably, these instruments include the implementation of a GHG pricing mechanism within the agricultural sector depending on the point of obligation (see Chapter 7), along with the full or partial withdrawal of income support for climate-harmful agricultural practices under the CAP (see Chapter 6). As discussed in these chapters, a principal concern associated with such measures is the risk of carbon leakage under certain design options.

Leveraging food and trade policy frameworks can contribute to reducing carbon leakage, with the latter constituting the focus of this chapter.

Chapter 5 identifies two primary policy strategies to address this risk. The first involves the adoption of food policies designed to ensure that supply-side transformations are accompanied by corresponding adjustments in consumer demand. The second entails the development of targeted trade policies aimed at establishing a level playing field between European producers and their international counterparts (Jakob, 2021). In addition to mitigating carbon leakage, such trade policies may also contribute to safeguarding agricultural incomes.

While food policy considerations are addressed in Chapter 10, this chapter focuses on trade policy mechanisms that could serve to reduce the risk of carbon leakage, including their benefits and challenges. To this end, it is structured as follows:

- **Section 11.2** provides a conceptual overview of carbon leakage, including the various channels through which it may occur.
- **Section 11.3** introduces a range of trade policy instruments that could be employed to mitigate carbon leakage.
- **Section 11.4** offers an in-depth examination of the CBAM. The reason for this focus is that such a policy is already being implemented within the current EU ETS.

11.2 Overview of carbon leakage channels

Carbon leakage is a risk relating to unilateral climate policies, reducing their global efficacy.

Carbon leakage occurs when GHG emissions increase in countries outside the EU as a consequence of the EU implementing more stringent climate policies with the objective of reducing its own emissions (Hoel, 1996). This phenomenon can compromise the global efficacy of climate mitigation policies, as the reduction of emissions within the EU may be (at least partially) counterbalanced by increases in other regions.

Leakage is typically expressed as a percentage, calculated by dividing the increase in emissions outside the EU by the decrease in emissions within the EU. In the event of a 100% leakage rate, global emissions would remain constant despite the implementation of mitigation policies within the EU, thereby rendering the policy essentially ineffective. In case of a leakage rate above 100%, global emissions would increase, making the policy counterproductive. This situation could occur if European production is fully replaced by more GHG-intensive production from another region.

Whereas various carbon leakage channels exist, this chapter focuses on the competitiveness channel.

Following Matthews (2022), climate policies can result in carbon leakage through four different channels.

- **Competitiveness channel**. When climate policy raises production costs, it can reduce the competitiveness of domestic industries compared with countries with no or weaker climate measures. This could result in leakage through either higher imports into or reduced exports from the EU, thereby leading to higher production and emissions abroad, which could be exaggerated if cleaner EU production is replaced by more polluting alternatives elsewhere.
- **Demand channel**. When a climate policy in one country reduces the consumption of a specific product, such as by imposing a carbon levy, this can slightly lower the global market price of that product. As a result, consumption may increase in other countries, partially offsetting the reduction in the implementing country. A related mechanism, the fuel market channel (Tan et al., 2018), though less relevant for agriculture, operates in a similar way: when consumption of an emission-intensive product (e.g. gasoline) declines, global market prices may fall, prompting higher consumption elsewhere and thereby contributing to carbon leakage.
- **Incentive channel**. Climate policy can influence the mitigation efforts of non-EU countries through what is known as the incentive channel. This effect can be either negative or positive. On the one hand, more ambitious targets in the EU might discourage others from acting, prompting them to reduce their own efforts (free-rider problem). On the other hand, such leadership could motivate or pressure other countries to raise their ambition particularly if reinforced by mechanisms like climate clauses in trade agreements.
- **Technology spillover channel**. Carbon leakage can be affected by technology spillovers. Ambitious climate targets in the EU can accelerate the development of low- or zero-emission technologies. Once these technologies are available, other countries can adopt them to reduce their own emissions.

Chapter 7 explored GHG pricing instruments, such as an AgETS, which may increase the cost of EU producers. Such policy tools often raise concerns about potential carbon leakage through the competitiveness channel. Accordingly, this chapter focuses primarily on trade measures designed to counterbalance those effects.

Carbon leakage occurs in both domestic and export markets.

Within the realm of the competitiveness channel of carbon leakage, it is important to differentiate between two types of leakage.

- **Import-related carbon leakage** occurs when EU policies increase domestic production costs, making cheaper, less-regulated imports more attractive. When European consumers are switching to these imports, they are effectively outsourcing emissions to regions with weaker environmental standards.
- **Export-related carbon leakage** occurs when EU producers experience a loss of market share in foreign markets due to rising compliance costs, enabling foreign competitors with lower environmental requirements to increase their market share.

The EU is a net exporter of the most GHG-intensive products, in particular relating to livestock. Still, the bloc simultaneously imports and exports livestock products. For this reason, both of these dimensions of carbon leakage are relevant for global emissions, with respective risks being determined by world market conditions, including elasticities of supply and demand, along with potential trade restrictions imposed by the EU or trading partners. However, as will be evident in the discussions in the rest of the chapter, various policy instruments address these two dimensions of carbon leakage in different ways.

11.3 Overview of policies to mitigate carbon leakage

To counter the risk of carbon leakage, three main pathways can be identified.

1. **Multilateral instruments**. These are policy tools that involve coordination between multiple countries to reduce the risk of carbon leakage. Instead of each country acting alone and facing competitiveness concerns, countries agree on common approaches to GHG pricing or carbon constraints, for example in the context of the WTO or the COPs.
2. **Unilateral (European) instrument with a focus on trade flows.** These measures are adopted by one jurisdiction to protect domestic industry from loss of competitiveness by adjusting the treatment of imports and exports. In view of the exclusive competence of the EU for trade policies, these measures will often have to be taken at the EU level.
3. **Unilateral instruments with a focus on domestic policy.** These measures seek to mitigate carbon leakage by cushioning the impact of GHG pricing on emissions-intensive, trade-exposed industries within the domestic economy.

Table 28 provides an overview of selected policy options under each pathway, and the different instruments are then discussed in more detail in the rest of the section.

Table 28 Various policy options to mitigate carbon leakage

<table>
<tr><th colspan="2">Type of instrument</th><th colspan="2">Examples</th></tr>
<tr><td colspan="2">Multilateral instruments</td><td colspan="2">• Global GHG pricing scheme
• Climate clubs
• Climate provisions in FTA
• Climate provisions in the EU's Generalised Scheme of Preferences</td></tr>
<tr><td rowspan="2">Unilateral instruments (EU)</td><td>Targeting trade flows</td><td>Import-related leakage:
• CBAM
• Mandatory import standards
• Import quotas</td><td>Export-related leakage:
• Export rebates
• Export exemptions</td></tr>
<tr><td>Domestic policy options</td><td colspan="2">• Production subsidies (e.g. free allocation of emission allowances)
• Consumption taxes:
  o As a substitute for GHG pricing at the producer level
  o As a complement to GHG pricing at the producer level
• Innovation and investment support
• Lead markets for climate-friendly products</td></tr>
</table>

11.3.1 Multilateral instruments

Although global climate instruments currently appear unattainable, multilateral initiatives involving a select group of the EU's trading partners may represent a viable alternative.

Multilateral policy coordination represents the most direct strategy for mitigating carbon leakage. When identical climate policies are adopted both domestically and by trading partners, the relative competitiveness of firms remains largely unchanged, thereby minimising the risk of emissions shifting across borders. A globally harmonised GHG pricing scheme is often cited as the ideal embodiment of such coordinated action, as it ensures that all firms, irrespective of their geographic location, are subject to the same GHG price. However, despite its theoretical appeal, the implementation of a global GHG pricing scheme appears increasingly unrealistic given the current geopolitical context. Further, such a global carbon tax could jeopardise food security in some parts of the world (Jansson et al., 2024).

There are currently over 250 multilateral environmental agreements in force worldwide, of which approximately 15 incorporate provisions relating to the environmental dimensions of trade in goods (Matthews, 2022). While existing standards primarily address the safety of food, animals and plants, they do not explicitly regulate the climate-related impacts associated with traded goods. In principle, new international agreements could establish harmonised climate standards for food production. However, the negotiation and implementation of such agreements are typically protracted processes, and the resulting standards often reflect minimal consensus thresholds. Consequently, their effectiveness in mitigating carbon leakage remains limited.

In light of this, more limited forms of international cooperation may offer a pragmatic alternative. For instance, climate clubs (coalitions of countries with ambitious climate agendas) could serve to reduce internal carbon leakage by establishing a level playing field through harmonised climate standards among members.

By combining trade and climate objectives, FTAs could extend the EU's climate ambitions to trading partners.

Trade policy instruments, such as FTAs, have the potential to serve as strategic tools for aligning trade and climate objectives. The EU, for example, might leverage access to its internal market as an incentive for trading partners to adopt more stringent climate policies, thereby extending the reach of ambitious climate action beyond its borders.

Within the framework of existing EU FTAs, climate-related provisions most commonly reference the Paris Agreement as exemplified by the EU-Japan and EU-Vietnam agreements. The most explicit and comprehensive climate commitments are found in the EU-United Kingdom and EU-New Zealand FTAs (EC, 2021e, 2024j). Notably, the EU-New Zealand FTA introduces, for the first time, binding and enforceable obligations to effectively implement the Paris Agreement. Furthermore, the EU-UK Trade and Cooperation Agreement mandates that both parties maintain a GHG pricing mechanism encompassing electricity, heating, industrial processes and aviation (EC, 2021e). Despite these advancements, climate provisions in FTAs generally reaffirm pre-existing commitments rather than establishing novel obligations.

Looking ahead, FTAs could incorporate more targeted measures aimed at reducing GHG emissions in the agri-food sector. Such provisions could help narrow the gap in climate policy ambition between the EU and its trading partners, thereby mitigating the risk of carbon leakage in global markets. However, the implications for carbon leakage within domestic markets remain uncertain. If the EU demands more stringent climate commitments from partner countries, these countries may, in turn, seek broader market access for their products, potentially intensifying competition within the EU's internal market (Matthews, 2022).

It is important to acknowledge that FTAs, by facilitating trade liberalisation, inherently shift production and emission patterns among participating countries. For instance, Ferrari et al. (2024c) estimate that ten agreements concluded by the EU with Australia, Chile, India, Indonesia, Mercosur (Argentina, Brazil, Paraguay, Uruguay), Mexico, New Zealand, the Philippines and Thailand are projected to increase EU imports of beef by over 20%, accompanied by a corresponding decline in domestic production. However, Gohin and Matthews (2025) argue that the EU-Mercosur agreement, in particular, is unlikely to exert a substantial impact on the EU beef market, because the beef and poultry offer is limited to additional import quotas.

The EU's generalised scheme of preferences could be reformed so that beneficiaries must ratify and effectively implement the Paris Agreement to retain tariff preferences.

Tariff-based mechanisms may also be employed to promote sustainability objectives through the EU's generalised scheme of preferences (GSP). The GSP is designed to offer tariff reductions or duty-free access to the EU market for developing countries that have ratified and are implementing relevant international agreements. Within this framework, the GSP+ incentive scheme provides preferential market access to countries demonstrating effective implementation of international conventions on human rights, labour rights and sustainable development (including environmental agreements). In 2021, the European Commission proposed the inclusion of the Paris Agreement among the conventions required for eligibility under the revised GSP+ (MacLennan and Nordin, 2021).

However, the practical impact of granting preferences under the GSP approach, particularly with respect to the Paris Agreement, is currently likely to be limited. This is primarily because nearly all countries have ratified the Paris Agreement, which itself allows for considerable variation in national ambition levels. At best, this policy could serve to penalise countries that fail to fulfil the commitments they have undertaken under the Paris Agreement.

11.3.2 Unilateral instruments targeting trade flows

Border carbon adjustment (BCA) could unilaterally address the risk of carbon leakage in both domestic and export markets.

In light of the constraints facing multilateral options, a more feasible option for addressing carbon leakage is the unilateral targeting of trade flows by the EU. In view of the competence of the EU in the fields of trade and agriculture, this will often require common policies through the EU. The most prominent example examined in the literature is the concept of BCA which seeks to equalise carbon costs between domestic producers and foreign competitors (Markusen, 1975; Hoel, 1996; Fischer and Fox, 2012; Böhringer et al., 2014). BCA often includes two components:

- charging **imports** for their embedded emissions (e.g. CBAM);
- providing domestic producers with output-based rebates (subsidies) for **exports**.

By equalising carbon costs across domestic and foreign goods in domestic and foreign markets respectively, this policy prevents competitive disadvantages and leakage. As Hoel (1996) showed, if import tariffs and export subsidies can be applied to all traded goods, the country can maintain an undiluted GHG price without outsourcing emissions abroad. The downside is that exporters face less incentive to reduce production of emission-intensive products compared with producers selling to domestic markets, resulting in less efficient mitigation of domestic emissions. This highlights the trade-off between reducing carbon leakage and maintaining domestic cost-effectiveness.

This unilateral approach is confronted with significant administrative challenges, particularly in tracing embedded emissions throughout global supply chains, many of which lie outside the jurisdiction of the regulating country. In the absence of precise emissions data, this approach is compelled to rely on simplified benchmarks. Moreover, export subsidies in particular will often violate trade rules under the WTO (see Box 20Box) (Grubb et al., 2022).

The EU has already implemented a CBAM for industrial goods to complement the EU ETS, representing one of the two components of the BCA approach. Therefore, to supplement the proposed AgETS outlined in Chapter 7, a CBAM covering agricultural products is explored in more detail in Section 11.4 in combination with export rebates and exemptions of exporters from GHG pricing to address export-related carbon leakage.

Mandatory import standards may incentivise the EU's trading partners to adopt climate regulations that align with those of the EU, if the EU itself chooses the regulatory path.

Mandatory import standards refer to environmental criteria that agri-food products imported into the EU must meet (Gohin and Matthews, 2024). These standards may be either practice-based, specifying required or prohibited production technologies, or performance-based, requiring compliance with specific metrics such as emissions intensity or resource efficiency. For example, a hypothetical practice-based standard could restrict beef imports to producers using methane inhibitors (Matthews, 2022). In contrast, performance-based standards offer greater flexibility, allowing firms to select the most cost-effective technologies to meet the prescribed environmental outcomes. It should be noted that developing countries in particular may face insurmountable administrative burdens in complying with such EU requirements, especially if they are regularly subject to change. This may raise issues of fairness in international trade.

To ensure compliance with WTO rules (see Box 20), mandatory import standards are likely to be implemented as mirror clauses, whereby imported agri-food products must adhere to the same environmental and health standards as those applied to EU produced goods. This approach aims to establish a level playing field at the EU border (hlr, 2022; Englisch and Falcão, 2021). While a mirror clause here is classified as a unilateral instrument, it could also be implemented as part of a multilateral free trade agreement.

Hence, the scope and effectiveness of import standards are contingent upon the EU's own regulatory framework. Broad coverage is only feasible if the EU adopts a 'command-and-control' approach, such as the implementation of MCS (as discussed in Chapter 7) or the use of conditionalities within the CAP (see Chapters 5 and 6). Conversely, a more market-oriented strategy, such as the introduction of an AgETS, would necessitate alternative mechanisms to address carbon leakage (e.g. a CBAM).

Box 20 WTO rules and carbon leakage mitigation

To address carbon leakage, the EU and others have proposed carbon border measures (e.g. CBAMs). These must comply with WTO rules, particularly the General Agreement on Tariffs and Trade. Three key provisions apply.

- **Article I (most-favoured-nation treatment).** This requires equal treatment of similar products from all WTO Members. For example, a CBAM must not discriminate between trading partners.
- **Article III (national treatment).** Imported goods must be treated no less favourably than domestic equivalents. CBAMs must reflect domestic GHG pricing to avoid protectionist effects. In the same way, mandatory import standards must be aligned with domestic regulation.
- **Article XX (general exceptions).** This allows environmental measures if they are justified under clauses b (protection of health) or g (conservation of exhaustible resources), and applied in a non-arbitrary, non-discriminatory manner.

To be WTO compatible, trade measures must pursue legitimate climate goals, treat all trading partners fairly and mirror domestic efforts. They must also be transparent, proportionate and offer recognition of equivalent climate action abroad. While WTO law permits environmental trade measures, success depends on non-protectionist design and cooperative implementation.

Import quotas are already used by the EU to protect local markets from outside competition.

For numerous agricultural commodities, the EU applies a relatively high tariff on imports, referred to as the most favoured nation (MFN) tariff, on imports. To facilitate trade liberalisation for products considered critical, the EU frequently employs tariff rate quotas (TRQs). A TRQ establishes a specified volume of imports eligible for a preferential tariff rate (which could be zero); once this quota is exhausted, subsequent imports are subject to the higher MFN tariff (Matthews, 2025c).

When a TRQ remains underutilised, import levels are constrained primarily by market demand rather than trade barriers. Under such circumstances, EU producers may face a loss of competitiveness in domestic markets if stricter climate regulations increase production costs. Conversely, if a TRQ is fully utilised, but no over-quota imports occur, the MFN tariff is sufficiently prohibitive to deter additional imports, thereby providing a degree of protection for EU producers even if their costs rise. Thus, import leakage can be mitigated. In a third scenario, where over-quota imports occur despite the application of the MFN tariff, this suggests that certain foreign products maintain competitiveness despite the tariff disadvantage.

Trade barriers could reduce global climate adaptation.

It should be noted that while trade barriers like quotas and tariffs may address carbon leakage, they could also hinder climate adaptation. Climate change is expected to shift comparative advantages in global agriculture, with yields rising in higher latitudes and falling in southern regions (Bozzola et al., 2023; Gouel and Laborde, 2021; Magalhães Vital et al., 2022). In this context, international trade plays a crucial role in adaptation: flexible trade flows can offset regional yield shocks, reduce global welfare losses (Gouel and Laborde, 2018) and ensure food security (Janssens et al., 2020) where local production becomes constrained. Free markets thus provide an adaptive mechanism, reallocating resources dynamically in response to climate-related impacts.

11.3.3 Domestic policy options

A system of production subsidies and consumption taxes can resemble the effects of BCA.

In practice, explicit import tariffs and especially export subsidies for climate reasons, as in BCA, raise concerns about WTO legality and trade retaliation (Böhringer et al., 2024). Implementation is further complicated by potential resistance from trading partners who could view such measures as disguised protectionism.

Due to these concerns and the overall complexity of the policies, the literature has explored alternative instruments within domestic policy such as production subsidies and consumption taxes that achieve similar results. Importantly, research demonstrates that for a country that has already implemented an emissions price (such as a carbon tax or an emissions trading system) combined with output-based allocation (OBA) for emissions-intensive and trade-exposed (EITE) industries, it is welfare is improving additionally imposing a consumption tax on EITE goods (Böhringer et al., 2017). In this policy combination, the producer-level GHG price ensures climate mitigation incentives, output-based allocation provides leakage protection by acting as an implicit production subsidy, and the consumption tax corrects for the excessive consumption of EITE goods that OBA otherwise induces. This three-instrument combination of emissions price, OBA and consumption tax can thus replicate the effects of BCAs (Böhringer et al., 2017).

This approach could reduce the risk of international disputes and could be implemented within existing domestic tax and emissions trading systems. However, it is more comprehensive than BCA since all domestic production and consumption of EITE goods is targeted, not only traded goods. Moreover, it should be noted that applying OBA to agricultural products presents practical challenges, as it requires determining product-specific carbon footprints. In practice, market-average or generic benchmarks would need to be applied, which may be subject to measurement uncertainty and contention given the heterogeneity of agricultural production systems.

Chapter 7 discussed the use of OBA in the form of free allocation of emission allowances within an AgETS, while Section 11.4 provides a comparison of the instrument with a CBAM. One limitation of an emissions price combined with OBA but without a complementary consumption tax is that although it preserves incentives for emissions intensity improvements (technical mitigation) it weakens incentives for output reductions and consumption shifts away from emission-intensive products (structural mitigation). This is because OBA acts as an implicit production subsidy that counteracts the output-reducing effect of the GHG price (Fischer and Fox, 2012). The resulting excessive production and consumption of EITE goods diminishes overall domestic cost-effectiveness.

Furthermore, Chapter 7 discussed shifting the point of obligation of the pricing instrument from the producer level to the retailer level. This differs fundamentally from the approach outlined above (Böhringer et al., 2017), where a consumption tax supplements rather than replaces the producer-level GHG price. A sole consumption tax imposed at the retailer level would eliminate carbon leakage as embedded emissions from food imports are priced while emissions from food exports are not, but at the same time such an approach would provide no mitigation incentives for exporters, leading to an ineffective reduction of domestic emissions.

Supporting innovation and investments constitutes an alternative policy instrument for mitigating the risk of declining competitiveness and associated carbon leakage.

Given that carbon leakage arises from a decline in the competitiveness of EU producers, an alternative strategy is to enhance productivity within the EU (Mehling and Jakob, 2024). By fostering investments, innovation, or pilot projects (for example through the EU Innovation Fund), abatement costs can be reduced, enabling a greater proportion of domestic emission reductions to be achieved through technological mitigation (improving emissions intensity) rather than through structural changes (reducing output). The latter are more likely to induce leakage, as reductions in EU production may be offset by increased production in regions without equivalent GHG pricing.

Support for innovation and other investments has the potential to address both import- and export-related carbon leakage, especially when directed towards sectors and products exposed to international competition. Still, such targeted support may be perceived as inconsistent with international trade law, potentially necessitating broader eligibility criteria for the support allocation.

Investment and transition support within the CAP is further explored in Chapter 8.

The effectiveness of establishing lead markets for certified low-emission agricultural products as a strategy to mitigate carbon leakage remains uncertain.

Lead markets for low-emission agricultural products could be established, wherein goods are traded at a price premium contingent upon meeting specific GHG intensity thresholds or upon the adoption of designated climate-friendly practices and technologies. Such markets would constitute a distinct segment for certified products that comply with low-carbon standards and thereby qualify for preferential pricing. This approach is analogous to existing certification schemes such as fair trade and organic farming but would be explicitly linked to embedded emissions or other climate-related criteria.

These markets would be accessible to producers within and outside the EU, with demand driven by environmentally conscious consumers and public procurement initiatives. The associated price premium could enhance the economic viability of technological mitigation strategies, thereby incentivising emission reductions through technical mitigation rather than structural changes, which are more likely to result in carbon leakage. Still, there are limits to such a strategy as livestock emissions can only be reduced to a certain extent through technical options.

In addition, the implementation of such a policy framework entails several challenges and complexities.

- **Market displacement.** There is a risk that demand for certified low-carbon products may substitute rather than supplement existing market demand, potentially undermining other product attributes such as fair trade or ecological certifications.
- **Monitoring, reporting and verification (MRV).** The establishment of credible low-carbon standards for individual products necessitates robust and harmonised certification protocols. The data requirements for such certification processes are expected to be substantial and technically demanding.
- **Limited impact of public procurement.** The potential of public procurement to drive demand may be constrained by the limited number of relevant institutions (e.g. schools, hospitals) and their budgetary restrictions. Moreover, private sector demand remains uncertain and difficult to forecast.
- **Export-related carbon leakage.** While EU-based lead markets may help mitigate import-related leakage, they do not address the risk of carbon leakage associated with exports, thereby limiting the overall effectiveness of the approach.

11.4 Carbon Border Adjustment Mechanism for agriculture

The current CBAM for industrial goods could be extended to agricultural products.

Within the EU ETS framework, free allocation of emission allowances has historically served as a mechanism to support industries exposed to significant international competition. While this approach has been shown in the literature to be effective in mitigating carbon leakage, it lacks a consumption-based pricing element, thereby failing to ensure that domestic consumption of emission-intensive goods is appropriately internalising GHG emissions as discussed in Section 11.3 (Böhringer et al., 2017).

As an alternative approach, the EU introduced the CBAM, which began its transitional phase in October 2023 and entered its definitive phase in January 2026. CBAM applies to selected sectors (cement, iron and steel, aluminium, fertilisers, electricity and hydrogen) and is being phased in gradually alongside the phase-out of free allocation, with full implementation expected by 2034 (EC, 2025d). This policy shift ensures that imported goods face a carbon cost equivalent to that faced by domestic producers. Under the EU ETS, free allocation mitigates the cost burden on producers but also dampens the pass-through of carbon costs to product prices. By requiring importers to pay for embedded emissions, CBAM levels the competitive playing field and enables fuller carbon cost internalisation in product prices as free allocation is phased out. However, CBAM does not compensate producers for the loss of protection in export markets. As discussed in Chapter 7, several policy options are currently under consideration to mitigate this shortcoming within the existing CBAM regulatory framework (Marcu et al., 2025; EC, 2025e).

Despite these limitations, the evolution of the EU ETS may offer a model for the development of an AgETS. Specifically, a transitional phase involving free allocation could precede the introduction of a CBAM for agricultural products as the primary instrument for addressing carbon leakage. It should be noted that if an AgETS operates as a separate system from EU ETS, price differentials between the two systems would need to be reflected in the design of any CBAM for agriculture, as the border adjustment would need to correspond to the GHG price faced by domestic agricultural producers rather than the EU ETS price.

A CBAM would preserve EU competitiveness in domestic markets, but the effect on overall leakage is questionable.

As noted, a CBAM is a trade policy instrument designed to impose a levy on imported goods based on the GHG emissions associated with their production. This mechanism aims to mirror the carbon costs borne by domestic producers, thereby ensuring a level playing field. In the context of agricultural products, should the EU implement a GHG pricing scheme, a CBAM could be implemented for imported agricultural commodities to account for their embedded emissions. This would serve to harmonise cost structures between EU and non-EU producers, thereby safeguarding the competitiveness of EU agriculture within domestic markets (Fournier Gabela et al., 2024; Matthews, 2022). However, resource shuffling could result in cleaner products being directed towards the EU market, while more carbon-intensive goods are diverted to other regions, thereby diluting the global climate benefits (Matthews, 2022).

Moreover, the risk of carbon leakage through exports remains largely unaddressed. The EU's status as a net exporter of agricultural goods (see Chapter 2) limits the effectiveness of CBAM in mitigating overall leakage under an AgETS or similar pricing instruments.

Studies have attempted to simulate the potential impacts of a CBAM covering agricultural products within the EU. Nordin et al. (2025) find that under a EUR 120 per tonne CO_2e GHG tax, introducing a CBAM reduces the leakage rate from 91% to 25% as imports are being substituted by domestic production, effectively mitigating import-related leakage. An equivalent study by Jansson et al. (2024) reaches similar conclusions.

It is important to note that these studies generally assume that climate policies in exporting countries remain static in response to the EU's CBAM. However, the imposition of a carbon charge on imported agricultural goods may incentivise exporting nations to align their climate policies with those of the EU in order to maintain access to its market (Clausing and Wolfram, 2023; Bradford, 2020; Beaufils et al., 2024), as far as they have the capacity to do so. Although the probability of such policy convergence is uncertain, its occurrence could significantly reduce carbon leakage since EU producers would now also regain competitiveness abroad.

Introducing a CBAM for agriculture presents significant technical and administrative hurdles.

The effective implementation of a CBAM for agricultural products is contingent upon robust MRV of the GHG emissions embedded in traded goods. This presents considerable challenges in the agricultural sector, where accurate quantification of emissions requires detailed, farm-level data. Even for relatively straightforward products such as beef, pork and poultry, reliable MRV necessitates information on variables such as animal husbandry practices and age at slaughter, which are both costly and complex to collect at scale (Trinomics, 2023). The complexity increases substantially for processed or composite food items, such as a pepperoni pizza, where ingredients may originate from multiple countries, further complicating the attribution of emissions.

To address these MRV-related constraints, the literature proposes the use of emission intensity benchmarks. For example, the EU could establish a benchmark expressed in CO_2e emissions per kilogram of imported beef, and levy charges based on this. Such benchmarks facilitate simplified reporting and promote consistency across products and regions (Fournier Gabela et al., 2024). This approach aligns with the methodology adopted in the EU's existing CBAM for industrial goods. During its transitional phase (2023–2025), the CBAM registry provides default emission factors, such as five-year average CO_2 intensities for electricity by country (EC, 2023c). Analogously, a CBAM for agriculture could assign average GHG intensities to specific product–origin combinations, allowing importers to rely on standardised values rather than conducting bespoke emissions calculations.

A further consideration in the current CBAM framework is the treatment of products originating from countries that already impose a GHG price. In such cases, the EU must first recognise the foreign GHG pricing scheme, after which the importer may deduct the corresponding amount from the CBAM liability. However, this calculation is complicated by the need to account for carbon costs incurred at various stages along the supply chain.

Insights from the implementation of the existing CBAM will be instrumental in evaluating the feasibility of extending the mechanism to agriculture. In particular, lessons learned regarding administrative capacity, data infrastructure and compliance mechanisms will inform the design of a sector-specific CBAM for agricultural products.

An agricultural CBAM is a complex regulation that could be implemented gradually.

Given the administrative burdens, a CBAM could focus on a limited set of high-emission commodities. Research indicates that the most effective approach is to target products and stages in the supply chain responsible for the majority of carbon leakage, ensuring the measure remains both effective and manageable (Fournier Gabela et al., 2024). For example, Agora Agriculture (Agora Agriculture, 2024) suggests covering GHG-intensive, livestock products traded in bulk including beef, milk powder and butter.

A phased approach could be adopted, substantially reducing initial complexity. In early years, an agricultural CBAM could cover only primary products (e.g. raw grains, soybeans, meats) and use average emission factors, while also drawing on lessons learned from the existing CBAM applied to industrial sectors. Later, it could include more products, incorporate additional supply-chain emissions (processing, transport) and split products into more categories as data-quality improves.

A CBAM for agricultural products would likely comply with WTO rules.

As mentioned in Section 11.3, a main concern relating to BCA is how they comply with international rules of trade. To be WTO compatible, carbon border measures must pursue legitimate climate goals, treat all trading partners fairly and mirror domestic efforts. They must also be transparent, proportionate and offer recognition of equivalent climate action abroad. (hlr, 2022; Englisch and Falcão, 2021).

Upon the establishment of the EU ETS in 2005, the EU voiced concerns of whether complementing the system with a BCA-type policy would be within WTO regulation (Durel, 2024). However, in 2019 the European Commission first proposed a CBAM as part of the Green Deal, convinced that such a policy would be WTO compatible. In 2021, the European Parliament adopted a resolution towards a WTO-compatible EU border carbon adjustment mechanism (European Parliament, 2021). Moreover, the legal literature has increasingly been confident that a BCA is compatible with WTO rules (Durel, 2024).

Nevertheless, the CBAM drew severe criticism at the COP Climate Change Conference from countries such as India, China and Brazil, which see it as a protective trade measure placing a disproportionate burden on developing countries (CICERO, 2025). Thus, while extending the current CBAM to agricultural products may not violate international rules of trade, it could lead to substantial diplomatic backlash in the current international situation.

While farmers are likely to gain from a CBAM, consumers face higher prices.

From the perspective of agricultural producers, the principal advantage of CBAM lies in its potential to raise domestic market prices by curbing competition from foreign suppliers. But as noted above, while domestic producers may benefit from reduced import competition, they may simultaneously encounter intensified competition in external markets, where foreign producers redirect their exports in response to the CBAM.

The upward pressure on domestic prices resulting from CBAM implementation also entails distributional consequences for consumers. Specifically, consumers lose the ability to substitute towards lower-cost foreign products to avoid paying for the embedded emissions associated with their food consumption. The CBAM levy thus functions as an additional tariff, layered on top of existing EU import duties, which can already be substantial.

Various policy options could supplement a CBAM to address export-related leakage.

As already mentioned, a major shortcoming of a CBAM is that export-related carbon leakage is not addressed. As pointed out by the theoretical literature and explained in Section 11.3, a CBAM needs to be accompanied by export rebates to also tackle this side of leakage. Basically, such a rebate of the GHG payments should be provided as an output-based export subsidy, either by free allocation of emission allowances or as a direct financial compensation (Mehling and Jakob, 2024; Marcu et al., 2025). A less complex variation would be to exempt exported goods entirely from any GHG pricing, but as this would remove all incentives to reduce the emission intensity of such products, the loss of overall domestic climate mitigation in the sector could be significant.

Common to these options is that national exporters are given preferential treatment which is likely to be prohibited under WTO rules. Based on this concern, Mehling and Jakob (2024) find that innovation and investment support as mentioned in Section 11.3 could provide the most viable solution to addressing export-related leakage. However, while such efforts are critically important as ingredients for competitiveness, they are not a substitute for more comprehensive policies to address the risk of export-related carbon leakage.

Given these limitations, it may be prudent to refrain from implementing EU policies that directly target export-related carbon leakage. Instead, a more viable approach could involve leveraging bilateral and multilateral trade agreements to promote convergence in climate policy frameworks across trading partners. Such agreements could help establish a level playing field for agricultural goods in terms of GHG pricing and environmental standards. However, the effectiveness of this strategy depends critically on the willingness of key trading partners to engage in meaningful efforts to reduce the climate footprint of their agricultural sectors.

A CBAM could gradually replace free allocation in line with the evolution of the EU ETS.

In the evolution of the EU ETS, initial efforts to mitigate carbon leakage relied primarily on the free allocation of emission allowances. Over time, policy emphasis has shifted towards the implementation of a CBAM.

Drawing on this precedent, a similarly phased approach could be applied in the design of an agricultural GHG pricing scheme. As discussed in Chapter 7, the initial reliance on free allocation is intended to ease the financial burden on farmers during the early stages of implementation, while concurrently contributing to the mitigation of carbon leakage. As the system evolves towards a polluter pays principle, the free allocation of allowances is to be gradually phased out. In parallel, the introduction of a CBAM could ensure that emissions embedded in imported agricultural goods are subject to carbon constraints equivalent to those applied to domestic production. The CBAM, in its capacity of a cross-border equivalent to an AgETS, will establish a level playing field for agricultural products within EU markets. However, careful consideration must be given to the respective advantages and limitations of substituting free allocation with a CBAM framework (see Table 29).

Table 29 Comparison of a CBAM with free allocation of emission allowances

	CBAM	Free allocation
Effect on carbon leakage	Addresses leakage in domestic markets, not in export markets	**Addresses leakage in both domestic and export markets**
Domestic cost-effectiveness	**Maintains a uniform GHG price across all producers and climate mitigation options**	Reduces the marginal incentive for structural mitigation compared with the incentive for technical mitigation
Alignment with the polluter pays principle	**Aligned with the principle**	Violates the principle
Public revenue	**Provides additional public revenue**	Reduces auctioning revenues of the AgETS
Support of farmer's income	Higher prices in domestic markets	**Provides direct alleviation of financial burden of AgETS**
Administrative complexity	Complex MRV relating to activities outside the EU	**Benchmarks must be defined for each product category**

Note: Bold text indicates the instrument that is most likely to perform best on each dimension, although a comprehensive comparison would depend on the specific modalities of the policies.

Chapter 12

Funding the transition

Key messages

A successful transition of the agri-food system will require substantial public funding.

Increased support for climate action and for helping farmers cope with climate-related impacts requires sufficient public budget for climate action. Other recommended policies – namely phasing out harmful subsidies and pricing GHG emissions – can free up existing public funds or provide additional funds but, due to their gradual implementation, this will only become available over time.

This means that there is a temporal mismatch between when public funding is most needed (in the short term) and when additional public revenues would become available (in the longer term). If left unaddressed, this mismatch risks stalling climate action due to liquidity constraints.

The EU should provide sufficient and well-timed public funding to support climate action in the agri-food system.

To support the transition of the agri-food system, the EU should explore different options that can already provide sufficient funding in the short term, including the following.

- **The reallocation of existing CAP resources towards climate action** by increasing the share of the CAP budget dedicated to climate action, while ensuring that this budget for climate action effectively delivers meaningful mitigation and adaptation outcomes. This would require adjustments to the current legislative proposal for the 2028–2034 CAP, which is expected to decrease rather than increase the budget for climate action.
- **The frontloading of the auctioning of allowances** under a future greenhouse gas pricing system for the agri-food system, following the precedent of the EU ETS2 for buildings and road transport. This could be done once there is a clear legal basis for the introduction of such a system and could help to accelerate investment in adaptation and mitigation measures.
- **Other EU funds,** either via existing EU instruments or through the creation of a separate, dedicated fund. Additional funding for this could be mobilised via the upcoming multi-annual financial framework (for example by aligning all EU funding programmes with the EU climate objectives) through the European Investment Bank and national co-financing.

12.1 Introduction

A successful transition of the agri-food system will require both substantial private and public funding.

Whereas the available estimates on funding needs are fragmented, climate-proofing the EU agri-food system will require tens of billions of euros per year (see Section 2.5.4). This will need to be delivered through both private and public funding.

Several of the policy instruments discussed in previous chapters will already help to mobilise private funding towards more climate-proof production systems. The removal of climate-harmful subsidies (see Chapter 6) and the introduction of a greenhouse gas pricing instrument (see Chapter 7) do so by directly improving the business case of investments in climate mitigation. Similarly, the provision of transition support (see Chapter 8) can help to mobilise private funds by removing financial and non-financial barriers to mitigation and adaptation options.

Many of the recommendations presented in the preceding chapters will also rely on public funding. As discussed in Chapter 8, increased investment and transition support, more funding for knowledge dissemination and higher payment rates for more ambitious environmental incentive schemes would all require an increase in the available public budget. Similarly, Chapter 9 has highlighted the need for a higher budget for an EU-wide disaster relief mechanism for the agricultural sector.

Whereas concrete estimates are lacking, there is general consensus among stakeholders that financial support for environmental and climate action in the agri-food system would need to increase substantially throughout the following two CAP periods (2028–2034 and 2035–2042), on top of the current budget for eco-schemes (EUR 9 billion per year) and Pillar 2 measures for climate and environment (EUR 4.5 billion per year) (EC, 2024h).

This chapter explores options to increase public funding for climate action within agriculture. To this end, it is structured as follows.

- **Section 12.2** considers whether the European Commission's proposal for the next MFF and CAP could provide additional public funds for climate action in the agricultural sector.
- **Section 12.3** assesses to what extent recycling revenues from polluter pays policies, such as a GHG-pricing instrument and the phase-out of climate-harmful subsidies, could generate public revenues, which can be reinvested to support the agricultural sector in the transition.
- **Section 12.4** explores additional options that could be considered to increase public funding for climate action, which are not per se related to the polluter pays principle.

12.2 The proposed financing for the next CAP

The European Commission's proposal would fundamentally change the way the CAP is financed.

Whereas the current CAP is financed through two stand-alone dedicated funds with their own budgets, the proposal for the next MFF would see the CAP being financed through a broader fund for National and Regional Partnerships Plans (hereafter referred to as the 'National and Regional Partnerships Fund' or NRPF) (EC, 2025i). This fund would finance both the CAP and other policy objectives such as cohesion and migration. It would be allocated a total budget of EUR 865 billion for the period 2028–2034, of which minimum EUR 295.7 billion would be earmarked for CAP income support and an additional EUR 6.3 billion for the EU Agricultural Reserve. Member States could then decide to either spend only the minimum required budget on the CAP or use an additional part of their national NRPF envelopes to this end.

The Commission's proposal raises concerns regarding the protection of ring-fenced climate spending.

The Commission's proposal would see an increase in the overall EU budget, from EUR 1 221 billion (or 1.02% of the EU GNI[32]) under the current MFF to EUR 1 985 billion (or 1.26% of the EU GNI) for the 2028–2034 period (EC, 2025i). Despite this increase in the overall EU budget, preliminary assessments have warned that when considering the different elements of proposals on the MFF and the CAP, the overall CAP budget available for climate and environmental action is likely to decrease (IEEP, 2025d; Matthews, 2025b). This is due to several factors, which are briefly summarised below.

- **Overall lower minimum CAP budget.** On a like-for-like basis, the overall minimum budget earmarked for the CAP during 2028–2034 would be reduced by 16% or on average EUR 12.5 billion per year compared with the 2021–2027 period (Matthews, 2025d). Whereas Member States could decide to spend more than this, there are two reasons why a substantial increase beyond this minimum is unlikely. The first is that the CAP is competing with other objectives under the NRPF, including other themes which are high on the political agenda including defence, security and migration. The second is that it is far from given that Member States and the European Parliament will approve the proposed increase in the overall EU budget. If the proposed overall EU budget is reduced during the legislative process, this would put further pressure on the overall CAP budget.
- **Reduced ringfencing for climate and environmental action.** Whereas the current CAP requires that at least 25% of direct payments is spent on eco-schemes and at least 35% of Pillar 2 payments on the environment, the climate and animal welfare, the Commission proposals for the next MFF and CAP no longer include such earmarking. They only maintain the more general objective of spending at least 35% of the overall MFF budget and 43% of the NRPF towards climate and environmental objectives (EC, 2025i). However, these high-level objectives are less effective due to generous coefficients that determine the contribution of different spending towards these goals. For example, direct CAP payments could be accounted towards these goals with a coefficient of 40%, even if the conditionality framework for these payments would be weakened (see Box 19) and even if some payments can be considered as harmful for the climate (see Section 6.2).

[32] The MFF budget for 2021–2027 was originally foreseen to account for 1.13% of the EU GNI but eventually represented only 1.02% due to higher-than-expected inflation (EC, 2024a).

- **Increased competition from direct decoupled and coupled payments.** The proposal foresees several changes regarding decoupled payments, including a better targeting of the payments to those most in need and a reduction of decoupled payments for the largest farms through mandatory degressivity and capping. However, as explained in more detail in Box 21, decoupled payments could actually increase by EUR 6 billion per year in the least ambitious scenario, further reducing the remaining budget for climate action. Similarly, the proposal makes coupled payments mandatory for Member States, and increases the maximum ceiling of such payments from 13% of the total budget under the current CAP to 20% of the total budget under the next CAP.
- **Unfavourable rules on national co-financing.** In principle the proposal allows Member States to prioritise CAP payments for climate action over direct decoupled and coupled payments. However, the proposed rules on national co-financing discourage them from doing so. These rules require Member States to provide co-financing for all CAP instruments, except for decoupled and coupled income support, crop-specific cotton payments and payments to small farmers. This provision would incentivise Member States with constrained national budgets to prioritise decoupled and coupled income support over other CAP instruments that could better support climate action, as this would reduce the overall need for national co-financing.

Box 21 Decoupled payments under the next CAP

The European Commission's proposal for the next CAP (EC, 2025i) follows the logic of better targeting decoupled payments towards those who need it most. To this end, it replaces the different decoupled payment schemes under the current CAP by one system that would work as shown below.

- Overall, Member States are required to provide decoupled payments with payment rates of minimum EUR 130 and maximum EUR 240 per hectare.
- Within this range, payment rates need to be differentiated across farmer groups and regions based on objective and non-discriminatory criteria, with the aim to target support at those farmers most in need (with the proposal referring in particular to young and new farmers, women, family or small farmers, mixed farms and farmers in areas with natural or other area-specific constraints). The concrete implementation of these principles is left to the Member States.
- The proposal requires the preliminary direct payments (calculated by multiplying eligible hectares by the corresponding payment rates) to be reduced through a tiered, degressive approach with a maximum payment set at EUR 100 000 per farm (Matthews, 2025d).

The eventual aggregate volume of decoupled payments will thus depend on the initial payment rates as set by Member States (within the EUR 130 to EUR 240 per hectare range) and the degressivity and capping. Based on the methodology developed by Matthews (2025d), the Advisory Board has estimated potential aggregate decoupled payments under the next CAP under different scenarios. As shown below, the proposed rules could result in either an increase or decrease of decoupled payments compared with the current CAP.

- In case of low support rates (EUR 130 per hectare), the total required budget for decoupled payments could be reduced by EUR 7 billion per year compared with the current CAP budget of EUR 24 billion.
- In case of high support rates (EUR 240 per hectare), the total required budget for decoupled payments could increase by EUR 6 billion per year compared with the current CAP.
- In a third scenario where current support rates are maintained except where they are outside the EUR 130–240 per hectare range, the total required budget for decoupled payments would be reduced by EUR 2 billion per year compared with the current CAP.

12.3 Recycling revenues from polluter pays policies

A GHG pricing instrument could generate substantial auctioning revenues which can be recycled to support climate action.

When emission allowances are auctioned under a GHG pricing instrument, this generates public revenues which can be reinvested to support climate action in the sectors covered. This is a common approach under the EU ETS (e.g. via the Innovation Fund and Modernisation Fund) and EU ETS2 (via the Social Climate Fund) and could also be applied to a pricing instrument for agriculture.

How much budget this could generate, and by when, is difficult to predict, as it will depend on the GHG price and the overall volume of allowances to be auctioned. Table 30 includes some rough estimates to provide an order of magnitude, based on the methodology and assumptions discussed in Box 22. Even if based on a range of assumptions, these estimates suggest that GHG pricing could raise tens of billions of euros in auctioning revenues that could be reinvested in agriculture and the broader agri-food system, potentially in the same order of magnitude as the proposed minimum budget for the CAP in 2028–2034 (approximately EUR 42 billion per year).

Table 30 Rough estimates of annual revenues for pricing GHG emissions from agriculture

Billion EUR	Assumed GHG price	
	EUR 45/t CO_2e	EUR 100/t CO_2e
Pricing CO_2 from agricultural energy use	3.4	7.4
Pricing agricultural non-CO_2 emissions:		
• 60% scope	10	22
• 90% scope	15	34
Pricing land-based agricultural CO_2 emissions	3.4	7.5

Box 22 Underlying methodology and assumptions for the estimations in Table 30

The estimations in Table 30 are derived by multiplying the latest available emissions (as included in the GHG inventories) by an assumed price per tonne of CO_2e. This is a substantial simplification, as the number of allowances that will be auctioned will decrease in line with the emissions cap. However, this can also be expected to further increase the GHG price. For simplicity, both dynamics are assumed to cancel each other out.

The estimations are based on the following assumptions.

- Pricing CO_2 from agricultural energy use. The estimation assumes that agricultural energy use would be covered by the EU ETS2. The GHG price is estimated to range between EUR 45/t CO_2e (the price level which would trigger mechanisms to reduce further price increases (EC, 2025s)) and EUR 100/t CO_2e (the estimated average price for 2027–2030 by independent analysts based on the system's current design (BNEF, 2025)). It is assumed that all allowances will be auctioned, similar as for other sectors covered by the scheme. The volume of allowances to be auctioned for agriculture is assumed to be 75 Mt CO_2e, based on the emission level in 2023.

- Pricing agricultural non-CO_2 emissions. The GHG price under such a mechanism is highly dependent on the emissions cap. For simplicity reasons, the estimate is based on the same range as for the EU ETS2. This price range would unlock substantial mitigation potential in the sector: out of a total estimated reduction potential of 83 Mt CO_2e, almost 50 Mt could be unlocked at EUR 45/t CO_2e and almost 70 Mt CO_2e at EUR 100/t CO_2e (EC, 2024f). The amount of allowances to be auctioned would depend on the scope (share of emissions covered) and allocation rules. Two variants are provided, with either 60% or 90% of all agricultural non-CO_2 emissions covered by the pricing scheme (based on 2023 emissions). Full auctioning is assumed, meaning that revenues would be lower than the estimates during the pilot phase with free allocation (see Section 7.7).
- Pricing land-based agricultural CO_2 emissions. The estimation is based on land-based CO_2 emissions from organic soils in agricultural land, which amounted to 75 Mt CO_2 in 2023 (see Table 2). A similar price range of EUR 45 to EUR 100/t CO_2 is assumed. The impact assessment to the European Commission's 2040 communication (EC, 2024h) estimates that such a price range would unlock substantial mitigation potential in degraded peatlands (approximately 30–50 Mt CO_2 per year by 2050.

Phasing out climate-harmful CAP subsidies would free up public budget, which can be reallocated to support climate action.

The different options to avoid climate-harmful subsidies as discussed in Chapter 6 could free up CAP budget, which can be reallocated towards other CAP instruments that can support the climate transition.

- **Phasing out coupled payments for livestock.** Under the current CAP, these payments are budgeted at EUR 16 billion for the period 2023–2027 or an average EUR 3.2 billion per year (JRC, 2023c), which could be reoriented to support climate action.
- **Phasing out decoupled payments for degraded peatlands.** Under the current CAP, the total budget for decoupled payments (excluding eco-schemes) amounts to EUR 120 billion for the period 2023–2027 or on average EUR 24 billion per year. As degraded peatlands account for 2% of the EU's UAA (see Chapter 2), phasing out their decoupled payments could free up EUR 0.5 billion per year.
- **Reforming all direct payments.** The total budget of all direct payments (excluding eco-schemes, including coupled payments for livestock and decoupled for degraded peatlands) is set at EUR 143 billion for the period 2023–2027, or on average EUR 28.6 billion per year.

Depending on the speed of reforms, many of these revenues might only become available in the longer term, meaning additional funding sources might need to be explored for the short term.

Whereas the application of policies based on the polluter pays principle could thus provide substantial public funds for climate action, the bulk of these funds is only likely to become available over the longer term.

As discussed in Section 7.7, a pricing mechanism for agricultural non-CO_2 emissions might need to start with a limited scope (e.g. covering only larger farms) and free allocation to address concerns about administrative burdens and carbon leakage. Auctioning revenues from such a system would thus be limited in the initial phases. Only the inclusion of energy use in agriculture in existing GHG pricing frameworks might be able to generate substantial auctioning revenues already in the early 2030s.

Similarly, as discussed in Section 6.5, reforming all direct CAP payments needs to be considered carefully and implemented gradually over several years or even several CAP periods, to allow the sector to adjust. Whereas it is recommended to phase out the most climate-harmful payments already over the next CAP period (2028–2034), the potential to free up budget in this manner for other purposes is more limited (EUR 3.7 billion in total).

12.4 Addressing the public funding gap

The Advisory Board recommends exploring additional funding sources to aid the transition of agriculture already in the short term.

The assessment in the previous sections highlights a temporal mismatch between when funding would be most needed (in the short term, given the urgency to enhance climate action in agriculture) and when additional public funding from GHG pricing and phasing out harmful subsidies would become available (only in the longer term). Therefore, the Advisory Board recommends that the EU explores options to bridge this gap and ensure adequate public funding for climate action in the agricultural sector already in the short term. As a starting point, this chapter identifies three potential, non-exclusive approaches, which are briefly summarised in Table 31 and discussed in more detail thereafter.

Table 31 Options to increase public funding in the short term

	Option 1 Reallocation of CAP budget	Option 2 Frontloading of allowance auctions	Option 3 Tapping into other EU funds
Description	Increase the CAP budget available to support climate action with effective delivery mechanisms	Early auctioning of allowances under future GHG pricing system for agriculture (following the approach under the EU ETS2)	Using existing EU funds (other than the CAP) or institutions or creating a dedicated new EU fund
Budget implications	Budget-neutral or budget-increasing	Budget-increasing	Budget-neutral or budget-increasing
Legal path	Requires 2028–2034 CAP and MFF adjustments	Requires clear legal basis	Multiple channels available

Several options could be considered to increase the CAP budget available for climate action.

One potential funding approach involves increasing the total CAP budget. This could be achieved by increasing the total EU funds available for the CAP or by increasing national co-financing rates. Whereas this approach is possible in principle, such options would be very challenging given the current context of constrained public budgets and a substantial increase in competing budgetary demands, including for defence and industrial competitiveness. This challenge is also reflected in the European Commission's proposal for the next MFF and CAP budgets for the period 2028–2034 which would likely reduce the overall available EU budget for agriculture, despite an increase in the overall MFF budget (see Section 12.2).

A more feasible strategy relies on options that are budget-neutral, meaning that they would not increase the total CAP budget but would rather reallocate the available budget towards climate action (Option 1 in Table 31). One straightforward way would be to reintroduce a minimum ringfencing of budget to be spent on CAP instruments that support climate action. For example, Member States could be required to earmark a minimum share of their investment support for investments that support climate mitigation or adaptation, or a minimum amount of direct income support for agri-environmental and climate actions. As discussed in Sections 5.2.1 and 12.2, such ringfencing is required under the current CAP but would be discontinued under the Commission's proposal for the next CAP.[33] Another options (which could be used in parallel) is to reduce the amount of CAP budget needed for other purposes. One such option with significant potential is the better targeting of income support towards those who need it most, as discussed further below.

It should be noted that all these options would require further adjustments to the Commission's proposal for the next MFF and CAP. Furthermore, increasing the CAP budget for climate action would need to be combined with a further improvement of CAP instruments to ensure it delivers meaningful mitigation and adaptation outcomes (see Section 5.2.2 and Chapter 8).

Better targeting income support to those who need it most could free up CAP budget for climate action.

As discussed in Chapter 5, currently most income support is going towards already economically viable farm holdings, further exacerbating income inequality (Scown et al., 2020). Recognising this issue, there is broad support within the EU to better direct income support to those who need it most (EC, 2024h, 2025i). There are several types of farms which could be targeted to this end, as summarised below.

1. **Smaller farmers** are often considered to be among those most need. As discussed in more detail in Section 2.5.3, these farmers tend to generate lower agricultural incomes per AWU but are also more likely to generate a higher share of their incomes from non-farming activities. Therefore, farm size alone might not be the most suitable indicator to identify those farmers most in need of income support.
2. **Farms in less productive regions**, such as areas with natural or other area-specific constraints, for example mountainous regions are typically not economically viable without support, yet they often provide a wide array of public goods – both environmental and social – which can justify income support (Brady et al., 2017). The definition and zoning of such areas might need to be reconsidered as climate change impacts are projected to improve agricultural productivity in some regions and reduce it in others (see Section 2.3).
3. **Mixed farms**, combining crop and livestock production, tend to have the lowest average incomes (see Section 2.5.3) but could also deliver environmental benefits (see Box 23).
4. **Young farmers and new entrants** often earn lower incomes, partly because they face higher start-up costs due to the increase in land prices. Targeted support would help improve their economic viability, facilitate access to land and credit, and support innovation and long-term sustainability in European agriculture.

Both the strategic dialogue (EC, 2024h) and the Commission's vision on agriculture (EC, 2025i) argue that income support needs to be better targeted towards smaller farms,[34] farmers in areas with natural constraints, young and new farmers and mixed farms, without distinguishing or further differentiating between these groups.

Better targeting direct payments can be done either by increasing payment rates for those considered most in need (in which case it would reduce the remaining budget available for climate action), or by reducing it for others (in which case it could free up budget for climate action). In some

[33] Except for the overall 43% objective for climate and environmental spending under the NRPF, which can be easily met due to lenient coefficients.
[34] The strategic dialogue refers to 'small farms' and the EC vision to 'small- and medium-sized farms'.

cases, better targeting support to farm types identified as 'those who need it most' could also contribute to climate objectives directly, although this is not given by default (see Box 23 below).

Box 23 Link between farm types and their climate and environmental performance

Small farms. Whereas some studies conclude that overall, smaller farm holdings perform better in terms of climate and environment (Belfrage et al., 2015; Kirner and Kratochvil, 2006; Ricciardi et al., 2021), other studies have come to the opposite conclusion (Ren et al., 2019; Van Passel et al., 2007). Possible explanations are the lack of common definitions (e.g. on what constitutes a 'small farm') and metrics (e.g. performance per hectare or per unit of production), and different environmental dimensions assessed (GHG emissions, biodiversity, nitrogen surplus, resource use, etc.). Most studies agree that smaller farms perform better on biodiversity but the correlation with other environmental dimensions is less clear (Wuepper et al., 2020; Ricciardi et al., 2021; Van Passel et al., 2007; Dabkiene et al., 2021; Ebel, 2020; Van Der Meulen et al., 2014; Kirner and Kratochvil, 2006; Belfrage et al., 2015). Finally, whereas most studies found a correlation between farm size and environmental performance, the causality is less well-established as farm structure and management choices are often both determined by exogenous factors such as local climate, topography, labour markets and infrastructure. Therefore, it cannot be concluded that focusing support on small farms will by default generate more positive outcomes in terms of GHG emissions and other environmental dimensions.

Farms in less productive regions. Overall, farms in such regions are typically more extensive and less polluting on a per hectare basis (Scown et al., 2020), and can contribute to adaptation, mitigation and other environmental goals through the maintenance of grasslands. Maintaining some level of income support for these areas can therefore aid the EU's climate and environmental objectives. Brady et al. (2017) found that continued decoupled payments in such regions would lead to better outcomes for GHG emissions, nutrient surplus and biodiversity compared with removing CAP income support entirely, as the latter would lead to intensification or land abandonment. Scown et al. (2020) similarly argued for prioritising the phase-out of support in more productive, higher-polluting regions, but maintain some support for other regions. However, while extensive farming in less-productive areas may offer environmental benefits, some warn that this is not a given, and suggest that alternative land uses like nature restoration could in some cases deliver even greater gains (IEEP, 2025c). Furthermore, as these regions deliver lower yields, their environmental performance could be less beneficial when assessed per unit of production instead of per hectare.

Mixed farms. Prioritising income support for mixed farms could be expected to deliver some environmental benefits, as such farming systems can enhance nutrient cycling, reduce reliance on synthetic inputs and contribute to a more circular agricultural economy (Ryschawy et al., 2012).

Young farmers and new entrants. As previously discussed in Chapter 4, young farmers are generally more open towards innovation and new, sustainable farming methods. Furthermore, as discussed on several occasions throughout the report, the change in ownership of a farm holding provides an opportunity to restructure the holding in a way that contributes to climate mitigation and adaptation. Targeting support towards young farmers and new entrants can thus contribute to climate objectives, provided that this support is made conditional upon the uptake of specific climate measures.

The frontloading of auctions of a GHG pricing instrument could also help bridge the funding gap.

The EU ETS2 for buildings and road transport is expected to start operating in 2028, one year later than its original starting date (Council of the European Union, 2025). However, the European Commission is exploring a 'ETS2 Frontloading Facility' which would auction part of the scheme's allowance cap already in 2026–2027 (EC, 2025g), to allow for a gradual and smooth start of the system. This would also generate revenues before the start of the system.

As presented as Option 2 in Table 31, a similar approach could be used to generate revenues to support the transition in the agri-food system before a GHG pricing instrument would become fully operational. However, such an approach would at least require a clear legal basis for the introduction of such a GHG pricing instrument. Its ability to generate revenues in an earlier phase will depend on the volume of frontloaded allowances and the GHG price, which will depend on market participants' perception of the system's stringency.

Other existing or new EU funds and institutions could help to address the funding gap.

Option 3 in Table 31 involves mobilising additional EU funding through channels outside the CAP framework. As a first example, the European Investment Bank (EIB) could play a larger role in leveraging public-private finance for climate action in the agricultural sector and has recently taken steps to do so. In 2024, it announced a EUR 3 billion financing package for agriculture, forestry and fisheries for the period 2025–2027, alongside moves to improve farm insurance (EIB, 2024). More recently, it committed to further increase its role as climate bank by dedicating more than 50% of its financing activities on green investments in the 2026–2030 period (EIB, 2025). This includes EUR 30 billion of funding for climate adaptation, with a particular focus on agriculture, land use and integrated water management.

Another example is the creation of a separate, dedicated fund such as a temporary Just Transition Fund for the agri-food system as recommended by the strategic dialogue (EC, 2024h), although this might be challenging in the current budgetary context.

Finally, the Advisory Board has previously highlighted that a further integration of climate adaptation across all EU funding programmes through the upcoming 2028–2034 MFF could help increase the public EU budget available for adaptation investments (Advisory Board, 2026).

Acronyms and abbreviations

AECM	agri-environment climate measures
AgETS	agricultural emissions trading system
AKIS	Agricultural Knowledge and Innovation Systems
ANC	areas with natural or other area-specific Constraints
AR5	IPCC Fifth Assessment Report
AR6	IPCC Sixth Assessment Report
AWU	agricultural work unit
BCA	border carbon adjustment
CAP	common agricultural policy
CBAM	Carbon Border Adjustment Mechanism
CDR	carbon dioxide removal
CIS-YF	complementary income support for young farmers
CRCF	Carbon Removals and Carbon Farming Regulation
CRISS	complementary redistributive income support for sustainability
CSP	CAP strategic plan
CSRD	Corporate Sustainability Reporting Directive
DALY	disability-adjusted life year
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
EEA	European Environment Agency
EITE	emissions-intensive and trade-exposed
ESABCC	European Scientific Advisory Board on Climate Change
ESR	Effort Sharing Regulation
EU ETS	EU Emissions Trading System
EU ETS2	EU Emissions Trading System 2 (buildings, road transport, and additional sectors)
EU 27	European Union (27 Member States)
F2F	Farm to Fork
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organization of the United Nations
FTA	free trade agreement
GAEC	good agricultural and environmental conditions
GBD	global burden of disease
GDP	gross domestic product
GHG	greenhouse gas

GIS	geographic information system
GSP	generalised scheme of preferences
GWP	global warming potential
IED	Industrial Emissions Directive
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
KIC	Knowledge and Innovation Community
LSU	livestock unit
LULUCF	land use, land-use change and forestry
MCS	mandatory climate standards
MEL	monitoring, evaluation and learning
MFF	Multiannual Financial Framework
MFN	most favoured nation
Mha	million hectares
MRV	monitoring, reporting and verification
NRPF	National and Regional Partnerships Fund
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity
R&D	research and development
SCF	Social Climate Fund
SSP	shared socioeconomic pathway
TFEU	Treaty on the Functioning of the European Union
TRQ	tariff rate quota
TYFA	Ten Years for Agroecology
UAA	utilised agricultural area
VAT	value added tax
WAM	with additional measures
WEM	with existing measures
WTO	World Trade Organization

EU Member States and country codes:

Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES) and Sweden (SE).

Glossary

Acute climate-related impacts	Impacts from sudden-onset, short-duration climate-related events such as floods, storms, or heatwaves that cause immediate damage or disruption.
Advisory Board	The European Scientific Advisory Board on Climate Change.
Agrivoltaics	The co-location of agricultural production and solar photovoltaic energy generation on the same land, typically through elevated or spaced solar panels that allow crops to grow beneath or between them, or through integration with livestock grazing.
Agri-food system	The entire range of actors, activities, and processes involved in producing, processing, distributing, and consuming food and the processing of food waste, including inputs and outputs at each stage.
Agricultural livelihoods	The means by which farming households secure their basic needs, sustenance and wellbeing, primarily through crop production, livestock rearing and related agricultural activities.
Build back better	The use of the recovery, rehabilitation and reconstruction phases after a disaster to increase resilience through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalisation of livelihoods, economies and the environment. Associated emerging concepts are 'build back different' and 'build back elsewhere' to highlight the opportunity for transformational approaches in a post-disaster setting.
Carbon farming	Agricultural practices and land management strategies designed to sequester atmospheric carbon dioxide in soil and vegetation.
Carbon leakage	The increase in emissions in one jurisdiction resulting from emission reduction policies in another, typically through relocation of production or shifts in trade patterns.
Carbon dioxide removals	The anthropogenic withdrawal of carbon dioxide from the atmosphere and its durable storage in geological, terrestrial or ocean reservoirs, or in products.
Carbon sequestration	The process of storing carbon in a carbon pool.

Catastrophic risks	Risks of large-scale, pervasive, or irreversible damages, including systemic failures that cascade across interconnected systems.
Climate(-related) hazards	A climate hazard is a climate condition with the potential to harm natural systems, people or society. Examples include heatwaves, droughts, heavy precipitation events and sea level rise. Climate-related hazards include both direct climate hazards and secondary cascading or compounding hazards triggered or worsened by climate hazards, such as wildfires, pest and diseases. These can be either rapid-onset hazards such as floods, heatwaves and storms, or slow-onset such as soil erosion, desertification and sea level rise.
Climate-harmful subsidies	Government financial support or tax advantages that encourage activities leading to increased GHG emissions or reduced climate resilience.
Climate-proofing	In EU law, it refers to a process that integrates climate change mitigation and adaptation measures into the development of infrastructure projects. In the context of this report, it refers to the process of ensuring sufficient adaptation to current and future climate risks and an adequate contribution to the EU's overall objectives on climate mitigation.
Climate resilience	The capacity of social, economic and environmental systems to cope with climate-related hazards, responding or reorganising in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation. As a policy goal, it often implies both the result of and capacity for adaptation.
Climate(-related) risks	The potential for adverse consequences for human or ecological systems, resulting from the interaction of vulnerability, exposure, and hazard (which can be direct, cascading or compounding, see 'climate(-related) hazards'). In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change (see 'maladaptation').
Coupled payments	Agricultural subsidies directly linked to the production levels of specific commodities.

CRCF framework	The set of rules for the certification of carbon removals and carbon farming credits, as developed under the Carbon Removals and Carbon Farming Regulation (Regulation (EU) 2024/3012) and its delegated acts.
Decoupled payments	Agricultural support payments that are not linked to production levels. In the EU, such payments are provided per hectare of agricultural land instead.
Ecosystem services	Ecological processes or functions having monetary or non-monetary value to individuals or society at large, including provisioning, regulating, cultural, and supporting services.
Fair and just transition	A framework ensuring that the shift to a sustainable economy is socially equitable, leaving no workers, communities or regions behind while addressing historical inequities.
Food environments	The physical, economic, cognitive and sociocultural contexts in which consumers engage with the food system, influencing food choices and nutrition outcomes.
Food waste	Food intended for human consumption that is discarded, lost, degraded or consumed by pests at any stage of the food supply chain.
Healthy, climate-friendly diets	Dietary patterns that simultaneously promote human health outcomes and reduce the climate footprint of food consumption, typically by increasing the intake of healthy, plant-based foods and reducing the intake of unhealthy foods and greenhouse gas-intensive animal-based foods.
Incremental adaptation	Adaptation that maintains the essence and integrity of a system or process at a given scale. Incremental adaptations to changes in climate are understood as extensions of actions and behaviours that already reduce the losses or enhance the benefits of natural variations in rapid onset climate-related hazards.
Land-based carbon sinks	Terrestrial ecosystems that absorb more carbon dioxide from the atmosphere than they release, primarily through photosynthesis in forests, soils and wetlands.
Limited transition capacity	Constraints on the ability of individuals, organisations or systems to adapt to changing conditions due to insufficient resources, knowledge or institutional support.

Limits to adaptation	The point at which an actor's objectives (or system needs) cannot be secured from intolerable risks through adaptive actions. This can refer to hard limits – no adaptation options exist – and soft limits – options may exist but are currently not available due to e.g. institutional, financial, social and cultural barriers.
Maladaptation	Actions that may lead to increased risk of adverse climate-related outcomes, including via increased GHG emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence.
Monitoring, reporting and verification (MRV)	A systematic process for quantifying emissions or removals, documenting results and independently checking their accuracy to ensure transparency and accountability.
Most GHG-intensive and/or least climate-resilient production systems with limited transition capacity	Production systems with high-emissions per unit of production and/or high vulnerability to climate impacts, where feasible transition options are either unavailable or constrained by significant financial or non-financial barriers.
Polluter pays principle	An environmental policy principle stating that those who produce pollution (e.g. farmers) or in other ways benefit from it (e.g. retailers or consumers) should bear the financial burden of the environmental damage.
Proactive adaptation	Anticipatory measures taken before climate impacts occur to reduce vulnerability and build adaptive capacity, rather than responding after damage occurs.
Removal technologies	Engineered systems and processes designed to capture carbon dioxide directly from the atmosphere or enhance natural carbon sequestration processes.
Transformational adaptation	Adaptation that changes the fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts.
Unavoidable climate impacts	Climate change effects that will occur regardless of mitigation efforts due to past emissions and committed warming, requiring adaptation responses.

Consulted organisations and experts

In support of its work, the Advisory Board asked Ecologic Institute to organise and moderate three workshops with senior experts to gather input for specific topics covered in this report. The workshop topics, dates and list of external participants, including their respective affiliations, are provided below.

- **Expert workshop on spill-over effects from climate policies in the agri-food sector (27-09-2024).** Jonathan Gardiner, Aaron Scheid and Benjamin Görlach (Ecologic Institute); Julio Fournier Gabela (German Emissions Trading Authority); Michael Jakob (Climate Transition Economics); Christopher Leisinger (Potsdam Institute for Climate Impact Research); Alan Matthews (Trinity College Dublin); Ida Nordin (Agrifood Economics Centre & Swedish University of Agricultural Sciences); Margarethe Scheffler (Öko-Institut); Alisa Spiegel and Davit Stepanyan (Thuenen Institute).
- **Expert workshop on reform options for the common agricultural policy (7-11-2024).** Karin Attström (Ramboll); David Baldock (Institute for European Environmental Policy); Stefano Ciliberti (University of Perugia); Ana Frelih Larsen (Slovenian Ministry of Agriculture Forestry and Food); Simone Højte and Anna Johansen (Concito); Alan Matthews (Trinity College Dublin); Jaroslav Pražan (Institute of Agricultural Economics and Information); Andy Reisinger (consultant); Artur Runge-Metzger (Mercator Research Institute on Global Commons and Climate Change); Aaron Scheid (Ecologic Institute).
- **Expert workshop on policy options for an emissions trading scheme (8-11-2024).** Karin Attström (Ramboll); Julia Bognar (Institute for European Environmental Policy); Frank Convery (University College Dublin); Johannes Flatz (Concito); Julio Fournier Gabela (German Emissions Trading Authority); Hugh McDonald, Aaron Scheid and Benjamin Görlach (Ecologic Institute); Michael Jakob (Climate Transition Economics); Hermann Lotze-Campen and Christopher Leisinger (Potsdam Institute for Climate Impact Research); Jaroslav Pražan (Institute of Agricultural Economics and Information); Andy Reisinger (consultant); Artur Runge-Metzger (Mercator Research Institute on Global Commons and Climate Change).

In addition, the Advisory Board consulted the following experts and organisations during the analysis (in alphabetical order).

- Agora Agriculture
- Animal Task Force
- Climate Change Advisory Council of Ireland
- Concito
- Copa Cogeca
- Dr. Guy Pe'er (Helmholtz-Centre for Environmental Research)
- Dr. Jeroen Candel (Wageningen University)
- Dr. Sabine Wichman (University of Greifswald, partner in the Greifswald Mire Centre)
- Dutch Ministry of Economic Affairs and Climate Policy
- Dutch Scientific Climate Council ('Wetenschappelijke Klimaat Raad')
- European Federation of Food, Agriculture and Tourism Trade Unions
- Eurogroup for Animals
- European Commission – Directorate-General for Agriculture and Rural Development
- European Commission – Directorate-General for Climate Action
- European Environmental Bureau

- Food Policy Coalition
- FoodDrinkEurope
- Green Transition Denmark
- IDDRI
- IFOAM Organics Europe
- Institute for European Environmental Policy
- IPES-FOOD
- Irish Climate Change Advisory Council
- Nuseed
- Prof. Alan Matthews (Trinity College Dublin)
- Prof. Bente Halkier (University of Copenhagen)
- Swedish Climate Policy Council

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