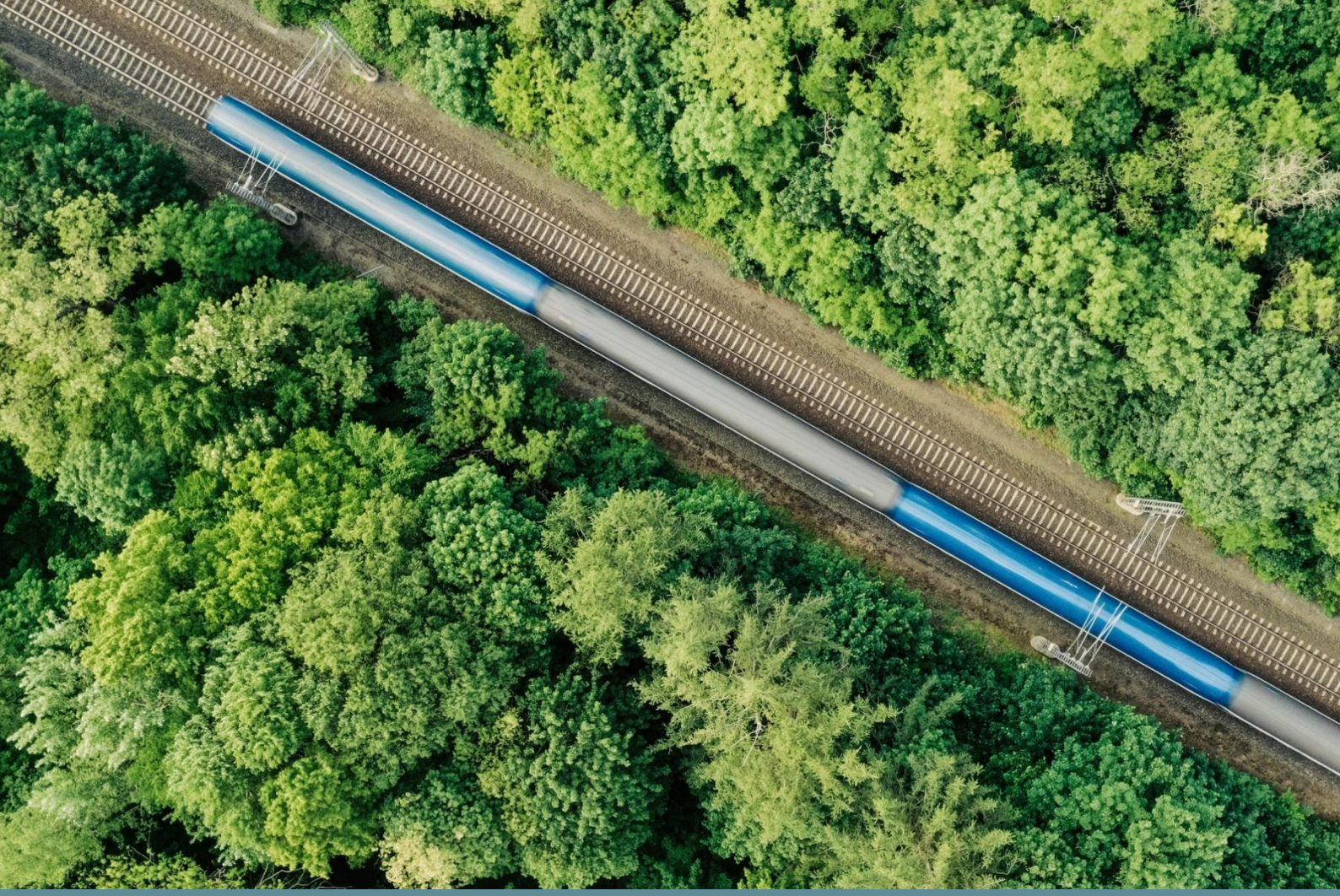


Towards EU climate neutrality

Progress, policy gaps and opportunities

Chapter 8: Agriculture

Assessment Report 2024

European Scientific Advisory Board on Climate Change

Contents

8 Agriculture

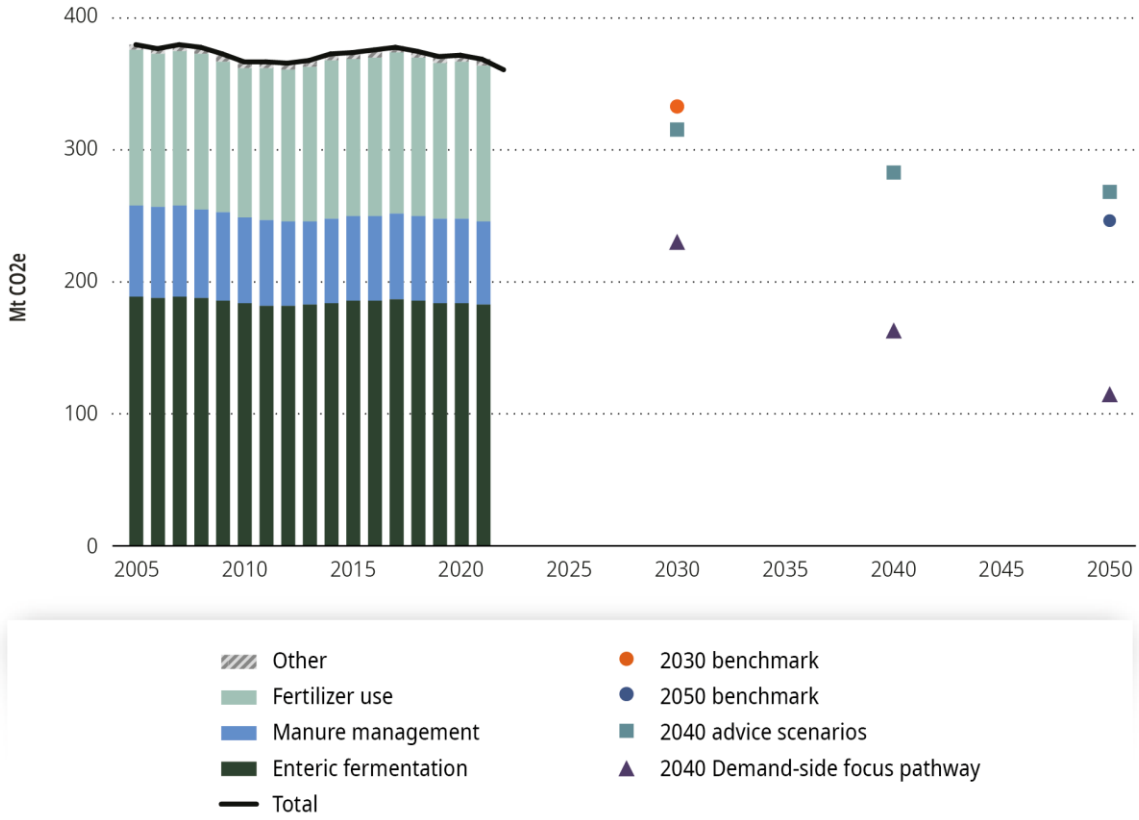
This chapter covers non-CO_2 greenhouse emissions associated with the production of crops and livestock, and the relationship of these emissions with the food system. Some aspects of agriculture are dealt with in Chapters 9 and 10. Chapter 9 'Land use, land use change and forestry' covers emissions, removals and storage of GHGs on land, including in forests and agricultural soils. Chapter 10 'Pricing emissions and rewarding removals' contains a dedicated section discussing how emissions and removals from agriculture and land use can be incorporated into an emission-pricing regime.

Key messages

Emissions from agriculture have remained largely unchanged since 2005, and reductions are needed to align with the EU's climate objectives.

Today, non-CO_2 emissions from agriculture account for 11 % of the EU's total net GHG emissions ([1]). They have remained largely unchanged since 2005. Although the sector is regarded as having lower mitigation potential than other parts of the economy, emission reductions can be achieved and are identified in pathways consistent with EU and global climate goals. EU-level pathways examined by the European Commission and by the Advisory Board suggest that a reduction of around 30 % below 2005 levels by 2050 could be achieved largely through supply-side measures identified in the literature, and around 60 % in the most ambitious pathways featuring additional demand-side action.

Figure 54 Indicator A1 – overall progress in reduction of agricultural non-CO_2 emissions



Source and Notes: See Figure 56 for detailed sources and notes.

([1]) This excludes emissions from energy use in agriculture, which are covered in other chapters. CO_2 emissions from agriculture (apart from its energy use) are minor (2–3 % of the sector's GHG emissions).

Ambitious climate targets, and the policies and incentives for achieving them, should be at the heart of the EU's CAP.

Needs. GHG emissions from agriculture need to be reduced to a level consistent with the EU's climate neutrality objective. The EU and Member States therefore need to adopt and implement policies and incentives consistent with this level of ambition.

Gaps. Within the CAP, the aim of contributing to climate change mitigation is largely qualitative and forms part of a broader set of agri-environmental objectives (also covering adaptation, soil and biodiversity preservation, and animal welfare) **(ambition gap)**. The CAP's climate and environment aims are pursued by Member States in their CAP Strategic Plans (CSPs), where the emphasis given to climate change mitigation is largely discretionary and difficult to quantify *ex ante* **(ambition gap)**. Although the 2023–2027 CAP includes some mandatory good practices (conditionality), the CAP still provides direct support to emission-intensive agricultural practices such as livestock production rather than focusing financial support on the transition to less emission-intensive activities **(policy inconsistency)**. Emissions from agriculture are also not covered by a GHG emission-pricing regime **(policy gap)**.

Recommendation A1. The CAP should be reformed to include standalone emission reduction objectives in addition to obligations to pursue other environmental and sustainability objectives.

— The CAP should move towards mandatory good practices with greater clarity about their mitigation outcomes. Land management rules (both statutory management requirements and conditionality under the CAP) and criteria for eco-schemes should be strengthened and defined more concretely to ensure that they are more closely related to positive environmental outcomes and that their mitigation impact can be estimated quantitatively.
— The EU should shift CAP support away from emission-intensive agricultural practices, including livestock production, and towards lower-emitting products, environmental services and economic diversification (see Chapter 11 'Whole-of-society approach'). In parallel, the EU should strengthen measures to encourage healthier, more plant-based diets, and develop a framework for just transition to an agricultural sector consistent with the climate neutrality objective.

Recommendation A2. A system for estimating and pricing agricultural emissions targeting the source should be introduced, complemented by policies that seek to ensure that more sustainable, healthier food choices are available to consumers at all income levels. This could be activity-based (rewarding specific activities) or results-based (such as a cap-and-trade system based on verified emission estimates). Their socioeconomic impact of emissions pricing – in particular on small farms and farms in vulnerable regions – should be assessed *ex ante,* and potentially adverse economic, social and environmental impacts should be addressed to ensure a just and fair transition. See also next recommendation, on sustainable food systems, and Chapter 10 'Pricing emissions and rewarding removals'.

EU policies on agriculture and biofuels should also better reflect the need to maintain and expand the area of forests and wetlands for carbon sequestration purposes (see Chapter 9 'Land use, land use change and forestry').

The Farm to Fork Strategy should be translated into concrete policies for delivering a sustainable food system, reducing food waste and encouraging healthy, plant-based diets.

Needs. From a strictly climate mitigation perspective, reductions in the production and consumption of GHG-intensive agricultural products (especially livestock products) need to go hand in hand, otherwise emission reduction efforts risk being offset by increased imports (displacing emissions to other countries) or exports (maintaining EU emissions in spite of consumption changes).

From a broader perspective, there is a need to shift towards healthier diets, reducing the over-consumption of animal products and increasing the consumption of plant products, since these are associated with lower emissions. Ensuring sustainable production and consumption of food – as well as reduced food waste – also requires further action in the middle part of the agri-food value chain (food processing, distribution and retail companies), given its influence on food product availability, accessibility and affordability, marketing strategies and information provision.

Gaps. The overarching framework for climate action in the food system is the Farm to Fork Strategy, published in 2020. At the time of writing, however, the European Commission has not made a proposal on some of its key initiatives (such as the legislative framework for a sustainable food system, and rules on labelling and sustainable public procurement of food). In other cases, proposed legislation has not yet been adopted by policymakers (such as targets on food waste reduction) **(policy gap)**. The Farm to Fork Strategy has been criticised for lacking quantified objectives (and delivery mechanisms for achieving the objectives that it has) and for its reliance on monitoring and labelling requirements and information provision measures. This represents an **ambition gap** (and a **policy gap**, since, at the time of writing, the European Commission has not yet released its proposal on some of the topics announced in the strategy). Other **ambition gaps** identified in food system governance include the expected low impact of the EU Code of Conduct on Responsible Food Business and Marketing Practices, the food waste reduction targets of the Waste Framework Directive revision proposal (which falls short of the 50 % reduction target of the Farm to Fork Strategy) and the revised Industrial Emissions Directive, which postpones stronger controls on emissions from intensive livestock production to 2030 at the earliest.

Recommendation A3. Policies should encourage and incentivise the sale and marketing of, and access to, healthier, more plant-based foods, the reduction of food waste and a sustainable food culture.

- In the middle of the food chain, EU-level food policy should go beyond voluntary codes of conduct and explore binding regulations and incentives to improve the sector's climate performance (for example on food waste) and empower consumers to make more sustainable choices (for example through regulation of labelling and marketing).
- Additional policies should be considered to encourage and improve access to more sustainable, healthier diets, paying particular attention to the influence of the social environment on food choices. Action on sustainable public procurement of food is an example of this. Other opportunities should be identified.

Needs. Reducing agricultural emissions implies shifting away from bioenergy for uses that can be decarbonised by other means (see Chapter 6 'Transport').

Gaps. Continued promotion of first-generation biofuels in EU energy policy also represents a **policy inconsistency** in applications where electrification offers a lower-emitting route to decarbonisation.

Recommendation A4. Future revision of EU energy policies should limit support for biofuels to areas that cannot reasonably be decarbonised by other means.

8.1 Scope and sectoral assessment framework

Scope

This chapter covers all non-energy related emissions from agriculture as reported under the UNFCCC (CRF category 3), primarily CH_4 and N_2O emissions from livestock and N_2O emissions from fertiliser use ([2]).

- Energy-related emissions in the agricultural sector are included in the buildings (space heating), transport (rolling equipment) and industry (food processing) sectors respectively.
- CO_2 emissions and emission removals from agricultural soils and forestry are included in the LULUCF sector.

Greenhouse gas emission reductions required in the agricultural sector to reach climate neutrality

Today, non-CO_2 emissions from agriculture account for 11 % of net EU GHG emissions. There is an overall scientific consensus that the cost-effective mitigation potential in agricultural non-CO_2 emissions is limited compared to the reduction potential of energy-related CO_2 in other sectors, if production and consumption patterns remain unchanged (Fellmann et al., 2021), but also that emission reductions from this sector are an important element of achieving both global and EU climate goals (JRC, 2023c; IPCC, 2022a; Leahy et al., 2020).

Although the European Green Deal does not specify the extent of climate mitigation expected from the agricultural sector, the sector's non-CO_2 emissions are reduced by 30–45 % below 2005 levels by 2050 in scenarios underpinning the European Commission's analysis (EC, 2018e, 2020s). Scenarios assessed in the Advisory Board's recent report on a GHG target for 2040 suggest that a 23–57 % reduction could be achieved by 2040, depending on the extent of demand-side action, including a shift to sustainable, healthy diets ([3]).

The European Commission's scenarios see agricultural emissions remaining essentially flat up to 2030 (– 3 % compared to 2022), JRC analysis has identified supply-side options equivalent to a 20 % reduction ([4]) (Pérez Dominguez et al., 2020) and the Advisory Board's 2040 analysis suggests a reduction of at least 10 % below the 2022 level could be achieved by 2030.

Climate change impacts might undermine the capacity of the agricultural sector to deliver on all these different objectives, and therefore the sector will also have to enhance its resilience against these impacts.

Assessment framework for the agriculture sector

Outcomes. Achieving the mitigation contribution described above requires some combination of the following two outcomes.

- **Reduced production and demand for GHG-intensive agricultural products.** Reducing production of the most GHG-intensive products will lower EU GHG emissions, while lower

([2]) In CRF category 3 (which excludes energy-related emissions in agriculture), CO_2 emissions typically account for 2–3 % of total GHG emissions.

([3]) This refers to emission reductions compared to 2015 at 'R10' geographical wider Europe ('R10') geographical resolution (all of Europe). The range encompasses the pathways underpinning the Advisory Board's 90-95% recommendation (23%-26%) as well as the reductions achievable in Demand-side focus pathway which has a greater focus on healthy & sustainable diets (-57%)

([4]) Figures 17 and 21 of Pérez Dominguez et al. (2020) identify approximately 75 Mt CO_2e of mitigation at the EU-27 level though measures such as feed additives, anaerobic digestion, winter cover crops and fallowing histosols.

consumption will reduce the market for them (as well as bringing health benefits in general). The two must go hand in hand to ensure that climate policy objectives are not counteracted by international trade. The issue of emission leakage (the movement of activity and emissions to locations with laxer climate regulation) is discussed in Chapter 10 'Pricing emissions and rewarding removals'.

— **Lower GHG-intensity of agricultural production in the EU.** This would deliver additional emission reductions.

Levers. To achieve these outcomes, five main levers were identified based on the agriculture, forestry and other land use chapter of IPCC AR6 (contribution of Working Group III) (IPCC, 2022a) ([5]).

— **Low-emission livestock production.** CH_4 emissions can be reduced by measures to reduce emissions from enteric fermentation (the digestion process of ruminant livestock such as cattle) and by improved manure management.
— **Low-emission crop production.** This would reduce N_2O emissions from fertiliser use (and CH_4 emissions from rice cultivation).
— **Reduced livestock production** and **sustainable and healthy diets.** These would reduce EU GHG emissions both directly (reduced livestock emissions) and indirectly (reduced demand and production of feed crops), provided that reduced meat and dairy demand and reduced livestock production happen simultaneously in the EU.
— **Reduced food waste.** This would also reduce EU emissions provided that reduced demand leads to reduced domestic production.
— **Minimise demand for biofuel crops.** According to the IPCC, it is not possible to precisely determine the scale of bioenergy (and BECCS) deployment at which negative impacts outweigh benefits, given the multiple interactions with food, land and energy systems. Minimising demand for biofuel crops is therefore included since this determines overall demand for (and therefore production of) agricultural crop production.

Enablers. In addition, eight enablers were identified that would facilitate the five levers described above.

— **Price signals and incentives** can support all the abovementioned levers, both on the demand side and on the supply side.
— **Information provision and education** can help consumers to reduce food waste and make informed food choices, which can contribute to more sustainable and healthy diets. However, they are insufficient on their own and need to be combined with other, more stringent types of policies.
— Cultural and social values might hinder the adoption of more sustainable diets and or more GHG-efficient agricultural practices. Therefore, it is necessary to promote **supportive social and cultural values** to enable the transition, for example by highlighting the various co-benefits (such as the health benefits of more sustainable diets), by working with the social context in which food is produced and consumed.
— Adequate access to **finance** combined with GHG-pricing incentives can enable an acceleration of the uptake of sustainable agricultural practices. While some mitigation measures in the agricultural sector relate to changes in management practices and can be implemented without large

([5]) Relevant topic headings in the IPCC chapter's agriculture and food sections (7.4.3–7.4.5) include the phrases 'soil carbon management', 'enteric fermentation', 'crop nutrient management', 'manure management', 'bioenergy and BECCS', 'sustainable healthy diets' and 'reduce food loss and waste'.

investments ([6]), others require considerable upfront investments. Rates of adopting these measures could be slow without available finance, even if price signals are implemented.

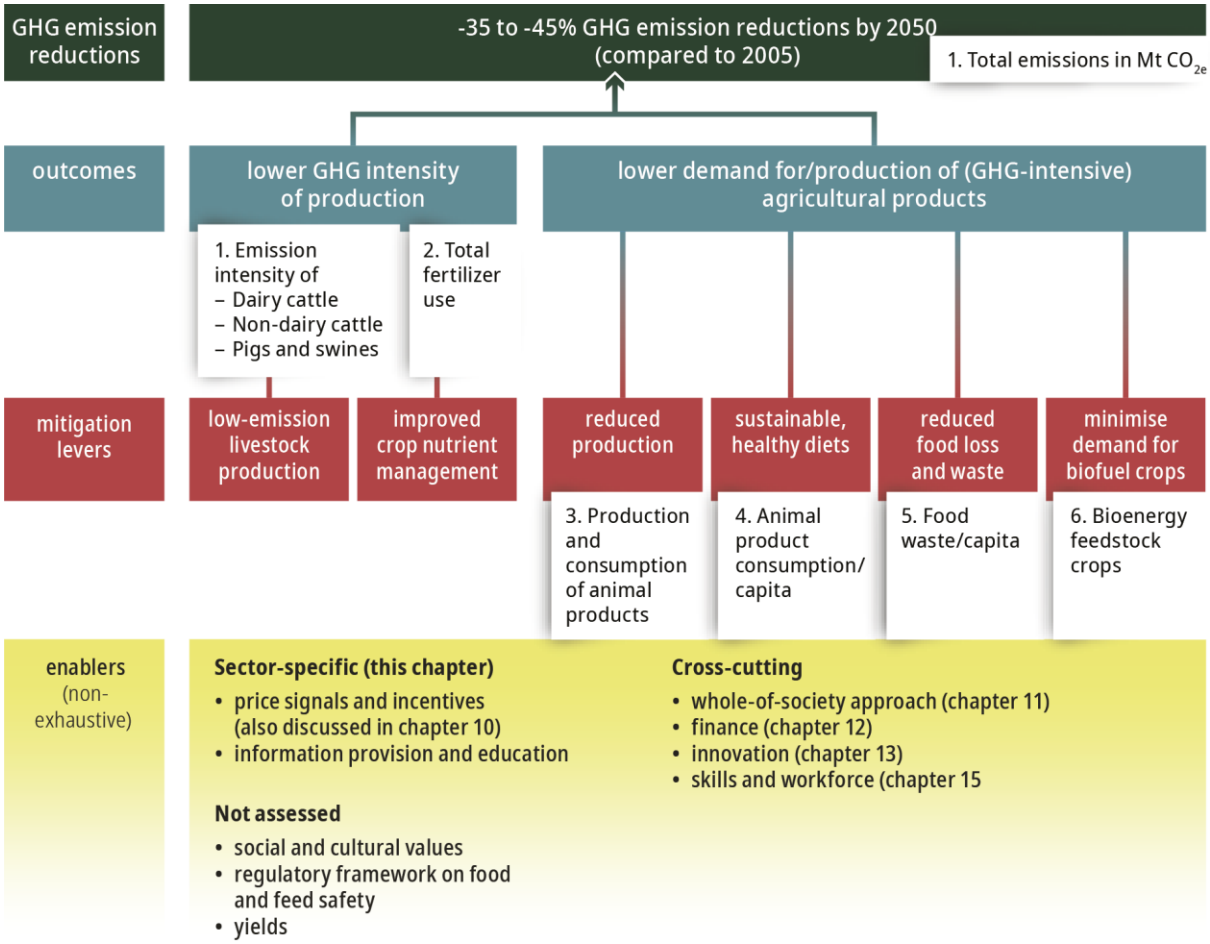
— European farmers, farm advisory agents and other professionals providing services to farmers (e.g. vets, or feed and fertiliser suppliers) need to be equipped with the required **skills and know-how** to implement different mitigation practices in an effective and efficient way, and need to be supported by industries.
— Some options for reducing GHG emissions require additional RD & D and **innovation**, especially in order to become affordable and deployable at scale. The IPCC gives several examples including ongoing innovations in crop breeding (e.g. through gene-editing technologies), feed additives and genomic selection to reduce enteric CH_4 in livestock, and further developments in precision agriculture (the use of sensors and satellites to improve crop yields, animal production and manage inputs more effectively) and remote sensing (IPCC, 2022a).
— The **regulatory framework on food and feed safety** needs to be aligned with the ambitions to reduce food losses and food waste and to enable novel, low-GHG-emission food and feed types (e.g. insect-based protein) to enter the market, without compromising public health or animal welfare.
— Overall, improved **yields** using the same amount of resources or less at the farm level can reduce overall GHG emissions, but only if they do not lead to higher aggregate production.

The assessment framework for the agriculture sector – including the selected indicators to track progress for this sector (see white boxes) – is shown in Figure 55.

Aside from the mitigation measures summarised in Figure 55, there are a number of climate action and broader environmental measures whose impact on overall GHG emissions is less certain. Organic farming has the potential to reduce emissions directly per unit land due to higher soil carbon sequestration (counted under LULUCF) and lower N_2O emissions from fertiliser use. However, it also leads to lower productivity, which could lead to additional land used for agricultural production if demand remains unchanged (EEA, 2022h; EC, Joint Research Centre et al., 2021; Skinner et al., 2014; Tuomisto et al., 2012). Similarly, evidence about shorter value chains is mixed, and could lead to both decreases and increases in emissions depending on specific circumstances (EEA, 2022h).

([6]) For example, the European Commission Target Plan (Figure 71) estimated that 12 Mt CO_2e of agricultural non-CO_2 emissions could be abated at a cost of up to EUR 5/t, while a further 35 Mt CO_2e could be abated at a cost of up to EUR 100/t (EC, 2020s). More detailed abatement cost curves for European agriculture are estimated by the JRC (JRC, 2020b).

Figure 55 Assessment framework for the agricultural sector



Source: Advisory Board (2024)

8.2 Emission reduction progress

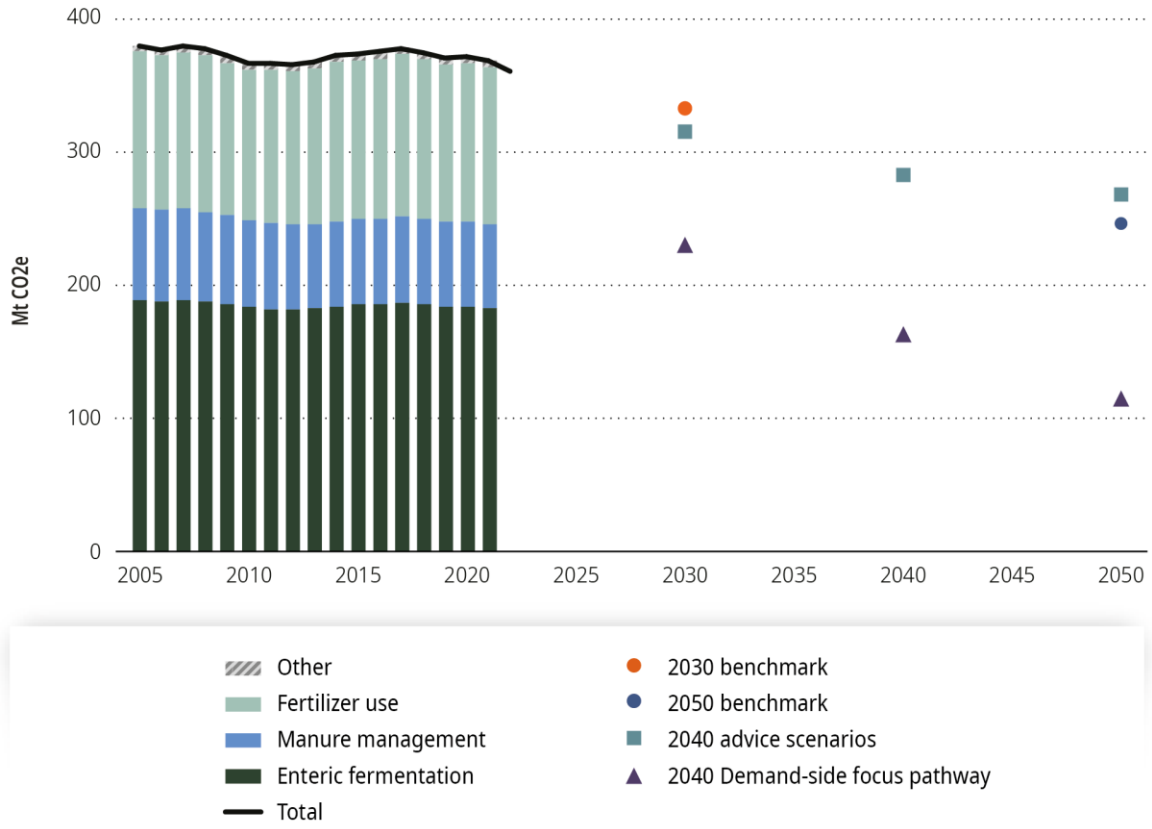
In the 1990s, agricultural non-CO_2 emissions in current EU Member States were considerably higher than today's levels (average 420 Mt CO_2e per year). However, the EU has not achieved consistent annual reductions in agricultural emissions since 2005 (see Figure 56).

Emissions decreased slightly in 2007–2012 but rebounded again until 2017 before starting a new but modest downward trend. By 2022, emissions were 5 % below 2005 levels. In 2005–2022, emissions reduced by on average 1 Mt CO_2e per year. This rate would need to accelerate to on average 3.5 Mt CO_2e per year to put the sector on track towards reaching modest reductions by 2030 that are in line with the European Commission's reduction scenarios. After that, the average pace of emission reductions would need to accelerate further (to 4 Mt CO_2e per year) to reach the 35 % emission reductions (compared with 2005) presented in the European Commission's scenarios underpinning the EU climate objectives.

Scenarios underpinning the 90–95 % recommendation of the Advisory Board reduce emissions more quickly, by 17 % in 2030 and 26 % in 2040 compared with 2005 levels. Greater emission reductions than this (63 % below 2005 levels by 2050) are achieved in the demand-side focus pathway assessed by the Advisory Board, which has a particular focus on healthy and sustainable diets in line with the recommendations of the EAT-Lancet European Commission (Willett et al., 2019).

Direct livestock emissions (excluding emissions related to feed production) account for two thirds of agricultural non-CO_2 emissions, which consist mainly of enteric CH_4 emissions (50 % of total) and CH_4 and N_2O emissions from animal manure (17 % of total) (EEA, 2023f). The other third of total agricultural emissions are N_2O emissions related to fertiliser use on crop- and grasslands, a substantial proportion of which is also related to feeding livestock ([7]). These shares remained relatively stable throughout 2005–2021.

Figure 56 Indicator A1 – overall progress in reduction of agricultural non-CO_2 emissions



Notes: Historic emissions to 2021 from the EU GHG inventory, with 2022 data based on proxy data reported to the EEA. 2030 benchmark based on the MIX scenario underpinning the Fit for 55 package, with 2050 benchmark based on the MIX scenario from the Climate Target Plan impact assessment. 2040 advice refers to average agricultural non-CO_2 emissions in the scenarios which underpin the Advisory Board's 2040 advice. Data for demand-side focus pathway is downscaled from wider Europe (R10 region) resolution to EU27 for comparability. The Advisory Board's 2040 advice describes the demand-side focus pathway in greater detail.

Sources: EU GHG inventory (EEA, 2023f), Fit for 55 MIX scenario (EC, 2021v), Climate Target Plan impact assessment (EC, 2020s) (Figure 19), Advisory Board's 2040 advice (ESABCC, 2023b).

([7]) For example, Guyomard et al. (2021) state that more than 60 % of the EU's agricultural area is used for feeding animals.

8.3 EU food and agriculture policies, and movement towards a whole-system perspective

EU policies affect agricultural emissions mainly through the CAP and the more recent farm to fork Strategy. This section examines each of these and considers the extent to which EU policies constitute a consistent approach to reducing GHG emissions within a broader context of environmental, social and sustainability goals.

Common agricultural policy

The CAP primarily supports food production, incomes and environmental outcomes.

The CAP is the EU's overall agricultural policy. It was established in 1962 and revised most recently in 2021 (covering 2023–2027) (EC, 2023e). Its founding objectives include increasing agricultural productivity, and ensuring fair incomes for the agricultural community and affordable food for consumers (EU, 2016). These objectives are still central to the CAP today, but the scope has gradually broadened to include environmental concerns, and the design of financial support has changed accordingly. It currently represents 35 % of the total EU budget, making it the largest budget item (EEA, 2022h).

The CAP for 2023–2027 requires Member States to set targets, including on climate action, under a new pledge-and-review system.

The CAP regulation for 2023–2027 (EU, 2021d) establishes a pledge-and-review process (often referred to as a performance- and results-based approach) whereby each Member State produces a CSP, sets targets and reports progress (with regular reviews by the European Commission). The regulation also establishes a series of objectives and indicators that Member States are to use, including on climate change mitigation and adaptation. The climate indicators include targeting and monitoring the share of land covered by measures to reduce emissions, store carbon or adapt to climate change, and investments in renewable energy capacity (measured in megawatts). Member States use these indicators to set their own targets and milestones, and must aim to make a 'greater overall contribution' to the achievement of environment and climate objectives than in 2014–2020 (Article 105 of EU (2021d)).

Implementation of the CSPs is subject to an annual review meeting and biennial performance review by the European Commission. If the review reveals a significant shortfall with respect to its milestones or targets, the European Commission may ask it to submit an action plan detailing remedial actions.

The majority of the CAP budget is not dedicated to climate change mitigation per se.

For 2023–2027, the majority of the CAP budget (75 % of pillar I and 65 % of pillar II) will continue to be spent on agricultural activities that do not per se contribute to climate mitigation, although there is some mainstreaming of climate action into the CAP via environmental **conditionality** requirements. These are largely based on the greening criteria of the 2013–2020 CAP but are now mandatory for all beneficiaries of CAP support. They include climate-relevant criteria such as requirements to maintain or protect grassland, wetland, peatland and soil cover.

Reviews such as those by the EEA (2022h) and Pe'er et al. (2022) argue that the CAP, overall, continues to consolidate rather than phase out conventional GHG-intensive farming practices. Even with a switch to area-based payments as the dominant approach (rather than direct payments, which subsidise production volume), the tendency in the EU is to use intensive farming methods to maximise income. The CAP therefore continues to indirectly provide considerable subsidies to food production practices that can result in high GHG emissions. In addition, the revised CAP will continue to subsidise the livestock

sector, including through coupled support ([8]), which is a direct subsidy for GHG-intensive food products and undermines the goal of having food products reflect their true costs.

Dedicated green spending accounts for a growing proportion of the budget.

Although it does not account for the majority of spending, the green share of the CAP has increased over time. During 2014–2020, over a quarter of the CAP budget was assigned to climate change mitigation and adaptation, and consequently representing half of the EU's total climate spending (ECA, 2021). For 2023–2027, 40 % of the CAP budget is 'expected' to contribute to the achievement of climate-related objectives (recital 94 of EU (2021d)). The climate share of the budget will be tracked by the European Commission, with progress towards the indicative 40 % climate-mainstreaming target encouraged through annual review meetings and biennial performance reviews between the European Commission and Member States (EC, 2022g; EU, 2021d).

The CAP's 'green architecture' consists of mandatory environmental criteria and voluntary incentives.

Measures under the CAP that promote climate action and environmental protection are referred to as its green architecture. According to Guyomard et al. (2023), this consists of three main elements.

— Conditionality requirements are mandatory for all CAP beneficiaries.
— Eco-schemes and agri-environment climate measures are additional support that farmers can receive in exchange for implementing additional sustainability practices. Eco-schemes must represent at least 25 % of pillar I budget allocations (direct income support) over 2023–2027, and agri-environment climate measures must represent at least 35 % of pillar II (rural development funding).

There are considerable concerns regarding the likelihood that the green architecture will deliver additional climate action.

Although the CAP's green architecture provides significant opportunities for Member States to address both climate and biodiversity challenges, its delivery mechanism is primarily based on voluntary efforts. Independent assessments indicate that these are unlikely to be effective for the reasons given below.

The conditionality requirements consist mainly of broadly defined principles, which allow a high degree of flexibility for Member States, including broad exemptions (Guyomard et al., 2023; Matthews, 2021; Pe'er et al., 2022). Furthermore, ensuring compliance with these requirements, in terms of both monitoring and enforcement, remains a weak point (Pe'er et al., 2019). Guyomard et al. (2023) argue that the ambition of these measures cannot be truly appreciated without knowing about the implementation choices made by Member States. For example, Ecorys et al. (2023) point out that it is difficult to estimate the carbon sequestration effect of the requirement to maintain permanent grassland, since the definition of this term varies between Member States.

Similarly, the possible eco-schemes are defined in general terms in EU legislation, leaving their elaboration up to Member States. As a result, they risk funding (or continuing to fund) measures with very limited added value from an environmental perspective, which would de facto make them additional income support mechanisms under the guise of being environmental schemes (Matthews, 2021; Pe'er et al., 2022). Scientists have therefore made specific recommendations about developing eco-schemes, including avoiding support for practices that can be harmful to one of the environmental objectives of

([8]) 'Coupled support' refers to support payments to farmers that are linked to the level of production.

the CAP, and focusing the bulk of the budget on measures with high added (environmental) value on multiple dimensions (climate, biodiversity, etc.) (Pe'er et al., 2022).

The governance of the CAP allows Member States a great deal of flexibility. This arrangement provides opportunities for Member States to take climate action, but little incentive to be ambitious. An approach incorporating national flexibility can be advantageous, given the heterogeneous character of the agricultural sector and national geographies, but only if that flexibility does not come at the expense of ambition. The new CAP regulation requires Member States to set targets to achieve its specific objectives (which include climate action) but does not specify the ambition level of these targets (other than the requirement that they be more ambitious than in the past). Therefore, Member States arguably have an incentive to keep their ambition levels low in order to avoid having to justify themselves and develop potential remedial action during their performance reviews with the European Commission (Matthews, 2021).

Furthermore, although the European Commission can make recommendations on the CSPs, Member States are not obliged to adhere to them as long as they are in compliance with the broadly defined legal requirements of the CAP. Finally, national CAP budgets are pre-allocated under the MFF, regardless of the ambition levels of their CSPs, which leaves the European Commission with neither carrot nor stick to enhance their environmental ambition levels (Matthews, 2021).

It is also likely that many national administrations will lack the capacity and know-how to develop and implement ambitious CSPs, despite the technical assistance offered by the European Commission (Matthews, 2021; Pe'er et al., 2022).

This lack of incentive is confounded by a lack of quantified objectives that need to be met (as also evidenced by the lack of benchmarks that could be found for this report), and the few quantified objectives put forward by the Farm to Fork Strategy have yet to be endorsed either legally or politically. This means that the European Commission cannot refer to such targets as an argument for more ambition.

As a result, the impact of the new CAP on climate change mitigation is difficult to assess quantitatively, as the European Commission acknowledges in its summary assessment of the final CSPs submitted in 2022 (covering 2023–2027) (EC, 2023bf). In general, this assessment and the detailed mapping analysis underpinning it (Ecorys et al., 2023) are able to identify efforts that should contribute to mitigation, but are not able to estimate outcomes in terms of reduced emissions. For example, they identify efforts to support agroforestry and improve nutrient management, which should increase carbon sequestration or reduce N_2O emissions. Livestock emissions are identified as a priority area in 20 CSPs, but only 12 include a target, leading to an EU average of only 9 % of livestock units being covered by commitments to reduce GHG emissions or ammonia. The ability of the European Commission to reach these kinds of conclusions is in part due to the national recommendations formulated as part of the Farm to Fork Strategy including a request to set 'national reference values' for Green Deal targets such as reducing pesticide use and nutrient loss (Annex I of EC (2020r)). The summary assessment also acknowledges that further work is needed to support quantification of the CSPs' impacts and suggests that this is ongoing as Member States prepare to implement amended CSPs ([9]).

([9]) The European Commission's summary assessment (published 23 November 2023) covers the CSPs submitted and approved up to the end of 2022. However, Member States are required to assess (and potentially amend) their CSPs in light of the ESR and the LULUCF regulation. The summary assessment indicates that 18 amendments had been submitted, and 9 had been adopted by the European Commission, as of 4 October 2023.

Farm to Fork Strategy

The Farm to Fork Strategy is the European Green Deal's overarching strategy for pursuing a sustainable food system (EC, 2020f). Its main aims are to 'reduce the environmental and climate footprint of the EU food system and strengthen its resilience, ensure food security in the face of climate change and biodiversity loss, and lead a global transition towards competitive sustainability from farm to fork and tapping into new opportunities' (EC (2020f), p. 4).

The lack of an overarching strategy for the EU agri-food system had been identified by the scientific community as a major gap in the EU policy mix (EC, Group of Chief Scientific Advisors, 2020; SAPEA, 2020). The scientific community has generally welcomed the Farm to Fork Strategy as an important step in the right direction, while pointing out several shortcomings (EEA, 2022h; König and Araújo-Soares, 2021; Moschitz et al., 2021; Schebesta and Candel, 2020).

The strategy includes six environmental targets, of which the most relevant to lowering GHG emissions from the EU agricultural sector are reducing fertiliser use by 20 % and increasing the share of organic farming to 25 %, both by 2030 (EC, 2020f). As noted earlier in this chapter, while organic farming has the potential to reduce emissions directly per unit of land, it can increase overall land use (and therefore emissions) on account of lower productivity.

The Farm to Fork Strategy also announced 27 initiatives – both legislative and non-legislative – to deliver on its objectives, with mixed results so far in terms of ambition and delivery.

These aims, targets and initiatives reflect previous criticisms concerning the lack of clear and quantified environmental objectives under the CAP (Matthews, 2021). The Farm to Fork Strategy does not have a single delivery mechanism to achieve its objectives. Instead, the European Commission's approach has been to enhance food- and sustainability-related aspects of other initiatives. Some new legislation has been adopted (on the Farm Sustainability Data Network). Some legislation has been proposed by the European Commission but not yet adopted by the Parliament and Council (food waste reduction, corporate governance framework). The European Commission has also taken some non-legislative action (CAP recommendations, a voluntary code of conduct on responsible food business and marketing). However, the European Commission has not yet delivered several proposals announced in the Farm to Fork Strategy, including on sustainable food systems, public procurement, food labelling and regulation of feed additives. The list below details progress on the initiatives most relevant to climate change mitigation.

— The legislative framework for sustainable food systems was due to appear before the end of 2023 but has not been published at time of writing. Its stated aim is to promote policy coherence at the EU and national levels, mainstream sustainability in all food-related policies and strengthen the resilience of food systems. However, although the inception impact assessment recognises many of the challenges and bottlenecks – including the lack of financial incentives, of internalisation of externalities, and of a clear and common objective – there are signals that the upcoming proposal will be limited to a voluntary labelling scheme, and some limited mandatory measures for public procurement practices (EC, 2021t; Euractiv, 2023).
— In agriculture, outputs linked to the strategy include recommendations (featuring a dedicated climate section) to each Member State for consideration when drafting its CAP CSP (EC, 2020r), and the establishment of the Farm Sustainability Data Network to improve the collection of farm-level environmental and social data (Council and Parliament of the EU, 2023a). However, the proposal to revise legislation on feed additives (which could facilitate efforts to reduce livestock CH_4 emissions) has not been tabled at time of writing (European Parliament, 2023c).

— In the middle of the food chain (processing, wholesale, retail, hospitality and food services), a voluntary code of conduct on responsible food business and marketing practices has been produced and signed by a number of companies and associations, accompanied by individual pledges (discussed further in the next subsection) (EC, 2021o). Large companies (including in the food sector) would also be affected by requirements to incorporate climate and sustainability into their corporate strategies under the Directive on corporate sustainability due diligence (political negotiations are ongoing at time of writing (European Parliament, 2023b)).
— Regarding sustainable food consumption, the Farm to Fork Strategy mentions minimum mandatory criteria for sustainable food procurement, and sustainability labelling for food products. The European Commission consulted on both of these issues during 2021 and 2022 (EC, 2021an) but has not made a proposal at the time of writing.
— Regarding reduction of food waste, the European Commission proposed a revision of the Waste Framework Directive that would include a 10 % food waste reduction target in processing and manufacturing, and a 30 % per capita target among retailers, restaurants, food services and households (EC, 2023aq). At time of writing, this is being negotiated at the political level, with the possibility that some targets will be weakened, postponed or narrowed in scope (European Parliament, 2023d).

Towards a whole-system approach

According to the IPCC, a food system approach enables the identification of cross-sectoral mitigation opportunities, including both technological and behavioural options (IPCC, 2022e). Taking a whole-system approach to EU agriculture and food policies would involve exploring options for mitigation by producers, consumers and intermediate links in the food supply chain, and ensuring that a coherent approach is taken to balancing the different environmental, economic and social demands placed on the agricultural sector.

On farming, in addition to the CAP and the Farm to Fork Strategy, emissions from the largest pig and poultry farms are governed under the Industrial Emissions Directive. In November 2023, the European Parliament and Council agreed a revision of this directive that will expand the number of farms covered (Council and Parliament of the EU, 2023b). In its original proposal, the European Commission estimated that a revised directive would reduce CH_4 emissions by 7.4 Mt CO_2e per year ([10]) (equivalent to around 3.2 % of annual agricultural CH_4 emissions) (EC, 2022ae). However, the politically agreed revision is considerably less ambitious than this, since it covers fewer pig and poultry farms and excludes cattle entirely, although it mandates the European Commission to produce an assessment of how best to address CH_4 emissions from cattle by 2026. The functioning of the directive's implementation will be reviewed every 5 years starting in 2028. However, the new rules on animal farming will only start to be applied from 2030.

The middle part of the agri-food value chain (food processing, distribution and retail companies) plays a vital role in the transition given its influence on food product availability, accessibility and affordability, marketing strategies and information provision. Aside from energy-related emissions (which are addressed in other chapters), actors in the middle of the supply chain can reduce emissions directly through improvements in the packaging, conservation and GHG intensity of food, and indirectly through their influence on consumers and producers. An effective policy mix should include targeting those in the middle of the agri-food value chain, through a combination of voluntary measures and

([10]) Conversion from 265 000 t of CH_4 per year using the 100-year global warming potential given in the IPCC Fifth Assessment Report (IPCC, 2013).

more stringent types of policy (carbon pricing and regulations, including on advertising practices, standards and financial incentives) to achieve the necessary scale of change.

While the Farm to Fork Strategy addresses the middle part of the agri-food value chain, it does so primarily through soft policies such as voluntary agreements. However, there is limited scientific evidence to lead one to expect such an approach to have a significant impact on its own. An EEA report on Europe's food system gives the example of the EU Code of Conduct on Responsible Food Business and Marketing Practices (EEA, 2022h). Firstly, the code of conduct has become more general and less concrete than originally envisaged, as illustrated by the deletion of references to avoiding advertising cheap meat. Secondly, it relies completely on self-regulation and voluntary pledges, and signatories have a high degree of choice about to which of the aspirational objectives they want to commit. Despite the high level of subscription to the code (130 signatories in mid 2022, representing a considerable share of the EU market), its overall impact is expected to be low. This is also confirmed by the European Commission's own 2022 mapping report, which concludes that, although the commitments made under the initiative are generally aligned with the Farm to Fork Strategy (and in some cases anticipate EU regulation on deforestation-free supply chains), there is room for improvement concerning their level of ambition and specificity (EC, 2022ag).

Shifting to sustainable food consumption and production is an essential part of climate policy in food and agriculture.

Aside from the multiple benefits of sustainable and healthy diets, several studies have pointed out that a strategy focusing exclusively on supply-side reductions risks being undermined by trade-related leakage effects (e.g. (Henderson and Verma, 2021; Zech and Schneider, 2019)). The importance of sustainable food consumption, including its health and environmental benefits, is recognised in the EU farm to fork Strategy, and in IPCC AR6, which finds that a transition to more plant-based consumption (including more pulses, fruits and vegetables) and reduced consumption of animal-based foods (in particular from ruminant animals) has considerable potential to reduce GHG emissions both directly (reduced enteric and manure-related emissions) and indirectly (reduced land and inputs needed for feed production). In addition, it could enhance public health and bring a range of other environmental co-benefits (biodiversity, reduced air, soil and water pollution). Potential trade-offs relate mainly to the risk of adverse economic and social impacts on the livestock sector, which would need to be well managed to ensure a just transition (IPCC, 2022a). Up to now, EU policies to encourage sustainable diets have focused primarily on information provision and voluntary codes of conduct, but these measures are not sufficient by themselves. Further action of this kind, on food labelling and public procurement, is promised in the Farm to Fork Strategy, although these at time of writing these proposals have not yet been tabled (see subsection 'Farm to Fork Strategy' above).

More ambitious policies to encourage healthy, sustainable diets, such as the introduction of emission pricing, would also have to be managed carefully, taking into account the social environment and economic implications for low-income consumers (see 'Lever: sustainable, healthy diets' below and Chapter 11 'Whole-of-society approach').

However, studies have warned that the farm to fork Strategy's goals of reducing fertiliser use and expanding organic farming risk displacing production and related environmental pressures outside the EU, if not accompanied by reduced demand for the most GHG-intensive products, which can be achieved through more sustainable and healthy diets and reduction of food waste (Bremmer et al., 2021; EC, Joint Research Centre et al., 2021; Matthews, 2021). **Climate change impacts are already affecting crop and livestock productivity in the EU**, and are projected to reduce crop productivity in parts of southern Europe and to improve conditions for growing crops in northern Europe in some years. Furthermore, increased intensity and frequency of extreme weather events are expected to negatively affect

agriculture in the EU overall (EEA, 2019). Reduced productivity risks undermining mitigation ambitions, as it could require increased inputs (including land use) to continue to meet demand, as well as risking maladaptation.

Achieving the ambitions of the European Green Deal will also require a **just transition in the agricultural sector**. Millions of farmers across the EU will need to change their farming practices, and this will require investments and lead to increased costs/reduced income in the short term. On the other hand, it is also recognised that in a broader sense the European Green Deal can improve farmers' incomes and resilience by reducing environmental damage and providing new income streams (e.g. bio-economy feedstocks, payment for carbon sequestration) and reduce costs (resource efficiency and circular economy) (Matthews, 2021; NESC, 2023). As discussed above, the mix of policies that would deliver a Green Deal-based transition in agriculture is not yet agreed. Nevertheless, a report commissioned by the Institute for European Environmental Policy attempts to identify who might benefit in a hypothetical transition, and who might be negatively affected (IEEP, 2021). The report indicates that potential beneficiaries include farmers and businesses able to exploit markets such as products with higher value added (nuts, fruit and vegetables), higher-welfare livestock products, organic products, ecosystem service and carbon sequestration markets, and recreation, amenity and hospitality activities. Those who may be negatively affected include some livestock producers and workers in meat-processing industries, suppliers of agrochemical inputs and producers with high reliance on these inputs, as well as famers unable to take advantage of growing markets or new support schemes.

Given the limited investment capacity and low profitability of many (mainly smaller-scale) farms in the EU, active policies will be needed to ensure the transition to a greener agricultural sector will be fair. In terms of building a policy approach for just transition (in the CAP beyond 2027), the Institute for European Environmental Policy report recommends combining better use of CAP basic payments to support environmental sustainability, development of new income streams and markets for sustainable activities, thorough preparatory work including building capacity and skills in the agricultural sector, and enhanced engagement to identify and address multiple dimensions of fairness (e.g. towards multiple stakeholders along the food supply chain, and those initially disadvantaged in the transition).

This need is not sufficiently reflected in the CAP. Although its latest revision has increased the overall environmental ambitions, its overall budget has remained unchanged in nominal terms, meaning that the additional requirements are not met by additional means (Matthews, 2021). Furthermore, CAP subsidies have been biased towards larger farms by the 'per hectare' basis of direct income support, and the system does not have any dedicated instruments to address potentially uneven social repercussions resulting from a sustainability transition (EEA, 2022h).

The Farm to Fork Strategy is a step forward in this regard, putting the aim of a just transition at the centre of its strategic goals. However, as with other objectives of the strategy, the main shortcoming is the lack of an effective delivery mechanism to achieve this objective (EEA, 2022h).

8.4 Outcome 1: lower greenhouse gas intensity of production

The GHG intensity of EU agriculture has remained largely unchanged over the past 10 years, as measured by GHG emissions per tonne of production in the livestock sector, and by use of nitrogen fertiliser per hectare in crop cultivation (as a proxy for intensity of N_2O emissions).

As discussed above, the reformed CAP for 2023–2027 is expected to consolidate rather than challenge existing high-GHG-intensity production practices, since these continue to be subsidised while the encouragement of more sustainable practices through the green architecture is largely voluntary or at Member State discretion.

Lever: low-emission livestock production

The emission intensity of livestock has remained largely unchanged over the past 10 years. Livestock production can become less emission-intensive through improved manure management and measures to reduce emissions from enteric fermentation.

In the livestock sector, the data shown in Figure 57 indicates an increase in GHG emission intensity for beef of 3 % by 2020, compared with 2010, which has partially offset the 4 % reduction in production levels (leading to an overall emission reduction of 2 %). By 2020, the direct emission intensity was about 15 kg CO_2e/kg product.

The direct emission intensity of dairy products and pig meat fell by 11 % and 6 % respectively over the same period. However, the improvements in GHG emission intensity were offset by increased production, which resulted in a quasi-stabilisation of total GHG emissions.

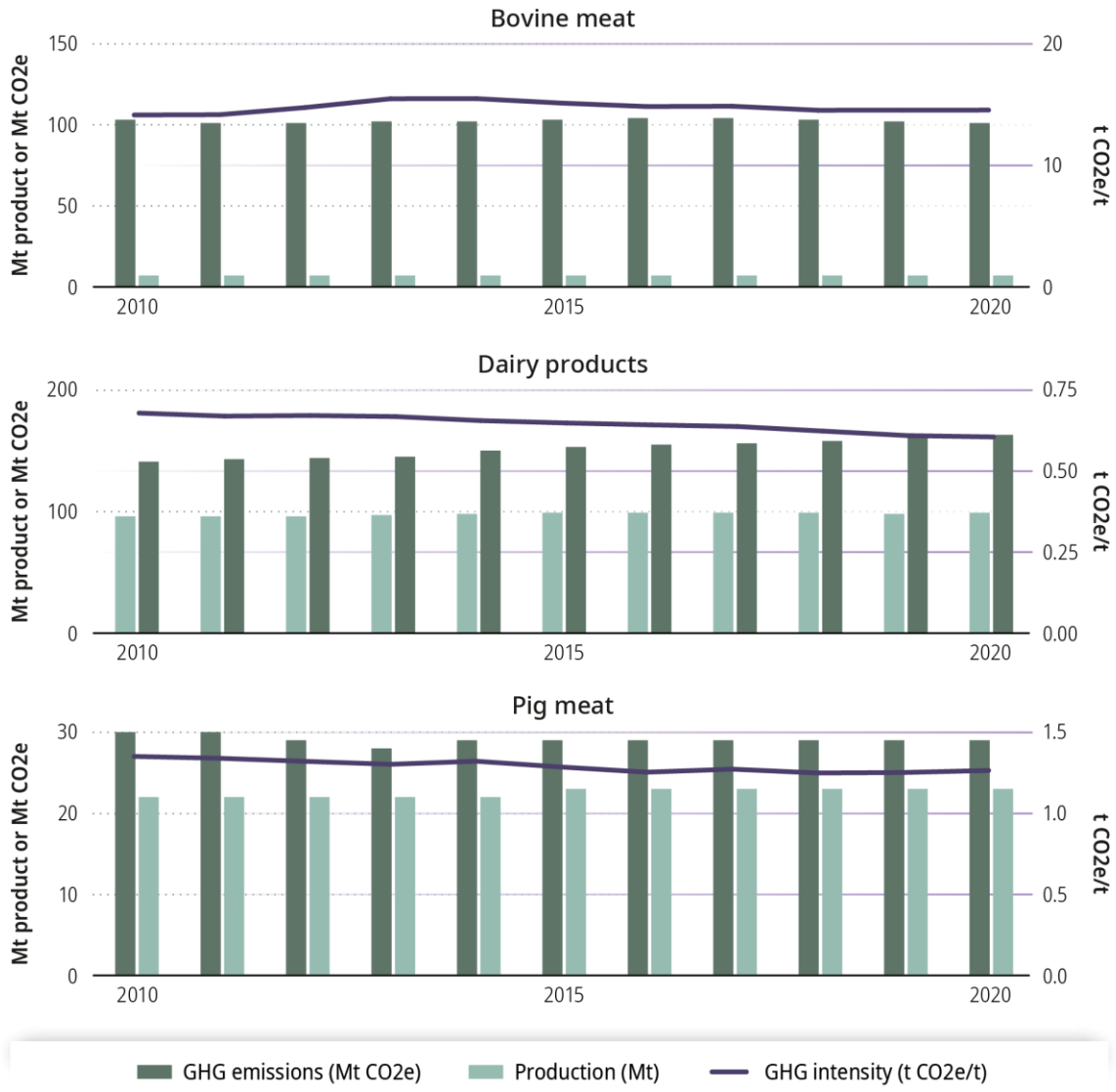
It should be noted, though, that these indicators only cover direct emission intensity and do not take into account indirect emissions from feed production. Feed production can cause considerable GHG emissions due to land use, fertiliser use and transport. JRC data (JRC, 2023) shows that about 50 % of all cereal supply (own production + imports) in the EU is used for feed purposes, indicating that the indirect GHG emissions of feed production constitute a large part of the livestock total GHG impact. For oilseed crops and related products, the share of total supply use for feed is even higher, at 66 %. With 50 % of total oilseed product supply coming from imports, the use of this feed type could be linked to significant indirect emissions – including those due to deforestation – outside the EU.

CH_4 emissions per unit of output can be reduced by focusing on two areas, namely enteric fermentation and manure management, as discussed by Reisinger et al. (2021) and the IPCC (2022a).

Enteric fermentation is a natural part of the digestion process of several species of livestock such as cattle, sheep and goats (ruminant species). The resultant CH_4 emissions account for half of total agricultural GHG emissions in the EU ([11]). A range of options exist to reduce these emissions, including changes to the feeding mix and the addition of feed additives. Other measures that can reduce emissions from both enteric fermentation and manure are optimising herd composition (fewer non-productive animals), improved animal health, livestock breeding and genetics to improve overall efficiency, and precision livestock-farming technologies. It is difficult to give a precise estimate of these measures' mitigation potential, given their inherent differences and varying technological maturity. Nevertheless, Reisinger et al. (2021) estimate potential reductions of 20–50 %, while the IPCC (2022a) reports that the reductions in the literature range from 16 % to 70 % for chemically synthesised CH_4 inhibitors, and also notes the large potential of additives derived from plants and algae. Potential co-benefits include enhanced resilience against climate change impact and higher productivity, whereas potential trade-offs include poor permanence of mitigation, ecological impacts associated with changes in feed mix, and potential toxicity and reduced animal welfare.

([11]) Emissions expressed in terms of CO_2 equivalent using 100-year global warming potential as per EEA (2023f).

Figure 57 Indicator A2 – livestock products: total production and GHG emissions (left axis), and GHG emission intensity (right axis)



Notes: GHG emission intensity calculated as emissions/production.

Sources: EU CRF tables (EEA, 2023h), FAO Food Balances (FAO, 2023)

CH_4 emissions from manure management are the third most important source of EU agricultural emissions (accounting for around 17 %) (EEA, 2023k). Changes in manure management can contribute to reductions in both CH_4 and N_2O emissions. The main reduction options – in addition to those mentioned in the previous paragraph – are switches in manure management systems (e.g. anaerobic digestion and slurry acidification), the application of nitrification and urease inhibitors to stored manure or urine patches, improved manure removal and storage systems, changes in grazing and housing practices, and changes in the feeding mix. Potential co-benefits are renewable energy production (biogas), improvements to the fertiliser potential of manure, additional income streams for farmers, and improved air and water quality from reduced ammonia emissions. Potential trade-offs include increased N_2O emissions from manure application to poorly drained or wet soils, trade-offs between N_2O and ammonia emissions, potential eco-toxicity associated with some measures, and increased incentives to maintain livestock herd numbers.

At the EU-28 level (including the United Kingdom), JRC modelling estimates that 21 Mt CO_2e of mitigation can be achieved at a carbon price of EUR 100/t CO_2e through a combination of anaerobic digestion, low nitrogen feeding, feed additives and vaccination against methanogenic bacteria (Figure 17 of Pérez Dominguez et al. (2020)) ([12]).

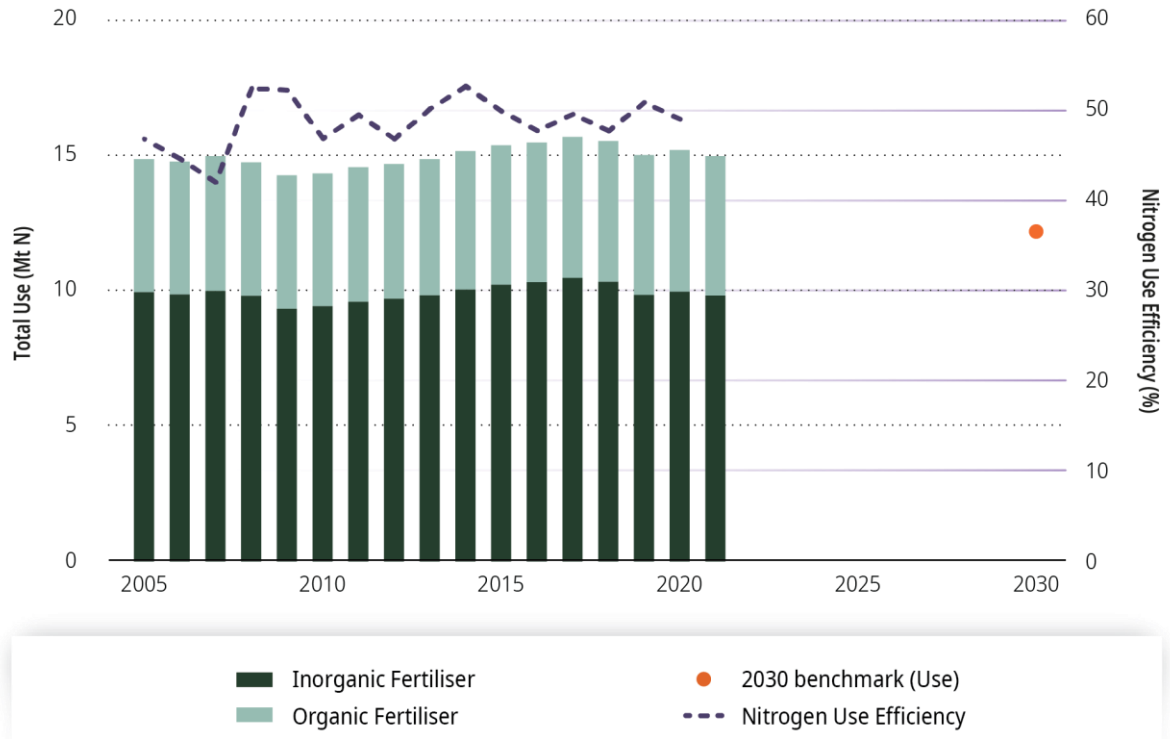
Lever: low-emission crop production

Crop cultivation techniques that use synthetic fertiliser less intensively can reduce emissions as well as enhancing resilience to climate change impacts and improving soil, air and water quality.

N_2O emissions from agricultural soils are the second-highest contributor to GHG emissions from agriculture, accounting for 31 % (EEA, 2023k). In crop cultivation, the use of fertilisers (shown in Figure 58) has been increasing steadily (+ 10 %) between 2009 and 2017. However, since the peak in 2017, fertiliser use has been reducing in absolute volumes (kt N). The efficiency of fertiliser use (measured as the percentage of applied nitrogen that is harvested as crops) varies from year to year but appears to be improving gradually over time.

On average, fertiliser use reduced by 180 kt N per year in 2017–2021. This average rate of decline would need to accelerate by 75 % in absolute value (– 310 kt N per year) in 2022–2030 to achieve the objective of the Farm to Fork Strategy to reduce total fertiliser use by 20 % by 2030 (EC, 2020f). The shares of inorganic and organic fertilisers have remained relatively stable since 2005, at 66 % and 34 % respectively.

Figure 58 Indicator A3 – total fertiliser use (left axis) and nitrogen use efficiency (right axis) in the EU agriculture sector



Notes: 2030 objective based on the European Commission's Farm to Fork Strategy.

Sources: EU CRF tables (EEA, 2023h) (Fertiliser Use), Ludemann et al. (2023) (Nitrogen Use Efficiency), Farm to Fork Strategy (EC, 2020f)

([12]) GHGs in Pérez Dominguez et al. (2020) are expressed using the 100-year global warming potential from the IPCC Fourth Assessment Report (IPCC, 2007a).

Improved crop nutrient management could lower N_2O emissions from fertiliser use in the agricultural sector. At the EU-28 level, JRC modelling estimates that 65 Mt CO_2e of mitigation can be achieved at a carbon price of EUR 100/t CO_2e through measures including fallowing histosols, growing winter cover crops and using nitrogen inhibitors (Pérez Dominguez et al., 2020)[13]. More broadly, options mentioned by the IPCC (2022a) include improved crop rotation practices increasing biological nitrogen fixation by legumes used as main crops (grain legumes, alfalfa) or as cover crops, optimised fertiliser application rates and timing (including precision application technologies), improved manure-spreading machinery, the reduction of inorganic fertiliser use by better utilising the nutrients in organic fertilisers, the application of nitrification and urease inhibitors, and better overall efficiency in crop production (e.g. reduced soil compaction and degradation, optimised irrigation, improved crop health).

Potential co-benefits are emission reductions in other sectors (due to lower mineral fertiliser production and increased carbon sequestration in agricultural soils), improved soil, air and water quality (due to less nitrate leaching, eutrophication and ammonia emissions), and better climate resilience due to increased water-holding capacity of the soil (if soil carbon is increased). In addition to improving biological nitrogen fixation, improved cropping systems with a higher share of grain legumes could also provide plant-based proteins for supporting the shift towards more sustainable diets, or replace soybeans that are imported for feed from non-EU areas undergoing tropical deforestation. Trade-offs relate to the potential reduction in yields in specific circumstances, which could therefore lead to negative impacts from ILUC either within or outside the EU, if the food, feed and bioenergy crop demand is not reduced simultaneously.

8.5 Outcome 2: reduced production and consumption of GHG-intensive agricultural products

While Outcome 1 focused on the intensive margin (reducing the GHG intensity of each product), Outcome 2 focuses on the extensive margin (reducing the production and consumption of GHG-intensive products).

As noted in the subsection 'Towards a whole-system approach' above, production and consumption need to be addressed jointly, otherwise emission reduction efforts risk being offset by increased imports (displacing emissions to other countries) or exports (maintaining EU emissions in spite of consumption changes). Several food and agricultural products are internationally traded commodities. For example, the EU is a net exporter of beef, pig meat, dairy products and cereals.

Lever: reduced livestock production

Agricultural emissions in the EU come predominantly from livestock production (two thirds of emissions) and N_2O emissions associated with growing crops (over half of which are used for feed purposes (JRC, 2023)).

The main contributors to emissions from livestock production are dairy cattle (40 % of total), non-dairy cattle (36 % of total) and pigs (10 % of total) (EEA, 2023h). Over the past 10 years, data on production and consumption of these products (summarised in Figure 59) indicates an increasing production to consumption ratio. The EU is a net exporter of beef, dairy products and pig meat (FAO, 2023), and since 2005 exports of each have grown by more than imports (although both have increased). Slight decreases in consumption of pig meat and beef have therefore not led to a similar reduction in production volumes, and the increase in dairy consumption has been outpaced by dairy production. Overall, increases in

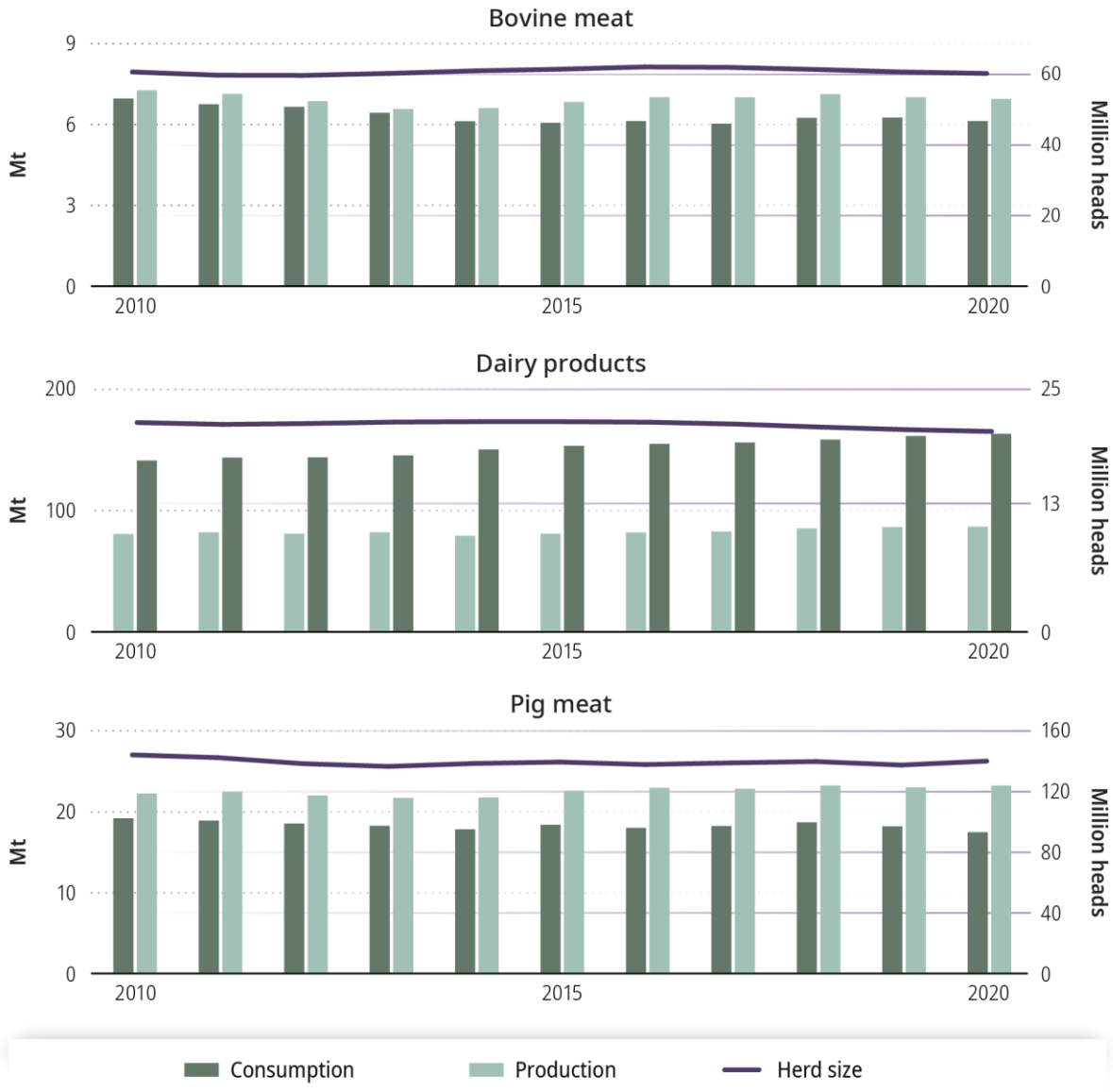
[13] GHGs in Pérez Dominguez et al. (2020) are expressed using the 100-year global warming potential from the IPCC Fourth Assessment Report (IPCC, 2007a).

production have been achieved through improved productivity, with the total herd size declining for dairy cattle and pigs (stable since 2013) and relatively stable for non-dairy cattle.

Total beef consumption decreased in 2010–2020 (by 1 Mt). Production decreased in line with consumption until 2013, but then decoupled from consumption and started to increase again. The herd size fluctuated slightly and was 1 % lower in 2020 than in 2010. The ratio between production and herd size might be explained by a shift towards slaughtering cattle at a later age, which is also supported by the lower ratio of slaughtering to herd size observed in the United Nation's Food and Agriculture Organisation (UN FAO) Corporate Statistical Database (FAOSTAT) data.

The consumption of dairy products increased by 6 Mt between 2010 and 2020 but was outpaced by an increase in production of 22 Mt. Production increases were mainly driven by improved productivity due to genetic selection (larger animals with higher milk production per head), while the total herd size decreased by 1 million head.

Figure 59 Indicator A4 – total production and consumption of livestock products (left axis) and herd sizes (right axis)



Sources: EU CRF tables (EEA, 2023h) (Herd Size), FAO Food Balances (2023) (Consumption & Production)

Despite a reduction in pig meat consumption (by 2 Mt in 2010–2020), production levels increased by 1 Mt. This increase in production was achieved through higher productivity, as the total herd size decreased only slightly in the same period, by 3 %.

To be beneficial for the global climate, lower production of GHG-intensive products will have to be matched by a shift to more sustainable, plant-based diets (addressed in the next section). Such a change should be possible given that agricultural production in the EU is supported by the CAP, which could be reformed to become more ambitious on climate change and provide greater support to low-emission production and environmental stewardship (see subsection 'Common agricultural policy' above).

Lever: sustainable, healthy diets

The health and environmental benefits of sustainable diets are recognised in the EU Farm to Fork Strategy. EU policies to encourage sustainable diets focus primarily on information provision and voluntary codes of conduct, but these measures are not sufficient by themselves.

Despite the heterogeneity of production practices, it is generally true that meat from ruminant animals has the highest GHG emissions (20–50 kg CO_2e per 100 g of protein), followed by other meat and fish (5–8 kg) and dairy (3–11 kg) (Poore and Nemecek (2018), Figure 1) ([14]). For ruminant livestock, a large share of emissions come from CH_4. However, meat (in particular, beef) has higher emissions than other products even when CH_4 emissions are excluded (Ritchie, 2020).

As mentioned above ('Towards a whole-system approach'), shifting to healthier, sustainable, more plant-based diets is important both because of the health and environmental benefits, and because an exclusively supply-side approach risks being undermined by trade-related leakage effects. According to data from the UN FAO shown in Figure 60 ([15]), the average consumption of beef and pig meat per capita has fallen over the last 10 years, although the trend seems to have stagnated and even slightly rebounded in the second half of the period. The observed average reduction in bovine meat consumption in 2016–2020 of 0.01 kcal per person per day would have to accelerate to 0.14 kcal per person (a more than 18-fold increase) to align with a linear trajectory towards the 2050 benchmark. On the positive side, the reduction of pig meat consumption (– 1.3 kcal per person per day on average in 2016–2020) is well on track towards the 2050 benchmark of 0.6 kcal per person per day in 2021–2050.

In contrast to the consumption of meat, the average consumption of dairy products has been increasing in the last 10 years.

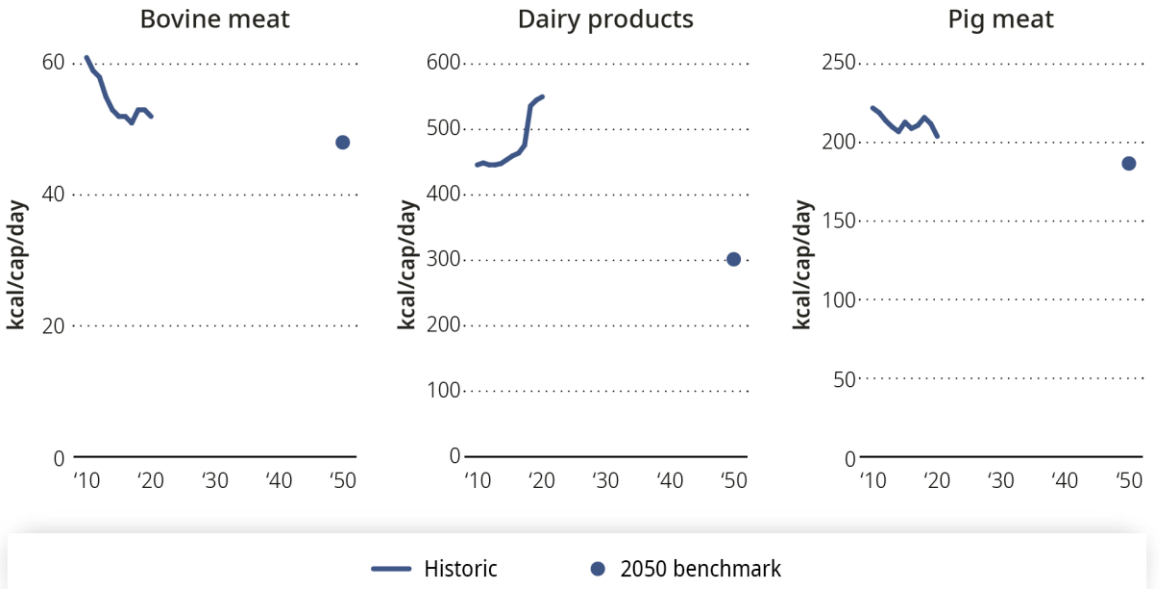
The benchmark used for this assessment is the most ambitious ('diet 5') of five possible diet scenarios included in the in-depth analysis supporting the European Commission's 2018 LTS. This scenario could deliver reductions of around 100 Mt CO_{2e} in 2050, reduces animal-based calorie intake by around a third between 2013 and 2050, and would be consistent with reaching meat consumption in line with recommended diets by 2070 (EC, 2018e). Therefore, even though it is the most ambitious of all the scenarios assessed, it still reaches recommended diets only 20 years after the EU's deadline to achieve climate neutrality. The benchmark should therefore be considered as a strict minimum, and further (and faster) reductions in animal product consumption would be recommended. This would not only contribute to further GHG emission reductions but also be recommendable from a health perspective. For example, the World Cancer Research Fund has issued a recommendation to limit the consumption

([14]) Figures refer to mean values. For dairy, the low value refers to milk and the high value to cheese.

([15]) The UN FAO database provides information on average animal product consumption per capita in different countries and regions, including for the EU-27. This data is based on consumer surveys, and the values are therefore estimates with some degree of uncertainty.

of red meat ([16]) to a maximum of 525–750 g per week to reduce cancer risks (WCRF, forthcoming). This would imply a reduction of 30–50 % compared with the average red meat consumption in the EU-27 of 1.1 kg per person per week in 2020 (FAO, 2023).

Figure 60 Indicator A5 – average animal product consumption



Notes: 2050 benchmarks based on 'Diet 5' from the in-depth analysis accompanying A Clean Planet for All.

Sources: FAO Food Balances (2023) (historic), In-depth analysis accompanying A Clean Planet for All (EC, 2018e) (Figure 76) (benchmark).

Looking at the issue of sustainable and healthy diets more broadly, the European Commission's Farm to Fork Strategy states that current EU food consumption patterns are unsustainable on both health and environmental grounds, citing evidence that 950 000 deaths a year and 16 million lost healthy life-years can be attributed to unhealthy diets. The strategy therefore calls for promoting sustainable food consumption and facilitating the shift to healthy, sustainable diets.

To this end, it proposes empowering consumers to make healthy and sustainable food choices, improving the availability and price of sustainable food and putting in place tax incentives to encourage healthy diets.

One criticism of the Farm to Fork Strategy is that it **remains vague on definitions and lacks quantified objectives for the shift towards sustainable and healthy consumption patterns**. It uses several general concepts such as 'food sustainability', 'sustainable (agri-)food system' and 'sustainable agricultural practices' without being specific about what they mean. This absence of clear definitions can lead to diverging interpretations, lack of a clear and common vision of the desired end goal, and therefore an increased risk of policy inconsistencies. This is evidenced by the EEA's analysis of the consultation responses to the Sustainable food system framework initiative, which found that stakeholders have different understandings of what a sustainable food system would look like (EEA, 2022h). Similarly, the strategy lacks quantified objectives for its demand-side ambitions (with the

([16]) Under World Cancer Research Fund International's interpretation of red meat, this includes beef, pork, lamb, mutton, horse and goat.

exception of reducing food waste by 50 % by 2030) which makes it difficult to track progress and hold policymakers accountable for the delivery of the objective (EEA, 2022h).

Overall, consumer choices are constrained by food product availability, accessibility and affordability, marketing strategies, and psychological (e.g. habits) and sociocultural (e.g. norms) factors. **Pricing policies could be among the most effective tools but are largely absent from the Farm to Fork Strategy.** The advisory bodies' reports found that pricing policies can be effective to steer consumer demand and ensure that food prices reflect their true costs of production and consumption (EEA, 2022h; EC, Group of Chief Scientific Advisors, 2020; SAPEA, 2023). The Farm to Fork Strategy acknowledges the importance of **tax incentives**, stating they 'should also drive the transition to a sustainable food system and encourage consumers to choose sustainable and healthy diets' (EC (2020f), p. 14). It refers to the ability of Member States to differentiate value added tax (VAT) levels to support specific types of more sustainable foodstuffs. However, the 2022 EEA report found that, at the national level too, there is an almost complete absence of favourable taxation schemes for sustainable consumer food products (EEA, 2022h).

One possible way to address this at the EU level while taking into account the EU's limited powers in the field of taxation is to apply **emission pricing** to the agri-food system (see Chapter 10 'Pricing emissions and rewarding removals' for a discussion of this). The European Commission is considering this option, and launched a survey in June 2023 to gather expert views on how such a system should be organised (EC, 2023bd). In order to have an impact on consumer behaviour, an emission-pricing regime would have to ensure that price incentives favouring low-emission food choices are eventually passed through to the end consumer.

There is a general consensus that introducing emission pricing for food would be regressive, because low-income households spend a larger share of their income on food (Kehlbacher et al. (2016), Klenert et al. (2023) and a number of studies reviewed by Temme et al. (2020)). Temme et al. (2020) suggest that a combination of taxes and subsidies could reduce regressive effects and may enable consumers to change to a more healthy and sustainable diet without additional cost. Modelling by Klenert et al. (2023) supports this conclusion, estimating that a EUR 50/t CO_2e tax on meat would cost the lowest quintile of consumers EUR 72 per year (around 0.6 % of total food expenditure), that recycling the revenue into reduced VAT for fruit and vegetables would reduce this cost to EUR 15, and that recycling the revenue as a lump sum transfer would reduce inequality by returning EUR 13–350 to the lowest income quintile (the range depending on whether the transfer goes to all households or only the poorest quintile).

Pricing policies promoting healthier diets (while ensuring access to healthy food for all) can also be justified on health grounds, with Temme et al. (2020) suggesting that this rationale may increase public acceptability. Predominantly plant-based diets such as the EAT-Lancet diet (Willett et al., 2019) have been designed with objective of improving both health and sustainability outcomes.

Given the evidence outlined above, policies based on emission pricing can in principle incentivise shifts from red to white meat, and to more plant-based diets, while achieving positive outcomes for health, climate and inequality. However, the use of emission pricing or taxes without complementary policies could lead to unintended health outcomes. For example, it could encourage consumers to switch to lower-quality meats, or to sugary products that are not emission-intensive (Kehlbacher et al., 2016; Klenert et al., 2023).

The Farm to Fork Strategy places a great emphasis on **improved information provision** as a key driver of consumer behaviour change (although the European Commission has not yet published the announced proposals at time of writing). The overall approach focuses on providing better information to consumers (e.g. through labelling), in the expectation that they will make well-informed and rational

choices towards more healthy and sustainable diets (EEA, 2022h; SAPEA, 2023). According to a number of recent reports by EU advisory bodies (EEA, 2022h; EC, Group of Chief Scientific Advisors, 2020; SAPEA, 2020, 2023), soft policies such as information provision, sensibilisation and choice architecture ('nudging') can support the required shifts in consumer behaviour but are insufficient on their own to drive the required change. As discussed above ('Towards a whole-system approach'), the EU code of conduct on responsible food business and marketing practices has had mixed results so far in facilitating a shift towards healthy and sustainable diets.

Regarding the **social, cultural and behavioural aspects of food consumption**, SAPEA (2023) and other studies such as those by Eker et al. (2019) and Wendler and Halkier (2023) point to the importance of the social environment (i.e. the fact that dietary change is not merely carried out by isolated individuals). Wendler and Halkier go further, arguing that the social aspect (essentially whether a plant-based diet is considered more or less normal) could have a greater influence on meat consumption than an individual's intention to change their diet. In this respect, measures such as improving the sustainability of public procurement (suggested in the Farm to Fork Strategy) can also have an important role to play.

In conclusion, the introduction of price-based policies to encourage healthy and sustainable diets appears to be the main element missing from the EU's farm to fork policy. If well designed, it could be introduced with a modest regressive effect, or even be a financial benefit to low-income consumers. Therefore, the introduction of more binding measures such as regulations and financial incentives appears necessary but should be combined with further efforts to enhance information provision and education about sustainable and healthy diets as part of a broad policy mix.

Lever: reduced food loss and waste

EU policies to reduce food waste are in preparation, and the recent establishment of a monitoring system is an important first step. However, the proposed targets are less ambitious than the aims of the Farm to Fork Strategy.

Reducing food loss and waste could deliver considerable emission reductions. Currently, food waste represents approximately 15 % of the total GHG footprint of the EU food system (EEA, 2022h). Reducing food losses and waste could reduce emissions both directly (by reducing agricultural production, food processing and transport) and indirectly (by making land available that could be used for biomass production or carbon sequestration). Food loss and waste take place across the entire agri-food value chain, and in particular the distribution and (post-)consumption stages. Options to reduce them include incentives to reduce business- and consumer-level waste, active marketing of cosmetically imperfect products, improved information provision and regulation of unfair business practices. Potential co-benefits are reduced environmental stress and improved food security.

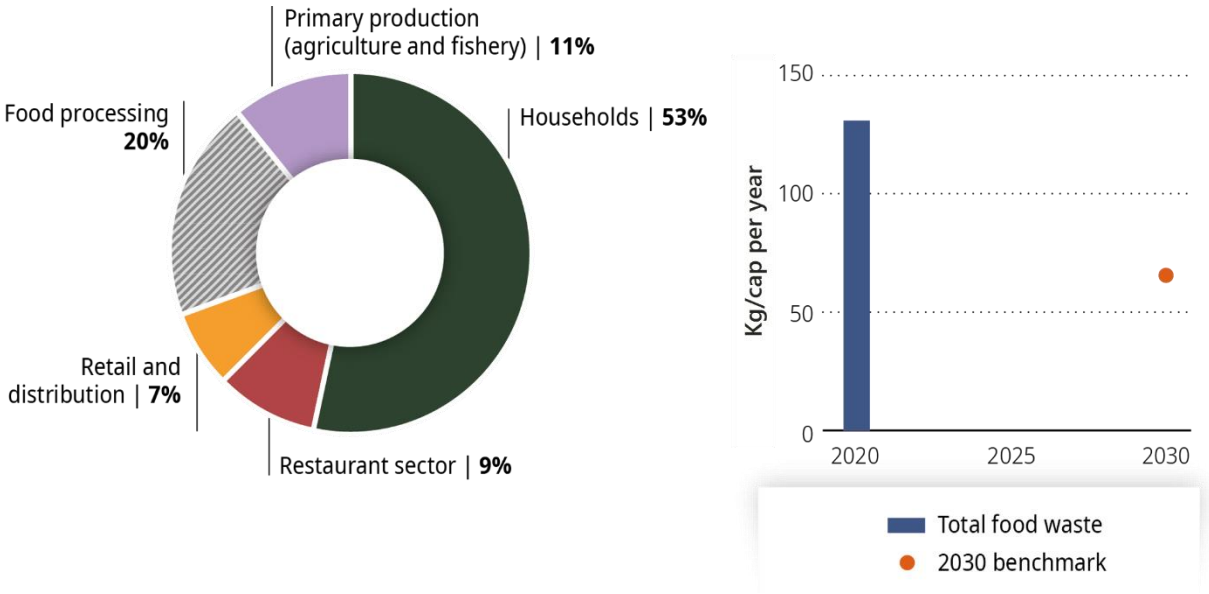
Before the adoption of the Farm to Fork Strategy, food waste was already considered in a number of EU-level policies and strategies. The European Commission proposed a series of actions under the 2015 Circular Economy Action Plan (EC, 2015a), and the 2018 Waste Framework Directive (EU, 2018a) included obligations for Member States to reduce food waste (without any quantified objective), to measure food waste levels and to report on progress made. To this end, in 2019 the European Commission adopted a common food waste measurement methodology (EC, 2019a) to ensure harmonised food waste monitoring and reporting across Member States.

The Farm to Fork Strategy puts forward a concrete, quantified objective of reducing food waste per capita by 50 % by 2030. Recently, it also published a proposal to revise the Waste Framework Directive (EC, 2023aq), which sets legally binding objectives for Member States to reduce food waste. Under the proposal, food waste in processing and manufacturing would need to be reduced by 10 % by 2030, and food waste in the retail, distribution, restaurant and food services and households would need to be

reduced by 30 % by 2030 (both compared to 2020, in kilograms per capita). No objective is set for primary producers, which accounted for 11 % of total food waste in 2020. Given that the objective does not cover all food waste and sets targets below the overall 50 % reduction objective, it is highly uncertain that it will be sufficient to meet that objective. The European Commission acknowledged this ambition gap but argued that lower targets were needed to ensure feasibility, and that targets can be revised upwards in the event of sufficient progress.

Data collected under the common food waste measurement methodology in Figure 61 shows that in 2020 the EU wasted on average 131 kg of fresh food per capita, most of it during the consumption phase: 53 % of the total waste was generated by households and 9 % in the restaurant sector. Under its Farm to Fork Strategy, the European Commission is committed to halving this by 2030, in line with sustainable development goal 12.3 (EC, 2020f). Data for 2021 will bring further clarity about whether the EU is moving in the right direction and at an adequate pace to achieve this objective.

Figure 61 Indicator A6 – food waste in the EU in 2020, per source (left) and compared to the 2030 benchmark (right)



Notes: Food waste during the primary production of foods excludes pre-harvesting food losses. 2030 benchmark based on the European Commission's Farm to Fork Strategy.

Sources: Eurostat (2023i) (2020 data), Farm to Fork Strategy (EC, 2020f) (benchmark).

Lever: minimise demand for biofuel crops

In the long term, use of food crops for first-generation biofuels is expected to decline thanks to advances in electric vehicles and second-generation biofuel technology. However, first-generation biofuel production may continue to grow in the short term as a result of renewable fuel mandates.

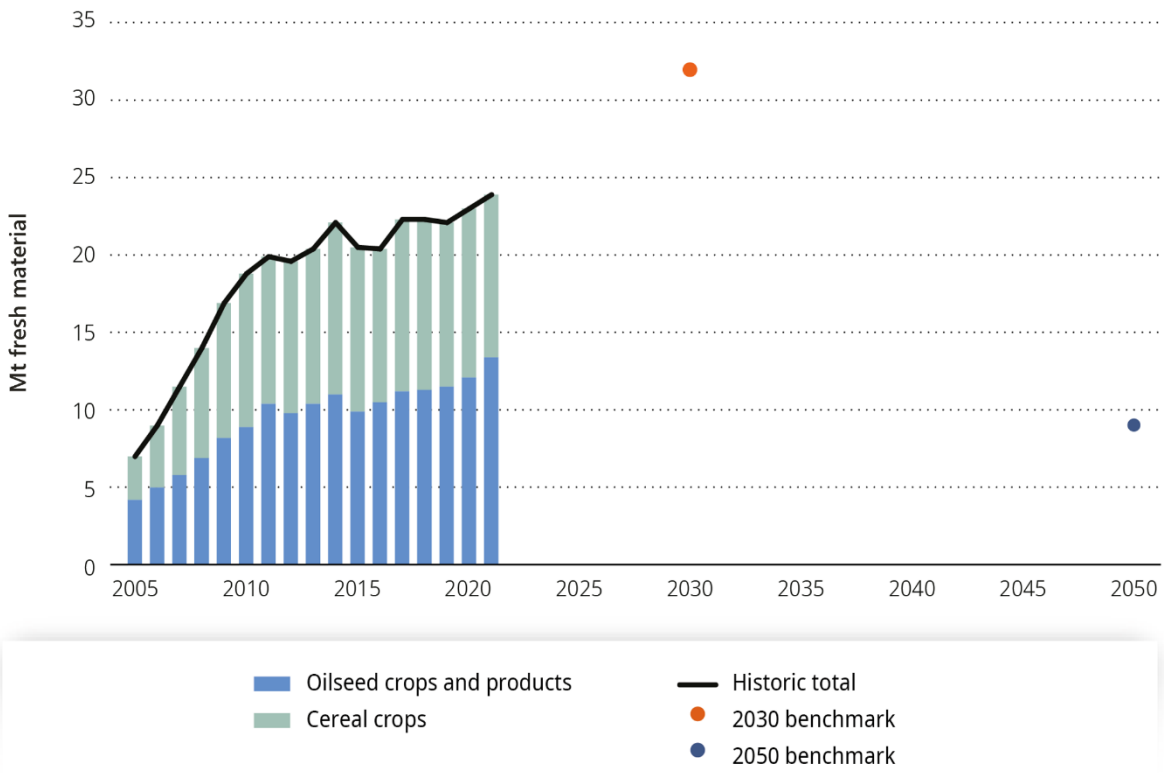
The use of bioenergy can lead to either increased or reduced emissions, depending on the scale of deployment, the conversion technology, what fuel it displaces and how/where the biomass is produced (IPCC, 2022i). In particular, some of the GHG emissions and other sustainable development impacts associated with demand for bioenergy cannot be observed or measured directly, because it is entangled with a large number of other changes in agricultural markets at both the global and local levels (Valin et

al., 2015). This chapter considers the influence of bioenergy markets on the EU agricultural sector, while Chapter 6 (on transport) examines EU bioenergy policies in general.

The use of agricultural crops as feedstock for biofuels has been increasing since 2005 as the result of EU policies promoting the use of biofuels to decarbonise the transport sector (see Section 6.4 under 'Lever: fuel switches'). The increase was strongest in 2005–2010, after which it slowed down. Nevertheless, by 2021 the absolute volumes of cereal crops and vegetable oils used as biofuel feedstocks more than tripled compared with 2005. Whereas the share of cereal crops used for biofuel production is relatively small (4 % of total), a large minority (40 %) of the total vegetable oil use in 2021 in the EU was linked to biofuel production.

Under the European Commission's MIX scenario underpinning the 55 % reduction objective, the use of food crops for biofuel production would continue to increase up to 2030 at a rate of 0.9 Mt fresh material per year, faster than the observed trend in 2016–2021 (0.4 Mt fresh material per year). After 2030, the MIX scenario envisages continued growth in production of bioenergy feedstocks overall, but largely from non-food crops (lignocellulosic grass) and agricultural residues. Total food crop use for biofuel production should be 66 % below 2021 levels by 2050. Given recent declines in the cost of both batteries and variable renewable generation technologies (IPCC, 2022g), more up-to-date scenarios may find that EU climate targets can be met with lower production and bioenergy use than that set out in the MIX scenario.

Figure 62 Indicator A7 – use of agricultural products as bioenergy feedstocks



Sources: JRC Medium-term outlook commodity flows (Gurría Albusac et al., 2021) (historic), Climate Target Plan impact assessment MIX scenarios (EC, 2020s) (Figure 79) (benchmarks).

8.6 Summary tables

Table 12 Progress summary - agriculture

Indicator	Reference period	Historical progress	Required up to 2030	Required in 2031–2050
A1: GHG emissions	2005–2022	– 1 Mt CO_2e/yr	– 3.5 Mt CO_2e/yr	– 4 Mt CO_2e/yr
A2: livestock GHG intensity				
A2a: beef	2016–2020	– 73 kg CO_2e/kg/yr	No benchmark	No benchmark
A2b: dairy products	2016–2020	– 9 kg CO_2e/kg/yr	No benchmark	No benchmark
A2c: pig meat	2016–2020	+3 kg CO_2e/kg/yr	No benchmark	No benchmark
A3: total fertiliser use	2017–2021	–179 kt N/yr	– 313 kt N/yr	No benchmark
A4: livestock production				
A4a: beef	2016–2020	Stable	No benchmark	No benchmark
A4b: dairy products	2016–2020	+ 2 Mt/yr	No benchmark	No benchmark
A4c: pig meat	2016–2020	Stable	No benchmark	No benchmark
A5: livestock product consumption				
A5a: beef	2016–2020	– 3 kcal per person y^{-1}	No benchmark	– 50 kcal per person/yr
A5b: dairy products	2016–2020	+ 7 777 kcal per person/yr	No benchmark	– 2 970 kcal per person/yr
A5c: pig meat	2016–2020	– 468 kcal per person/yr	No benchmark	– 204 kcal per person/yr
A7: food waste	2020	131 kg per person/yr [a]	– 7 kg/cap/yr	No benchmark
A7: bioenergy feedstock crops	2017–2021	+ 0.4 Mt FM/yr	+ 0.9 Mt FM/yr	– 1.2 Mt FM/yr

Legend

On track	The required change [b] is ≤ 1.
Almost on track	The required change [b] is between 1 and 1.5.
Somewhat off track	The required change [b] is between 1.5 and 2.
Considerably off track	The required change [b] is ≥ 2.
Wrong direction	The required change [b] is < 0.

[a] Only data for one year available; not possible to compare with required progress.
[b] See Section 2.2 for more details on how the required change is calculated.

Table 13 Policy consistency summary – agriculture

Policy inconsistencies	– Support to emission-intensive agricultural practices such as livestock production continues under the CAP through area-based and, in some cases, production-linked payments. – EU energy policy continues to promote first-generation biofuels.
Policy gaps	– GHG emissions from agriculture are not covered by an emission-pricing system. – Several initiatives announced in the Farm to Fork Strategy have not yet been adopted as final legislation. In some cases, the initial proposal from the European Commission has not been published.
Ambition gaps	– Emission reduction targets and objectives under the CAP are combined with general agri-environmental objectives and are largely qualitative. – Emphasis on mitigation in Member States' CAP CSPs is largely discretionary. Expected mitigation outcomes are difficult to quantify. – The Farm to Fork Strategy lacks delivery mechanisms and relies on non-binding measures (such as information provision). – The impact of recent food and agriculture initiatives such as the EU Code of Conduct on Responsible Food Business and Marketing Practices, food waste reduction targets in the Waste Framework Directive revision proposal and the revised industrial emissions directive are expected to be low.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