EU 2040 Climate Target:

Contributions of the agriculture sector

Part 3 of 7 studies on sectoral contributions to the 2040 target

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Abbreviations

Agri-ETS	Name for a potential emissions trading system for the agricultural sector
BAT	Best available technology
CAP	Common agricultural policy of the EU
CRCF	EU carbon removal certification framework
CRF	Category in the Common reporting format (CRF) tables - a series of standardised data tables containing mainly quantitative information of the National Inventory Report (NIR)
ECL	European Climate Law
ESABCC	European Scientific Advisory Board on Climate Change
ESR	EU Effort Sharing Regulation
ETS	Emissions trading system
ETS1	EU Emissions trading system for Industry and energy plants
ETS2	EU Emissions trading system for road transport and buildings sectors
GHG	Greenhouse gas
IACS	Integrated Administration and Control System
IED	Industrial Emissions Directive of the EU
LULUCF	Abbreviation for the Land use sector (Land use, land use change and forestry)
NEC	National Emissions reduction Commitments (NEC) Directive
WAM	With additional measures projection
WEM	With existing measures projection

Executive summary

The 2040 climate target

The EU is legally obliged to achieve climate neutrality by 2050 and has an interim target for 2030 of reducing net GHG emissions by 55% compared to 1990. The European Climate Law also requires the EU to adopt a climate target for 2040.

In its communication of 6 February 2024, the European Commission proposed a net emission reduction of 90% by 2040 when compared to 1990. The ESABCC recommends 90–95% reductions (ESABCC 2023). The indicated target range means that all sectors will have to contribute significant emission reductions.

This paper explores the past contribution of the agricultural sector[1] of already achieved emission reductions to the upcoming 2040 climate target and what it takes to achieve the proposed future emission reductions.

Emission trends

Between 2005 and 2022, agricultural emissions fell slightly by around 5 %. And the trend is not expected to change, so climate protection in EU agriculture is currently threatened by stagnation. If politically planned additional measures are implemented (WAM scenario), only a slight reduction of -3.2% is expected until 2030, and until 2050 not more than -7.4% reduction is expected compared to 2022.

What does the 2040 target mean for agriculture?

The EU impact assessment scenarios (S1, S2, S3 and LIFE) reveal a wide range of contributions from the agricultural sector towards achieving the proposed emission target in 2040. Through the implementation of technical measures, it is feasible to achieve an emission reduction ranging from -19% (S2) to -27% (S3) compared to 2022 levels. The range observed in the two scenarios highlights the distinction between partial and full implementation of technical mitigation measures. Significant emission reductions are attainable only through demand-side changes, such as reducing animal-product consumption, coupled with corresponding reductions in livestock numbers on the supply side. The impact of demand-side changes becomes evident in both the LIFE scenario proposed by the European Commission and the Demand-side focus scenario outlined by the ESABCC. The extent of demand-side modifications, combined with the adoption of technical mitigation options, could lead to emission reductions ranging from -44% to -56% compared to the 2022 baseline.

Key challenges

Agriculture is the largest sector under the Effort Sharing Regulation (ESR) for which there is no follow-up regulation for the period after 2030 (ESABCC 2024). Furthermore, the entire sector

[1] The emission inventories attribute only a part of agricultural activities directly to the agricultural sector (CRF category 3): emissions directly from livestock (enteric fermentation and manure management) and from soil fertilisation. The remaining sources only account for less than 5%. Further emissions are recorded in the land use sector, especially those from the management of organic soils and from the conversion of grassland. Emissions from energy use are aggregated and reported in CRF category 1.A.4c. Further details in Chapter 1.

lacks directional certainty. A clear mitigation target vision, e.g. analogous to the expansion of renewable energies in the energy sector, has not yet been formulated for the agricultural sector.

In the agricultural sector, nitrous oxide and methane emissions from natural biological processes predominate, for which only limited mitigation technologies are available. As scenario studies show, about 70% of emissions from agriculture will persist as residual emissions if technical options are fully implemented. Further reduction potential could only be realised via the demand side.

What is in current EU legislation?

The agricultural sector is part of the Effort Sharing Regulation, which covers all GHG emissions outside the ETS 1, LULUCF, aviation and international shipping. If not amended or reintroduced, the ESR will expire in 2030.

Climate protection is also one of the strategic objectives of the common agricultural policy (CAP), a total of 40 percent of CAP funds should be provided for climate change objectives.[2] However, there is no binding target for GHG emission reduction which should be reached by the central policy instrument for agriculture within the European Union. Instead of an ambitious climate protection policy, the CAP is inconsistent and includes climate-damaging subsidies (e.g. for agricultural use of drained peat soils).

Furthermore, there are several environmental regulations that influence agricultural production and therefore have an impact on emissions. This applies especially to nitrogen use and emissions whereas methane emissions are currently largely unregulated.

Policies, measures and options to further reduce emissions in agriculture

A diverse mix of instruments is essential to effectively implement climate change mitigation in the agricultural sector. These instruments encompass demand-side measures, targeted approaches for smaller farms, regulations for large farms, support for agri-environmental initiatives within the sector, and strategies to reduce emissions and enhance carbon sequestration at the farm level. There is currently a considerable debate surrounding the feasibility of implementing an emissions trading scheme (ETS) in the agricultural sector. Although practical implementation poses several unanswered questions, it is conceivable that certain segments of the agricultural sector could be covered by an emissions trading scheme. However, an ETS alone cannot tackle all the challenges facing the agricultural sector. Even with ETS implementation, robust measures are required to support climate protection efforts on small farms, in addition to continued support for environmental initiatives. The primary objectives for an instrument mix in the agricultural sector should be to minimise greenhouse gas (GHG) emissions at the farm level, address demand-side factors, and maintain environmental production methods — such as the extensive use of grasslands or biodiversity measures on arable land.

Conclusions and recommendations

In order to prevent further stagnation of emissions and to stimulate further mitigation measures, the contribution of agriculture to climate neutrality at the EU level by 2050 needs to be clarified in a first step. Given the increasing risks to the natural carbon sinks of the LULUCF sector, the precautionary principle requires that emissions from agriculture should be minimised beyond what can be achieved by technical options alone.

[2] Article 100 of the Cap Strategic Plans Regulation lays down the tracking of climate expenditure by a simple and common methodology (e.g. Rio Marker). REGULATION (EU) 2021/2115 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 2 December 2021

In this sense, a significant contribution from the demand side is also needed to reduce the land footprint of food consumption and to achieve the other objectives of the Green Deal, such as biodiversity, circular economy and extensification. **This requires halving emissions compared to 2022, at least in line with the LIFE scenario** (EC 2024). Urgent action is needed to set targets and instruments at the latest for the next CAP period starting in 2028. Instruments should apply the “polluter pays” principle such as emissions taxes or an ETS with tradable certificates. Binding targets can be set within legislation or through a cap as part of an ETS. To distribute an overall EU target among the Member States in a fair way, a follow-up regulation to the Effort Sharing Regulation would be suitable. Price instruments and effort sharing could be implemented in parallel.

1 Introduction

The EU will adopt a climate target for 2040 in the coming years that is compatible with the Paris Agreement and climate neutrality by 2050. This is a legal obligation set out in the European Climate Law (ECL). Article 4.4 of the ECL stipulates that "a Union-wide climate target for 2040 shall be set" – with a view to achieving the ECL's climate neutrality objective. Once the target is adopted, the EU is also set to adopt a legislative package to implement this target. This package will reform relevant EU laws and policies.

This paper is part of a group of sectoral papers, published in the context of a project funded by the German Federal Ministry for Economic Affairs and Climate Action. In this project, Ecologic and Oeko-Institut analyse the ambition level of the 2040 target and examine the impacts of a new 2040 target on Member States, sectors, and instruments. For more information about this project see: "EU 2040 Climate Target. Level of ambition and implications". Besides other outputs of this project, these sectoral papers explore contributions of respective sectors to the upcoming 2040 climate target and what it takes for these sectors to achieve the related emission reductions. Relying on various emission reduction scenarios, the papers discuss different measures and policies that could help achieve the necessary contributions.

Non-CO_2 greenhouse gas emissions from the EU agricultural sector are covered by the Effort Sharing Regulation (ESR). So far, there has been no follow-up regulation for the period after 2030. As indicated above, article 4.4 of the European Climate Law (ECL) stipulates that a Union-wide climate target will be set for 2040.

The agricultural sector caused about 12% of the EU's GHG emissions in 2021 (EEA 2023b). Agricultural emissions are dominated by methane (61%) and nitrous oxide (36%), which are a result of natural biochemical processes and cannot be eliminated completely. For both gases, agriculture accounts for the majority of these emissions in the EU: for methane 56% und for nitrous oxide 74% in 2021 (EEA 2023b). Agriculture will therefore become the sector with the highest GHG emissions in the future. The scenarios of the EC impact assessment 2024 project the ratio of agricultural emissions in total emissions in a range of 33-76% for 2040 (see Table 1). Today, approximately two thirds of these come directly from livestock's enteric fermentation and manure management (CRF 3A and 3B) and from soil fertilisation (CRF 3D). The remaining sources only account for less than 5%. Minor emission categories are rice cultivation (CRF 3C), prescribed burning of savannahs (CRF 3E), field burning of agricultural residues (CRF 3F), liming (CRF 3G), urea application (CRF 3H), other carbon containing fertilisers (CRF 3I) and other agricultural emissions (CRF 3J).

However, emission inventories attribute only a part of agricultural activities directly to the agricultural sector (CRF category 3). While the cultivation of meliorated peat soils, the conversion of grassland to arable land or vice versa, and the establishment of permanent woody plants (agroforestry, short-rotation coppice, hedges) cause changes in the carbon stock of agricultural land, respective emissions are reported in the LULUCF sector in the land-use categories of cropland and grassland (CRF categories 4B and 4C).

The technical mitigation potential in the agricultural sector is limited. However, there is a significant potential for emission reductions linked to shifts in the demand for animal products. Nevertheless, establishing a target under the current framework conditions remains complex. Unlike the energy sector, which has a clear zero emission vision with energy savings and expanding renewable energies, the agricultural sector has not yet formulated a clear mitigation target.

2 Sectoral trends

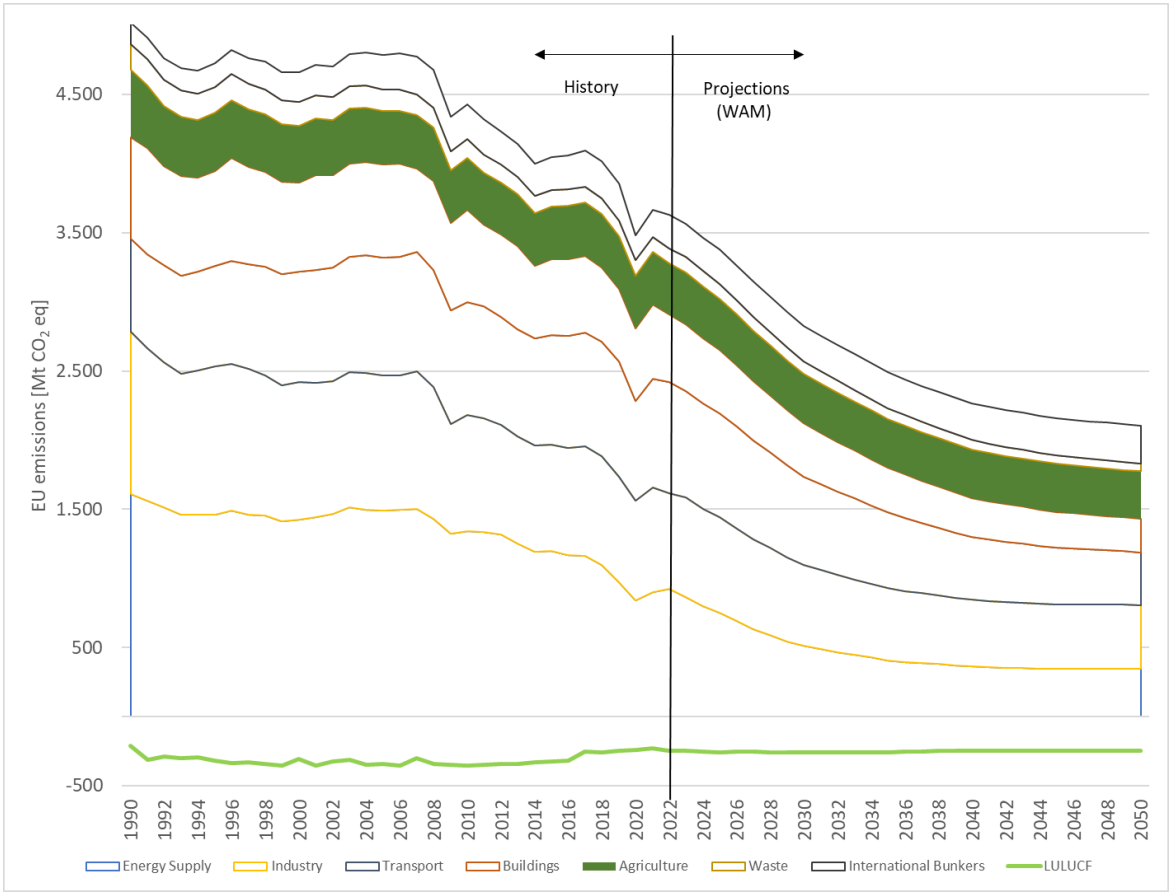
2.1 Historical and projected emission trends

In the EU-27, greenhouse gas emissions from agriculture have fallen by a quarter as of 2022, compared to 1990. While emissions decreased by 95 million tons of CO_2e in the first 15 years (-20% between 1990 and 2005), the reduction achieved between 2005 and 2022 was only 19 million tons of CO_2e (-5%). In 2022 total emissions from agriculture amounted to 371 million tons of CO_2e.

The eastern European Member States have the highest GHG reductions (a maximum of -60% since 1990 in Slovakia) with decreasing animal numbers and modernisation of technologies as the major drivers. In all EU countries - except France and Spain - the reductions between 2005 and 2022 are lower than in the period from 1990 to 2005. Only in Ireland and Cyprus did emissions rise during the whole period from 1990 to 2022.

Reductions in agricultural emissions are projected to stagnate: If politically planned additional measures are implemented (WAM scenario), only a slight reduction of -3.2% is expected until 2030 and not more than -7.4% until 2050 , compared to 2022. These figures underline the need for further action to reduce non-CO_2 emissions in the agricultural sector.

Figure 1: Historical and projected EU agricultural GHG emissions (with additional measures projection, WAM)



Source: EEA (2023b)

Agricultural emissions are dominated by emissions from livestock farming. 65% of total emissions from agriculture are direct emissions from livestock production (CH_4 from enteric fermentation, and CH_4 and N_2O from manure management) (EEA 2023b).

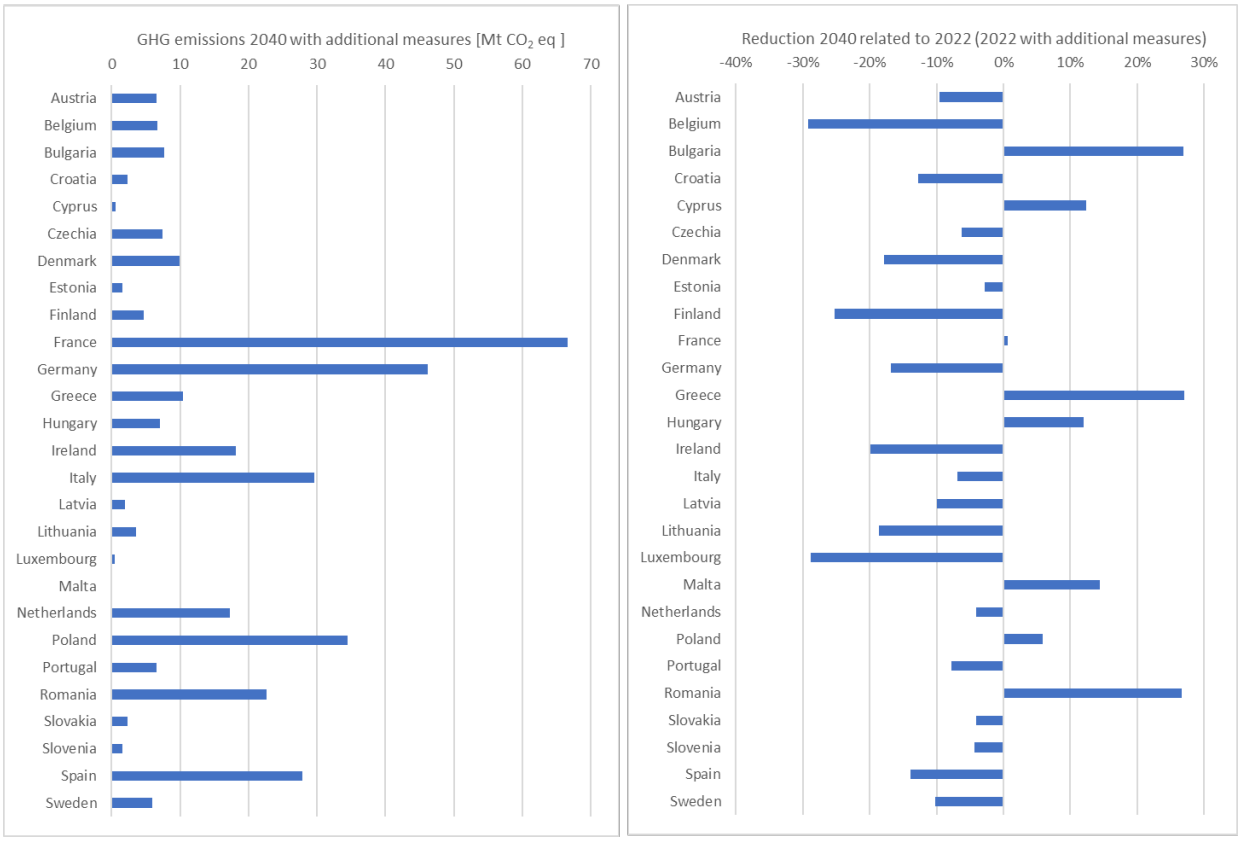
2.2 Future trends in national projections

Agriculture is currently covered by the ESR. Compared to 2005 levels, the ESR sectors must reduce their GHG emissions collectively by -40%. Taking into account the emission projections in the WAM scenario, the agricultural sector will reduce its emissions only by -8% by 2030 compared to 2005 levels. Given these national projections and the national targets established in the ESR, the agricultural sector puts additional pressure on the other ESR sectors in most Member States.

The projection with additional measures (WAM) shows that eight Member States project an increase in emissions. This includes especially eastern European Member States like Bulgaria, Greece, Poland, and Romania with low agricultural intensity. The expected increase amounts to 12 Mt CO_2e, which equals 3% of total agricultural emissions in 2022. The other 19 Member States project a decrease of emissions by 34 Mt CO_2e in 2040, which equals an emission reduction of -9% compared to 2022. Thus, the total emission reduction in the agricultural sector under the WAM scenario is only -5% compared to 2022 emissions. The highest absolute contribution of emission reductions is achieved in Germany, mainly by a reduction in animal numbers and an expansion of the digestion of animal manure. Besides Germany also Spain, Ireland, Belgium and Italy contribute larger parts to the emission reductions of the WAM projections. Only three Member States show an emission reduction of more than -20% until 2040 compared to 2022 levels. These include Belgium, Finland and Luxembourg. The emission reduction in Belgium is based mainly on investments in precision fertilisation, reducing methane emissions per animal by improving feed efficiency and other measures like the reduction of fertiliser use by improved cropland management under the CAP.[3] In Finland main GHG reductions are related to measures for reducing emissions from organic soils, affecting also N_2O emissions from the agricultural sector and the promotion of the use of biogas. In Luxembourg a focus is put on reducing GHG emissions from livestock management and a reduction of ammonia emissions and fertiliser input to reduce N_2O emissions from soils.

[3] Policy and measures database EEA

Figure 2: Member States' agricultural emission projections: absolute level in 2040 and relative change 2040 to 2022



Source: EEA (2023a)

2.3 Relationship to other sectors

There are several interactions of the agricultural sector with other sectors due to biomass supply from agricultural land for energy and non-energy demand. Furthermore, there is a strong sectoral overlap with the LULUCF sector. There are also links with industry via upstream products such as fertilisers and pesticides.

LULUCF

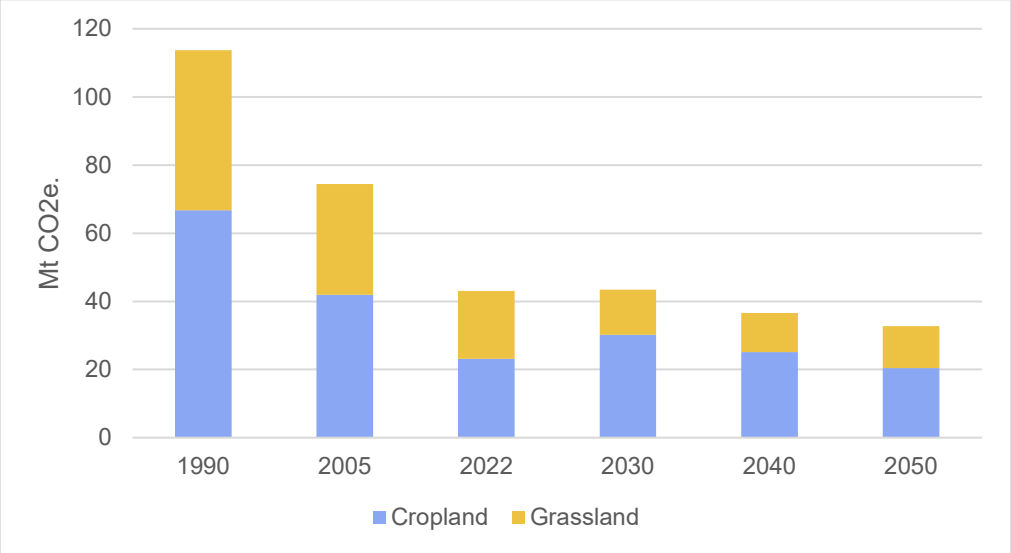
Besides emissions from direct agricultural processes (reported in the CRF sector 3 in the GHG inventory reports), various agricultural practices lead to changes in the carbon pools of agricultural land. Changes in the carbon pool based on the management of agricultural land can result in a carbon sink or in a carbon source. In the inventories, sinks and sources from agricultural land use are reported in the LULUCF sector and include e.g.

1. drainage of organic soils (major source of emissions)
2. conversion of grassland to arable land (source)
3. conversion of cropland to grassland (sink)
4. planting woody crops like agroforestry or hedges (sink)
5. grassland remaining grassland (sink)

EU-wide drained peatland represents only 2% of the total surface of agricultural land (EEA 2023b), but 76 Mt CO_2e originate from organic soils under grassland and cropland, an equivalent of 20% of agricultural emissions. These emissions are partially offset by carbon sinks resulting from land use, such as carbon storage in remaining grasslands. Therefore, the reported

net CO_2 emissions from grassland and cropland in 2021 amounted to 48 Mt CO_2e, accounting for both sinks and sources. Beyond the ongoing emissions resulting directly from agricultural processes, there will also be emissions from the land use sector in the future (as depicted in Figure 1). However, by enhancing carbon sinks through effective management of agricultural land and mitigating emission sources (such as rewetting organic soils), it is possible to offset these emissions.

Figure 3: Historical and projected development of LULUCF emissions from cropland and grassland



Source: EEA (2023a)

Biomass supply for energy and non-energy demand

Agriculture is linked to the sectors of industry, energy, transport and buildings through the provision of bioenergy and biomass materials. Agriculture provides bioenergy in the form of biogas (anaerobic digestion) from annual crops, slurry and field residues, biodiesel, and bioethanol (mainly from annual crops), and increasingly in the form of wood from perennial crops. The demand for energy crops for biodiesel and bioethanol in Europe is partially met through imports from other regions, especially from China, Malaysia and Indonesia.[4] Biogas production from agricultural residues and annual crops plays a large role in only a few countries, especially in Germany. As of 2021, biogas constitutes only 1% of total EU energy consumption, whereas biofuels account for 2%. Solid biomass remains the dominant contributor, making up 9% of the total energy consumption.[5]

Bioenergy contributes to climate change mitigation by reducing GHG emissions in the energy sector. In addition, rising energy prices for other energy carriers have made energy production from biomass more economically viable. As a result, the agricultural sector plays a crucial role in providing the necessary feedstock for bioenergy production. Within EU scenarios the role of bioenergy to meet reduction targets in the energy sector remains relevant, however the cultivation of energy crops on agricultural land warrants careful considerations due to potential adverse effects on soil quality, biodiversity, and food security, also related to the shortage of agricultural land and rising food prices.

Besides the provision of biomass for energy consumption, the agricultural sector plays a role in providing biomass for non-energy purposes. These include the production of fibre crops (cotton,

[4] https://www.eca.europa.eu/ECAPublications/SR-2023-29/SR-2023-29_DE.pdf
[5] EU UNFCCC Inventory submission 2023, CRF table 1.A.(b)

flax, hemp), oil seed crops (soybean, sunflower, rapeseed) or starchy crops (potatoes) which can be used in the industry sector for textiles, paper, construction, and feedstocks. The transition away from fossil feedstocks in the industrial sector, such as the replacement of plastics, is anticipated to drive an increased demand in this field. As biomass for non-energy purposes is a cornerstone for the transformation of the economy, the allocation of biomass to the different purposes is expected to change significantly.

2.4 Key challenges in the agricultural sector

Challenging framework conditions due to social effects and missing direction

Agriculture is a sector with challenging framework conditions, which makes regulation complex: First, many individual actors must be addressed (analogous to transport and buildings). Furthermore, the highest proportion of emissions comes from animal husbandry, which is closely linked to dietary habits and for which there have been only few technical mitigation options so far. In addition, issues like food security, the impact of agricultural production on the environment (air, water, soil and biodiversity), high heterogenity of farms, social policy / social aspects for farms and the effects of price changes in food products on consumers need to be taken into account.

Overall, the economic situation of many farms in the European Member States is deteriorating due to rising expenditures,global market competition and pressure from the agrifood industry. Rising environmental requirements in regulations, a high level of bureaucracy, and the impacts of climate change are exacerbating the economic problems and lead to ongoing farmers' protests.

In view of the absence of subsequent regulations and clear objectives, the entire sector lacks certainty in terms of its future direction. A clear emissions mitigation target, e.g. analogous to the expansion of renewable energies in the energy sector, has not yet been formulated for the agricultural sector.

Limited technical mitigation potential

In the future, the agricultural sector will be the sector with the highest residual emissions (ESABCC 2023; EC 2024). In the agricultural sector, nitrous oxide (36%) and methane emissions (61%) from natural biological processes predominate, for which only limited mitigation technologies are available.

Mitigation options within the agricultural sector encompass **on-farm management measures**, such as enhancing nitrogen efficiency or curbing emissions through improved livestock practices. These practices include optimised feeding, extending calving intervals and life performance of dairy cows, and exploring breeding alternatives. However, assessing the effectiveness of on-farm management measures can be challenging due to the need for detailed data.

On the other hand, there are **measures with investment in infrastructure development** which lead to emission reductions in the agricultural sector. These include investment in construction of low-emission stables, slurry cover, biogas plants for anaerobic digestion of manure, efficient heating systems, installation of renewable energies or the purchase of new machinery (low-emission spreading technology and additives for slurry, more efficient tractors, etc.). Investment measures carry the risk of lock-in effects, particularly when the emission trajectory and future conditions remain uncertain.

The third category of measures includes **the addition of additives** to reduce CH_4 emissions from enteric fermentation and N_2O emissions from fertiliser application. There are EU-wide

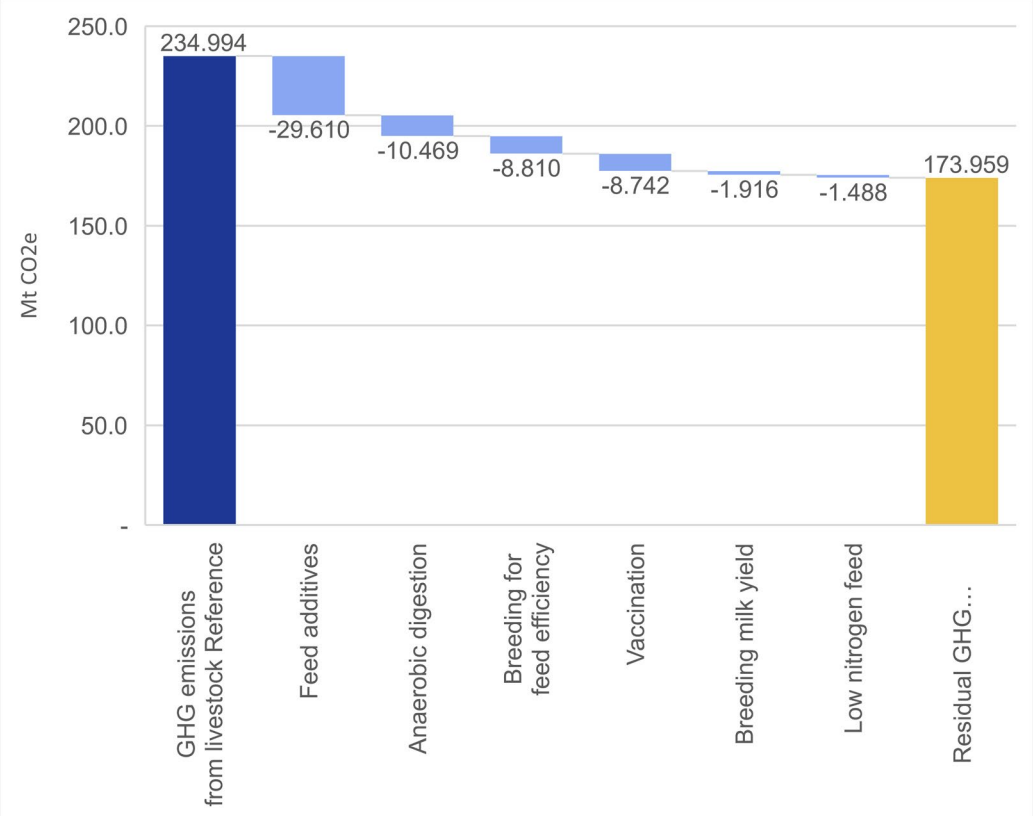
authorised substances for both areas of application. A significant portion of the technical mitigation potential lies in the utilisation of feed and nitrogen additives. However, these additives are accompanied by a high degree of uncertainty[6], making it challenging to conclusively demonstrate their mitigating impact.

Another source of emission reductions lies in production effects. These may involve altering the product shift (e.g. transitioning from cereal crops to agroforestry-based wood production) and/or production levels (e.g. adopting organic farming practices with lower yields per hectare but also reduced greenhouse gas emissions per hectare).

Relevance of emissions from livestock and mitigation potential

About 65% of total emissions from agriculture are CH_4 (92%) and N_2O (8%) emissions from enteric fermentation and manure management from livestock. There are only limited mitigation measures available to adress these emission sources by technical mitigation measures. The technical report of the Joint Research Centre of the European Commission from 2020 (Pérez Domínguez et al. 2020) outlines the mitigation potential for different mitigation measures compared to a reference scenario. The following figures show the mitigation potential for direct emissions from the livestock sector.

Figure 4: Technical mitigation potential of livestock emissions



Note: Only direct CH_4 emissions from enteric fermentation and CH_4 and direct N_2O emissions from manure management are included. Emission reductions are scenario assumptions on maximum feasible implementation and mitigation potential of the technical measures. This is in some cases not 100% of the technical potential, but includes already an assumption on what is feasible, e.g. only farms with more than 200 livestock units are eligible for anaerobic digestion of manure in biogas plants.
Source: Own figure, based on Pérez Domínguez et al. (2020)

[6] E.g. missing experience concerning long-term reaction, environmental compatibility, diversity of local characteristics (crop production) or diversity of feeding (husbandry).

Figure 4 shows the maximum **technical mitigation potential** based on assumptions made in the CAPRI framework (Pérez Domínguez et al. 2020). By implementing these mitigation options, it appears feasible to achieve an emission reduction of approximately 25% for addressing direct emissions from livestock. However, 75% of greenhouse gas emissions remain unavoidable. These emissions can further be reduced by lowering livestock numbers, coupled with shifts in consumer demand for animal products.

The EC impact assessment 2024 reflects these figures: Scenario S3, with full implementation of abatement measures in agriculture, ends up with 271 Mt CO_2e in 2040, which is a 27% mitigation against 2022 (see Table 2 in Section 3.2). Other studies for the EU agriculture show that scenarios with a demand-side focus achieve twice as much reduction as those that rely solely on technical measures (see Section 3.2 - ESABCC 2023; EC 2024, Stepanyan et al. 2023).[7]

Clark et al. (2020) prove that **dietary changes and food waste reduction** are two particularly strong interventions. In this context, nutrition, especially the level of animal product consumption, determines significantly the amount of residual emissions from the agricultural sector. The EU scenarios (EC 2024; ESABCC 2023) with a demand-side focus also document significant GHG reductions due to diet shifts and improved food efficiency. These scenarios relate to an increase in the consumption of plant based food, such as nuts, fruit, vegetables, and legumes and to a reduced consumption of animal-based food as described in the Planetary Health Diet (PHD) by Willett et al. (2019). The PHD suggests nutrition within planetary boundaries, for a growing earth population. It designs a diet required from an environmental science perspective.

Discussion of unavoidable residual emissions

It is not easy to define “unavoidable residual emissions” for the agricultural sector, taking into account missing targets and limited technical mitigation options on the one hand, and a large demand-side mitigation potential on the other. One approach could define “unavoidable residual emissions” as **remaining emissions after the implementation of technical reduction options**. There is, however, a first uncertainty: in recent years several feed and fertiliser additives were approved and have become technical options in practice. In the light of technological developments, the technical reduction potential could still change. The substances and technologies are still being developed and tested, so the long-term effectiveness is unclear as are the long-term effects on the environment and health. To date, organic farming has generally permitted the use of additives and only restricted the use of individual active substances. Further developments in this area are expected in the future.

A normative approach like the one presented by the Planetary Health Diet could also be used to describe “unavoidable residual emissions” by **excluding emissions which are related to a certain lifestyle and exceed a defined level.** The concept of the Planetary Health Diet needs further development. Regionalisation is crucial, taking into account dietary traditions to ensure better acceptance and adherence, as well as ensuring adequate nutrition from a medical point of view. Another key aspect of regionalisation is the further differentiation needed to take into account agricultural heterogenity (climate, soil, etc.).

The Farm to Fork Strategy, which is a key approach for EU agriculture in the future, acknowledges the importance of addressing diets and the substantial greenhouse gas emissions associated with livestock farming (EC 2020b).

[7] In the latter study, the demand-side effect arises from carbon pricing.

Scarcity of land due to rising demand for agricultural products and environmental requirements

An increasing demand for agricultural land must be assumed for the future, for example, for renewable raw materials especially used for non-energy purposes and for food due to a growing world population. Harvest risks are also accelerating as a result of extreme weather events resulting from climate change. Also current agricultural practices, based on irrigation, will become critical due to increasing heat and droughts, thus affecting the availability of drinking and ground water. The pressure on land is further exacerbated by restrictions on existing agricultural land. This is primarily due to climate and environmental protection purposes with the need to safeguard biodiversity and to secure the carbon stock in agriculturally utilised peatland soils through their rewetting. In addition, the generation of renewable energy partly takes place on agricultural land.

To fulfil the objectives of the EU Biodiversity Strategy, the regulation on nature restoration aims to include at least 20% of the EU's land and sea areas by 2030, and all ecosystems in need of restoration by 2050 (awaiting Council approval, cf. Halleux 2024). Agricultural ecosystems are also concerned by the regulation. In addition, nearly natural, uncultivated areas such as wildflower strips, fallow land and hedges are needed to restore and safeguard habitat species. Furthermore, the rewetting of peatlands (restoration of at least 50% of drained peatlands until 2050, half of it rewetted), restrictions on cultivation (synthetic plant protection, mowing date for grassland, etc) as well as greater crop rotation diversity and extensification of individual areas (organic farming, agroforestry, etc.) are factors affecting agricultural production.

These aspects are reflected to some extent in the scenarios LIFE (EC 2024) and an even more demand-side focus pathway (ESABCC 2023). Here, dietary changes lead to more land available for carbon farming and include highly diverse elements such as set-aside and fallow land with natural vegetation on agricultural land.

Role of agricultural land use on LULUCF targets

Currently, LULUCF emissions from agricultural land use are partially offset by the large forest sink in the EU. According to the 2021 EU inventory, there is a net sink (which combines land use emissions and carbon sinks) of 230 Mt CO_2e (EEA 2023b) for the total LULUCF sector. However, climate change poses a growing risk to the forest sink (and also to the carbon content in agricultural soils) and endangers both the natural sink and the LULUCF targets.

The use of organic soils or the conversion of grassland into cropland are directly tied to high CO_2 emissions resulting from carbon losses. These emissions are closely associated with agricultural activities. By contrast, the agricultural sector can also contribute to creating natural carbon sinks on agricultural land by increasing carbon sinks in soils or establishing agroforestry systems.

The creation of carbon sinks in the agricultural sector as well as the reduction of high emissions from organic soils changes the amount and type of agricultural products available (reeds instead of milk from peatlands, nuts and wood from agroforestry systems instead of cereals). This will also impact the direct GHG emissions from agricultural production.

So far the role of the agricultural sector in contributing to the LULUCF targets is rather unclear, as the net targets in the LULUCF regulation for 2030 are dominated by the large forest sink and agriculturally induced emissions are reported in two different sectors (agriculture and LULUCF). Again, a target for agriculture is missing or only exists implicitly. Consequently, there is a lack for clear incentives for increasing the carbon sink in the agricultural sector and reducing emissions from soils.

3 Sector contributions to the 2040 climate target

3.1 Status quo of current legislation

3.1.1 Effort Sharing Regulation (ESR)

The agricultural sector is part of the Effort Sharing Regulation, which covers all GHG emissions outside the ETS1, LULUCF, aviation and international shipping. The ESR establishes national binding emission reduction targets for each EU Member State, reflecting their economic strength. Transport and buildings constitute the largest sectors covered by the ESR, accounting for 35% and 25%, respectively (EEA 2023a). Agriculture ranks third with an 18% share. The remaining ESR emissions stem from energy installations, industrial processes, manufacturing, construction, and waste (22%). The ESR aims to reduce EU emissions in all these sectors by 40% compared to 2005 levels by 2030. Starting in 2027, nearly all sectors covered by the Effort Sharing Regulation (ESR), which have energy-related emissions, will be integrated into an ETS2 system. However, outside of the ETS2, emissions from agriculture, waste, some emissions from energy consumption (including energy consumption from agriculture like heating and fuel use in agricultural machineries) and fugitive emissions from industry will persist. Notably, the agricultural sector will have the largest share, contributing 46% in 2019 (EEA 2023a) of emissions not covered by either ETS1 or ETS2. So far, no decisions have been taken regarding the future regulation of emissions that do not fall under either ETS1 or ETS2. If not amended or reintroduced, the ESR will expire in 2030. Instead of ESR or complementary to it, new or strengthened sectoral regulations and other policies could be introduced. The ESR is the appropriate mechanism to set responsibilities through national targets. Strengthened responsibilities could be introduced through existing instruments (see this chapter) or additional ones (see Section 4.1 for further options). Alternatively additional emissions could be covered by existing emission trading systems or potentially new ones.

3.1.2 Common Agricultural Policy

The common agricultural policy (CAP) is the central policy instrument for agriculture within the European Union. The CAP encompasses a comprehensive array of operational objectives, addressing critical environmental concerns, including climate change mitigation and adaptation since 2014. The CAP primarily centres around financial support mechanisms, achieved through direct payments tied to adhering individual environmental standards (commonly referred to as conditionality), as well as encouraging voluntary measures. Out of the nearly 400 billion euro allocated to the CAP during the 2014-2020 period, over 100 billion euro have been designated as climate-relevant by the Commission. A total of 40 percent of CAP funds should be provided for climate change objectives.[8] In a special report covering the CAP period from 2014 to 2020, the European Court of Auditors scrutinised the efficacy of these funds in advancing climate protection. According to the Institute for European Environmental Policy (IEEP) as well as the Climate Action Network (CAN) and the German Environment Agency (UBA) in 2022, most climate protection measures exhibit only limited potential impact. The European Court of Auditors highlighted and criticised the EU's failure to apply the polluter-pays principle to agricultural greenhouse gas (GHG) emissions. This observation is based on the fact that the Effort Sharing Regulation, which also covers agriculture, is currently not associated with specific sectoral

[8] Article 100 of the Cap Strategic Plans Regulation lays down the tracking of climate expenditure by a simple and common methodology (e.g. Rio Marker). REGULATION (EU) 2021/2115 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 2 December 2021

targets or instruments for the agriculture sector at EU level. Additionally, the common agricultural policy (CAP) does not prescribe any emission limits.

Negotiations regarding the design of the common agricultural policy (CAP) for the upcoming funding period from 2028 to 2035 are set to commence soon. The CAP's design for this period will play a crucial role in determining its impact on achieving the 2040 climate target. Currently, the specific adjustments remain uncertain. Nevertheless, there are ongoing efforts to shift away from distributing available funds solely through lump-sum direct payments. Instead, these funds may be tied to specific environmental measures, aligning with the principle of 'public money for public goods'.

3.1.3 LULUCF Regulation

The LULUCF Regulation governs carbon removals and emissions within the LULUCF sector. The revised LULUCF Regulation establishes a land-based net carbon removals target of 310 million tonnes of CO_2 equivalents by 2030. This target is to be implemented through binding national targets for emission reductions and carbon removals within the LULUCF sector.

Agricultural land use contributes significantly to CO_2 emissions in this sector. Notably, emissions arise from practices such as using organic soils as arable land or grassland and ploughing up grassland. Achieving the 2030 targets will also hinge on reducing emissions from agricultural land use.

There is no regulation for the time after 2030 included under the current LULUCF regulation. However, there are other developments ongoing to address carbon removals and CO_2 emissions from soils (Carbon Removal Certification Framework, discussion on integrating carbon removals into the ETS; cf. Meyer-Ohlendorf et al. 2023).

3.1.4 Other relevant Directives or regulations

Currently there are no EU regulations which regulate emissions from agriculture directly. Environmental regulations influence agricultural production, which in turn has an impact on emissions.

Nitrogen emissions from agriculture fall under the purview of several EU directives. About 30% of total emissions from agriculture are related to direct and indirect N_2O emissions from nitrogen inputs into soils. The directives play a crucial role in managing nitrogen inputs into both air and water. These inlcude:
The **Water Framework Directive (Directive 2000/60/EC)**, which aims to protect and restore the quality of inland and coastal waters across Europe. The Water Framework Directive establishes upper limits for nitrate concentrations in groundwater, with a threshold of 50 mg/l nitrate. Additionally, it includes distance regulations concerning water bodies to prevent contamination.
The **Nitrates Directive (Directive 91/676/EEC)** specifically addresses water pollution caused by nitrates from agricultural sources. It requires EU Member States to monitor water quality and identify areas at risk of pollution. It sets limits for the use of fertilisers and promotes the implementation of good agricultural and environmental practices.
In 2024 an evaluation of the Directive is planned. This evaluation will analyse whether the Nitrates Directive remains fit for purpose and contributes to sustainable and resilient agriculture and food security. In addition, the assessment will examine the Directive's contribution to the Kunming-Montreal Global Biodiversity Framework commitments to reduce nutrient losses globally by 50% by 2030 (EC 2023).

The **National Emissions Ceilings (NEC) Directive (Directive (EU) 2016/2284)**, which sets limits on emissions of certain air pollutants, including NH_3 which is especially relevant with a

view on agricultural production. The NEC Directive has set targets for the air pollutants NO_x, SO_2, NMVOC, NH_3 and PM2.5 for the year 2030 compared to 2005. The Member States have implemented measures for complying with national reduction targets and a reporting obligation for air pollutants. Agricultural production is particularly affected by the regulation of ammonia emissions. Emissions of ammonia (NH_3) are currently stagnating at a high level or have even increased in some Member States, and have exceeded emission limits in a number of Member States (EU n.d.).

Even though about 60% (EEA 2023b) of total agricultural GHG emissions in the EU consist of **methane emissions**, the EU regulations do not adequately address methane emissions from agriculture.

So far methane emissions are addressed by the **Industrial Emissions Directive (Directive 2010/75/EU)**. The Industrial Emissions Directive (IED) regulates pollution from industrial installations, including intensive livestock farms. For large livestock farms in the poultry and pig farming sector with over 300 livestock units, the IED imposes requirements related to emissions of methane (CH4), nitrogen oxide, ammonia, and carbon dioxide (CO_2). However, cattle farms are currently exempt from these regulations. At present, the Industrial Emissions Directive (IED) encompasses only 4% of pig and poultry farms, corresponding to only 3% of total methane emissions. Initially, the EU Commission proposed incorporating cattle into the regulations and reducing the threshold for pig and poultry farms. This adjustment would expand the coverage of regulated methane emissions from a mere 3% to a substantial 43% of total methane emissions (EU n.d.).
By implementing Best Available Techniques (BAT), the IED has the potential to achieve an estimated 8% reduction in methane emissions from cattle farms and a substantial 37% reduction from pig farms under its regulation (EU n.d.). Regrettably, this proposal did not find its way into the revised Industrial Emissions Directive (IED). As per a compromise, the Commission has an opportunity, granted until December 2026, to assess again the feasibility of extending the Directive to include cattle farms (DNR 2024).

Methane emissions are both an air pollutant and a powerful greenhouse gas, thus regulating methane emissions under the **National Emissions Ceilings (NEC) Directive** would also be possible, but has so far not been practiced. In the EU Strategy to reduce methane emissions (EC 2020a), the Commission announced its intention to evaluate the potential inclusion of methane in the list of regulated pollutants as part of the review of the NEC Directive, scheduled for completion by 2025.

Other regulations affect biodiversity and impact agricultural production intensity in the respective areas. These include the **Nature Restoration Law** and the **Flora-Fauna Habitat Directive**, which prioritise the conservation of natural habitats and species. Additionally, there are other directives, such as the **Animal Welfare, Sustainable Food System Law,** and **Healthy Soils,** which can indirectly influence agricultural emissions.

3.2 Scenarios offer further insights

The European Union aims to achieve climate neutrality by 2050. As an interim target for 2030, net greenhouse gas (GHG) emissions should be reduced by at least 55% compared to 1990 levels. The 2040 target is currently under consideration and the European Commission has proposed a net emission reduction of 90% compared to 1990. The European Scientific Advisory Board on Climate Change (ESABCC) suggests reducing emissions in the range of 90–95%.

Scenarios offer further insights into the expected GHG emissions in 2040.

3.2.1 Possible range of emissions in 2040

The European Environment Agency (EEA) presents two scenarios: one with existing measures (WEM) and another with additional measures (WAM), both based on projections from Member States assuming a continuation of the current policy framework (see Section 2.2). Additionally, the European Commission has published four scenarios (S1, S2, S3, Life), while the ESABCC has contributed two more scenarios (advice-scenario, demand-side focus scenario). Among the eight scenarios, two emphasize demand-side measures, while the remaining scenarios focus on technical reduction measures.

In the WAM scenario from the EEA and the S1 scenario from the European Commission emissions from the agricultural sector decrease by -9% compared to 2015 and by -5% compared to 2022 until 2040. These scenarios reflect the current policy framework in the agricultural sector. To gain insight into the potential role of agriculture in the 2040 target, the scenarios S2,S3, LIFE and the scenarios from the ESABCC become more relevant. For the agricultural sector these pathways indicate that net GHG emissions range from 160 to 302 Mt CO_2e. The differences arise between the S2 scenario (European Commission) and the Demand-side focus scenario by the EU Advisory Board. Compared to 2015, their projected reduction is between -21% and -58 (see Table 1). This is an extreme range and illustrates the importance of nutrition in terms of reducing agricultural emissions.

Table 1: Scenarios' assumptions for emissions from agriculture in 2040

Year Scenario	Emissions (Mt CO_2e)	Percentage reduction compared to 2022	Share of agri emissions in total emissions 2040	Assumptions on measures and drivers	Data source
2015	384				
2022	371				
EU Commission 2024 EU 2040 climate target, S1 scenario	351	-5%	33%	Current policy framework	EC (2024)
EU 2040 climate target, S2 scenario	302	-19%	52%	Larger deployment of technological options	EC (2024)
EU 2040 climate target, S3 scenario	271	-27%	76%	Full deployment of technological options	EC (2024)
EU Commission, **EU 2040 climate target, LIFE scenario (2024)**	209	-44%	59%	Change towards more sustainable food diets, reduction of food waste objectives (25% shift to realisation of EAT-Lancet planetary health diet), implementation of farm to fork and biodiversity strategy, full deployment of technological options	EC (2024)
ESABCC 2024, **Advice scenario**	283	-24%	-		ESABCC (2024)
ESABCC 2024, **Demand-side focus scenario**	163	-56%	-	Sustainable food diets based on realisation of Eat lancet planetary health diet	ESABCC (2024)

Note: Because of using different methodologies and emission factors, scenarios from different sources are not completely comparable.
Source: Own compilation based on ESABCC (2024), EC (2024)

Comparing the scenario results shows that without additional ambitious measures emission reductions in the agricultural sector are at only **-9%** compared to 2015 (see S1 and WAM scenario). By introducing ambitious measures on the supply side, about **-21 to -29%** of emission reduction can be achieved compared to 2015 levels (see S2, S3 and advice scenario). Further emission reduction is only possible if measures are implemented on the demand side which lead to reduced consumption of animal products. Depending on the assumption made on the level of animal product consumption a reduction between **-46% and -58%** compared to 2015 seems possible (see LIFE scenario and Demand-side focus pathways scenario). Along with the reduction in livestock numbers and the release of forage area, the LULUCF sector can enhance carbon sequestration in the LIFE scenario. Beyond the 60 Mt CO_2e reduction in agricultural emissions compared to the S3 scenario, there is an additional carbon sequestration of 40 Mt CO_2 within the LULUCF sector. The Demand-side focus pathways from the Advisory Board show the strongest emission reduction as healthy and sustainable diets in line with the recommendations for the planetary health diet of the EAT-Lancet Commission (Willett et al. 2019) are implemented.

All scenarios show a growing share of emissions from the agricultural sector in total emissions, with higher shares the lower total emissions decrease: In the WAM scenario, the share of agricultural emissions in total emissions rises from 11% today to 15% in 2040. At 76% of total emissions, the share of agricultural emissions is highest in S3, where the other sectors (transport, building, energy, industry) are largely decarbonised. The only way to reduce the share of agricultural emissions is through achieving more ambitious emission reductions in this sector, by reducing livestock numbers in combination with demand-side measures. This is achieved in the LIFE scenario, where the share of agricultural emissions is only 59% of total emissions (with the same level of total emissions as in S3).

All scenarios (except S1 and WAM) include ambitious mitigation options. Differences between the scenarios result from different levels of adoption of these options.

3.2.2 Glimpse on 2050

Until 2050 all scenarios achieve climate neutrality, but residual GHG emissions from agriculture remain at different levels. In 2050 mitigation options are fully applied in the scenarios, yielding a reduction of emissions of about one third compared to 2022 (see Table 2). Only by introducing measures on the demand side can further emission reductions be achieved in the agricultural sector (including full implementation of technical measures). Thus, climate neutrality can still be attained even with higher residual emissions from agriculture. However, this would place additional strain on other sectors and necessitate intensified efforts towards carbon removals and industrial carbon capture.

Table 2: Remaining GHG emissions from agricultural sector in 2050 in different scenarios

	S2	S3	LIFE*	ESABCC Advice	ESABCC Demand-side focus*
Emissions in 2050 in Mt CO_2e	249	194	268	114	
Reduction compared to 2022	-33%	-48%	-28%	-69%	

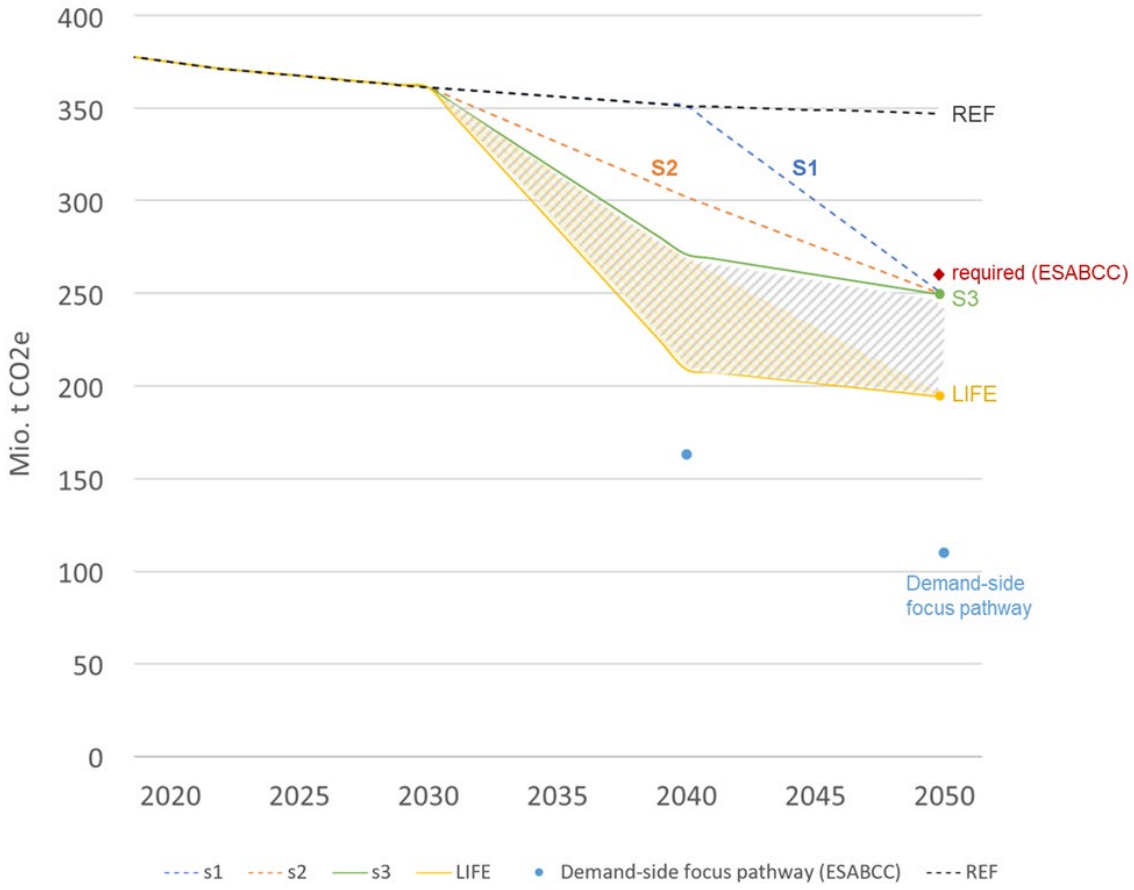
* LIFE and ESABCC demand-side focus pathway based on different ambition of dietary changes
Source: Own compilation based on ESABCC (2024), EC (2024)

3.3 Exploiting agriculture's mitigation potential

In order to determine the mitigation path up to 2050, the EU will adopt a climate target for 2040 in the coming year. In February 2024, the Commission presented a recommendation for a net reduction target of 90 percent – and in parallel, the Commission presented an impact assessment with scenario results that outline a spectrum of emissions for the year 2040 (see previous Section 3.2). In comparison, the climate expert council (ESABCC) recommends reducing emissions by a total of 90-95% by 2040.

A net reduction target of 90% lies between the results of the two scenarios S2 and S3. For agriculture, scenario S3 shows sector emissions of 271 million tonnes of CO_2e (EC 2024) in 2040, see Figure 5.

Figure 5: Broad range of agricultural GHG reduction pathways within different scenarios



Note:
S3: full adoption of technical measures
LIFE scenario: with 25% shift to optimal plant-based diet in 2040, food waste reduction, more sustainable food production
Demand-side focus pathway: shift to optimal plant-based diet in 2040 for EU citizens
Source: Own figure, based on EC (2024) and ESABCC (2023)

However, the EU Commission has not issued any further target recommendations for agriculture for the year 2050. According to the 2024 Assessment Report of the ESABCC 2050 emissions in the advice scenario amount to 268 Mt CO_2e (Table 2, (ESABCC 2024). This value is in the order of magnitude of scenario S3 for the year 2050.

Adhering to the precautionary principle, emissions from agriculture should be minimised to a greater extent than can be achieved by technical options alone. Technical sinks come at a high

cost, while the reliability of natural sinks remains uncertain due to the impacts of climate change. Against this background, the European Scientific Advisory Board on Climate Change (ESABCC) recommends the complementary implementation of demand-side policies to reduce food waste and promote plant-based diets (ESABCC 2024): two of its four recommendations address sustainable and healthy diets on the demand side (pricing agricultural emissions and incentivising consumption of plant-based products).

Given the results of the scenarios presented, this would suggest a more ambitious target than S3: **The climate targets for the agricultural sector in 2050 should at least correspond to the LIFE scenario** (EC 2024). This requires halving emissions compared to 2022. The 2040 target can be derived from the 2050 target, and a linear emissions trajectory starting from 2030 seems feasible. This is indicated by the yellow shaded area in Figure 6. The LIFE emissions in 2050 (209 Mt CO_2e) mark a value about halfway between S3 (271 Mt CO_2e) and the demand-side focus pathway of ESABCC (163 Mt CO_2e) in 2040.

4 How to achieve the necessary contribution: Discussion of possible policies and measures and options

4.1 Necessity of setting mitigation targets for agriculture

Binding targets are a prerequisite for an ambitious and effective climate policy, independent of the choice of instruments for implementing agricultural policy. Without a clearly defined target, it is impossible to assess the effectiveness of the instruments used. This principle extends to established instruments, including subsidy policies and regulatory laws, as well as other policy instruments such as greenhouse gas pricing or emissions trading.

If targets are not met, adjustments must be made. As the political process of readjustment is time-consuming (necessary analyses/projections, proposals, decisions), the target should be binding so that the GHG-mitigation process does not fall behind.

The 2040 target is the final intermediate target on the road to GHG neutrality in 2050. In order to prevent further stagnation of emissions and to stimulate further mitigation measures, the contribution of agriculture to climate neutrality at the EU level by 2050 needs to be clarified in a first step. In short: without an agriculture-specific target for 2050, no interim target can be set for 2040. Allocating targets among Member States could consider emissions per hectare[9] for agricultural activities. If needed, a distinction between N_2O and CH_4 gases could be made.

Policy is not only concerned with climate target setting for the year 2040, but also with elaborating and selecting political instruments that should be used to achieve the mitigation target. There are a number of reasons why the current policy should not be continued as is:

The EU Court of Auditors criticises the lack of effective instruments of the current agricultural climate policy, which is mainly organised within the framework of the CAP (European Court of Auditors 2021 and see Section 3.2.1). Furthermore, consumption should be steered more towards plant-based demand. It is assumed here that incentives through pricing would be particularly effective.

Current low reduction rates suggest that the chosen mix of instruments for agriculture is not effective. As already mentioned in Section 3.1.1, there is currently no binding reduction target for agriculture under the ESR and hardly any emission ceilings at farm level.[10] The influence of the LULUCF sector on the goals of agriculture is equally unclear. The widespread net view distracts from analysing and implementing emission sources and sinks and their potential.

Regarding the follow-up regulation after 2030 for the agricultural sector, various options are currently under discussion.

4.2 Policy options

4.2.1 Financical incentives and regulatory legislation

This approach means continuing the existing policy with a mix of subsidy policy and regulatory law. Leveraging existing tools and creating new ones, such as advancing the common agricultural policy (CAP) and refining regulatory laws through directive amendments, can facilitate effective implementation (see Section 3.1.4). The common agricultural policy (CAP) is an important building block. Here, climate-harmful subsidies should be stopped (e.g. coupled premiums for livestock production, direct payments for meliorated peatland sites) and dedicated, effective climate measures should be added. Another important building block is the improvement of regulatory law. However, addressing emissions in the agricultural sector requires a multifaceted approach, combining policy, innovation, and practical measures.

Post-2030, emissions not covered by an ETS (such as those from agriculture and waste) must have a defined reduction target by 2050, primarily focusing on non-CO_2 emissions.

4.2.2 Pricing agricultural emissions via taxes or levies

The objective of pricing emissions is to raise the cost of greenhouse gas-intensive products. Achieving this goal can be done through various means, including taxes, levies, or emissions trading (Isermeyer et al. 2019).

Drawing inspiration from carbon taxes implemented in several European countries, a set price for agricultural emissions could be introduced. For instance, this fixed price might apply to CH_4 emissions from ruminant digestion or N_2O emissions resulting from nitrogen fertilisation. Implementing such pricing mechanisms would encourage emissions reduction efforts while also generating state revenues. These funds could then be directed toward further activities aimed at reducing emissions. A tax is defined as an unrequited payment to the government. Therefore, the direct reallocation to the agricultural sector is not guaranteed. This is a drawback if the tax is levied directly at farm level and if the farms are not able to pass the additional costs on to the value chain. Taxes or levies cause also costs on the part of consumers, and resultant social impacts need to be managed. Accordingly, there are various interest groups that could benefit from the carbon taxes collected.

Nevertheless, this approach offers less direct oversight over the development of emissions when contrasted with an emissions trading system that operates under a fixed cap. Regular adjustments to the pricing level would be required to align with emission trends. However, securing political consensus on a clear emissions reduction trajectory remains crucial. Although theoretically feasible, harmonising minimum tax levels across the EU — similar to the principles outlined in the Energy Taxation Directive — may encounter practical hurdles due to the EU's unanimity rule governing tax-related decisions.

[10] Except large animal farms which are subject to the IED.

4.2.3 Emissions trading for agriculture

Expanding beyond a fixed greenhouse gas (GHG) price, the introduction of tradable emissions certificates emerges as an alternative. One option is integrating the agricultural sector into the existing ETS2 framework, which currently encompasses emissions from road transport, buildings, and small installations. Alternatively, discussions are ongoing about introducing a third emissions trading system within the EU. This system could include the agricultural sector only or extend beyond the agricultural sector to include sectors currently not covered by a successor regulation under the existing ESR (waste, LULUCF). An ETS could be flanked by an ESR to avoid unequal burdens of an ETS resulting from different regional conditions (see Section 4.3.1).

Establishing an absolute cap within the system is essential for issuing emission credits. Only when the appropriate system for agriculture has been determined (whether it is ETS2, a separate AgriETS, ETS for all sectors outside ETS1 and ETS2, or AgriETS combined with LULUCF) will it become evident whether a precise definition of the emissions pathway for agriculture is necessary.

Implementing an ETS involves addressing several critical questions. These questions encompass:

1. Who bears the obligation? Where along the value chain should emission certificates be traded?
2. What emissions should fall under the system's coverage? Should it include only livestock emissions (CH_4 and N_2O), emissions from fertiliser use (N_2O), all farm-related emissions, or even CO_2 emissions from organic soils?
3. How do free allowances factor into the system?
4. Is it appropriate to incorporate natural sinks? Can agricultural emissions be offset through carbon sinks from natural processes?

Many of these questions are still open and cannot be answered briefly. Therefore, only a brief classification of the points of obligation and some overview is given below. All figures of this section are taken from Bognar et al. (2023) and EU GHG inventory submission to UNFCCC (EEA 2023b).

Upstream: Manufactures or traders of fertilisers and animal feed

Manufacturers and traders of nitrogen fertilisers or animal feed would bear the responsibility of procuring emission allowances. They must acquire these allowances on behalf of farmers to cover nitrous oxide emissions resulting from fertiliser use, as well as CH_4 emissions from enteric fermentation. Additionally, feed and fertiliser suppliers have the flexibility to directly incorporate additives into fertilisers or animal feed. The cost of purchasing emission certificates can be incorporated into the price of fertilizers.

Number of actors:
Manufactures of prepared feed for farm animals: 3,786
Manufactures of fertilisers and nitrogen compounds: 1,509

Amount of emissions covered: CH_4 from enteric fermentation, N_2O from mineral fertilisers, CO_2 from urea application: 58% of total emissions (220 Mt CO_2e in 2021).

Direct obligation for farms

Farmers will be required to purchase allowances to cover their on-farm emission budget. A crucial prerequisite for this system is the establishment of comprehensive greenhouse gas

(GHG) balances for each regulated farm. These balances serve as the foundation for acquiring the necessary emission allowances. It is important to acknowledge that the administrative burden associated with maintaining GHG balances at the farm level could pose a potential constraint for direct farm obligations. Nevertheless, there are ongoing initiatives related to climate balancing on farms.

Number of actors: > 9 million farms, 2.3 million with more than 10 ha per farm

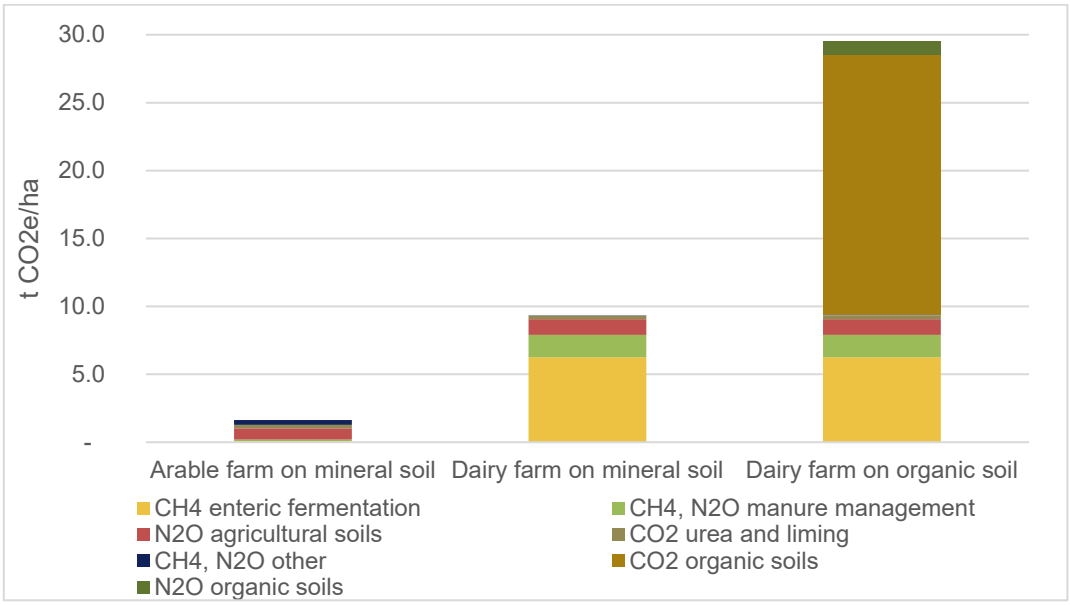
Amount of emissions covered: Up to 100%, depending on number of farms included. Additionally emissions from energy consumption on farms and CO_2 emissions from land use could be included. (378 Mt CO_2e from agriculture, 78 Mt CO_2e from energy consumption on farms, 78 Mt CO_2e from organic soils in 2021)

GHG emissions at farm level and relevance of organic soil emissions

GHG emissions at farm level differ substantially between regions and farm types. Emissions per hectare in Germany in arable farms are on average 1,3 t CO_2e.. On dairy farms GHG emissions per hectare are on average 6 t CO_2e., ranging from about 3.5 to 4 t CO_2e/ha in the eastern federal states up to 9 to 10 t CO_2e/ha in the federal states in the northwest of Germany with high livestock density. Taking into account emissions from organic soils for farms located in the peatland-rich regions increases GHG emissions per hectare dramatically. Figure 6 shows the emission sources at farm level for arable farms and for dairy farms on mineral soils and on organic soils in Germany. There are very low emissions on arable farms on mineral soils compared to dairy farms on mineral soils. The total emissions from dairy farms on peat soils are approximately three times greater than those from dairy farms on mineral soils.

Given the high emissions per hectare for farms in peatland regions it becomes obvious that instruments dealing with emissions from organic soils need to be established.

Figure 6: On-farm GHG emissions for arable farms, dairy farms and dairy farms on organic soils



Source: Own calculation Oeko-Institut based on LISE-Modell

Downstream: Dairy and meat processors

Allowances are essential for managing emissions from agriculture at the processing level. Dairy companies or slaughterhouses must procure allowances to offset greenhouse gas (GHG) emissions associated with the volume of milk or meat they purchase. Verification is typically based

on operational data or more detailed GHG balances from the farms. These companies can address the additional cost in two ways: firstly, by adjusting the purchase price based on the GHG balance of the milk, and secondly, by passing any remaining costs on to consumers.

Number of actors:
Meat processors: 34,066, more than 50 employees: 2,619
Dairy processors: 12,634, more than 50 employees: 909

Amount of emissions covered: 261 Mt CO_2e (68% of total emissions) = direct emissions from CH_4 enteric fermentation and CH_4 and N_2O from manure management (excluding animal feed, excluding peatland), in principal also N_2O and CO_2 emissions from forage production could be covered, but this requires detailed GHG balances at farm level.

Challenges of price approaches from the perspective of farms

Some of the options presented lead to carbon costs directly at farm level, particularly in the case of the focus on regulatory law in the target-based approach and an ETS with direct obligation at the farms. In this case, it should be ensured that the costs of agriculture are passed on to the value chain, firstly, to create a price signal for consumers, and secondly, to reduce the financial risk for farms. An EU regulation to strengthen the market position of agriculture is required here, as is already being discussed today (in various MS).

Another aspect is the trading of allowances in the case of a farm-based ETS. In addition to the effort required to improve farming practices and to account for greenhouse gases, farmers also have to deal with emission allowances.

The question arises whether the farms are well equipped for this. Trading involves administrative effort and costs. Challenges include responding to fluctuating prices, having a good understanding of the costs associated with their own mitigation options, and overall cost transparency. Trading could also be organised through intermediaries. Both Bognar et al. (2023) and Verschuuren et al. (2023) see advantages in terms of administrative burdens and trading with an ETS using an upstream or downstream approach.

4.3 Challenges of target setting and monitoring

4.3.1 Different target setting levels

Environmental legislation sets target values for environmental quality in a target year (NEC-D, Nitrate-D, FFH-D etc.). Different binding regulations are required for their realisation, depending on the extent to which these targets are to be implemented through regulatory law. The most binding requirements are in the area of activities subject to authorisation. Agriculture is only affected by this to a small extent. The most important exception is large livestock farms, where upper emission limits are applied directly (see for example Industrial Emissions Directive). Emissions from soils and smaller stables are more diffuse and less strictly regulated and implementation of emission reduction targets is carried out by further regulations like further national regulation and conditionalities in the framework of direct payments of the CAP.

Today, there is no explicit regulation of GHG limits at farm level, as emissions are only indirectly addressed by existing regulations – for example the NEC Directive and the Nitrate Directive which limit nitrogen emissions to air and water. And the ESR sets national targets for emission reductions from several sectors, including agriculture.

There are various options for anchoring emission targets for the agricultural sector in the existing regulations or in new systems (ETS).

Table 3: Existing and potential new regulations for climate target setting in EU agriculture

Target setting level	Description	Adoption Level
Effort Sharing Regulation	Under the Effort Sharing Regulation, national emission targets could be established in addition to the EU mitigation instruments which cover the agricultural sector.	EU and national
Emission trading system (New)	An absolute emissions limit is an essential prerequisite for emissions trading. The EU Emissions Trading System (EU ETS) is based on the principle of cap and trade. An absolute cap is set on the total amount of defined GHG emissions that may be emitted each year by the entities covered in the system. This cap is reduced over time in order to reduce overall emissions.	EU
NEC Directive	Just as with the existing approach for ammonia and other pollutants, national targets for methane reduction could be established for a specific target year under the NEC Directive, if methane is recognised as a significant air pollutant and included under the NEC Directive. Nitrous oxide (N_2O) is not part of the NEC regulation.	National
Industrial Emissions Directive (IED)	Binding emission limit values are set for CH_4, NH_3 and other emissions. These limits vary depending on the type of animal, the size of the facility and other factors.	On-farm
Common agricultural policy (CAP)	The funding of the common agricultural policy could be tied to climate targets. At the EU level, an EU target can be enshrined in EU CAP regulations (e.g. CAP strategy plan regulation 2021/2115), while Member States could anchor national targets within their strategy plan regulations. These targets could then be implemented through measures aimed at promoting greenhouse gas (GHG) reduction at farm level. Emission targets could also be set for different types of farms.	EU, national, on-farm
GHG obligation for dairy and meat processors (New)	Just as with the GHG quota in transport, a mandatory GHG quota to reduce emissions from milk and meat production by x% could be set. This could also be established for dairies and slaughterhouses to mitigate emissions from milk and meat production. This quota could be achieved through the implementation of technical measures in animal husbandry or by expanding the availability of plant-based alternatives in the product range, such as oat milk and pea-based meat.	On-farm, processors, national?

Regardless of the policy options or specific instruments chosen, the Effort Sharing Regulation can be sustained. Establishing emission targets under the ESR for 2040 and beyond could serve as a safety net to ensure emission reductions, even if other mechanisms like an ETS falter (as observed in the beginning of the ETS1). Primarily, ensuring the equitable distribution of an EU-wide target among Member States and ensuring compliance with these targets at the Member State level continues to be a significant responsibility under the Effort Sharing Regulation.

A specific target for the agricultural sector can be established as a cap within an agricultural Emissions Trading System (ETS). In addition, the Effort Sharing Regulation (ESR) could set an overall cap for non-CO_2 emissions. Consistency between the ESR and the ETS cap must be ensured.

From the perspective of agricultural stakeholders, the IED sets the most specific requirements by specifying maximum quantities for individual gases by animal species at farm level. Emissions trading sets the lowest targets at farm level. In an ETS, the reduction pathway is described

by the upper limit, which must be politically agreed. At farm level, each individual farm can decide whether and what to reduce.

From a political point of view, the lower regulatory requirements of an ETS are attractive as the number of decisions could be lower and there might be less opposition or rejection. Once the system works, only minor corrections are necessary, whereas the other options require additional measures in the event of a deviation from the target. Further regulatory requirements as well as carbon price adjustments would be again part of political negotiations. If the group of obligated parties is heterogeneous, it remains less clear who must contribute to the reduction. This could lead to fewer starting points for criticism. In addition, target contributions among the EU Member States will not be part of the debate.

However, even with the introduction of emissions trading in agriculture, regulations like the NEC Directive or the IED Directive are expected to persist, necessitating negotiations at this level for setting targets.

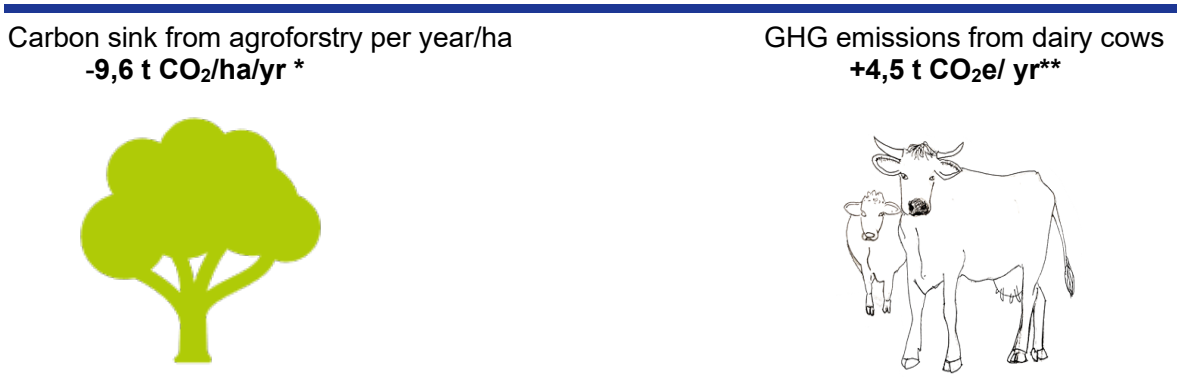
4.3.2 Addressing emissions from Land Use and Land use change

The future of LULUCF (Land Use, Land-Use Change, and Forestry) regulation for the period after 2030 remains uncertain. Discussions are ongoing regarding the Carbon Removal Certification Framework (CRCF) and the integration of carbon removals into the Emissions Trading System (ETS).

For any follow-up regulation on addressing emissions from land use and managing carbon sinks induced by agricultural practices it is crucial to **set up separate targets for emissions and sinks from land use**. At present, emissions and sinks induced by agricultural activities are "invisible" since they are overlapped by the large forest sink. Especially the high emissions from peatlands (see Figure 6) and the high carbon sinks from agroforestry (see Figure 7) in comparison to GHG emissions in agriculture remain relevant in the discussion.

Integrating these emissions and sinks into other ETS systems (such as ETS1, ETS2, or Agri-ETS) requires careful consideration of potential effects. These effects relate to land use and pricing implications, especially if farmers can establish a carbon sink at moderate costs. Additionally, policy must address the permanence of the sink and discuss which emissions should be offset by non-permanent removals (Meyer-Ohlendorf et al. 2023).

Figure 7: GHG emissions from dairy cows (direct CH_4 and N_2O emissions) in comparison to carbon sinks from agroforstry



Note: * Corresponds to the average carbon sequestration within a 20-year period. ** Includes only direct CH_4 emissions from enteric fermentation and direct CH_4 and N_2O emissions from manure management, EU average
Source: EEA (2023b); Scheffler et al. (2023)

4.3.3 Monitoring, reporting and verification of farm emissions

Implementing an ETS or other systems faces a significant challenge due to the complexities of measuring emissions directly at the farm level. Looking at the different policy options outlined in Table 3, there are also other policy options that require measuring emissions at farm level. This includes for example the Industrial Emissions Directive, where farms are obliged to prove compliance with the emission limit values. However, the IED only affects companies above a certain size. But also in case that financial support becomes a robust instrument for supporting climate mitigation measures, demonstrating the reduction in emissions resulting from these measures at the farm level becomes highly relevant. In addition findings from the Thünen Institute survey of German dairies indicate that a substantial number anticipate continued pressure from both food retailers and the industry for providing information and improving the climate footprint of the products (Agethen and Lassen 2022). The same would apply in case of a downstream ETS. Only an upstream ETS, which obliges the traders of nitrogen fertiliser and animal feed, could potentially eliminate the need for a GHG balance at farm level.

However, climate balancing at farm level is already being practised today and there are calculation standards for individual farm climate balances available.[11] Under the Integrated Administration and Control System (IACS) of the EU agricultural policy, farmers are obligated to report a wealth of farm-specific information in order to receive payments under the common agricultural policy (CAP). This data can be leveraged and integrated with greenhouse gas reporting to ensure farm-level accounting consistency with UNFCCC reporting. Furthermore, farm balances for nitrogen are closely related to the data requirements for a greenhouse gas balance. In countries where the efficiency of nitrogen utilisation is monitored in this way, an important element for a GHG balance already exists.

Despite the many starting points, GHG accounting for farms is an additional task and a challenge for smaller farms. The use of de minimis thresholds could offer a solution to exempt smaller farms from the obligation, but also to limit the complexity and administrative costs of an ETS. As with the verification of GHG savings under the RED, a more differentiated approach could be introduced on a voluntary basis.

Overall, a GHG-balancing tool for farms appears to be necessary, which uses IACS to avoid time-intensive data input and which is able to present GHG emissions consistently with the inventory. However, the inventory reference also leads to a problem for dairy farms, because organic farms and farms with grassland-based milk perform worse if the emissions from the upstream chain and carbon sequestration are not taken into account.

It can be assumed that GHG reporting represents an additional reporting obligation for farms. Reducing the overall bureaucratic burden for farms is another, independent task.

4.3.4 Challenges from inventory reporting

The measurement quality of greenhouse gas (GHG) emissions in the agricultural sector varies among Member States. While some Member States rely on Tier1 methods due to the absence of detailed data and emission factors, others have country-specific measured data available and can apply Tier3 methods for GHG reporting. This discrepancy poses a significant challenge in the agricultural sector compared to other industries. For instance, in the transport sector, saving one litre of diesel results in consistent emissions reduction across all Member States. However, when it comes to reducing emissions from synthetic nitrogen fertiliser, the impact

[11] For Example in Germany (Effenberger et al. 2021) as well as in France. The latter includes also certification of greenhouse gas reduction and carbon sequestration projects (Bas Carbone label), low carbon footprint premium in the rapeseed supply chain to fulfil the RED II Directive and also a low carbon agri-environmental and climate measure based on a greenhouse gas assessment at farm level (EEA 2024).

differs. In Germany, a reduction of one kilogram of synthetic nitrogen fertiliser leads to a decrease of 3.0 kg CO_2e/kg N, whereas in Poland, Bulgaria, and other Member States using at least partially the IPCC default emission factor, the reduction is approximately 5.5 kg CO_2e/kg N. Consequently, the same mitigation measure can yield varying emission reductions based on the chosen reporting methodology.

This fact requires also careful consideration when thinking about the implementation of an emission trading system in the agricultural sector. For example, this might be relevant when it comes to the distribution of free allowances. But it can also affect the level of productivity in certain Member States if emissions from fertilisation have larger mitigation effects in one country than in another (e.g. attractiveness for extensifying production at high GHG prices and high emission factors).

4.4 Role of common agricultural policy

So far, the CAP as a central instrument for the EU agricultural sector has not succeeded in making a major contribution to climate protection. Nevertheless, looking ahead, the CAP will continue to play a focal role in agriculture. Given its extensive history, the CAP consolidates valuable experience, data, and relevant institutions for regulating the agricultural sector. To ensure a future-oriented common agricultural policy (CAP), it is imperative to phase out climate-damaging subsidies and consistently align all subsidies with climate protection targets. The future role of agricultural policy hinges on the mix of policy options implemented.

Finanicial incentives and regulatory law

The CAP will play a crucial role in enhancing climate protection measures. The CAP would continue to provide financial support for the establishment of agroforestry systems, for investments in technical mitigation measures (e.g. biogas plants for manure digestions) and for the rewetting of organic soils. In addition obligations under the **conditionality** could be used to implement climate protection. This could include for example the introduction of the **farm sustainability tool for nutrients**, which was under discussion for the current CAP period 2023-2027 and contains a complete nutrient balance. Unfortunately, this sustainability tool was cancelled in the final version of the CAP directive. It is also possible to regulate the use of additives to mitigate CH_4 emissions from digestion and N_2O emissions from fertilisation through the common agricultural policy (CAP). This regulation could take the form of either mandatory conditionality or subsidies.

On the other hand, an **incentive system** could be established that rewards farmers for reducing their **hectare-specific farm emissions**. This could be done through technical measures or by reducing livestock numbers. This is already established in France with the “Low Carbon” Agri-Environmental and Climatic Measure (AECM)[12]. This AECM offers a 18,000 euro payment to farms which manage to reduce emissions by at least 15% within five years. (EEA 2024)

To ensure a significant contribution to climate protection through the CAP, additional funds will be necessary. This is particularly true considering that other objectives such as biodiversity will continue to be relevant.

It is crucial to assess the proportion of existing CAP funds allocated to climate-damaging subsidies (such as the direct payment subsidy for peatland cultivation) and to redirect these resources to future climate protection measures.

[12] Agri-Environmental and Climatic Measures are one type of payment for environmental services that can be implemented with common agricultural policy budget.

GHG pricing system

The introduction of a GHG pricing system at farm level reduces the role of conditionality within the CAP. Emission reduction is incentivised by paying a certain price for on-farm GHG emissions. To alleviate the burden on farms, the support of climate protection measures can remain under the CAP. The CAP can maintain and enhance further support measures aimed at reducing greenhouse gas emissions. These measures may include investment aids for biogas plants for anaerobic digestion of manure and other relevant measures.

The funding for these climate protection measures can be sourced from the revenues generated by the GHG pricing system.

Emissions trading system

Under an Emissions Trading System (ETS), the common agricultural policy (CAP) must serve as a robust instrument for advancing climate protection measures among small farms. Small farms are potentially excluded from an emission trading system, due to a de-minimis threshold.

With an emissions trading system in place, the CAP must evolve into a robust instrument for advancing other environmental aspects that might otherwise be compromised by the Emissions Trading System and the associated risk of intensification. These aspects include organic farming, extensive grassland utilisation, and biodiversity promotion. At the same time, the CAP can cushion the impact of emissions trading on companies by continuing to pay investment aids and other subsidies for climate protection measures. Analogous to the GHG pricing system, the revenues generated from the Emissions Trading System (ETS) can be utilised to fund climate protection measures under the CAP.

4.5 Effects on consumers and diets

Ambitious climate targets in the agricultural sector hinge on consumer action. Reducing animal product consumption, coupled with a decrease in livestock numbers on the supply side, is essential for achieving substantial emission reductions in the agricultural sector. Besides supporting measures in the field of consumption (e.g. information and education measures) the introduction of a price signal to reflect the GHG intensity of a product is useful. The measures discussed in this chapter lead to different effects on the price level of products.

Extensive funding for climate protection measures at farm level will only have a marginal impact on consumers' dietary choices. In this case, the low price signal to consumers persists as farmers receive compensation for their climate protection efforts and therefore do not have to transfer costs to consumers. There is a higher effect on consumer prices if there is a higher share of regulatory law in the agricultural sector.

Depending on the mix of both options the implementation of further measures at the demand side to tackle the high consumption of animal products could be necessary. This can be achieved by raising VAT rates on animal products or introducing a GHG price at the final consumption level. With a focus on funding measures, GHG savings are limited to technical measures.

By implementing a GHG pricing or an ETS system e.g. at farm level or another point of obligation, costs could be directly passed on to consumers. The higher the GHG price and the lower the free allowances in the system, the more pronounced the impact on consumer prices. This, in turn, influences the level of reduction in the consumption of animal products.

As the price signal strengthens, consumer costs rise and it becomes crucial to consider the impact on low-income households. Exploring the implementation of a climate fee as a means

to offset extra expenses is an ongoing topic of debate. Currently, discussions primarily revolve around the elevated energy costs associated with this approach. Nevertheless, if pricing agricultural GHG emissions or an ETS will drive up the price for animal-sourced food products, it is essential to compensate rising food expenses for low-income households.

With the increase of consumer prices, particularly for animal products, external safeguards to avoid carbon leakage become necessary. Otherwise, inexpensive goods may flood the market through imports. Under the Carbon Border Adjustment Mechanism (CBAM) external protection for specific greenhouse gas-intensive products is being established. Consequently, it warrants exploration to what degree animal products, and potentially other agricultural items, can be incorporated into the CBAM framework to mitigate carbon leakage.

5 Conclusion and recommendation

To summarize this report, the following key points have been identified:

1. The European Union should establish binding targets for agriculture's contribution to climate neutrality at the EU level by 2050. These targets must extend beyond technical emission reductions and encompass the demand side. This is associated with a reduction in livestock numbers.
2. The climate targets for the agricultural sector in 2050 should at least correspond to the LIFE scenario (EC 2024). This requires halving emissions compared to 2022. Setting of relative targets prevent weakening due to methodological changes. The 2040 target can be derived from the 2050 goal, and a linear emissions trajectory starting from 2030 seems feasible.
3. A significant contribution from the demand side by reducing the consumption of animal products is also needed to reduce the land footprint of food consumption and to achieve the other objectives of the Green Deal such as biodiversity, circular economy and extensification.
4. Continuing the Effort Sharing Regulation remains a viable option for a fair distribution of the EU target among Member States and to serve as a safety net. This also applies if a future ESR includes only an overall emission target for example for all non-CO_2 emissions and irrespective of the specific instruments (such as emissions trading or a mix of non-pricing mechanisms) employed to achieve the target.
5. Urgent action is needed to establish targets and instruments latest for the next CAP period starting in 2028 and for the implementation of GHG-pricing instruments.
6. The CAP will remain an important instrument for the agricultural sector and the strategic design of the upcoming CAP period from 2028 to 2035 is relevant for the sector's meaningful contribution to climate action.
7. The implementation of emissions trading or greenhouse gas pricing will become relevant in attaining climate targets. The precise point of obligation for emissions trading or GHG pricing remains an open question. However, the approach involving milk and meat processors, coupled with GHG balances at farm level, seems promising, whereas unanimity limits the EU's power in the field of taxation.
8. In addition to implementing an emissions trading system, it is crucial to establish robust instruments that ensure the successful implementation of the European Green Deal, including the biodiversity strategy and climate change adaption. Simultaneously, continued funding is essential to support the sector's social resilience. This necessitates additional financial resources for the sector (e.g. integration into the CAP, creation of a nature restoration fund), sourced partly from emissions trading revenues and other financing mechanisms. Overall, this has to be combined in a broader package by bringing up a rural deal to support rural regions.

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