Climate adaptation and mitigation in the agri-food system

Recommendations for coherent EU policies

Technical Annex

CONTENTS

This technical annex provides detailed assessments of key mitigation and adaptation options for the agricultural sector, covering practices ranging from agroforestry and precision farming to dietary shifts and wetland restoration. Each option is evaluated across a consistent framework examining its contribution to climate mitigation and adaptation, co-benefits and trade-offs, costs and impacts on yields and farmers' incomes, and current level of uptake.

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1. Crop rotation (focus on improved crop rotation)

Description

Improved crop rotation involves growing different types of crops in a specific sequence on the same field over multiple growing seasons. This practice aims to manage environmental pressures, balance nutrients and water, improve crop performance, and enhance the resilience of farming systems. It often includes primary cereals, secondary cereals, grain legumes, and temporary fodder crops.

Contribution to climate mitigation

- **Carbon sequestration**: Crop rotations, particularly those involving legumes, enhance soil organic carbon (SOC) stability. Rotations with legumes and grass leys contribute to long-term increases in soil carbon stocks.
- **N_2O emissions**: Incorporating legumes in crop rotations results in lower N_2O emissions compared to non-leguminous crop rotations (Weiner et al., 2024).

Contribution to climate adaptation

- **Sustainability and resilience**: Diversifying crop rotations enhances sustainability and resilience to yearly weather fluctuations, promoting consistent yields (Macholdt et al., 2020). Incorporating permanent grassland, forage or grain legumes boosts resilience to hot and dry conditions by preserving soil moisture and enhancing plant access to water (Zou et al., 2024).
- **Yield resilience**: Diversity within farms positively influences yield resilience, reducing the chance of losses or failure (Dardonville et al., 2020). Further diversification in crop rotation boosts temporal yield stability and enhances the yield of individual crops. Grain yields improve with greater species diversity, with significant benefits observed over time (Gaudin et al., 2015; Macholdt et al., 2020).

Co-benefits and trade-offs

- **Soil health**: Rotations with greater complexity result in increased soil multifunctionality, bacterial species richness, microbial abundance and diversity, supporting soil health and fertility (Li et al., 2021; Tiemann et al., 2015).
- **Biodiversity**: Diversifying crop rotations enhances agrobiodiversity, providing more habitat niches for wildlife and improving natural pest control (Frelih-Larsen et al., 2022).
- **Ecohydrological regime**: Improved crop rotations manage the ecohydrological regime by increasing daily discharge, groundwater seepage and reducing evapotranspiration (Sietz et al., 2021).
- **Soil erosion**: Crop rotation reduces soil erosion and decreases the need for N-fertilisers due to the nitrogen-fixing capacity of legume crops (Blanco-Canqui, 2018).

Costs and impacts on yields and farmers' incomes

- **Marginal abatement costs**: Costs vary widely, with estimates ranging from EUR 49 to 124 per tCO_2e (Tang et al., 2016). Some studies indicate potential cost savings, with costs as low as EUR -45 per tCO_2e for crop rotation (Tang et al., 2016).

Level of uptake

- **Current practices**: Cereals dominate the arable landscape for crop rotations in Europe, making up 75% to 100% of rotations. Legumes are rarely included, accounting for only 0.6% of rotations (Vanino et al., 2019).
- **Funding and policy**: Funding for voluntary measures related to improved crop rotation is available through eco-schemes and agri-environmental and climate measures under the CAP. However, there are no specific requirements on the degree of variation or inclusion of beneficial crop types (EC, 2023c).
- **Barriers**: Barriers to diversifying crops include limited knowledge, local experience, suitable machinery, market outlets for minor crops and systemic issues such as insufficient consumer demand and limited public R&D (Frelih-Larsen et al., 2022).

2. Improved nitrogen management

Description

Improved nitrogen management on croplands and grasslands aims to reduce N_2O emissions linked to fertiliser and manure use. Practices include adjusting application rates to expected yields and local soil conditions, optimising the timing of fertiliser delivery and using different fertiliser types such as controlled-release fertilisers (CRFs) and nitrification inhibitors, as well as precision farming approaches like variable rate technology (VRT) for nitrogen application. Combining these agronomic and technological measures is likely to achieve the greatest N_2O reductions.

Contribution to climate mitigation

- **Nitrification inhibitors**: These have a mitigation potential of 11 $MtCO_2e$ for the EU-28 between 2010 and 2030 (European Commission. Joint Research Centre., 2020).
- **Better timing of fertilisation**: This practice has a lower mitigation potential, estimated at 0.08 $MtCO_2e$ for the EU-28 between 2010 and 2030 (European Commission. Joint Research Centre., 2020).
- **Optimised practices**: Practices such as timing of planting, harvest and fertilisation can reduce N_2O emissions from croplands by 21% (Molina-Herrera et al., 2016).

Contribution to climate adaptation and resilience

- **Food productivity**: Improved cropland management, including nutrient management, is essential to maintain current crop production levels while respecting environmental boundaries for nitrogen pollution. In the EU, reducing nitrogen inputs to comply with thresholds for biodiversity, surface water and groundwater quality without improving nitrogen use efficiency (NUE) would reduce crop production by approximately 50%. However, improving NUE through better management practices can reconcile around 80% of current EU crop production with these environmental thresholds (Schulte-Uebbing and De Vries, 2021).

Co-benefits and trade-offs

- **Soil health**: Overuse of mineral fertilisers can degrade soil health by inducing acidification, reducing microbial diversity and disrupting nutrient cycling (Geisseler and Scow, 2014). CRFs can mitigate these impacts by improving nitrogen use efficiency, reducing reactive nitrogen losses to the environment and better synchronising nutrient supply with crop demand.
- **Ammonia emissions**: Nitrification inhibitors might increase ammonia emissions, posing risks for biodiversity and human health (Erisman et al., 2011; Zaman and Nguyen, 2010).

Costs and impacts on yields and farmers' incomes

- **Marginal abatement costs**: Nitrification inhibitors and VRT have relatively low abatement costs, estimated at EUR 40 and EUR 10 per tCO_2e, respectively (Maglia and Raimondi, 2025). Better timing of fertilisation has higher costs, between EUR 60-100 per tCO_2e abated (European Commission. Joint Research Centre., 2020).

Level of uptake

- **Environmental efficiency**: There are significant disparities in environmental efficiency, including nutrient use efficiency, across EU crop production systems, with some Member States demonstrating higher efficiency than others (Lassaletta et al., 2014).
- **Policy incentives**: The EU Nitrates Directive and Water Framework Directive set mandatory requirements for nutrient management. The CAP 2023–2027 provides additional voluntary funding through eco-schemes (e.g. precision farming, enhanced crop diversification, reduced inorganic fertiliser use) and agri-environment-climate measures under Pillar 2 for longer-term commitments such as integrated nutrient management (EC, 2023c).
- **Barriers**: Barriers to adoption include technical challenges, financial constraints, inconsistency in decision support tools, and concerns about food safety and human health (Kuśmierz and Skowrońska, 2024; Nicholson et al., 2020).

3. Reduced tillage

Description

Reduced tillage is a soil conservation technique that minimises soil disturbance, including methods such as minimum tillage, subsoil tillage, non-inversion or shallow inversion. Unlike conventional tillage, which involves deep soil inversion, reduced tillage aims to disturb the soil as little as possible. No-tillage (or zero tillage) is a specialised form where seeds are sown directly into the soil without prior tilling.

Contribution to climate mitigation

- **Carbon sequestration**: Reduced tillage can increase soil organic carbon stocks, with sequestration rates estimated at 0.09–0.27 tCO_2/ha/yr (Farmaha et al., 2022). At EU scale, projections suggest potential sequestration of 9–38 $MtCO_2$/year by 2050, depending on carbon prices (Frank et al., 2015).
- **N_2O emissions**: Reduced tillage can increase soil N_2O emissions, but long-term implementation (>10 years) significantly reduces these emissions, especially in dry climates (van Kessel et al., 2013).
- **Increased mitigation from combination with cover crops**: The mitigation potential of reduced tillage can be enhanced when combined with cover crops (IPCC, 2014).

Contribution to climate adaptation and resilience

- **Soil properties**: Reduced tillage enhances soil drainage, stability, and protects surface soil from erosion, improving water holding capacity and ecosystem services such as water regulation and filtration (EEA, 2019).

Co-benefits and trade-offs

- **Biodiversity**: Reduced tillage positively influences soil properties, contributing to a biodiverse ecosystem. However, it may increase the need for pest and weed control and the survival of soilborne plant pathogens (EEA, 2019).
- **Soil health**: It enhances microbial biomass, activity and diversity, particularly favouring fungal communities (Emmerling, 2007)
- **Leaching risks**: No-tillage systems may increase nitrate and pesticide (mainly herbicides) concentrations, indicating a trade-off between improving soil structure and increasing the risk of leaching agrochemicals (Blanchy et al., 2023).

Costs and impacts on yields and farmers' incomes

- **Marginal abatement cost**: Costs vary, with estimates ranging from EUR 2 per tCO_2e to EUR 250 per tCO_2e, depending on the practice and location (Bamière et al., 2023).
- **Yield impact**: No-tillage may result in a small reduction in crop yields compared to conventional tillage in the short- and medium-term. However, ridge tillage (where crops are planted on permanent raised beds) and strip tillage (where only narrow bands along crop rows

are tilled, leaving the inter-row area undisturbed) may result in higher yields (Achankeng and Cornelis, 2023).

Level of uptake

- **Current practices**: Conventional tillage is predominant in the EU-27, applied to approximately two-thirds of arable land. Conservation tillage accounts for nearly one-fifth, and zero tillage for 3.7% of arable land. The remaining share comprises arable land for which tillage practices are not recorded, such as areas under temporary grassland or multi-annual crops (Eurostat, 2020).
- **Barriers**: Barriers include yield penalties, increased weed pressure, and the need for specialised equipment. No existing policy incentives encourage the uptake of reduced tillage in Europe (Blanchy et al., 2023).

4. Cover crops

Description

Cover crops are grown to provide vegetative cover on soil between the cultivation of two main crops. Summer cover crops are grown during the summer months, while winter cover crops protect the soil during the winter period. They are also referred to as catch crops, since they uptake nitrogen and other nutrients left in the soil after a cash crop thereby reducing nitrate leaching and water pollution.

Contribution to climate mitigation

- **Carbon sequestration**: Cover crops increase carbon storage by enhancing the carbon sink capacity of agroecosystems. The CO_2 sequestration rate in the EU ranges between 0.15 and 0.47 tCO_2e/ha/year (Lugato et al., 2020).
- **Non-CO_2 emissions**: They can reduce N_2O emissions by decreasing nitrogen fertiliser use and reducing leaching. However, under certain conditions, cover crops may increase N_2O emissions (Schön et al., 2024). Legume cover crops provide biological N-fixation (Peoples et al., 2009).
- **Energy-related emissions**: The production, processing, packaging and transport of cover crop seeds generate additional emissions, which should be considered in the total climate impact assessment (Schön et al., 2024).

Contribution to climate adaptation and resilience

- **Soil properties**: Cover crops improve soil properties and hydrological functions, enhancing water regulation and infiltration capacity, while reducing surface runoff (Blanchy et al., 2023).
- **Soil resilience**: They increase soil organic matter, promote stable aggregation and enhance bio-porosity, improving soil moisture retention and plant-available water capacity (Blanchy et al., 2023).
- **Trade-offs**: Continuous living cover may lead to higher water consumption, potentially affecting groundwater recharge in dry climates (Blanchy et al., 2023).

Co-benefits and trade-offs

- **Ecosystem services**: Cover crops improve nutrient cycling, enhance soil biology, increase biodiversity, and restore soil structure. They also minimise soil erosion and nutrient leaching (Gentsch et al., 2022).
- **Environmental impact from termination (trade-off)**: The choice of termination method (herbicides, shallow tillage) can influence overall sustainability. Herbicides such as glyphosate raise environmental and health concerns, while mechanical methods may increase soil disturbance and fuel use.

Costs and impacts on yields and farmers' incomes

- **Marginal abatement cost**: The cost for winter cover crops as an EU standalone measure is around EUR 150 per tonne CO_2e (Perez Dominguez et al., 2020).

- **Yield impacts**: The impact on yields varies by region and crop type. While cover crops can enhance soil health and potentially increase yields, some studies report lower yields in certain conditions (Scavo et al., 2022).
- **Economic benefits**: Cover crops introduce costs related to seed purchase, planting and termination but can provide additional economic benefits through forage and grazing opportunities (Rivière et al., 2022).

Level of uptake

- **Current adoption**: An estimated 10–15% of the EU's total arable land is under cover or catch crops during the winter season. Adoption varies considerably across regions: it is highest along the Atlantic coast (with wetter summers and warmer autumns favouring establishment), but lower in both Southern Europe due to water scarcity and Northern/Continental Europe where late harvest dates and short, cool autumns limit the window for successful cover crop establishment (Heller et al., 2024).
- **Policy influence**: The adoption of cover crops is driven by the CAP and the Nitrates Directive. The current CAP (2023–2027) does not mandate cover crops before spring-sown crops but includes conditionality requirements for winter soil cover (Kathage et al., 2022).
- **Barriers**: Barriers to adoption include high costs, lack of access to resources, and limited knowledge. Policies can address these issues by providing financial incentives and enhancing the perceived benefits of adoption. In addition, biophysical constraints limit adoption in many regions: short growing seasons in Northern and Continental Europe reduce the window for cover crop establishment after late-harvested main crops; water scarcity in Southern Europe hampers germination and growth; wet spring conditions can delay cover crop termination and subsequent cash crop planting; and tight rotations involving winter cereals leave insufficient time for cover crop establishment in autumn (Kathage et al., 2022; Heller et al., 2024).

5. Biochar

Description

Biochar involves adding biomass-based charcoal to soil to enhance soil health and store carbon. It is created by heating biomass or organic matter through pyrolysis and gasification. Biochar's effectiveness depends on the type of biochar selected for specific soil and environmental conditions and on the pyrolysis process.

Contribution to climate mitigation

- **Carbon sequestration**: Biochar enables long-term storage of carbon that was originally sequestered from the atmosphere by biomass during growth. When applied to soil, a significant fraction of this carbon can persist for centuries to millennia. Woody biomass (high lignin) produces a more stable biochar that lasts longer in the soil than biochar from 'green waste' or manure. The carbon storage potential of biochar in Europe is estimated between 73.8 and 169 $MtCO_2e$ per year — depending primarily on the availability of sustainable biomass feedstocks — potentially offsetting up to 8.0% of European GHG emissions (Tisserant et al., 2023). The carbon footprint of biochar varies with the source of biomass and the emissions from transportation (Roberts et al., 2010).
- **Non-CO_2 emissions**: Biochar can reduce non-CO_2 emissions (N_2O and CH_4) from soil by 12-50%. It partly suppresses denitrification and enhances CH_4 uptake in soils (Joseph et al., 2021).

Contribution to climate adaptation and resilience

- **Soil fertility**: Biochar can enhance soil fertility, structure and nutrient availability. It can retain moisture and improves water holding capacity, benefiting drought-prone areas (Scott et al., 2014).
- **Soil erosion**: Biochar can promote the formation of stable aggregates and reduce soil erosion (Wortmann and Shapiro, 2008).
- **Bioremediation**: Biochar can adsorb heavy metals and contaminants, making it effective for bioremediation in polluted soils (Ravi et al., 2016).

Co-benefits and trade-offs

- **Soil health**: Biochar stabilises soil organic matter, enhances soil porosity and reduces bulk soil density, improving plant growth and soil biodiversity (Blanco-Canqui, 2017; (Han) Weng et al., 2017).
- **Particulate matter emissions**: Biochar-amended soils can increase emissions of particulate matter (PM10), which is a form of air pollution (Ravi et al., 2016)
- **Biodiversity**: The type of feedstock and pyrolysis temperature can influence biochar's impact on soil microbial communities (Budai et al., 2016; Vijay et al., 2021).
- **Land and biomass demand:** Scaling up biochar production requires substantial biomass feedstocks, which can increase competition for land and biomass resources. If feedstock sourcing is not managed sustainably — for instance, by relying on dedicated crops rather than residues and wastes — it risks displacing food or feed production, increasing pressure on

forests, or undermining the carbon benefit if biomass is harvested faster than it regenerates. These trade-offs underscore the importance of coupling biochar deployment with robust sustainability criteria for feedstock sourcing.

Costs and impacts on yields and incomes

- **Marginal abatement costs**: Costs vary depending on feedstock, production process and application. In Spain, costs range from EUR 175 to 258 per tCO_2e removal (Fawzy et al., 2022).
- **Crop yields**: Biochar can increase crop yields by 10-42% (Joseph et al., 2021), with greater benefits in acidic soils (Bai et al., 2022) and drylands (Liu et al., 2019). Yield increases can be as high as 126% for certain crops under specific conditions (González-Pernas et al., 2022).

Level of uptake

- **Current adoption**: Biochar application is a fast-developing field but faces inconsistencies in production costs, variations in feedstock quality and uncertain effects on plant growth.
- **Barriers**: Economic challenges, high production costs, limited access to large-scale production facilities and lack of standardised monitoring systems hinder widespread adoption (Bhattacharya et al., 2024).
- **Regulatory framework**: The EU Carbon Removal and Carbon Farming Regulation (Regulation (EU) 2024/3012) and its implementing Delegated Regulation C(2026) 553 establish certification methodologies for biochar carbon dioxide removal, requiring pyrolysis temperatures ≥350°C, H/Corg ratios ≤0.7, compliance with RED II biomass sustainability criteria, and contaminant limits for soil application. Activities must demonstrate permanence through laboratory analysis or decay functions, with maximum application limits of 50 tonnes per hectare cumulatively and mandatory chain of custody from production to application (EC, 2026).

6. Improved irrigation efficiency

Description

Improved irrigation efficiency encompasses various practices within water management, including enhanced infrastructure for water storage, limiting irrigation quantity and rates, restricting specific irrigation methods, and implementing systems to capture rainfall. Techniques include modern pressurised systems like drip and sprinkler irrigation, climate-smart or precision irrigation, and crop-specific methods such as intermittent or automated irrigation. Strict caps on total water allocation are needed to avoid increasing total water consumption through a rebound effect (EEA, 2012).

Contribution to climate mitigation

- **CO_2 emissions**: Efficient, low-carbon irrigation methods could reduce CO_2 emissions from the irrigation process by up to 90%, though feasibility may limit this to a 55% reduction globally (Qin et al., 2024).
- **N_2O emissions**: Drip irrigation could reduce N_2O emissions by 32% and 46% compared to furrow and sprinkler irrigation systems, respectively (Kuang et al., 2021).
- **Carbon storage**: Improved irrigation efficiency can enhance carbon storage in soils due to increased yields and residues (EEA, 2019).

Contribution to climate adaptation and resilience

- **Water availability**: Efficient irrigation combats soil water deficiency and improves water availability for agriculture and for other uses, which is crucial as droughts and heat stress become more frequent.
- **Social resilience**: Efficient water use translates into cost savings (however one has to factor in the investment cost) and efficiency gains for farmers, reducing pressure on groundwater recharge (Gelati et al., 2020).
- **Water-energy-food nexus**: When assessed using an integrated water-energy-food (WEF) nexus approach, drip irrigation outperforms other irrigation systems across dry, temperate, and tropical agro-climatic regions, offering the most crop per drop per joule per hectare (Taguta et al., 2022).

Co-benefits and trade-offs

- **Soil ecosystems**: Improved irrigation efficiency supports healthier soil ecosystems and biodiversity by positively impacting water ecosystem services and conservation (EEA, 2019).
- **Nitrogen leaching**: Drip irrigation decreases nitrogen leaching and enhances fertiliser use efficiency, reducing nitrogen losses.

Costs and impacts on farmers' incomes

- **Economic returns**: Optimal irrigation scheduling improves yields, conserves water, and increases economic returns. Drip irrigation can reduce water usage and costs, leading to significant savings in capital and operating costs.

Level of uptake

- **Regional practices**: Irrigation practices vary across Europe, with sprinkler irrigation predominant in northern and western EU Member States, and drip irrigation more common in southern EU countries (European Parliament, 2019).
- **Challenges**: Barriers to adoption include an aging farm population, small farm sizes, low investment levels, and inconsistent implementation of water pricing policies (Giannakis et al., 2016).
- **Funding**: While no EU legal framework mandates improved irrigation efficiency, funding for voluntary adoption is available through the CAP (EC, 2023c).

7. Precision farming

Description

Precision farming is an advanced agricultural approach that utilises technology to optimise crop and livestock production and resource management. It employs sensing technologies (such as GPS, remote sensing and smart crop and livestock sensors), decision support tools (estimating input needs at a high resolution within fields or for individual animals, integrating geographic information, forecast information and agronomic models) and reactive technologies which allow precision resource use (e.g. variable rate technology to change the amount of an input such as seed, fertiliser or water within the field, and precision feeding stations). Precision crop farming also requires guidance and auto-steering systems that allow machinery to position itself with high accuracy. This technology can enhance profitability via optimising the ratio of yield and inputs, and thus it can reduce environmental impacts.

Contribution to climate mitigation

- **Emission reductions**: Precision agriculture optimises input use, potentially mitigating GHG emissions across various agricultural practices. For example, precise nitrogen fertilisation can increase soil carbon stocks and reduce N_2O emissions by 21% in croplands and 55% in grasslands (Molina-Herrera et al., 2016).
- **Technical mitigation potential**: Precision farming technologies have an estimated technical mitigation potential of 12 $MtCO_2e$ in the EU, the majority of which is attributable to variable rate nitrogen application, which alone accounts for approximately 3.6 $MtCO_2e$ through reduced N_2O emissions and lower fertiliser manufacturing emissions. Additional savings derive from reduced fuel use through GPS guidance and optimised field operations (European Commission. Joint Research Centre., 2020).
- **Mitigation from variable rate technology (VRT)**: This technology has a mitigation potential of 3.6 $MtCO_2e$ for the EU-28 over the same period (European Commission. Joint Research Centre., 2020).
- **Fossil fuel use**: Optimised farm operations can reduce fossil fuel use by up to 6%, with proportional reductions in emissions associated with fertiliser production (Shockley et al., 2011).

Contribution to climate adaptation and resilience

- **Soil functions**: Precision agriculture improves soil functions, including water regulation, organic carbon storage, and nutrient cycling (Blanchy et al., 2023).
- **Ecological resilience**: Efficient use of inputs like water, fertilisers and pesticides reduces water usage and maintains soil structure, improving ecological resilience (EEA, 2019).
- **Preparedness from decision support tools**: Decision support tools and early warning systems improve farmers' capacities to prepare for climate and weather extremes, as well as climate-related pests and diseases (EEA, 2019).

Co-benefits and trade-offs

- **Resource optimisation**: Precision agriculture optimises resource use, reducing negative impacts on biodiversity, soil and water. For example, camera-based automatic mechanical weed control reduces herbicide use.
- **Pollution reduction**: It improves nitrogen, manure and phosphorus-use efficiency, minimising off-target movement of fertilisers into waterways and reducing emissions of nitrogenous gases (Schrijver, 2016).
- **Soil health**: Precision agriculture reduces soil compaction and promotes soil fertility. Autonomous agricultural robots and automated steering systems minimise soil disturbance and maintain soil integrity (Schrijver, 2016).
- **Food safety**: Precision agriculture improves tracking, tracing, and documenting, positively impacting human health through improved crop quality (Schrijver, 2016).

Costs and impacts on yields and farmers' incomes

- **Marginal abatement cost**: The marginal abatement cost of precision farming is EUR 120 per tCO_2e (European Commission. Joint Research Centre., 2020).
- **Yield improvement**: Precision agriculture can increase crop yields by optimising resource use.
- **Economic perspective**: High initial investment in precision agriculture technology can be a barrier for farmers, particularly small farm-owners. However, it can reduce costs and improve profitability through more efficient machinery operation and reduced waste of seeds, pesticides, herbicides and fertilisers (EEA, 2023)

Level of uptake

- **Current adoption**: The uptake of precision agriculture remains relatively low across the EU, with only 25% of farms using technologies that include a precision agriculture component. Adoption rates are projected to grow gradually (Schrijver, 2016). Adoption is limited in small farms by the large investments needed and by the training required. Adoption is also limited by gaps in high-capacity telecommunication networks in rural areas and interoperability issues as manufacturers use proprietary software.
- **Financial support**: Financial support for the voluntary adoption of precision agriculture is available through the CAP (EC, 2023c).
- **Barriers**: Barriers to adoption include high costs, technical expertise requirements and the ability to manage large data sets.

8. Protecting and restoring wetlands/peatlands

Description

Wetland and peatland conservation and restoration focus on managing these ecosystems to maintain their natural functions and biodiversity while reducing GHG emissions. Peatlands, and wetlands where prolonged waterlogging inhibits decomposition, accumulate carbon-rich soils (classified as organic soils or histosols under IPCC reporting guidelines). Not all wetlands develop such soils: those on well-drained mineral substrates, such as riverine floodplains, store considerably less carbon. Approximately 50% of all EU peatlands are currently classified as degraded or drained, primarily for agriculture and forestry; these areas are losing their carbon stocks, contributing to CO_2 emissions

There are three broad categories of land-use options for rewetted peatlands in Europe (Bognar et al., 2023):

1. **High-Intensity paludiculture**: Cultivation of selected wetland crops under intensive management to produce high quantities or high-quality biomass (e.g., cattail, *Sphagnum* moss).
2. **Low-Intensity paludiculture**: Regular harvesting of spontaneously established vegetation for biomass use, involving practices like permanent grassland paludiculture under mowing or grazing.
3. **Wet wilderness**: Focuses on rewilding, ecosystem services and biodiversity conservation with no biomass harvesting or on-site management.

Contribution to climate mitigation

- **GHG emissions**: Drained peatlands accounted for 74% of total EU LULUCF gross emissions (i.e. excluding carbon sinks in forests) in 2020 (Van Giersbergen et al., 2025), despite covering only 2.5% of agricultural land (Tanneberger et al., 2021). Reducing GHG emissions from peatlands is crucial for meeting the EU's climate targets.
- **Mitigation potential**: The total mitigation potential of peatlands in the EU is estimated at 48–57 $MtCO_2e$ per year. Rewetting drained peatlands can deliver substantial emission reductions, ranging from 3.5 to 29.7 tCO_2e per hectare per year, depending on the prior land use (Frelih-Larsen et al., 2022).
- **Non-CO_2 emissions**: Drained peatlands also contribute to methane (CH_4) and nitrous oxide (N_2O) emissions, with significant shares in some peatland-rich countries (Tanneberger et al., 2021).

Contribution to climate adaptation and resilience

- **Hydrological regulation**: Peatlands reduce hydrological risks such as floods and droughts by regulating water flows, raising groundwater levels, increasing baseflow and attenuating peak flows during storms (Maltby and and Acreman, 2011).
- **Ecological and social resilience**: Peatlands improve water quality through nutrient and pollutant filtration, support ecosystem stability and reduce economic damage from extreme weather events. Rewetting drained peatlands lowers the risk of deep burns in fire-prone regions (Lennartz and Liu, 2019).

Co-benefits and trade-offs

- **Biodiversity**: Restoring peatlands improves biodiversity and supports vital ecosystem functions like soil carbon storage and nutrient cycling (Woziwoda and Kopeć, 2014).
- **Hydrological cycle**: Healthy peatlands offer ecosystem services such as nutrient management, water quality improvement and aquifer recharge (Maltby and and Acreman, 2011).
- **Land use competition**: Trade-offs may occur in regions where peatlands are used for food production, leading to competition for land.
- **CH_4 impact**: Rewetting drained organic soils leads to an immediate reduction in CO_2 and N_2O emissions, but it also triggers a spike in methane emissions due to the anaerobic decomposition of submerged biomass. As a result, the net GHG emissions may increase initially. One strategy to mitigate the CH_4 spike is to cut and remove the living biomass before rewetting, thereby preventing its anaerobic breakdown. However, this also eliminates many of the biodiversity benefits typically associated with rewetting (Cui et al., 2025).

Costs and impacts on yields and farmers' incomes

- **Economic potential**: While rewetting is cost-effective from a societal carbon-mitigation standpoint, the economic potential of restoration efforts is uncertain (IPCC, 2022b), with risks for farmers unless supported financially.
- **Marginal abatement cost**: The cost of rewetting peatlands is calculated on average at EUR 52 per tCO_{2e}. Costs vary by land use type, with controlled drainage, drainage-based paludiculture and full paludiculture having different economic viabilities (Niemi et al., 2024).
- **Paludiculture products**: Potential products include fibre, construction materials, bioenergy, and biofuels. Challenges exist in creating viable business models for such products (de Jong et al., 2021; Rowan et al., 2022).

Level of uptake

- **Current coverage**: Peatlands in the EU cover approximately 268,000 km^2. Of this area, 51% are classified as natural peatlands, meaning they remain in a near-natural state with intact hydrological and ecological functions. However, about 50% of the total peatland area is considered degraded, primarily due to drainage, extraction or conversion for agriculture and forestry. These two categories are generally mutually exclusive, but the percentages do not sum to 100% because some peatlands may be in transitional states (e.g., partially degraded, under restoration or protected), which are not always distinctly accounted for in broad classifications. The overlap in percentages reflects the complexity of peatland condition assessments and the use of different criteria across studies (Tanneberger et al., 2021).
- **Challenges**: Restoration faces challenges such as consensus among landowners, feasibility within hydrological and biological constraints, and socio-economic justifications. Opportunities for restoration vary by region, being more available in less populated areas.

9. Agroforestry

Description

Agroforestry is a land-use system that combines woody vegetation (trees and shrubs) with agricultural crops or livestock on the same land. It includes silvopastoral systems (trees and shrubs in grasslands) and silvoarable systems (trees or hedges with crops).

Contribution to climate mitigation

- **Carbon sequestration**: Agroforestry has been documented to remove up to 7.29 tonnes of carbon per hectare per year with high-density fast-growing trees, although the typical sequestration rate is much lower. The theoretical potential in the EU and Switzerland reaches up to 252 $MtCO_2e$/year (EC, 2023b), though this represents an upper-bound estimate assuming large-scale deployment; current agroforestry systems deliver a fraction of this, and significant economic, agronomic, and institutional barriers constrain uptake.
- **Soil organic carbon**: Agroforestry can increase soil organic carbon stocks up to 21% compared to crop monocultures (Muchane et al., 2020).
- **N_2O emissions**: Emissions vary by system, with some agroforestry practices increasing N_2O emissions due to higher nitrogen inputs.

Contribution to climate adaptation and resilience

- **Climate adaptation**: Agroforestry enhances resilience to climate change by improving soil quality, water infiltration, and reducing flood risks, while also providing shade and shelter for livestock — reducing heat stress under rising temperatures — and buffering crop microclimates against drought and temperature extremes (IPCC, 2022b).

Co-benefits and trade-offs

- **Biodiversity**: Agroforestry improves biodiversity by creating diverse habitats, but can negatively impact high biodiversity grasslands and certain bird species (Ecologic Institute, 2023).
- **Nitrogen pollution**: Can reduce nitrogen loss through leaching, runoff and soil erosion by 55-60% (Kim and Isaac, 2022).
- **Desertification**: Provides protection against desertification and improves soil stability and water infiltration (IPCC, 2022a).

Costs and impacts on yields and incomes

- **Carbon sequestration costs**: Removing 60 $MtCO_2e$/year at a cost of EUR 250 per tCO_2e (INRA, 2020).
- **Yield impacts**: Yields may be lower than high-input systems but can enhance productivity and profitability in some contexts (IPCC, 2022b). Additionally, the integration of income-generating tree species such as fruit, timber or medicinal trees can enhance the economic viability of these systems while maintaining or even increasing ecological benefits (Moreno et al., 2018).

- **Economic viability**: Agroforestry can be less competitive than traditional agriculture unless the climate adaptation benefits are strong or environmental benefits are internalised through higher carbon prices or specific payments (Kay et al., 2019)

Level of uptake

- **Current adoption**: Agroforestry covers approximately 8.8% of the EU's agricultural area, with significant adoption in countries like Spain, France, and Greece (Den Herder et al., 2017).
- **Barriers**: High initial conversion costs, long production cycles and lack of targeted subsidies are major barriers to adoption (Abdul-Salam et al., 2022).
- **Common agricultural policy (CAP)**: Agroforestry has not benefited as much from subsidies as arable farming. Increased promotion in the current CAP (2023-27) aims to address knowledge and cost barriers (Kim and Isaac, 2022).

10. Agrivoltaics

Description

Agrivoltaics (agri-PVs) involve the simultaneous use of land for both solar photovoltaic power generation and agricultural production. They are classified into open and closed types, with closed systems mainly consisting of greenhouse-integrated PV structures. Open agri-PVs are further categorised based on system structure (interspace and overhead agri-PVs), module type (fixed or tracking), and agricultural activity (grassland, arable farming or horticulture).

Contribution to climate mitigation

- **Emission reductions**: Agri-PVs reduce energy-related CO_2 emissions by replacing fossil-based energy sources. The potential capacity for agri-PVs in Europe is estimated to be very high, with some estimates suggesting up to 51 terawatts (TW), significantly exceeding the EU's 2030 target for photovoltaic expansion (Ali Khan Niazi and Victoria, 2023).
- **GHG inventories**: The climate mitigation contribution of agri-PVs is recorded under the energy sector rather than the agricultural sector.

Contribution to climate adaptation and resilience

- **Microclimatic effects**: Agri-PVs introduce microclimatic heterogeneities that influence crop cultivation and resilience to extreme weather. They can reduce solar radiation, lower maximum air and soil temperatures, and improve water use efficiency (Weselek et al., 2019).
- **Protective infrastructure**: Agri-PVs can serve as protective infrastructure against extreme weather events, such as hailstorms, benefiting high-value crops like fruits (Weselek et al., 2019).

Co-benefits and trade-offs

- **Biodiversity**: Agri-PVs can negatively impact biodiversity through habitat loss and disturbances but can also enhance biodiversity if managed strategically (EC, 2023d). For example, the partial shading provided by solar panels can create a more favourable microclimate, reducing soil moisture evaporation and temperature extremes. This can promote the growth of shade-tolerant plant species and provide habitat for invertebrates and pollinators, thereby increasing local biodiversity.
- **Pesticide reduction**: Solar panels could reduce the need for synthetic chemical pesticides by the panels acting as a shield against rain-borne fungal diseases (Trommsdorff et al., 2023).

Costs and impacts on yields and incomes

- **CO_2 abatement costs**: Agri-PVs have low CO_2 abatement costs, making them a cost-effective climate mitigation option (Sponagel et al., 2024). In Europe, studies estimate the abatement cost for Agri-PVs to be in the range of EUR 10–30 per tCO_2, depending on the region and system design. For example, in Baden-Württemberg (Germany), implementing Agri-PV on 1–5% of agricultural land reduced emissions by 1.2–5.9 $MtCO_2e$ at minimal economic costs (less than 0.5% reduction in agricultural gross margin), translating to abatement costs at the lower end of this range (Sponagel et al., 2024).

- **Crop yields**: The impact on crop yields varies; some crops benefit from partial shading, while others may experience yield reductions. Agri-PVs create new revenue streams by enabling farmers to generate electricity alongside agricultural production. The Land Equivalent Ratio (LER) of agrivoltaics is often higher than one, indicating that co-locating energy and food is more productive than separate land use (Trommsdorff et al., 2025).

Level of uptake

- **Current adoption**: The overall uptake of agri-PVs remains limited due to regulatory and financial uncertainties (EC, 2023d).
- **Barriers**: Key barriers include the lack of a clear, harmonised definition and standard at the EU level, legal uncertainties and the potential exclusion from CAP support. Public awareness, acceptance, high upfront capital cost and technical challenges also hinder widespread adoption (EMBER, 2024).

11. Anaerobic digestion

Description

Anaerobic digestion is a process where bacteria break down organic matter, such as animal manure and crop residues, in the absence of oxygen. This process can be done using only manure (mono-digestion) or a mix of manure and other inputs (co-digestion), and also without manure 2 (e.g. purpose-grown crops, food waste or sewage sludge). The result is biogas (a mix of CH_4 and CO_2) and digestate, which can be used as a fertiliser. Anaerobic digestion systems vary considerably in scale and design: large-scale centralised plants typically process manure and organic waste from multiple farms, feeding biogas into combined heat and power (CHP) units or upgrading it to biomethane for grid injection, while smaller on-farm installations offer simpler, lower-cost solutions particularly suited to individual livestock operations. Maximising climate and energy benefits depends on capturing both the heat and electricity generated as well as ensuring proper digestate management to realise its fertiliser value and avoid additional emissions.

Contribution to climate mitigation

- **Emission reductions**: Anaerobic digestion can significantly reduce methane (CH_4) and nitrous oxide (N_2O) emissions from manure storage and deposition. It produces biogas, which can be used as a substitute for fossil fuels, digestate which can be used for synthetic N fertiliser replacement. Biogas can be used to generate electricity and heat, for grid injection of biomethane, or as liquefied bio-natural gas.
- **Potential**: The potential for anaerobic digestion to reduce emissions from manure management in the EU28 is estimated at 12.7 $MtCO_2e$ by 2030 (European Commission. Joint Research Centre., 2020). When including fossil fuel displacement (the energy the biogas replaces) and synthetic fertiliser replacement, the mitigation potential is broader — though it is worth noting that since manure would otherwise be applied directly to land, the net fertiliser saving is limited to the marginal increase in plant-available nitrogen that digestate offers over raw slurry.

Contribution to climate adaptation and resilience

- **Adaptation benefits**: Small-scale anaerobic digestion (SSAD) provides income diversification for farmers and reduces waste, supporting energy production in rural areas (O'Connor et al., 2021).
- **Risks**: Digestate may contain harmful pathogens, requiring careful risk assessment (Nag et al., 2019).

Co-benefits and trade-offs

- **Soil health**: Digestate can improve soil biodiversity and health, though its impact varies based on carbon content and other properties (Van Midden et al., 2023).
- **Water pollution**: Anaerobic digestion can reduce water pollution but may not significantly impact nitrate leaching compared to undigested slurry.
- **Air pollution**: The composting process can emit various air pollutants, though improved aeration can help reduce these emissions (Preble et al., 2020).

Costs and impacts on yields and incomes

- **Crop yields**: Composted digestate can outperform synthetic fertilisers in terms of soil health and crop productivity (Gurmessa et al., 2024).
- **Economic viability**: Anaerobic digestion can provide additional income through biogas and digestate sales, but financial support is needed to make it economically viable. Costs vary significantly across sources and regions (European Commission. Joint Research Centre., 2020; Wainaina et al., 2020).

Level of uptake

- **Current adoption**: As of 2021, there were approximately 18,843 operational biogas plants in the EU, generating 159 TWh of energy (JRC, 2023b). Despite this, the potential for converting existing waste streams into biogas remains underutilised (JRC, 2023b; Bumharter et al., 2023). However, livestock excreta represent only a fraction of total AD feedstock across the EU.
- **Barriers**: Financial barriers, absence of subsidies, and lengthy permitting procedures hinder the expansion of anaerobic digestion (JRC, 2023b).

12. Improved livestock breeding

Description

Animal trait selection and breeding programs aim to enhance livestock performance and health by utilising genetic variation. This includes selecting traits that reduce methane and N_2O emissions, improve disease resistance, and increase longevity. Selection is accelerated by the use of genome-wide DNA markers to predict the future performance of an animal shortly after birth.

Contribution to climate mitigation

- **GHG emissions reduction**: Breeding goals focusing on production and fitness traits can reduce GHG emissions per unit of output by improving animal feed conversion efficiency and overall herd productivity. Faster growth rates in beef cattle and improved feed efficiency in ruminants can significantly lower emissions (Eory et al., 2020).
- **Potential**: Livestock breeding in Europe could reduce cattle GHG emissions by 1 to 2% each year by reducing emission intensity. Crossbreeding dairy with beef cattle can also reduce emissions intensity, by producing heifers delivering more meat per unit of feed. (JRC, 2019).
- **Disease resistance**: Selecting for disease resistance can reduce GHG emissions, as healthier animals require less energy for maintenance (Williams et al., 2015).
- **Non-CO_2 emissions**: Efficient animals excrete less nitrogen, reducing nitrogen pollution. Improved genetics can also lower enteric methane emissions (EEA, 2019; FAO, 2023; Grossi et al., 2019).

Contribution to climate adaptation and resilience

- **Resilience**: Breeding for feed efficiency can reduce grazing pressure on grasslands. Adaptation traits from locally adapted breeds can increase resilience to extreme climate conditions, such as high temperatures and low-quality diets (Lal et al., 2011).

Co-benefits and trade-offs

- **Environmental benefits**: Breeding for lower grazing pressure can positively impact climate regulation, water and soil ecosystem services, and biodiversity (EEA, 2019). Selecting for lower milk urea nitrogen traits can reduce nitrogen pollution in water sources (Pereira et al., 2024).
- **Trade-offs**: Altering animal phenotypes to improve productivity or efficiency could negatively impact animal health and welfare if not properly managed. New breeds need to adapt to production systems and climates with limited resources (Grossi et al., 2019).

Costs and impacts on yields and incomes

- **Economic benefits**: The economic benefits from higher yields often exceed the costs of implementation. Cattle genomic breeding is considered one of the best livestock mitigation measures on the long term, offering significant savings to farmers (Eory et al., 2020).
- **Productivity**: Animal trait selection can enable better feed conversion, faster growth in meat animals, and higher milk production in dairy animals (Cole et al., 2023).

Level of uptake

- **Current adoption**: Despite the financial benefits, uptake levels in Europe have not been substantial. In the UK, adoption of better genetic material is around 20-25% in the dairy sector and lower in beef herds (Eory et al., 2020).
- **Barriers**: Barriers include the lack of a mandatory EU legal framework, complex funding structures, difficulty in accurate phenotype recording, and insufficient infrastructure and human capacity.

13. Methane reducing feed additives

Description

Feed additives are chemicals, organic substances, micro-organisms or preparations introduced into feed or water to reduce methane (CH_4) emissions from ruminants, particularly cattle. These additives work by inhibiting methanogenic archaea and include propionate precursors, antimethanogens, 3-NOP (3-nitrooxypropanol), linseed, essential oils, nitrate, seaweed, probiotics, saponins, monensin, bromochloromethane and tannins.

Contribution to climate mitigation

- **Mitigation potential**: The annual reduction of GHG emissions by 2030 for linseed and for nitrates used as feed additives is estimated at 20.1 and 9.5 $MtCO_2e$, respectively, for the EU28 (European Commission. Joint Research Centre., 2020). Nitrate as feed additive and the feed additive '3-NOP' (Veneman et al., 2016) are commercially available in the EU.

Contribution to climate adaptation and resilience

- **Adaptation and resilience**: Feed additives, including methane inhibitors, do not significantly contribute to climate adaptation and resilience.

Co-benefits and trade-offs

- **Pollution reduction**: Some feed additives can reduce emissions of ammonia, odours and excretions of nitrogen and phosphorus. However, some additives, like nitrates, can cause nitrate poisoning if ruminants are not gradually acclimatised (Lewis et al., 2015).
- **Animal welfare**: Certain feed additives may impact animal welfare, necessitating careful management (Lee and Beauchemin, 2014).

Costs and impacts on yields and farmers' incomes

- **Economic viability**: The inclusion of additives like 3-NOP increases feed costs, making them economically unappealing without additional benefits such as premium prices or methane taxes.
- **Yields**: 3-NOP can increase carcass weight in beef cattle, but no significant effect on milk production has been observed (De Carvalho et al., 2023).

Level of uptake

- **Regulatory approval**: Feed additives must receive EU Commission approval before use. 3-NOP was approved in 2022, making it the first such additive authorised for use. However, raw plant products (e.g. linseed) are classified as feed material and do not require a specific authorisation.
- **Funding**: Six Member States include measures related to feed additives in their CAP Strategic Plans, providing voluntary funding for farmers (EC, 2023c).
- **Barriers**: Barriers to adoption include potential impacts on animal health, consumers concerns about potential residues in animal products, cost-effectiveness uncertainties and challenges in administering additives to grazing animals (Lee and Beauchemin, 2014; SRUC, 2023).

14. Shift in human diets towards more plant-based food

Description

Shifting eating habits to reduce the consumption of animal products in the EU and increase the intake of healthy plant-based foods can substantially reduce emissions from agriculture and land use. However, the climate and environmental benefits of such dietary shifts can only be fully realised if they are mirrored by corresponding changes in EU production patterns — a reduction in consumer demand that is not accompanied by a contraction in livestock production would risk displacing emissions rather than eliminating them, either through continued domestic production or carbon leakage via imports. The EAT-Lancet Commission recommends a 'Planetary Health Diet' that emphasises reducing red meat and dairy consumption while increasing vegetables, legumes, whole grains, fruits, nuts and moderate amounts of fish, dairy products, meat and sugar

Contribution to climate mitigation

- **GHG emissions**: The global food system was responsible for approximately 34% of total anthropogenic greenhouse gas emissions in 2015. Livestock accounts for about 65% of total agricultural emissions and emissions from plants are substantially lower than from livestock for the same amount of calories and protein. Reducing livestock numbers and animal product consumption thus significantly lower emissions, with the co-benefit of improving human health (Oeko-Institut, 2024; Humpenöder et al., 2024; Gebara et al., 2025; Gerten et al., 2020).
- **Potential reductions**: Reducing EU animal product consumption by 50% could lower agricultural nitrogen emissions by 40% and GHG emissions by 19–42% by 2030 compared to 2004 levels (Westhoek et al., 2014). By 2045/2050, livestock-related emissions could decrease by 46% compared to 2020 levels (Agora Agriculture, 2024).

Contribution to climate adaptation and resilience

- **Environmental footprint**: Plant-based systems generally have a smaller environmental footprint per unit food (both in calories and in proteins) and shifting to plant-based food would free some grassland cropland area for other uses such as nature conservation (IPCC, 2022a; Poore and Nemecek, 2018; Springmann et al., 2018).
- **Sustainable agriculture**: Increasing the consumption of healthy plant-based foods promotes more diverse and sustainable agricultural systems (IPCC, 2022a; Poore and Nemecek, 2018; Springmann et al., 2018).

Co-benefits and trade-offs

- **Ecosystem pressure**: Lower red meat consumption reduces pressure on ecosystems, decreasing land-use change, biodiversity loss, freshwater use, pollution, and habitat destruction (IPCC, 2022a; Scarborough et al., 2023).
- **Health benefits**: Diets high in vegetables, fruits, nuts, and legumes, but low in red and processed meats, can decrease health issues such as cardiovascular diseases, obesity, and certain cancers (Rieger et al., 2023). However, not all plant-based food is healthy. Ultra-processed plant-based food has negative health impacts (EC, 2025).

- **Ammonia emissions**: Adopting a flexitarian diet in Europe could reduce ammonia emissions by around 40%, enhancing air quality and public health (Himics et al., 2022).

Costs and impacts on yields and farmers' incomes

- **Farm incomes**: A shift toward healthier eating habits generally leads to higher farm incomes in the EU-27, as the expansion of fruit and vegetable markets outweighs the reduction in livestock products. However, regions heavily reliant on animal farming may experience revenue declines that, in areas dominated by permanent grassland or other land types unsuitable for arable cropping, may not be short-term but structural as these regions have limited capacity to diversify into alternative farm enterprises (Rieger et al., 2023; Guyomard et al., 2023)
- **Income changes**: Pig and poultry farms could see earnings drop by up to 34-37%, while vegetable farms might experience an income increase of over 30% (Rieger et al., 2023; Geibel et al., 2021).

Level of uptake

- **Barriers**: Barriers to widespread adoption include cultural preferences, economic factors, limited availability of affordable alternative proteins, and lack of policy support (Agora Agriculture, 2024).
- **Acceptance**: There is growing acceptance of vegetarian and vegan alternative products, with improved access and availability in supermarkets and restaurants (Rieger et al., 2023).

15. Reduced food loss and waste

Description

Food loss and waste refer to edible food intended for human consumption that is discarded. Food loss occurs during the production, harvest and processing stages of the supply chain, whereas food waste refers to the discarding of edible food at the retail, food services and household levels. Households contribute the largest share to food loss and waste, followed by the processing and manufacturing sector, primary production, food services and retail.

Contribution to climate mitigation

- **GHG emissions**: Reducing food waste offers significant potential for climate mitigation. Ambitious reduction targets could lower GHG emissions by up to 16.7 million tonnes of CO_2e annually, primarily through reduced emissions from agricultural production and waste treatment (JRC, 2023a).

Contribution to climate adaptation and resilience

- **Efficiency and resilience**: Reducing food waste enhances climate adaptation by making food systems more efficient and resilient. It decreases the demand for overproduction, lessening the strain on agricultural systems and strengthening their ability to withstand climate-related disruptions (FAO, 2013).
- **Strategic reserves**: Improved storage and strategic food reserves can buffer against supply chain disruptions and price volatility (Bajželj et al., 2020).

Co-benefits and trade-offs

- **Ecosystem protection**: Reducing food waste alleviates pressure on ecosystems, protects biodiversity, and reduces the need for nitrogen-based fertilisers, decreasing water contamination and air pollution (FAO, 2013).
- **Nitrogen emissions**: Food waste accounts for significant nitrogen loss to the environment, contributing to water pollution and eutrophication (Grizzetti et al., 2013).
- **Localised policies**: Reducing food waste at the consumer level consistently leads to environmental improvements, while reducing losses earlier in the supply chain may not guarantee positive economic outcomes (Cattaneo et al., 2021).

Costs and impacts on yields and farmers' incomes

- **Economic impacts**: Higher food waste reduction targets come with increased costs but generate substantial savings for households. However, farm incomes may decline significantly, particularly in regions reliant on agriculture (JRC, 2023a).
- **Long-term savings**: The food wasted annually in the EU represents a market value of EUR 132 billion, indicating significant potential for economic gains through improved efficiency (Eurostat, 2023; EC, 2023a).

Level of uptake

- **Current trends**: Despite the EU's goal to halve food waste by 2030, recent data indicates that food waste has increased in recent years. EU Member States are failing to meet the SDG target 12.3 on food waste reduction (targeting a 50% reduction in food loss and waste by 2030) due to missing systemic and coordinated strategies (Agora Agriculture, 2024).
- **Interventions**: Food waste reduction interventions span the entire supply chain, emphasising improvements in storage, transportation and consumer behaviour. Better meal planning, normalising leftovers, and changes to date labels can help reduce unnecessary food disposal (Bajželj et al., 2020).

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