Land use, common agricultural policy subsidies, and farm economic exposure under planetary health diet scenarios in Europe: a physical input–output modelling analysis

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Summary

Background Animal-sourced food (ASF) production dominates agricultural land use in the EU and attracts a large share of public fiscal support. Although shifts away from ASFs have broad implications for land use, public spending, and farming livelihoods, the distributional effects across regions and supply chains remain largely unquantified. This study aims to quantify these effects and identify regional differences in the economic implications of transitioning towards plant-rich diets.

Methods We assessed the effects of adopting the planetary health diet (PHD) and its variants across the EU+UK relative to a 2020 baseline. Using the multiregional food and agriculture biomass input–output model, we linked farm income and labour accounts to agricultural supply, use, and trade to trace feed–animal–food linkages through supply chains. We summarised regional heterogeneity using six transition archetypes defined by sectoral composition, profitability excluding subsidies, and reliance on livestock.

Findings Adopting the PHD would release 58–78 million hectares of agricultural land in the EU+UK and free up €28–36 billion per year of common agricultural policy (CAP) subsidies under increasingly plant-rich variants of the PHD. Correspondingly, EU+UK farm employment would decline by 37–40% and farm profits excluding CAP subsidies would decrease by 15% (PHD) to 3% (PHD-vegan). These effects varied across regions: in places where livestock production was loss-making at baseline (excluding CAP subsidies), reduced ASF demand could eliminate these losses and increase regional profits; in contrast, profits declined in regions where livestock production was profitable.

Interpretation Dietary change creates substantial scope for land and fiscal repurposing; however, transition costs are concentrated geographically and across production systems. The diversity in regional archetypes will require differentiated support to achieve a plant-rich and just food transition, which could be partly financed via repurposed CAP resources.

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Introduction

The European food system faces growing pressure to meet targets for 2030, including halving greenhouse gas (GHG) emissions[1] and pesticide use[2] and protecting 30% of land and sea areas.[3] Meanwhile, climate impacts on the agricultural system are intensifying.[4] Animal-sourced foods (ASFs) dominate European land use and drive most food-related GHG emissions and biodiversity loss.[5,6] Efficiency gains alone cannot deliver the emission cuts required to meet the EU's targets, and absolute reductions in livestock numbers are necessary.[7] Dietary shifts towards plant-rich diets are required to reduce ASF consumption, livestock numbers, and food-system pressures while supporting public health.[8,9]

The common agricultural policy (CAP), the EU's main farm-support mechanism, predominantly allocates subsidies on an area basis. In our 2020 baseline, ASF systems occupied around 71% of the land used for EU+UK food production and received 77% of total CAP payments, embedding most subsidies in ASF systems. This pattern results in less support for more sustainable production.[5,10]

Although the environmental and health rationale for dietary change is well established,[6,8,9,11] its impacts on farm income, employment, and subsidy flows across regions and supply chains remain only partly quantified.[12,13] Recent modelling studies have assessed the environmental, distributional, and policy-bundle effects of dietary transitions aligned with the planetary health diet (PHD).[9,11,14–16] However, none of the studies trace the embodied CAP subsidies and farm profits across EU+UK food groups and supply chains. This supply-chain perspective identifies where dietary shifts create transition exposure, defined here as the structural gains or losses across existing supply chains, and highlights associated policy-reallocation needs.

Research in context

Evidence before this study

We considered relevant EU and UK studies that quantify farm income, farm profits, farm employment, or labour requirements by food group or agricultural sector under shifts in demand, including peer-reviewed studies and selected grey literature. Although the environmental and public health benefits of plant-rich diets are well established, we found little evidence linking dietary scenarios to EU+UK farm profits, employment, and CAP subsidy flows across global agricultural supply chains.

Added value of this study

By combining the physical multiregional food and agriculture biomass input–output model with farm income and labour accounts, we trace embodied land use, common agricultural policy (CAP) subsidies, farm employment, and farm profits (excluding CAP subsidies) for 123 food and feed products across the EU+UK, using a 2020 baseline. We used CAP subsidies to refer to public transfers recorded in farm accounts and embodied in agricultural supply chains, without implying that all payments are directly linked to current output. We then assessed how these outcomes change under four EAT–*Lancet* dietary scenarios (the planetary health diet and its pescetarian, vegetarian, and vegan variants). The scale of these ambitious dietary transitions is difficult to assess at this level of sectoral and supply-chain detail using many economic modelling frameworks. Our approach quantifies the structural implications of these dietary transitions across supply chains while abstracting from price-mediated, behavioural, and technological adjustments. This fixed-coefficient approach preserves high sectoral resolution and the biophysical representation of food and feed flows. We also define six transition archetypes that summarise differences in how different national production systems respond to dietary transition, identifying the countries, regions, and sectors where losses, gains, and policy needs arise.

Implications of all the available evidence

Progress towards diets aligned with public health goals could entail large, uneven changes in European land use and farm economics, with transition costs concentrated geographically and across production systems. At the EU+UK level, the dietary scenarios indicate lower land use, labour demand, and CAP subsidies, alongside lower unsubsidised farm profits, although impacts vary widely across countries and food groups. These findings suggest that CAP reform should be spatially differentiated, with explicit rules for reallocating freed funds towards restoration, targeted transition support, and demand-side health measures to manage uneven impacts and improve the feasibility of transitioning towards plant-rich diets.

We assessed how a shift towards PHD[9] could reshape the socioeconomic geography of food production in Europe. We quantified changes in farm income, labour distribution, and CAP subsidies under four dietary scenarios: (1) PHD, (2) PHD-pescetarian, (3) PHD-vegetarian, and (4) PHD-vegan. We compared full adoption of each diet with a 2020 baseline under *ceteris paribus* 2020 production systems, without modelling novel proteins or transition dynamics.

By combining the physical food and feed supply-chain structure of the food and agriculture biomass input–output (FABIO) model[17] with farm accountancy data from the Farm Accountancy Data Network (FADN)[18], we trace embodied land use, CAP subsidies, farm employment, and farm profits through feed–animal–food linkages at the product and country levels across the EU27 and UK. We identify land and fiscal space for reallocation and regional disparities requiring targeted support. Freed-up land, subsidies, and labour could be reallocated to accelerate climate action, protect biodiversity, or support rural development, provided that spatially differentiated policies mitigate disruption and expand options for farmers.

See Online for appendix

Methods

We used the FABIO database (v2.0),[17] a global physical input–output table for agriculture and food covering 186 countries plus the Rest of World, 123 commodities, and six final demand categories. For 2020, we obtained production, supply, use, and trade data from FABIO, land-use extensions from Liu and colleagues,[19] and country-level farm profits, subsidies, and labour accounts from FADN.[18] Throughout, profits denote constant-price profits excluding CAP subsidies (ex-CAP profits), calculated as FADN farm net income minus CAP subsidies using 2020 prices and cost structures. Transition exposure refers to the scenario change in land use, labour, CAP payments, and ex-CAP profits, which might be positive or negative. We used 2020 as the baseline because it was the last year for which FADN data included the UK and the year for which the land-use extension was constructed. The use of 2020 as baseline allows comparison with the 2014–19 period under the 2014–20 CAP framework. We included the UK because it participated in the CAP throughout 2014–19 and retained the CAP direct payments framework in 2020. Further details are provided in the appendix (pp 2–8).

We harmonised FABIO with country-level FADN farm accounts covering 14 farm types. CAP subsidies, farm employment, and farm profits excluding CAP (ex-CAP) were first converted to national farm-type totals and then allocated to corresponding FABIO commodities in proportion to national commodity output using a concordance matrix. The resulting country–commodity values (e^{sub}, e^{emp}, and e^{prof}) were converted to satellite intensities by dividing them by FABIO output, x:

$$b' = e'\hat{x}^{-1}$$

This step yielded employment intensities (annual working unit [AWU] t^{-1}), CAP subsidy intensities (€ t^{-1}), and ex-CAP profit intensities (€ t^{-1}). Farm profits excluding CAP subsidies were calculated as FADN farm net income minus CAP subsidies, and negative values were retained. Embodied impacts associated with final demand (Y) were calculated using standard multiregional input–output (MRIO) accounting:

$$R^c = \widehat{b'}\,\widehat{L}\,Y$$

where L is the Leontief inverse derived from the FABIO technical coefficient matrix, A:

$$L = (I - A)^{-1}$$

where I is the identity matrix. Intensities are assigned at the farm gate, whereas upstream impacts are propagated through intermediate inputs and feed flows. Using land-based crop allocation instead changed embodied ASF subsidies by 0·1%. FADN represents approximately 3·7 million farms across the EU27+UK in 2020 and excludes fisheries and farms below a minimum economic size.

We implemented the PHD and its pescetarian, vegetarian, and vegan variants (appendix pp 6–7) for all high-income and middle-income countries, affecting imports into and exports from the EU+UK. The PHD scenario represents the reference EAT–*Lancet* dietary benchmark, whereas the pescetarian, vegetarian, and vegan scenarios represent increasingly plant-rich variants with progressively lower ASF consumption.[9] Items not covered by the EAT–*Lancet* recommendations, including alcoholic beverages, are held constant at baseline consumption. The scenarios represent full dietary adoption with concurrent CAP reallocation. As an explicit scenario assumption, CAP payments embodied in ASF supply chains decline as ASF demand decreases. In contrast, payments embodied in expanding plant-based supply chains increase. The results represent a post-transition benchmark without specific policy instruments. CAP repurposing is, therefore, an outcome of the dietary scenarios rather than a policy driver for adoption. CAP repurposing space is calculated as baseline CAP payments minus scenario CAP payments, assuming fixed national budgets.

We classified regions into six transition archetypes based on baseline sectoral composition, aggregate profitability, and reliance on ASFs (appendix p 8). The archetypes indicate how structurally different production systems might respond to dietary transitions and why these systems might require differentiated policy support.

To test the robustness of our findings to income volatility, we compared 2020 values with the 2014–19 averages, corresponding to the 2014–20 CAP framework (appendix p 5). No region shifted archetype between the 2014–19 mean and 2020. All data processing and analyses were performed using Python (v 3·13·5).

The MRIO scenarios estimate structural exposure under fixed 2020 technical coefficients, cost–price structures, yields, CAP intensities, and trade shares. These scenarios trace how changes in final demand propagate through existing supply chains to estimate embodied land use, employment, subsidies, and ex-CAP profits across commodities and regions. Changes in domestic final demand do not translate proportionally into changes in domestic production, because country–commodity output also responds to export demand and intermediate requirements, including livestock feed. Unlike equilibrium models, our framework does not model endogenous responses in prices, production technologies, land rents, trade patterns, substitution, or producer and consumer behaviour. Therefore, the results should be interpreted as post-transition comparative benchmarks rather than forecasts of market adjustment. This fixed-structure approach isolates the distributional incidence of dietary change across existing EU+UK food-system structures.

Role of the funding source

The funders had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

As of 2020, approximately 134 million hectares (Mha) of land within the EU+UK was used for food production, of which 71% (approximately 95 Mha) was dedicated to ASFs (figure 1). The 134 Mha used for food production is less than the approximately 175 Mha of utilised agricultural area because land used for non-food final demand and fallow land fall outside the food-system boundary of the land-use extension.[19] Approximately 111 Mha supplied EU+UK consumption, and approximately 23 Mha supplied exports (appendix p 17). ASF land accounted for 60% of farm employment and received 77% (€39 billion) of the €51 billion in CAP subsidies allocated to food production; plant-based foods received €12 billion. CAP payments accounted for 58% of the total EU+UK farm net income (€87 billion, according to FADN data). Excluding CAP subsidies, EU+UK farm profits were only €36 billion, indicating a strong dependence on public funding; ASFs generated 41% of these ex-CAP profits (figure 1). Sectoral dependence on CAP subsidies was highest for ruminants: CAP payments accounted for 71% of dairy income and 96% of beef and lamb income (54% for pork, 50% for poultry meat, and 51% for eggs). Although plant-based, feed, and livestock systems were profitable on average at the EU+UK level without CAP subsidies, this pattern masked considerable heterogeneity across sectors and regions (figure 2A).

Beef and lamb were the most subsidy-dependent food groups, generating considerable losses in the absence of CAP subsidies in Finland, Czechia, and Slovakia, but remaining profitable in Greece, Romania, and Italy. Pork, poultry, and dairy were profitable overall, with country-specific profit margins. Several plant-based foods (eg, cereals, legumes, and vegetable oils) had near-zero

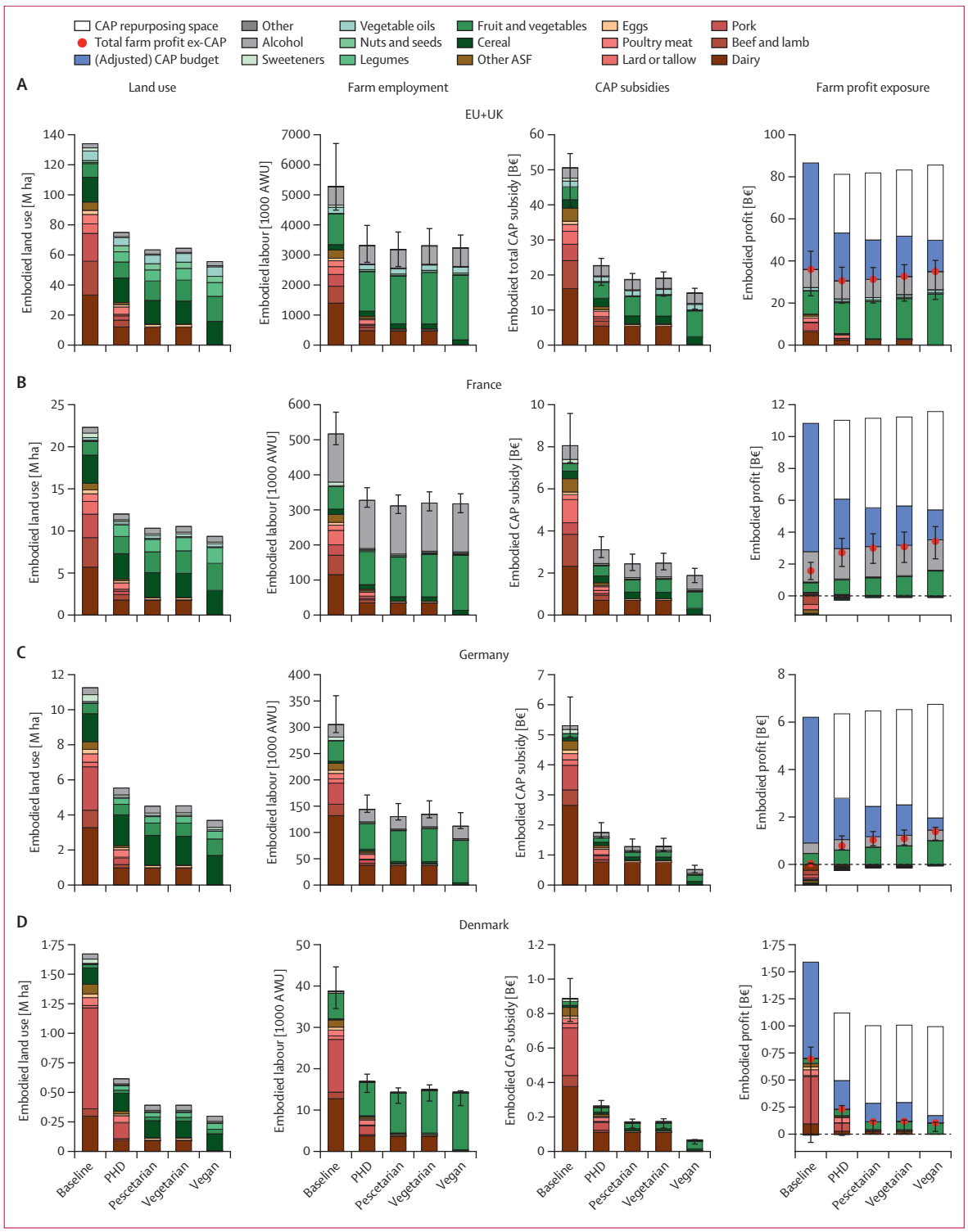

Figure 1: **Embodied land use (million hectares), farm employment (thousand AWU), CAP subsidies (billion €), and farm profits (billion €) attributable to domestic production for the EU+UK (A), France (B), Germany (C), and Denmark (D) under five dietary scenarios: baseline, PHD, and the pescetarian, vegetarian, and vegan variants of the PHD**

In the farm-profit exposure graphs, the red marker represents total farm profits excluding CAP subsidies, the blue bar represents the CAP budget, which corresponds to the current CAP budget for baseline and adjusted CAP budget for each of the diet scenarios, and the transparent bar represents the CAP repurposing space available for environmental and public health co-benefits. Sensitivity bars indicate the lower and upper deviations from 2020 values based on the minimum and maximum annual values observed for each region–sector combination during 2014–19 (6 years, inflation-adjusted). Therefore, the sensitivity bars represent a range rather than any single year or timepoint. ASF=animal-sourced food. AWU=annual working unit. CAP=common agricultural policy. PHD=planetary health diet.

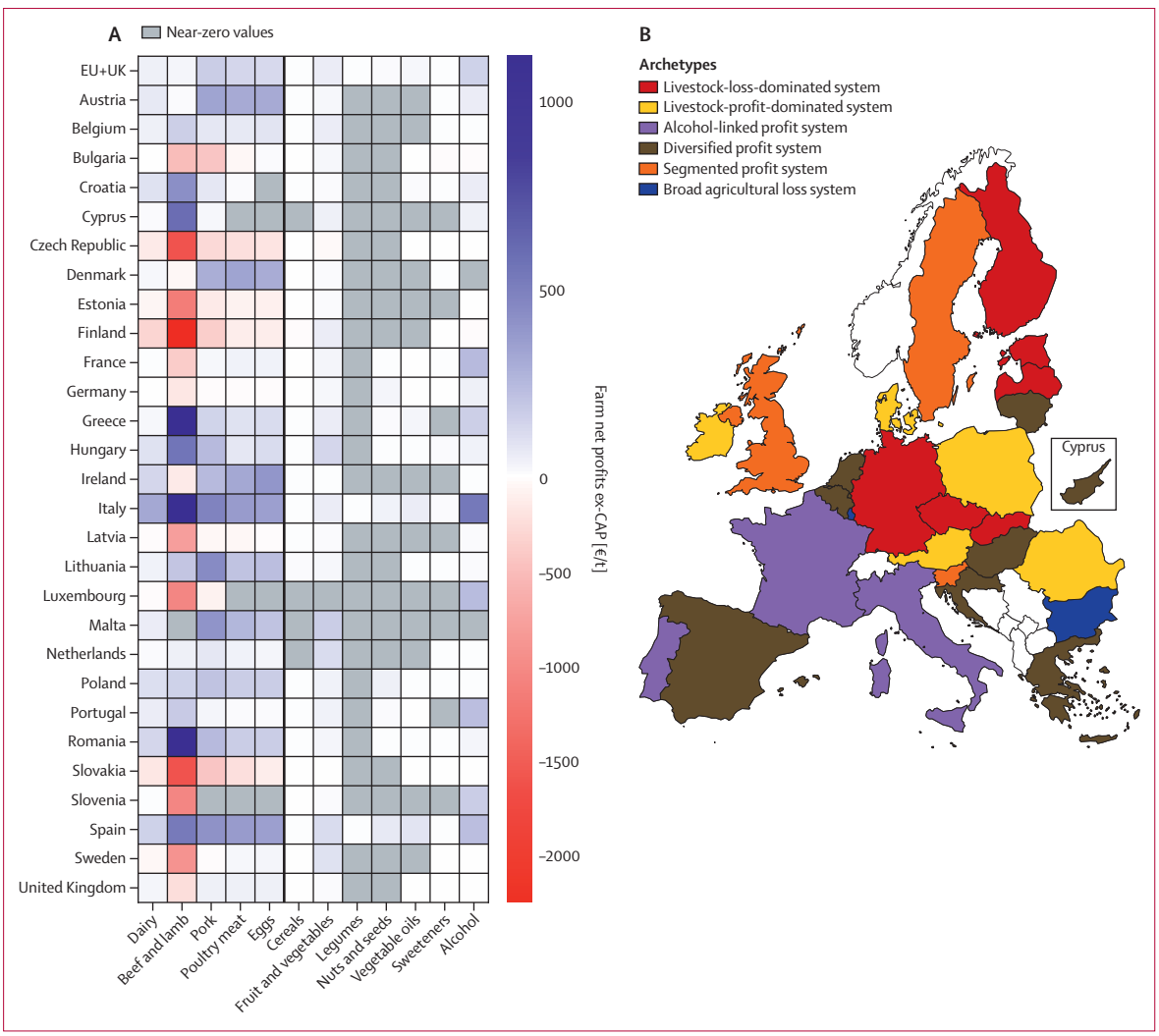

Figure 2: **Farm-profit intensities and transition archetypes**
(A) Farm profits per unit of product, excluding CAP subsidies (€ per tonne of food produced), for the EU+UK, all EU member states, and the UK. Grey cells indicate near-zero values to visually distinguish them from light red or blue cells. Near-zero values are defined as food groups with absolute total unsubsidised profits below €0·5 million. (B) Transition archetypes for each EU+UK country. Archetype classification is based on sectoral composition, aggregate unsubsidised profitability, and exposure to reduced ASF demand (appendix p 8). ASF=animal-sourced food. CAP=common agricultural policy.

unsubsidised profits and received little CAP support, resulting in low total profits, including subsidies, under prevailing cost, price, and support structures (figure 2A).

In France, CAP subsidies supplemented profits in sectors such as alcohol, fruit, and vegetables but were essential for maintaining profitability in beef, lamb, and animal fat production, which would jointly incur losses exceeding €1 billion without support. Approximately €7 billion of the €8 billion in CAP support was allocated to ASFs (figure 1B). In Germany, 91% of the approximately €5 billion in CAP support was allocated to ASFs, which incurred losses of approximately €791 million without CAP subsidies. Without subsidies, all ASF groups were unprofitable (figure 1C). Denmark shows an ASF-dominated food system in which CAP subsidies roughly doubled farm profits (figure 1D).

All indicators were calculated in embodied terms, capturing upstream inputs such as cropland used to grow livestock feed. Regional contributions were traced through international supply chains to final food products, with inputs generated outside a region's border attributed to their region of origin. The dietary scenarios released 58–78 Mha of land within the EU+UK and a further 18–22 Mha abroad as the land embodied in imports declined. We compared 2020 values with inflation-adjusted annual values from 2014 to 2019. The analysis also distinguishes farm profits excluding CAP subsidies from the CAP budget and the CAP repurposing space for environmental and public health co-benefits. The CAP subsidy, labour, and profit intensities per unit of food produced are presented in the appendix (p 4). Results for all other countries are shown in the appendix (pp 17–24), and a

country-level overview is also provided in the appendix (pp 8–16).

Across all regions, reducing ASF consumption lowered land use by 44% under the PHD scenario, 53% under the PHD-pescetarian scenario, 52% under the PHD-vegetarian scenario, and by 59% under the PHD-vegan scenario. Farm employment declined by 37% under the PHD scenario, 40% under the PHD-pescetarian scenario, 37% under the PHD-vegetarian scenario, and 39% under the PHD-vegan scenario, with the effects varying by agricultural structure (figure 1). The CAP budget adjusts with production, creating a CAP repurposing space of €28–36 billion (figure 1).

Although sourcing profiles were held constant, import and export volumes changed with dietary demand, and embodied land use in imports was traced through global supply chains. EU+UK food imports accounted for approximately 48 Mha of land use abroad, declining to approximately 30 Mha under the PHD scenario and further to approximately 26–27 Mha under other dietary variants. The decline was moderated by higher imports of legumes (+550–740% by mass) and nuts and seeds (+144–148% by mass). In 2020, 60% of EU+UK legume consumption by mass and 28% of nut and seed consumption were produced domestically.

Under fixed trade shares, imported embodied land use declined. In a sensitivity test in which additional demand was met within the EU+UK, imported embodied land use declined to approximately 16–22 Mha, whereas EU+UK land use for legumes increased up to 16 Mha and for nuts and seeds up to 7·3 Mha. These increases represent approximately 30% of the land saved in the EU+UK through reduced ASF (appendix p 17). Global land-use reductions, therefore, partly depend on supply-chain adjustments.

EU+UK ex-CAP farm profits declined by €5·4 billion under the PHD scenario, €4·8 billion under the PHD-pescetarian scenario, €3·4 billion under the PHD-vegetarian scenario, and €1·0 billion under the PHD-vegan scenario. The smaller decline under the more plant-rich variants occurred because these scenarios removed a larger share of baseline losses from ASFs. Gains in plant-based profits (18–64%) did not fully offset ASF profit declines (figure 1). Subsidy reallocation could partly mitigate these losses.

Contrasting patterns in land use, profitability, and subsidy dependence highlight the diversity of agricultural systems across the EU. We classified national agricultural systems into six archetypes based on sectoral composition, unsubsidised profitability (ex-CAP), and exposure to reduced ASF demand (figure 2B). We focused on the PHD scenario because it was the least radical and probably the most publicly acceptable while still implying a 64% reduction in ASF consumption across the EU+UK.

The six archetypes are livestock-loss-dominated systems, in which ASF production is economically dominant but largely loss-making without subsidies; livestock-profit-dominated systems, in which ASF sectors remain central and generate farm profits even without subsidies; alcohol-linked profit systems, in which crops used in alcohol-related supply chains are the largest contributors to farm profitability; diversified profit systems, in which farm profits are distributed across several food groups; segmented profit systems, in which farm profits are concentrated in a small number of food groups while others are loss-making; and broad agricultural loss systems, in which most food sectors operate at a loss (figure 2B).

As expected, livestock-loss-dominated systems incurred ASF-driven losses totalling €3·1 billion, concentrating in the dairy, beef, and lamb sectors. Although some countries generate small farm profits from fruit, vegetables, and alcohol, these are negligible relative to the scale of ASF-related losses. Under the PHD scenario, net losses fell sharply, although outcomes varied across countries. Germany shifted from near breakeven to farm profits, with profits increasing by €757 million (+2294%), driven by avoided livestock losses. In other countries, farm systems approached breakeven, as observed in Estonia, where profits increased by €63 million (+69%), and in Latvia, where profits increased by €42 million (+86%). Losses were substantially reduced, but farms remained unprofitable overall in Czechia (profits increased by €532 million [+63%]), Finland (profits increased by €617 million [+80%]), and Slovakia (profits increased by €193 million [+60%]; figure 3).

Livestock-profit-dominated systems were profitable or breakeven without CAP subsidies, but their ex-CAP profits depended heavily on ASFs (73–97%). Under the PHD scenario, total profits fell because increased plant-based production under current production systems does not offset the decline in ASF profits. This pattern was observed in Austria (€316 million; –52%), Denmark (€464 million; –67%), Poland (€1·1 billion; –38%), and Romania (€768 million; –54%). Denmark stands out because all ASF profits were concentrated in livestock, whereas feed was loss-making. Ireland was another exception (€350 million, –59%), with beef and lamb incurring losses of €12 million, whereas other livestock sectors, especially dairy (€185 million in profits), remained profitable.

Alcohol-linked profit systems showed similar reductions in land use, CAP subsidies, and employment as ASF production declined, but alcohol, particularly wine, buffered the transition. Under the PHD scenario, alcohol-linked crop production accounted for a larger share of remaining employment (35–42%) and ex-CAP profits (43–70%) because production from ASF-related sectors declined. Fruit and vegetables were also important, accounting for 28–34% of employment and 29–33% of ex-CAP profits under the PHD scenario. Some countries retained profitable livestock subsectors (eg, Italy maintained profitable dairy, poultry, beef, and lamb production). Other countries mainly benefited from the removal of loss-making sectors. In France, the removal of loss-making sectors, such as beef, lamb, animal fat, and cereal production, increased net profits (figure 1). Alcohol-linked profit systems showed

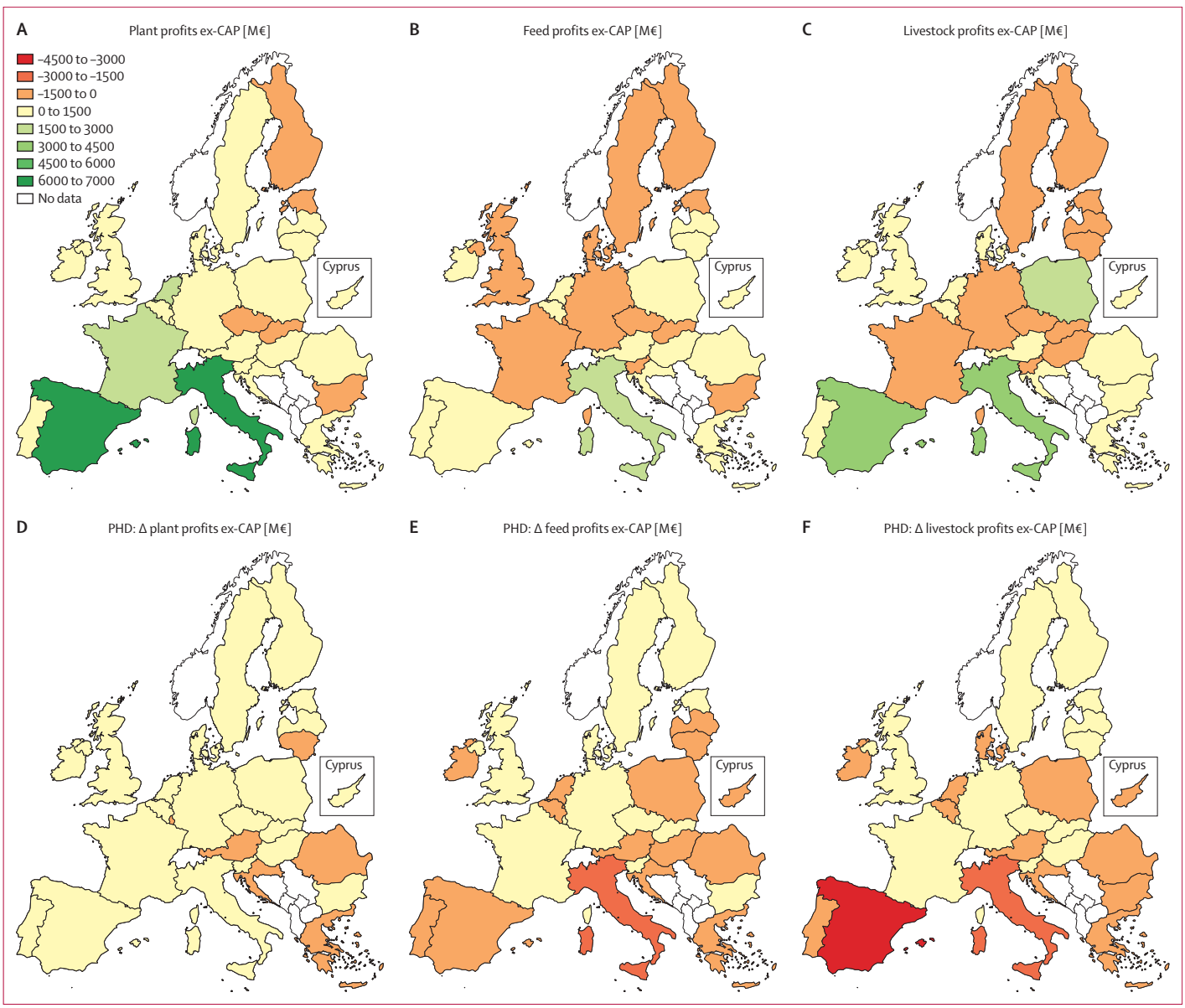

Figure 3: **Current farm-profit distribution and projected farm-profit exposure under PHD**

Current distribution of profits excluding CAP subsidies from plant-based food products (A), feed production embodied in ASF supply chains (B), and livestock production (C). (D–F) Projected farm-profit exposure under the PHD. Projected changes are shown relative to 2020 baseline. Maps show absolute values and indicate aggregate exposure at the country level; output-normalised differences are represented by the profit intensities in figure 2A. ASF=animal-sourced food. CAP=common agricultural policy. PHD=planetary health diet.

smaller declines in farm-profit exposure than livestock-dominated systems because profitable alcohol-linked crop, fruit, and vegetable sectors remained after production in ASF-related sectors declined.

Diversified profit systems lacked a dominant ASF or alcohol sector, and no sector incurred large losses, although several food items operated close to their breakeven point. Under the PHD scenario, profits generally declined with ASF revenues, but the declines were less than those in livestock-profit-dominated systems. Profits declined in Belgium (€194 million, –25%), Croatia (€89 million, –50%), Cyprus (€1·0 million, –3%), Greece (€224 million, –27%), Lithuania (€82 million, –31%), Malta (€2·0 million, –10%), and Spain (€2·54 billion, –21%). Hungary (€27 million, +3%) and the Netherlands (€383 million, +19%) showed slight increases, mainly owing to higher profits from fruit and vegetables.

Segmented profit systems concentrated profits in a small number of food groups, whereas other food groups were loss-making. In these countries, a shift towards more plant-rich diets could increase total profits not only by expanding profits in fruit and vegetables but also by reducing losses in

specific unprofitable livestock sectors. In Sweden, poultry products (€6·4 million) and fruit and vegetables (€174 million) remained profitable, whereas other food groups incurred substantial losses (€104 million). Slovenia retained profitable sectors in alcohol (€36 million), fruit and vegetables (€6·4 million), and dairy (€1·7 million), whereas losses were observed in beef and lamb (€8·4 million) and cereals (€1·1 million). In the UK, constant-price ex-CAP profits under the PHD scenario totalled €259 million (+105%); the increase was driven by higher profits from fruit and vegetables (€38 million) and a €245 million reduction in beef and lamb losses (ie, the sector became less unprofitable). The gains were partly offset by profit declines in dairy (€234 million), pork (€38 million), and poultry products (€54 million).

Broad agricultural loss systems, including those in Bulgaria and Luxembourg, had no clearly profitable sector and depended strongly on CAP subsidies. Under the PHD scenario, losses in ASFs declined, but the agricultural systems remained vulnerable. Profits increased by €57 million (+36%) in Bulgaria and €18 million (+113%) in Luxembourg.

Employment effects also varied across countries; full country-level results are reported in the appendix (pp 10–12). Unsubsidised profits per labour input increased from €6800 per AWU in the baseline to €9200–10 800 per AWU under the PHD variants. The increase occurred because employment declined more strongly than aggregate ex-CAP farm profits and because reductions in loss-making ASF sectors removed losses from the remaining profit aggregates. Including CAP subsidies, profits remained at approximately €15 000–16 000 per AWU.

Discussion

The EU cannot meet its current climate and biodiversity targets without a structural decline in livestock production and consumption. However, the distribution of land use, subsidy, farm-profit, and labour exposure across the EU's farming landscape remains only partly quantified. By connecting EU agroeconomic data with supply-chain modelling, we show that plant-rich diets would substantially reshape agricultural land use, CAP subsidies, and farm employment, with highly uneven economic outcomes for farmers. These outcomes reflect the structural diversity of national food economies and their varying degrees of reliance on ASF systems. Although some regions would have net gains or manageable declines in unsubsidised profits, others risk further income losses without targeted support. Managing these trade-offs requires differentiated policy responses and CAP reform that shares transition costs beyond farmers.[20] Policy implications are informed by both the structural patterns identified in our analysis and the broader literature on food-system transitions, labour adjustment, and CAP reform.

The current area-based CAP subsidy regime undermines the climate-aligned, biodiversity-aligned, and health-aligned diets promoted by the EU.[2] A large share of CAP support is embodied in ASF supply chains, particularly through land-intensive ruminant and feed systems, reflecting both the area-based structure of CAP support and the concentration of agricultural land occupied by ASF systems. CAP payments include income support, environmental payments, and support for farming in areas with natural constraints[18] and should not be interpreted as direct output subsidies. The concentration of CAP payments in ASF supply chains highlights the weak economic performance of several sectors, particularly land-intensive ruminant livestock, which are difficult to reconcile with tightening climate and biodiversity targets.[13,21,22] Similar dependence was recorded in 2018.[20] CAP payments are only one component of the broader policy environment affecting EU livestock sectors. Border measures, tariff-rate quotas, and trade agreements can also influence the competitiveness of EU livestock production;[23] however, these instruments were not modelled in this analysis.

CAP reform should be spatially differentiated because impacts of dietary change are concentrated in specific production structures and geographical areas. Differences in ruminant subsidy dependence show this variation (figure 2A). Some countries have profitable beef and lamb sectors without subsidies, whereas others show high subsidy dependence or incur losses. These differences probably reflect combinations of production systems, cost structures, farm sizes, and CAP allocation that we do not disentangle here. As much CAP support is area-based, countries and sectors with larger land requirements might receive substantial support even when their ex-CAP profitability is low (figure 1).[24] Recognising this heterogeneity would allow CAP instruments to be aligned more closely with the needs of different transition archetypes.

Because livestock-loss-dominated systems show the largest farm-profit exposure, these regions might require income support coupled with incentives for alternatives such as active or passive rewilding. Livestock-profit-dominated systems can retain grazing but require a shift from uniform area payments to outcome-based eco-schemes (eg, lower enteric methane intensity and legume-rich pastures). For broad agricultural loss systems, redirecting production subsidies towards rural development that funds agroecological practices and ecosystem restoration can address both environmental and income objectives.[12,22]

Archetype-specific measures require resources to move between sectors and regions. The €28–36 billion per year of CAP repurposing space identified under the PHD variants indicates the scale of funding that could be redirected, even after accommodating increased support for legumes, fruit, and vegetables at current subsidy intensities (figure 1). Alternative reallocations across countries are possible and would change the spatial distribution of repurposing space. Redirecting this repurposing space towards three EU-wide priorities would maximise public value. This approach aligns with multimodel evidence showing that dietary change is most effective when combined with other

measures that moderate pressures on prices, land use, and food affordability.[16]

The first priority is environmental restoration and climate action on the 58–78 Mha of European land released by reduced livestock and feed production. Restoration of this land would better align agricultural spending with the EU's climate and biodiversity objectives.[12,22,25] Possible measures include grassland rewilding, peatland rewetting, afforestation, agroforestry, and pollinator habitat restoration. Reallocation is urgent because on-farm conservation measures under the 2023–27 CAP, even with the additional green instruments, remain insufficient to address large-scale climate and biodiversity challenges.[12,22] Therefore, landscape-scale restoration of released land is required. This finding is consistent with that of Beier and colleagues,[11] who showed that dietary change reduces land-system pressure while emphasising the need for careful governance of released land, as bioenergy expansion and other land-based mitigation measures can create trade-offs across planetary boundaries.

Second, given that employment declines are concentrated in livestock-dominated systems, targeted safety nets and reskilling programmes are needed in regions facing net income or job losses to ensure that transition costs are shared.[15] Targeted support should include agricultural workers and rural economies affected by reduced ASF production.[15,26,27] Regionalised transition planning tailored to local employment structures and skill needs will be essential to avoid widening territorial inequalities and maintain public support for reform.[25,26]

Third, as the analysis identified substantial fiscal repurposing space (€28–36 billion per year), part of these resources could be directed towards consumer-side incentives that lower the retail price of fruit, vegetables, and legumes, mitigating regressive effects and amplifying health co-benefits. Demand for fruit and vegetables responds to prices, and meta-analysis indicates that subsidy-driven price reductions can meaningfully boost consumption.[28] Evidence remains conflicting regarding the overall costs of different, more plant-rich diets under the current system;[29] however, consumer-side subsidies, such as vouchers, discounts, and public procurement, can mitigate regressive effects while supporting healthier diets.[28,30] Kuiper and colleagues[31] similarly showed that price-based policy bundles can improve the affordability of PHD-aligned diets even when full adoption is not achieved.

With the current CAP framework approaching its end and the post-2027 framework under development, the next reform provides an immediate opportunity to align agricultural support more closely with EU climate, biodiversity, and food-system objectives. The proposed integration of CAP measures into national and regional partnership plans increases the scope for member states to tailor agricultural support to national and regional needs. Our results provide a basis for identifying regions with the greatest transition exposure based on regional differences in subsidy dependence, profitability, and labour exposure. Embedding EU-wide transition priorities alongside spatially differentiated measures could help to prevent agricultural support from continuing to reinforce conventional livestock systems rather than enabling dietary and environmental transitions.[7,12,21,22] National governments might invoke food security or rural employment to justify renewed support for high-emission sectors.[21] Additionally, national governments can create favourable benchmarks for sustainable meat that allow current livestock production to persist.[32] Resistance to green deal-type agricultural reforms suggests that large-scale land-use transitions require clear sequencing, compensation, and farmer-centred transition support.[21] Transparent EU-level rules on fund reallocation are, therefore, essential to ensure that CAP support is aligned with dietary health, climate, and biodiversity objectives, rather than perpetuating existing high-emission systems.

Ruminant livestock is among the EU's most labour-intensive farm types per hectare and per unit of output owing to daily demands of animal care, milking, and grazing management, excluding upstream labour associated with purchased feed.[27] Although on-farm employment in these systems has declined as herds have scaled up and tasks have become more specialised,[27] our analysis shows that ASF still accounts for approximately 60% of total embodied farm labour, with approximately 65% associated with livestock operations, and the remainder attributable to upstream feed production, including grazing. Scaling up the production of fruit, vegetables, legumes, nuts, and seeds adds 344 000–1 184 000 AWU, but total embodied farm employment still declines by 37–40% (1 963 000–2 093 000 AWU), because AWU losses in animal systems are larger. Vittis and colleagues[15] estimate global agricultural labour reductions of 5% for the PHD and PHD-pescetarian diets and 22–28% for the PHD-vegetarian and PHD-vegan diets, with larger reductions in livestock-oriented countries. Our estimated 37–40% decline in embodied farm labour in the EU+UK is consistent with the pattern in high-income, livestock-oriented systems. Our results extend this evidence by identifying policy-economic dimensions in the EU+UK: labour exposure is concentrated in the same supply chains in which CAP dependence and farm-profit exposure are highest. Realised job losses, labour mobility, and new employment creation will depend on regional labour markets, demographics, and policy design.[15,26,27]

Projected reductions in farm employment do not necessarily translate into equivalent numbers of direct job losses because some labour adjustment might occur through retirement and attrition, given the demographics of the EU farming population. In 2020, 33% of farm managers were aged 65 years or older.[33] This proportion was high in several archetypes, including Portugal (50%, alcohol-linked profit system), Cyprus (46%, diversified profit system), Romania (38%, livestock-profit-dominated system), Italy (42%, alcohol-linked profit system), Sweden (35%, segmented profit system), Bulgaria (31%, broad agricultural loss system), and Latvia (30%, livestock-loss-dominated system). In

contrast, livestock-loss-dominated systems in Estonia (26%), Slovakia (21%), Czechia (21%), Finland (17%), and especially Germany (11%) might require additional transition incentives because demographic attrition is likely to absorb a smaller share of labour adjustment.

Consumer-price effects of supply-side shifts might be muted as farm-price changes pass through subsequent stages of the food supply chain; primary production accounted for approximately 22% of gross value added in the EU food supply chain in 2022.[24] Cost pass-through from farm gate to retail is often incomplete and asymmetrical, whereas downstream actors in processing, wholesale, and retail capture a large share of value added.[34,35] CAP reform alone might have small effects on farm income or consumer affordability unless paired with measures that address market power and value distribution along the food supply chain.

For more on **FADN-FABIO allocation**, see https://doi.org/10.5281/zenodo.21028047

Our analysis did not capture several longer-term adjustments, including climate impacts on yields, automation, mitigation technologies, non-food land-use rebounds,[11,36] endogenous trade responses,[14] substitution towards novel proteins and the associated livelihood implications,[37] and policy instruments required to induce dietary change, which might affect prices, production decisions, and distributional outcomes.[31] Fixed trade shares also preclude production shifting towards more competitive countries or exports being redirected towards markets with sustained demand, both of which could alter country-level outcomes. PHD is applied at full adoption and scaled to caloric requirements, with consumption of alcohol and other items not covered by the PHD recommendations held constant (appendix p 7). Partial uptake and variation in caloric requirements are not modelled. These modelling choices complement equilibrium-based projections[14] and global labour-requirement inventories[15] by isolating the distributional incidence of embodied labour, CAP subsidies, and farm-profit exposure across food groups and regions in the EU+UK.

Our archetypes reflect patterns observed more widely in high-income food systems, in which livestock production dominates land use, subsidies, and emissions.[8,25,30] These findings point to three policy directions. First, food-security objectives should be defined in terms of nutrient supply, affordability, and resilience, so that livestock support is justified when production delivers these objectives (eg, grazing on land unsuitable for crop production).[21] Second, CAP support should be tailored to regional archetypes: income-support exit schemes and rewilding incentives for loss-making livestock areas; outcome-based eco-schemes for profitable livestock regions; and rural development funding for agroecological transition for broad agricultural loss systems.[12,22] Third, part of the €28–36 billion per year of CAP repurposing space should be used for ecosystem restoration and targeted livelihood support, consistent with the re-think, re-structure, and re-connect leverage points applied to EU livestock policy by Adams and colleagues.[20] Such measures could reduce subsidy dependence, limit uneven transition costs, and better align agricultural spending with EU climate, biodiversity, and equity goals.[10]

Contributors

AJK, JMM, and PB designed the study. AJK collected, verified, and analysed the data in collaboration with JMM and PB. AJK led the writing, with major contributions from PB, JMM, and OT. All authors approved the final manuscript and accepted responsibility for the decision to submit.

Declaration of interests

We declare no competing interests.

Data sharing

The study uses publicly available and derived open-access model data only; no individual participant data were collected. The FADN-FABIO allocation is available without restriction. No additional study documents or access criteria are applicable.

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References

1 European Commission. The European green deal. 2019. https://www.consilium.europa.eu/media/47573/st_15051_2019_init_en.pdf (accessed March 12, 2026).
2 European Commission. A farm to fork strategy for a fair, healthy and environmentally-friendly food system. 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0381 (accessed March 12, 2026).
3 European Commission. EU biodiversity strategy for 2030 – bringing nature back into our lives. 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52020DC0380 (accessed March 12, 2026).
4 Ray DK, West PC, Clark M, Gerber JS, Prishchepov AV, Chatterjee S. Climate change has likely already affected global food production. *PLoS One* 2019; **14:** e0217148.
5 Kortleve AJ, Mogollón JM, Harwatt H, Behrens P. Over 80% of the European Union's Common Agricultural Policy supports emissions-intensive animal products. *Nat Food* 2024; **5:** 288–92.
6 Sun Z, Behrens P, Tukker A, Bruckner M, Scherer L. Global human consumption threatens key biodiversity areas. *Environ Sci Technol* 2022; **56:** 9003–14.
7 Talenti R. Grounding a legal research agenda on the EU mitigation of livestock emissions – a systematic literature review. *New Medit* 2025; **3:** 67–84.
8 Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. *Science* 2018; **360:** 987–92.
9 Rockström J, Thilsted SH, Willett WC, et al. The EAT–Lancet Commission on healthy, sustainable, and just food systems. *Lancet* 2025; **406:** 1625–700.
10 Scown MW, Brady MV, Nicholas KA. Billions in misspent EU agricultural subsidies could support the sustainable development goals. *One Earth* 2020; **3:** 237–50.
11 Beier FD, Dietrich JP, Heinke J, et al. Planetary boundaries under a land-based climate change mitigation scenario with a food demand transformation: a modelling study. *Lancet Planet Health* 2025; **9:** 101249.
12 Pe'er G, Bonn A, Bruelheide H, et al. Action needed for the EU Common Agricultural Policy to address sustainability challenges. *People Nat (Hoboken)* 2020; **2:** 305–16.
13 Mennig P. A never-ending story of reforms: on the wicked nature of the Common Agricultural Policy. *NPJ Sustain Agric* 2024; **2.**
14 Rieger J, Freund F, Offermann F, Geibel I, Gocht A. From fork to farm: impacts of more sustainable diets in the EU-27 on the agricultural sector. *J Agric Econ* 2023; **74:** 764–84.

15 Vittis Y, Obersteiner M, Godfray HCJ, Springmann M. Labour requirements for healthy and sustainable diets at global, regional, and national levels: a modelling study. *Lancet Planet Health* 2025; **9:** 101342.

16 Sundiang M, Diniz Oliveira T, Mason-D'Croz D, et al. Bundling measures for food systems transformation: a global, multimodel assessment. *Lancet Planet Health* 2025; **9:** 101339.

17 Bruckner M, Wood R, Moran D, et al. FABIO–the construction of the food and agriculture biomass input-output model. *Environ Sci Technol* 2019; **53:** 11302–12.

18 European Commission. Farm Accountancy Data Network Public database. 2024. https://data.europa.eu/data/datasets/farm-accountancy-data-network-public-database?locale=en (accessed Dec 17, 2025).

19 Liu B, Behrens P, Sun Z, Scherer L. High-resolution carbon and biodiversity mapping shows correlated losses across space and agricultural products. *Nat Food* 2026; **7:** 792–801.

20 Adams N, Sans A, Trier Kreutzfeldt KE, et al. Assessing the impacts of EU agricultural policies on the sustainability of the livestock sector: a review of the recent literature. *Agric Hum Values* 2025; **42:** 193–212.

21 Candel J, Daugbjerg C. EU Green Deal's food system agenda fails to deliver post-exceptionalist breakthrough. *Nat Food* 2025; **6:** 563–70.

22 Röder N, Krämer C, Grajewski R, Lakner S, Matthews A. What is the environmental potential of the post-2022 common agricultural policy? *Land Use Policy* 2024; **144:** 107219.

23 Ferrari E, Chatzopoulos T, Pérez Domínguez I, et al. Cumulative economic impact of trade agreements on EU agriculture. update. 2021. https://agriculture.ec.europa.eu/system/files/2021-01/jrc-cumulative-economic-impact-of-trade-agreements-on-eu-agriculture_en_0.pdf (accessed March 12, 2026).

24 Eurostat. Key figures on the European food chain. 2024. https://ec.europa.eu/eurostat/web/products-key-figures/w/ks-01-24-000 (accessed March 12, 2026).

25 FAO, UNDP, UNEP. A multi-billion-dollar opportunity – repurposing agricultural support to transform food systems. 2021. https://openknowledge.fao.org/server/api/core/bitstreams/05983446-7ad7-4ea5-9257-fda5e186467f/content (accessed March 12, 2026).

26 Berdegué JA, Trivelli C, Vos R. Employment impacts of agrifood system innovations and policies: a review of the evidence. *Glob Food Secur* 2025; **44:** 100832.

27 Hostiou N, Vollet D, Benoit M, Delfosse C. Employment and farmers' work in European ruminant livestock farms: a review. *J Rural Stud* 2020; **74:** 223–34.

28 Huangfu P, Pearson F, Abu-Hijleh FM, et al. Impact of price reductions, subsidies, or financial incentives on healthy food purchases and consumption: a systematic review and meta-analysis. *Lancet Planet Health* 2024; **8:** e197–212.

29 Springmann M, Clark MA, Rayner M, Scarborough P, Webb P. The global and regional costs of healthy and sustainable dietary patterns: a modelling study. *Lancet Planet Health* 2021; **5:** e797–807.

30 Springmann M, Freund F. Options for reforming agricultural subsidies from health, climate, and economic perspectives. *Nat Commun* 2022; **13:** 82.

31 Kuiper M, De Lange T, Van Zeist W-J, Van Meijl H. Exploring environmental and distributional impacts of different transition pathways for healthier and sustainable diets: an economic modelling study. *Lancet Planet Health* 2025; **9:** 101327.

32 Resare Sahlin K, Röös E, Gordon LJ. 'Less but better' meat is a sustainability message in need of clarity. *Nat Food* 2020; **1:** 520–22.

33 Eurostat. Farm indicators by age and sex of the manager, economic size of the farm, utilised agricultural area and NUTS 2 region. 2026. https://ec.europa.eu/eurostat/databrowser/product/page/ef_m_farmang (accessed Oct 21, 2026).

34 Chen DMC, Bodirsky B, Wang X, et al. Future food prices will become less sensitive to agricultural market prices and mitigation costs. *Nat Food* 2025; **6:** 85–96.

35 Deconinck K. Concentration and market power in the food chain. 2021. https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/02/concentration-and-market-power-in-the-food-chain_aa5064d9/3151e4ca-en.pdf (accessed March 17, 2026).

36 Gatto A, Kuiper M, Van Meijl H. Economic, social and environmental spillovers decrease the benefits of a global dietary shift. *Nat Food* 2023; **4:** 496–507.

37 Nordhagen S, Beal T, Herrero M, Mane E, Neufeld LM, Sokourenko K. Livelihood implications of dietary shifts to animal-source food alternatives: a scoping review. *Lancet Planet Health* 2026; **10:** 101424.