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The reshaping of European food systems through plant-rich diets

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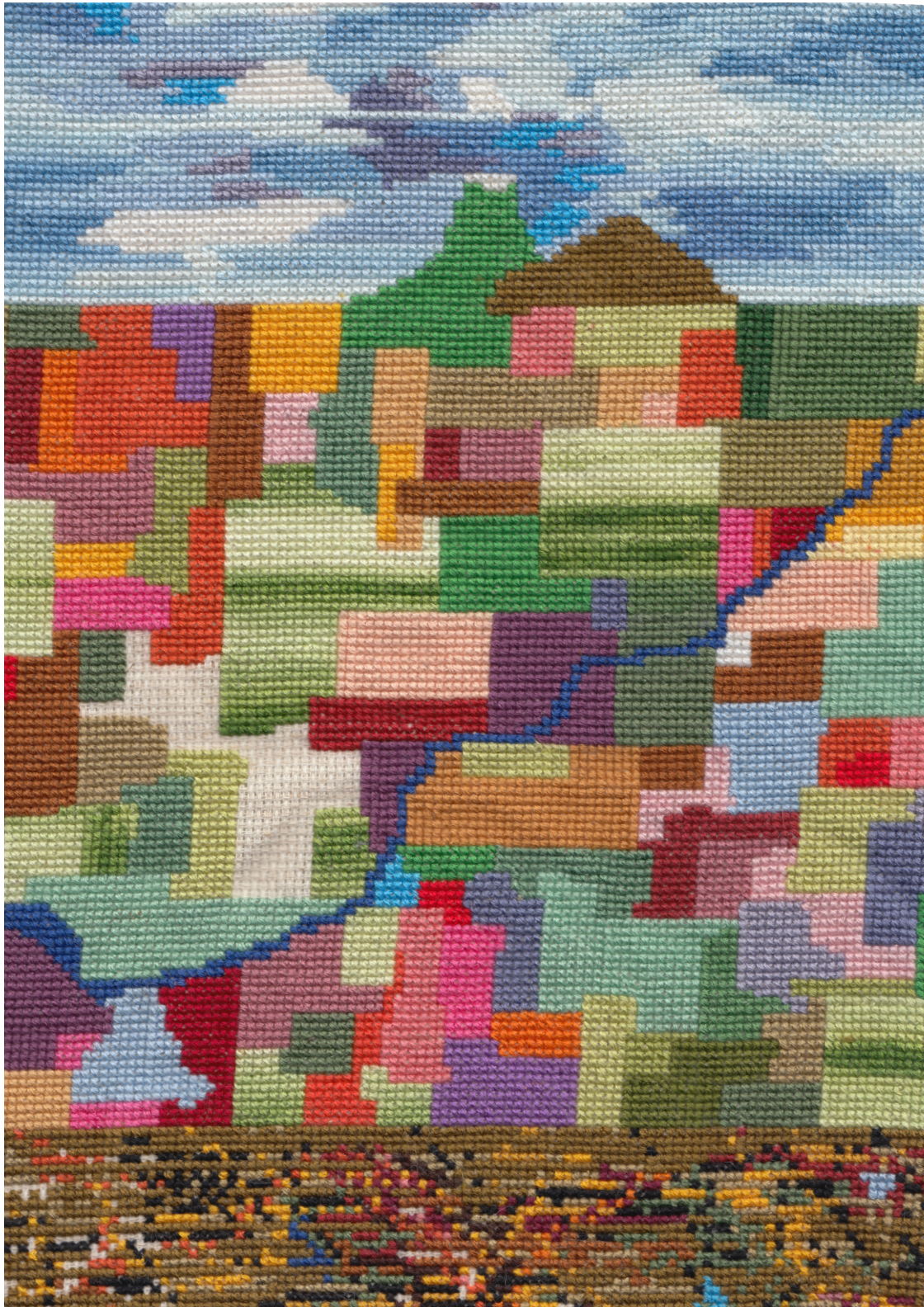
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Chapter 7. General discussion

7.1 Introduction

Despite growing consensus on the environmental and human health benefits of transitioning to more plant-rich diets, the socio-economic implications of such transitions remain poorly understood, particularly from a system and producer perspective. This thesis addresses that gap through a multi-scalar assessment of how dietary shifts in the EU+UK would reshape the structure, economic performance, and environmental footprint of the agrifood system.

This dissertation responds to three research gaps identified in Chapter 1.4. First, producer-side socio-economic exposure to dietary transition, including subsidy dependence, farm income, and employment, has remained insufficiently quantified within an integrated supply-chain framework (Gap A). Chapters 2 and 3 address this gap, while Chapter 6 extends the analysis to the subnational level. Second, agricultural asset stranding under dietary transition has increasingly been recognised but remains weakly quantified in terms of its scale, timing, and sectoral exposure (Gap B). Chapter 4 addresses this gap. Third, national-level analysis often masks substantial subnational variation in agricultural structure, subsidy dependence, and transition vulnerability (Gap C). Chapter 5 addresses this methodological gap and Chapter 6 applies the method empirically.

The analyses focus on three linked transition barriers that shape the feasibility and equity of plant-rich dietary transitions in the EU+UK (Chapter 1.3). First, the CAP shapes production incentives through land-based payments that systematically favour animal-sourced food production, even as public objectives shift towards climate, biodiversity, and dietary goals. Second, animal-sourced food systems depend on long-lived and specialised agricultural assets, creating capital lock-in and potential asset stranding under rapid changes in demand. Third, transition impacts are geographically uneven, while national averages often obscure where subsidy dependence, employment exposure, and farm-income vulnerability are concentrated.

These three transition barriers are embedded in a wider system of market structures, supply-chain power, cultural norms, innovation systems, trade policy, environmental regulation, and political resistance (Fig. 1.1). Their effects are mediated by national and regional policy contexts, meaning that similar changes in demand or CAP support may produce different outcomes across places. The dissertation focuses on these barriers because they remain insufficiently quantified in the EU+UK context and can be analysed consistently through a producer-oriented supply-chain framework. Together, they demonstrate how public support, accumulated capital, and regional specialisation can reinforce each other, shaping both exposure to change and the capacity to adapt.

Methodologically, the dissertation combines food-system EEMRIO modelling with harmonised farm-level data to quantify environmental and socio-economic footprints. It also develops a transparent regionalisation approach for subnational analysis where constructing bottom-up subnational EEMRIO models at the European scale is not feasible. The combined studies identify how subsidies and fixed assets sustain path dependence and where transition costs and opportunities are likely to concentrate across farm sectors and regions under plant-rich dietary scenarios.

7.2 Revisiting the five studies

Before presenting the cross-chapter synthesis, the discussion briefly revisits the five studies, highlighting their main insights and relevance to the overall thesis. Chapter 7.3 then integrates these findings to answer the main research question: **how would a transition towards plant-rich diets reshape the structure, economic, and environmental performance of the EU+UK food system, and what are the implications for agricultural assets, subsidies, and regional equity?**

7.2.1 Subsidy lock-ins along supply chains

As shown in Chapter 2, CAP support contributes to structural lock-ins along food supply chains (Table 7.1). This study shows that CAP support is structurally tilted towards animal-sourced food supply chains: 82% of food-related CAP subsidies are allocated to animal-sourced foods once animal feed is included (38% direct, 44% feed), which substantially increases subsidy intensity per kilogram (for example, beef rises from ~€0.71 to ~€1.42 per kilogram once feed is included). Because most CAP support is allocated via land-area-based payments, this structure disproportionately benefits land-intensive animal systems, embedding financial lock-ins that constrain diversification towards lower-emission alternatives. This allocation matters because the same animal-sourced food flows are associated with 84% of embodied GHG emissions while supplying a minority of calories, implying that the current CAP allocation weakens price and investment signals for a plant-rich transition. A further implication is that CAP support does not exclusively underpin domestic EU consumption: 12% of CAP subsidies (~€6.8 billion) are embodied in exports outside the EU, mainly to high-income and upper-middle-income countries, which complicates food security justifications for a non-trivial share of CAP spending. The analysis concerns CAP support for land-based agriculture and excludes fisheries subsidies; it should therefore not be interpreted as an assessment of EU support for all animal-sourced foods.

Table 7.1 Summary of key findings from Chapter 2 and their relevance to the main thesis

Finding	Key results	Relevance to main thesis
CAP overwhelmingly favours animal-sourced products	82% of food-related subsidies are allocated to animal-sourced foods (38% directly to animals, 44% embodied in feed). Feed inclusion doubles the implicit subsidy on beef and milk and triples that on pig meat, exposing hidden incentives (Fig. 2.1)	Quantifies the size of the economic lock-in that plant-rich scenarios must overcome
Environmental misalignment	Those same animal-sourced food flows cause 84% of EU+UK food-system GHG emissions while delivering only 35% of calories	Establishing the environmental rationale for subsidy reform; the potential fiscal repurposing space under dietary transition is quantified in Chapter 3
Externalised land footprint	For 23 of 28 EU+UK countries, the land embodied in current diets exceeds domestic arable land available; Germany's demand is 1.6 times its own arable land, the Netherlands 3.7 times (Fig. 2.2)	Demonstrates a hidden reliance on international land. A shift to plant-rich diets would ease foreign land demand and better align subsidies with true resource use
Export of subsidised impacts	63% of CAP is embodied in domestic consumption, 23% exchanged within the EU and 12% exported outside the EU (€6.8 billion), mainly to other high- and upper-middle-income countries (Fig. 2.1)	Shows that a non-trivial share of CAP subsidies does not support EU food security

Chapter 2 provides the institutional basis for the dissertation's systems assessment. It demonstrates that CAP rules structurally channel land and public funds towards animal-sourced food production. By supporting animal-specific buildings, machinery, and equipment, the CAP can also reinforce

capital lock-in and increase the stranded-asset risks assessed in Chapter 4. Chapters 3 and 6 use the quantified subsidy flows to model national and regional shifts under plant-rich diets. This chapter provides the financial baseline against which the socio-economic and spatial consequences of dietary change are later evaluated.

7.2.2 Regional winners and losers of a plant-rich transition

Chapter 3 maps the uneven national impacts of a plant-rich transition across the EU+UK (Fig. 3.3; Table 7.2). This study traces embodied land use, CAP subsidies, farm employment, and unsubsidised farm profits (ex-CAP) through EU+UK food supply chains under the PHD and its pescetarian, vegetarian, and vegan variants. At the EU+UK scale, adopting the PHD vacates ~58 million hectares of agricultural land and creates ~€28 billion yr⁻¹ of potential CAP repurposing space, alongside declines in farm employment (~37%) and ex-CAP farm profits (~15%). More plant-rich variants increase the land and CAP repurposing space (up to ~78 million hectares and ~€36 billion yr⁻¹) while reducing the ex-CAP profit decline (to ~3% under the vegan variant), but outcomes remain highly uneven across countries and production structures.

To make distributional patterns readable, Chapter 3 summarises heterogeneity using six transition archetypes based on sectoral composition, unsubsidised profitability, and exposure to reduced animal-sourced food demand: livestock-dominated-loss systems, livestock-dominated-profit systems, alcohol-linked profit systems, diversified profit systems, segmented profit systems, and Broad agricultural loss systems. These archetypes capture differences in economic structure and transition exposure, showing that the same dietary shift can relieve chronic losses in some animal-heavy systems while eroding profits in other animal-specialised systems, implying that transition design needs to be targeted to production structure rather than applied uniformly by country.

Table 7.2 Summary of key findings from Chapter 3 and their relevance to the main thesis

Finding	Key results	Relevance to main thesis
Large land and subsidy repurposing space	Land vacated ~58–78 million hectares; CAP repurposing space ~€28–36 billion yr ⁻¹ (Fig. 3.1)	Shows the scale of land and public-budget space created by plant-rich diets
EU-wide farm economics shift, but profits fall less than land/labour	Employment declines by ~37–40%; ex-CAP profits decline by 15–3% (PHD-PHD-vegan; Fig. 3.1)	Indicates that EU-wide adjustment is large, but income impacts depend on subsidy rules and sector mix
CAP dependence and animal-sourced-food concentration	77% of €51 billion CAP subsidies are linked to animal-sourced foods; CAP accounts for ~58% of total farm profits (sector dependence is highest in ruminants; Fig. 3.1)	Reinforces CAP as a central lock-in and main leverage point for managing distributional impacts
Impacts are structurally uneven	Loss-making systems can improve when losses disappear; profitable animal systems lose profits (Chapter 3.5)	Justifies differentiated support rather than uniform EU-wide instruments

By locating where profits, employment, and land-use pressures decline or expand, Chapter 3 adds a distributional perspective to the subsidy tracing in Chapter 2 and stranded-asset exposure in Chapter 4. The chapter shows that plant-rich diets can create large land and fiscal repurposing space while concentrating adjustment costs in specific animal-reliant production systems and regions. These findings support the six-archetype framework for targeted transition support and CAP reallocation.

7.2.3 Stranded assets in a plant-rich transition

Chapter 4 quantifies stranded-asset exposure in a dietary transition (Table 7.3). This study asks what happens to the EU+UK's agricultural assets when demand for animal-sourced food falls. It shows that animal-sourced food supply chains embody most fixed agricultural assets: 78% of EU+UK fixed

assets are linked to animal-sourced foods, including substantial exposure in upstream feed systems (~€100 billion), not only in on-farm animal production. This study adds another “intensity” dimension to the transition problem: beyond being land-, emissions-, and subsidy-intensive, animal-sourced food supply chains are also capital-intensive. Across EAT-*Lancet*-consistent scenarios, roughly 18–77% of animal-sourced-food-linked fixed assets are exposed to stranding as meat and dairy demand declines. Transition pace and signalling therefore matter: depreciation enables managed phase-out, but accelerated transitions increase residual stranded value and raise risks of political and financial resistance without repurposing and transition-finance support.

Chapter 4 builds on existing stranded-asset and transition-finance literature to frame stranded assets as a timing and cost-allocation problem rather than an inevitability. In this framing, stranded assets arise when demand or policy change more rapidly than specialised assets can depreciate, be repurposed, or reach the end of their economic life, and transition feasibility depends on how losses are allocated and managed. This perspective motivates policy attention to depreciation timelines, repurposing pathways, and transition-support instruments.

Table 7.3 Summary of key findings from Chapter 4 and their relevance to the main thesis

Finding	Key results	Relevance to main thesis
Animal-sourced foods dominate the asset base	78% of fixed assets are tied to animal-sourced foods: €158 billion to animals plus €100 billion in upstream feed production (Fig. 4.2)	Quantifies the scale of asset lock-in that must be reallocated in any plant-rich future
Stranding risk grows with the depth of dietary change	Moderate (-9.5%) animal-sourced-food scenarios strand €61 billion; low (-60%) strands €168 billion; zero (-100%) strands €255 billion (Fig. 4.3)	Shows that incremental shifts leave most assets intact, but deep cuts trigger systemic stranding
Depreciation buys time, unless the shift is abrupt	At the current depreciation rate, redundant assets under the low and moderate animal-sourced-food scenarios could depreciate fully within approximately thirty years, whereas an accelerated phase-out by 2030 could leave ~€99 billion in residual stranded value (Supplementary Information Fig. 4.3)	Underscores the importance of transition pacing and advance warning
Dairy is the single largest food exposed	€109 billion in dairy-linked assets (44% in buildings, 40% in machinery and equipment, 16% in breeding animals; Fig. 4.2)	Flags the sector where policy support and repurposing schemes matter most

Chapter 4 translates the animal-sourced food bias identified in Chapter 2 into quantified exposure to asset stranding. The chapter shows how animal-housing buildings, milking equipment, and feed-linked infrastructure may lose value under a shift towards plant-rich diets. Such exposure creates a producer-side financial friction that could hinder the transition unless policy supports asset retirement, depreciation management, and repurposing. This exposure extends beyond farms because devaluation can propagate through input suppliers, processors, and the financial institutions that finance agricultural assets. The stranded-asset metrics complement Chapter 3’s analysis of farm employment and profitability, providing a broader account of the socio-economic consequences of dietary transition.

7.2.4 Spatial disaggregation in IO models

Chapter 5 provided the methodological basis for the subnational analysis applied in Chapter 6 (Table 7.4). This methodological study introduces an open-source algorithm that disaggregates any EEMRIO database to the subnational level using widely available proxies. Extending the location-quotient logic

to a full multi-regional framework yields balanced tables without the need for RAS or other forms of reconciliation.

Table 7.4 Summary of key findings from Chapter 5 and their relevance to the main thesis

Finding	Key results	Relevance to main thesis
Self-balancing regionalisation	Aggregate of subregions exactly reproduces national accounts (Table 5.1); subnational GDP vs subnational value-added correlation $R^2 = 0.99$ for subregions of Spain and France (Chapter 5.5.2)	Provides a transparent spatial layer for scenario modelling
Scalable with minimal data	Proof-of-concept expands EXIOBASE from 49 to 93 geographic entities (19 Spanish + 27 French NUTS 2 regions) using only 2 generic proxies (Chapter 5.3)	Demonstrates practicality for EU-wide agrifood application in Chapter 6
Partial external validation	Territorial GHG alignment $R^2 = 0.60$ (0.77 with Madrid outlier removed) against official inventories; subnational consumption footprint within ~20% of survey-based MRIOs (Chapter 5.4)	Shows broad alignment with available external datasets while also indicating uncertainty in subnational estimates

Chapter 5 adds the geographical resolution needed to identify where the impacts of dietary transitions cluster. The regionalisation method nests NUTS 2 regions within the global supply chain while preserving national account consistency. Chapter 6 applies the resulting framework to map employment, farm profits, and subsidies across European regions.

7.2.5 Subnational subsidy dependence, labour exposure, and implications for tailored CAP reform

Chapter 6 examines how subsidy dependence and labour exposure vary strongly across subnational regions, with implications for more tailored CAP reform (Table 7.5). The core finding is that CAP reliance shows considerable subnational variation: embodied subsidy dependence in current food consumption varies by more than a factor of five across EU regions (from 1.76 to <0.3), implying that identical CAP reforms will be experienced very differently across places. A second conclusion is that direct subsidy dependence generally increases with farm size across most food groups (most clearly in cereals), while ruminant systems show more complex patterns, indicating that CAP design interacts with both land structure and production intensity rather than mapping cleanly onto a single farm type. Under an EU-wide shift to the PHD assessed at the subnational scale, adjustment pressures are large and uneven across regions, alongside substantial cross-regional variation in both profit and farm employment outcomes.

Beyond mapping, Chapter 6 connects these subnational patterns into an applied reform exercise. Building on the archetypes developed in Chapter 3, it uses region-specific case examples and supporting literature for 13 cases to illustrate how CAP repurposing space could be operationalised through place- and archetype-specific instrument bundles (as summarised in Table 6.1).

Table 7.5 Summary of key findings from Chapter 6 and their relevance to the main thesis

Finding	Key results	Relevance to main thesis
Subsidy dependence is uneven	Embodied subsidy dependence ranges from 1.76 to <0.3 across 134 EU regions (Fig. 6.1.a)	Identifies where CAP-linked dependence is concentrated and where reform may create particularly large adjustment pressures
Regional diversity in farm profits	Under the PHD in EU: EU-wide profits decline by €22.9 billion (28%; including CAP); profits increase in a small set of Mediterranean regions (net €611 million increase across these regions; Fig. 6.1.b)	Demonstrates that national averages may conceal hotspots of profitability and vulnerability, shaping reform feasibility
Labour demand varies sharply	Under the PHD in EU: EU farm employment declines by 1.32 million AWU (26%); employment increases in a small set of regions (net +54,000 AWU; Fig. 6.1.c)	Links dietary transition impacts directly to rural livelihoods and regional equity concerns
Farm size and subsidy dependence	Direct subsidy dependence generally increases with farm size across most food groups (strongest in cereals); relationships are weaker and more heterogeneous in ruminants (Fig. 6.2)	Connects CAP exposure to land structure and production intensity, informing targeting of instruments

The practical implication is that regional combinations of profitability, labour intensity, and subsidy dependence differ sharply. Feasible CAP reform therefore requires archetype- and place-specific instrument bundles, including, for example, exit and retirement support in some dairy regions and targeted ecological conditionality or diversification support in others. Uniform EU instruments would not account for these differences in regional exposure and adjustment capacity.

7.3 Cross-chapter synthesis and answer to the main research question

Taken together, the five studies trace how a shift to plant-rich diets would pass through the policy, economic, and spatial structure of the EU+UK food system. The analysis moves from the distribution of CAP support across supply chains, through the national socio-economic effects of dietary change and the resulting exposure of agricultural assets, to the development and application of a subnational analytical framework. On that basis, the discussion returns to the main research question: **how would a transition towards plant-rich diets reshape the structure, economic, and environmental performance of the EU+UK food system, and what are the implications for agricultural assets, subsidies, and regional equity?**

The overall result is that lower demand for animal-sourced foods would substantially reallocate resources within the EU+UK food system. Under fixed 2020 supply-chain structures, production requirements decline in animal farming and upstream feed production, shifting agricultural land, farm employment, CAP support, farm profits, and fixed agricultural assets away from animal-sourced food supply chains. At the EU+UK level, plant-rich diets create substantial land and fiscal repurposing space and reduce environmental pressures. The economic effects are more uneven, because current production systems differ in profitability, subsidy dependence, labour intensity, and asset exposure. CAP dependence and specialised assets can slow this reallocation, while regional concentration determines where adjustment pressures are greatest. The results therefore represent structural exposure within the current food system rather than a forecast of how prices, production, and trade would adjust or how markets might eventually absorb surplus production.

Subsidy dependence, environmental pressure, and capital exposure are concentrated in many of the same supply chains. Once feed production is included, 77–82% of food-related CAP support is associated with animal-sourced foods. The same supply chains account for most EU+UK agricultural land use (71%) and embodied food-system GHG emissions (84%). Approximately 78% of fixed agricultural assets are linked to animal-sourced food supply chains, including around €100 billion in assets used for feed production. CAP payments also account for a large share of total farm profits (58%), particularly in ruminant production, although the degree of dependence differs across sectors and countries. Some animal-sourced food systems remain profitable without CAP support, while others would operate at a loss, meaning that lower demand can remove losses in some production systems while reducing profits in others.

The current allocation of CAP support also affects incentives to change production. Annual payments help sustain current farm income and the continued operation of production systems built around animal buildings, machinery, equipment, and breeding animals. Where profitability depends strongly on CAP payments, those assets may remain economically viable for longer than under unsubsidised conditions, thereby weakening incentives to diversify and sustaining production capacity that is increasingly misaligned with dietary and environmental objectives. Depending on the depth of dietary change, 18–77% of animal-sourced-food-linked fixed assets could become exposed to stranding. A gradual reduction in production allows a larger share of redundant assets to depreciate before they cease to be used, whereas an accelerated phase-out within ten years could leave approximately €99 billion in residual stranded value. Stranded-asset exposure highlights the importance of transition timing and cost allocation, because feasibility depends on who bears residual losses and whether depreciation, debt, and repurposing are managed.

The interaction between subsidies and fixed assets can itself slow transformation. Where assets have not yet depreciated, or where investments are linked to debt, continued production may be the least costly option for individual farms. The risk of premature losses can strengthen demands for continued support and increase resistance to policy reform. Continued CAP support may then prolong the use of specialised assets and encourage replacement investment, deepening the same capital lock-in that later increases transition costs. Reforming CAP payments without addressing the existing asset base may increase financial exposure, while supporting assets without changing current subsidy incentives may maintain incumbent production structures. CAP reform, managed depreciation, debt support, and asset repurposing therefore need to be considered together.

Regional heterogeneity determines where these institutional and capital pressures are felt. Employment, farm profits, subsidy dependence, and animal-sourced food production are concentrated in countries and subnational regions. Production systems with large unsubsidised losses may experience improved aggregate profitability when loss-making activities contract, while profitable animal-specialised systems may face substantial income reductions. Expansion in fruit, vegetables, and other plant-based foods can create gains, but those gains do not necessarily occur in the regions where animal-related employment and profits decline. National accounts also conceal much of this variation in subsidy dependence and in regional profit and employment outcomes. Regional equity therefore concerns where adjustment pressures arise and whether affected farms and farmers have access to viable alternatives. Place- and archetype-specific instruments are needed alongside a common EU policy direction.

The Dutch nitrogen crisis illustrates how environmental limits interact with geographically concentrated production systems (Erisman, 2026). The crisis reflects several mechanisms identified here: animal production, environmental pressures, and farm livelihoods are concentrated in particular

places, while sunk investments can increase the costs of adjustment. Persistent policy uncertainty and delayed structural decisions can further discourage investment in alternative production systems and prolong incumbent activities. Measures that appear proportionate at national level may consequently impose concentrated costs on particular farms and regions. Area-specific measures and transition support can account for differences in ecological pressure and regional exposure, but such measures need to operate within a stable EU or national framework that sets clear long-term objectives and prevents environmental pressures from being displaced between regions.

The implications of dietary transition also differ across economic scales. At farm level, adjustment pressures are expressed through changes in profitability, labour requirements, subsidies, and asset values, while decisions to continue, diversify, or exit will depend partly on existing profitability and the age and specialisation of the asset base. At regional level, concentrations of farm employment and subsidy dependence determine where dietary and policy changes have the largest socio-economic effects. At national and EU levels, agricultural support, environmental regulation, and trade policy influence how costs and opportunities are distributed. International agrifood companies add a further scale because processors, retailers, and input suppliers can respond by changing sourcing, product portfolios, and trade flows. The finding that 12% of CAP support was embodied in exports outside the EU already shows that the effects of agricultural support extend beyond EU+UK consumption. Such responses could reduce exposure in some EU+UK supply chains, but they could also relocate production and environmental pressures elsewhere. The modelling traces existing supply-chain relationships but does not simulate strategic responses by companies or endogenous changes in markets.

The producer-side barriers operate within a broader transition system shaped by consumer preferences, supply-chain power, policy coherence, cultural norms, knowledge and innovation systems, and political organisation. The dissertation does not model these conditions endogenously, but it identifies how exposure is structured before wider market and political adjustments occur. In answer to the main research question, a transition towards plant-rich diets would substantially restructure the EU+UK food system by reducing the land, labour, CAP support, and fixed agricultural assets associated with animal-sourced food and feed production. Environmental performance would improve through lower agricultural land requirements and reduced activity in the supply chains associated with most embodied food-system GHG emissions. Considerable agricultural land and CAP expenditure would become available for other uses, while farm-profit and employment effects would vary across sectors, countries, and subnational regions.

The central policy implication is that a plant-rich transition involves institutional, capital, and regional restructuring alongside changes in agricultural output. Existing subsidy structures affect which production systems remain economically viable, specialised assets affect the pace and cost of adjustment, and regional concentration determines where those costs and opportunities arise. The main institutional concern is whether CAP reform, asset-management policy, and regional support can manage concentrated adjustment pressures at the pace required by climate, biodiversity, and public-health objectives.

Industrial ecology methods provide a system-wide evidence base for that task by connecting final consumption to upstream production, land use, trade, subsidies, employment, farm profits, and fixed assets. They identify the scale and location of structural exposure, but they do not determine how transition pathways will unfold. Market responses, policy sequencing, political negotiation, and the capacity of farms and regions to adapt will ultimately shape whether the environmental opportunities identified here can be realised equitably.

7.4 Limitations and future research

This dissertation applies an EEMRIO-based framework to assess the systemic implications of dietary transitions in the EU+UK food system. While this approach offers broad analytical advantages, several limitations should be acknowledged, many of which also indicate potential areas for future research. Importantly, these limitations mainly affect transition dynamics and feasibility (timing, behavioural response, and policy sequencing), rather than the dissertation's structural conclusions about (i) the direction and approximate magnitude of supply-chain reallocation under plant-rich diets, (ii) the concentration of CAP support in animal-sourced food supply chains, (iii) the scale of potential stranding of animal-linked assets, and (iv) the existence of strong regional heterogeneity in exposure and adjustment pressures.

Limitations of EEMRIO. While EEMRIO models can trace how consumption-driven changes affect producers across the supply chain, they typically do so by proportionally scaling production based on existing IO relationships and trade patterns. As a result, these models cannot capture endogenous adaptation over time through behavioural changes, price-mediated responses, or structural adjustments in production systems (for example, technological change or strategic shifts in trade). More broadly, food-system transformations involve non-linear interactions and socio-political feedbacks that static EEMRIO models do not represent.

A further limitation is that the underlying FABIO model is based on physical rather than monetary flows. While these physical units (tonnes and numbers of animals) are well suited to tracing food-system materials and constructing dietary scenarios in nutritional terms, they limit the representation of prices, value added, and economic adjustments. At the same time, using a physical-flow model reduces the price-homogeneity problems of monetary MRIOs. However, this modelling framework still relies on commodity and sector homogeneity assumptions, since foods within each category are treated as internally uniform and linked through average input relationships.

Relatedly, the analysis is not linked to the rest of the economy, and therefore does not capture spillovers to non-food sectors or broader substitution and rebound effects. Such linkages could be added through integration with a monetary MRIO such as EXIOBASE (see, for example, Sun, Behrens, Tukker, et al., 2022), though at the cost of lower food-sector resolution.

These limits mirror broader challenges in food-system modelling, where behavioural and socio-political drivers are often underrepresented (Moallemi et al., 2025). Rather than expecting these models to fully capture behavioural and socio-economic complexity, greater transparency about how these dynamics are represented is needed to avoid overinterpreting results.

Limitations of farm-level data integration. Linking top-down MRIO results (for example, FABIO; Bruckner et al., 2019) with bottom-up farm-level data (for example, FADN (European Commission, 2024) poses several challenges. Differences in sectoral classification and reporting structures require harmonisation steps that introduce uncertainty. Consequently, asset, subsidy, labour, and profit values are often allocated using simplifying assumptions, such as proportional scaling, which can obscure differences between farm types or production systems (Supplementary Information Fig. 3.4 includes a sensitivity test comparing allocation based on total output with allocation based on land use). This allocation method risks flattening heterogeneity within major food groups. Moreover, farm-level data coverage is uneven across Member States: in smaller EU countries, data quality and sample sizes are often more limited. In addition, survey-based datasets such as FADN apply minimum economic thresholds that underrepresent the smallest producers. These issues may bias the

estimated distribution of vulnerabilities across farm types, but they do not remove the central conclusion that producer-side exposure and dependence vary strongly across regions and sectors.

Fish and other aquatic animal-sourced foods are included within the broader category of animal-sourced foods in the dietary scenarios (through the FABIO food item 'Fish, Seafood'), but the subsidy, profit, and asset analyses only concern land-based agriculture. Fisheries and aquaculture subsidies, vessel and aquaculture assets, and seafood-processing infrastructure are governed through different policy frameworks and are not covered by FADN datasets. The conclusions on CAP dependence and agricultural assets should not be generalised directly to fish production. A comparable analysis would need to trace fisheries and aquaculture subsidies, fixed assets, and land-based feed inputs to aquaculture across aquatic animal-sourced food supply chains.

Limitations of regionalisation. Spatial disaggregation of MRIO data introduces uncertainty due to mismatches in sector detail in MRIO tables and available proxy data (Chapter 5.5.1). Moreover, the method lacks the granularity to fully capture intra-regional heterogeneity and localised supply chains, which may lead to under- or overestimation of impacts, particularly in regions with diverse agricultural structures (Chapter 6.6). These limitations are compounded by the fact that subnational validation is often constrained by the absence of consistent or high-resolution regional data, especially concerning subnational trade. These limitations reflect an unavoidable trade-off between subnational detail and consistent European coverage, as regionalising all EU countries within a harmonised framework necessarily requires proxy data and some simplifying assumptions.

Limitations of scenarios. The dietary scenarios used in this dissertation are stylised and normative. Rather than predicting likely future outcomes, they are designed to explore the structural consequences of progressively reducing animal-sourced food consumption under fixed assumptions. As such, they do not account for political, behavioural, or cultural feasibility, nor do they model the pace, sequencing, or policy drivers of change. This scenario limitation reduces the ability to represent dynamic socio-technical feedbacks and the role of gradual or contested transition pathways.

The EAT-*Lancet* diets (Rockström et al., 2025; Willett et al., 2019) used in this dissertation are also primarily health-focused: they were developed by the EAT-*Lancet* Commission from a human health perspective. The diets reflect expected environmental co-benefits rather than an environmental objective (Rockström et al., 2025). Consequently, these scenarios are not necessarily the diets that minimise GHG emissions, land use, nutrient losses, or socio-economic disruptions. Alternative scenarios could be designed as explicit environmental or socio-economic optimisations (or multi-objective trade-offs) within nutritional constraints.

Moreover, while the scenarios comprehensively allocate environmental and economic impacts across both food and non-food outputs, they do not explicitly consider the integrated nature of many animal-sourced food systems. For example, in many countries dairy and beef production are closely interlinked: dairy cows produce both milk and calves, many of which enter the beef supply chain. This linkage is captured in the MRIO model through sectoral interdependencies, but modelling reductions in dairy or beef consumption independently overlooks these biological and economic linkages. Similarly, non-food co-products such as leather or wool remain artificially unaffected in the scenarios, despite being tied to the same animal systems. This simplification may overlook the interdependencies of animal-sourced food systems that could affect the feasibility or consequences of transition pathways.

Finally, the scenarios do not include the potential for repurposing stranded assets, despite niche cases where repurposing is already happening. Excluding this potential may overstate exposure or understate adaptive capacity in transition planning.

Limitations of transition analysis. This dissertation is primarily quantitative and structural in orientation. It identifies how dietary transitions could reallocate land use, subsidies, profits, labour, and asset exposure across the EU+UK food system, but it does not analyse in depth the transition processes through which such changes are negotiated, resisted, enabled, or governed. In terms of transition management and system innovation literature, the dissertation says more about structural exposure and redistribution than about the dynamics of system change itself. It does not explicitly examine, for example, how farm organisations and other incumbent actors defend existing CAP support arrangements, how alternative coalitions around plant-rich production emerge, or how policy change unfolds amid tensions and incoherence across agriculture, health, and environmental domains. Quantifying socio-economic and environmental outcomes is useful for identifying where transition pressures and vulnerabilities may emerge, but it is less suited to explaining how transition pathways are shaped in practice.

A further conceptual limitation concerns how exposure, transition barrier, and adaptive capacity are interpreted. Subsidy dependence, asset exposure, and regional concentrations are used as indicators of potential adjustment pressure, but they do not directly measure whether a farm, sector, or region will resist change or successfully adapt. High exposure may coincide with limited alternatives, but it may also coexist with financial resources, infrastructure, knowledge, or land that support diversification into plant-based production, nature restoration, ecosystem-service provision, renewable energy, or other rural activities. Conversely, regions with lower measured exposure may still have limited capacity or weak access to finance or markets, few restoration funding opportunities, or biophysical constraints on alternative land uses. The scenarios identify land, labour, and capital that may become available, but they do not determine how these resources would subsequently be used or which options would be economically, environmentally, or socially preferable. Several chapters discuss these adaptation pathways qualitatively and situate them within the broader literature, although the dissertation does not quantify their feasibility, scale, or distribution across farms and regions.

The indicators also capture only part of the distributional consequences of transition. Farm profits are accounting aggregates rather than measures of household income or wellbeing, while changes in labour requirements should not be interpreted directly as unemployment. The analyses do not distinguish outcomes for farm owners, tenant farmers, hired workers, creditors, or other affected groups, nor do they assess who participates in transition decisions or whether policies recognise the different circumstances and needs of affected groups. Regional equity in the analyses is represented primarily through the spatial distribution of economic pressure. A fuller assessment would examine who owns exposed assets, who carries associated debts, who participates in policy decisions, and which groups have access to alternative livelihoods.

Limitations of scope. The datasets used (FABIO and FADN) are subject to publication lags. This time lag means the modelling reflects the food system structure in the most recent year available at the time of analysis (2013 for Chapter 2 and 2020 for Chapters 3, 4, and 6), potentially limiting applicability to more recent developments such as the post-COVID context, geopolitical disruptions, or CAP reform implementations after 2023.

The EU and UK are also analysed together because the 2013 baseline (Chapter 2) predates Brexit and UK agricultural support in 2020 (Chapters 3 and 6) still largely followed inherited CAP rules (Greer & Grant, 2023). The analysis does not estimate Brexit effects or compare current EU and UK agricultural support systems. Post-Brexit divergence may alter transition exposure, while CAP-specific recommendations apply primarily to the EU.

Together, these limitations qualify the precision of the estimated pathways more than the direction of the main findings. The core conclusions are therefore likely to remain robust, while the following section discusses how future research could address these remaining modelling, data, and transition-analysis gaps.

Future research on adjustment dynamics can build on existing modelling frameworks developed for agricultural policy analysis. Coupling EEMRIO with approaches better suited to representing food-system transitions as complex adaptive and socio-political processes would extend the analysis beyond movements towards a new market equilibrium. From transition management and system innovation perspectives, this distinction matters because dietary transitions depend on market adjustment as well as experimentation, learning, coalition formation, institutional change, and uneven capacities to adapt across actors and regions. Agent-based or system dynamics approaches can represent heterogeneous actors, adaptive behaviour, path dependence, diffusion, and non-linear socio-political feedbacks more explicitly. In such a coupled framework, EEMRIO could identify the regional and supply-chain structure of exposure, while agent-based or system dynamics models simulate how producers, consumers, firms, and policy actors adapt under different transition conditions.

Partial equilibrium and CGE frameworks such as CAPRI (European Commission: JRC, 2026a), FIGARO (Cazcarro et al., 2025), and related Joint Research Centre (JRC) and DG AGRI models (Barreiro-Hurle et al., 2024; European Commission: JRC, 2026b) also remain useful, particularly where the research focus is on price-mediated adjustment, trade responses, and policy shocks. Coupling such frameworks with EEMRIO could add endogenous market adjustment while retaining IO-based tracing of where pressures are likely to emerge. More explicit forms of model coupling could strengthen such analysis (Moallemi et al., 2025). Sequential coupling would use EEMRIO to identify regional and supply-chain exposure associated with dietary shifts, and then pass those outputs to another model to simulate subsequent adjustment, as illustrated by linkage of EEMRIO results to CAPRI in Tukker et al. (2011). Interactive coupling would reintroduce quantities and sourcing adjustments generated by a companion model into the EEMRIO framework to recalculate embodied exposure under a changed system configuration. EEMRIO would retain its role in structural attribution, while the companion model would represent adjustment, adaptation, and feedback over time.

Improved integration between EEMRIO, farm-level accounts, and spatially explicit data could further develop the producer perspective by allowing finer analysis of heterogeneity within regions and production systems, including, for example, organic farming. Such integration would clarify how different types of farms experience transition pressures. Analysis beyond the farm gate should also examine how producers, distributors, retailers, and policy actors reinforce or destabilise existing food systems. The middle of the supply chain remains difficult to analyse because consistent data on processing and distribution are limited across countries. Resolving this gap is therefore likely to remain a longer-term objective for food-system modelling.

Moallemi et al. (2025) recommend coupled modelling, ensemble scenario approaches, and more explicit treatment of uncertainty in food-system analysis. Because no single model can serve all

purposes (Saltelli et al., 2020), future studies should aim to integrate insights across methods as structural tracing, dynamic adjustment, and transition governance represent complementary analytical tasks.

Modelling should be complemented by empirical research on how transition decisions are made and contested. Comparative case studies, surveys, interviews, and participatory research could assess how asset age, debt, succession, policy credibility, access to finance, and expectations about future markets influence decisions to continue, diversify, or exit. Longer-term studies could track how these factors change over time as climate impacts intensify, but such research should proceed alongside policy implementation rather than delay it. European agriculture is already increasingly exposed to heat, drought, and other climate extremes, leaving little scope to postpone action. The current evidence base is sufficient to guide policy; while monitoring and evaluation can refine implementation as conditions change.

7.5 Policy implications

The findings imply four priorities for agricultural policy reform. First, current subsidy structures under the CAP disproportionately support animal-sourced foods, locking in high-impact production systems and slowing the shift towards plant-rich diets. This misalignment is problematic given the contradictions across major EU strategies: the Farm to Fork Strategy calls for healthier, plant-rich diets; the climate-neutrality target requires deep emission reductions; and the Biodiversity Strategy aims to restore ecosystems and protect 30% of land, yet the CAP continues to reinforce animal production. More broadly, this tension suggests that the growing prominence of sustainability goals in EU food-system policy has not yet been matched by equally substantial changes in agricultural policy, leaving existing support structures largely intact. Subsidies to activities with negative externalities tend to increase production and can lock in environmentally harmful systems unless they are deliberately reformed (Segerson et al., 2024). Subsidy reform may influence transition pathways not only through farm incomes, but also by changing the attractiveness and perceived risk of different investments. Public support can reinforce incumbent production systems or help redirect investment towards diversification, asset repurposing, and environmental restoration. This broader investment effect strengthens the case for coordinating subsidy reform with policies for managing specialised agricultural assets.

Second, CAP reform should not be understood as shifting money from one sector to another. As discussions on the post-2027 CAP continue, the more fundamental question is whether public support will continue to stabilise incumbent production structures, or whether it will be more clearly oriented towards public goods and transition outcomes that markets alone are unlikely to deliver. From this perspective, repurposed CAP support should be designed around additionality (Segerson et al., 2024), but also around political durability: reforms that impose visible losses without credible compensation or transition support are likely to trigger resistance and invite rollback (Candel & Daugbjerg, 2025). This policy logic implies prioritising measures such as ecosystem restoration, agroecological redesign, legume-based rotations, peatland rewetting, ammonia abatement, and other measures that generate climate, biodiversity, and resilience benefits beyond farm income support alone. Where direct pricing or regulation of environmental harm remains politically difficult, such subsidies may serve as a second-best instrument, but they should still be assessed against whether they reduce environmental pressures rather than merely greening existing systems while leaving production capacity intact (Heyl et al., 2022; Segerson et al., 2024).

Third, targeted financial instruments are needed to enable the timely phase-out or transformation of animal-sourced-food-related assets, including milking machines, pig sheds, and feed infrastructure. Without such mechanisms, stranded asset risks may delay food-system transformation and generate political resistance. Policy should therefore support debt and asset depreciation management, compensation schemes, liquidity assistance, and realistic regulatory timelines, while embedding these measures within a broader just-transition framework for affected farmers and regions.

Fourth, regional differences in land use, employment, asset exposure, and subsidy dependence demand spatially differentiated policies that address local vulnerabilities and opportunities, ensuring a just transition across diverse farming communities. At the same time, differentiation should not amount to unrestricted flexibility, as excessive divergence in national implementation may weaken policy coherence, create uneven ambition, and reduce the stability that farmers derive from a common multiannual CAP framework. The policy challenge is to combine a shared EU-wide direction and minimum standards with sufficient regional tailoring in instruments, timelines, and support packages.

Reform is likely more politically feasible and more equitable when the withdrawal or repurposing of harmful subsidies is paired with explicit and trusted mechanisms to offset losses faced by vulnerable groups (Segerson et al., 2024). In practice, this means combining CAP reform with region-specific just-transition packages, including income support during transition, retraining, exit schemes, and investment in alternative land uses and local plant-rich value chains. Overall, integrated policy frameworks that align subsidy reform, asset management, and regional equity measures are essential to steer the CAP in line with Europe's climate, biodiversity, and health ambitions, while safeguarding rural livelihoods during transition.

7.6 Conclusions

This dissertation examined how a transition towards plant-rich diets would reshape the structure, economic performance, and environmental pressures of the EU+UK food system, focusing on subsidies, fixed assets, and regional equity. Across the five studies, the main conclusion is that such a transition is constrained less by biophysical scarcity than by institutional, financial, and spatial lock-ins embedded in current food systems.

CAP support for animal-sourced food systems is larger and more structurally embedded than is visible from direct animal payments alone. Once feed is traced through supply chains, a much larger share of the CAP can be linked to animal production, substantially increasing the implicit subsidy intensity of animal-sourced foods. Part of this support is also embodied in exports outside the EU, showing that CAP spending is not only an issue of farm support, but also of how public money is routed through supply chains and trade.

Dietary transition is also a capital reallocation problem. Animal-sourced food systems are tied to a large stock of long-lived fixed assets, but the exposure is not limited to barns and breeding animals. A substantial share of stranded-asset risk sits upstream in feed-related crop systems. At the same time, the results show that stranded assets are not simply an inevitable lump-sum loss: under managed transition pathways, depreciation can absorb much of the adjustment. This finding makes transition pace, signalling, and repurposing policy central to feasibility.

The socio-economic effects of plant-rich diets are structurally uneven and cannot be understood from the EU-level aggregates alone. The same dietary shift can remove chronic losses in some animal-dependent regions, erode profits in currently profitable animal sectors, and create gains where plant-

based sectors expand. At the EU level, plant-rich diets create substantial land, budgetary, and labour reallocation pressures: large areas of agricultural land are freed, CAP repurposing space expands, and farm employment declines, though unevenly across production systems and regions. Whether these opportunities are realised fairly depends on how transition costs and support are distributed across sectors and regions.

Overall, a plant-rich food-system transition in Europe involves changing diets, redirecting public support, reallocating land, managing the retirement and repurposing of fixed assets, supporting labour reallocation, and designing spatially differentiated transition strategies. The interaction of these dimensions explains why plant-rich transitions may be environmentally desirable yet politically and economically contested. Effective policy must therefore address environmental objectives alongside the institutional and regional conditions under which dietary change becomes politically and economically feasible.