Assessing the Environmental and Socioeconomic Consequences of a Food System Transformation. An Overview of Economic Modelling Supporting the Second EAT–Lancet Commission

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Abstract

The first EAT-Lancet report proposed a great food system transformation composed of a shift to a healthy diet, increased agricultural productivity and reductions in food loss and waste. This study highlighted the potential of such a food system transformation to move towards greater environmental sustainability. However, questions were raised about the health and nutritional adequacy of the recommended diet as well as the socioeconomic and justice implications of such a food system transformation. In response to these questions the modelling in the second EAT-Lancet report looked to explore a broader range of socioeconomic and justice implications of a food system transformation. To do this the modelling efforts in the second commission were expanded to include a multi-model ensemble composed of 10 global economic models. This ensemble ran a series of scenarios to assess the potential impacts of the original 3 EAT-Lancet transformation drivers (dietary change, reduced food loss and waste, and increased agricultural productivity), as well as a new driver of ambitious climate mitigation, with the objective of identifying potential complementarities and trade-offs between the drivers of change. This paper presents the ensemble approach and summarizes key modeling results from this effort, which are broadly consistent with results from the first EAT-Lancet report. However, the application of economic models suggests that there may be greater challenges in achieving all environmental objectives (e.g., nitrogen and phosphorous) without additional measures. This class of models also facilitated an assessment of potential price and food affordability consequences of a global shift to a healthy diet. This paper will explore these findings and highlight where there is greater agreement across the model, as well as note where substantial model uncertainty remains.

1 INTRODUCTION

The first EAT–Lancet Commission (Willett et al. 2019) suggested that a global shift to a healthy diet could substantially reduce food system contributions to 5 planetary boundaries (climate change, land use, water use, nitrogen use, and phosphorous use), while simultaneously contributing to improved public health outcomes through the reduction in dietary risk factors, which are the primary cause of premature mortality globally (Afshin et al. 2019). However, questions were raised about the health and nutritional adequacy of the recommended diet (Beal et al. 2023) as well as the socioeconomic and justice implications of such a food system transformation (Hirvonen et al. 2019).

In response to these concerns a second EAT-Lancet commission was launched (EL2.0 Commission and Contributing Authors 2023), to begin to assess some of the justice implications of a food system transformation, and to update the healthy, environment, and modelling sections. As a part of this effort, the commission looked to incorporate a broader range of economic models to assess a food system transformation by 2050, expanding the modeling done in the first report using DIA-GIO (Springmann et al. 2018), a global input-output model, to a multi-model ensemble composed of 10 global economic models. This model ensemble ran a series of scenarios designed to assess the potential impacts of the original 3 EAT-Lancet transformation drivers (dietary change, reduced food loss and waste, and increased agricultural productivity), as well as a new driver of ambitious climate mitigation, which recognized that a achieving more sustainable food systems would likely need to be accompanied by society wide transitions to more sustainable futures. The scenarios run by the ensemble followed a scenario approach previously applied in Stehfest et al. (2019) to facilitate a decomposition of the individual and combined effects of the 4 drivers of change to identify potential complementarities and trade-offs across the transformation bundle.

This paper will describe the model and scenario approach applied in the second EAT-Lancet report, along with a summary of key food system, environmental, and socioeconomic results. The ensemble results will be presented with the ensemble range and median to facilitate a discussion of where the models are in greater agreement, and where larger ranges of model results may suggest greater uncertainty in the consequences of a food system transformation.

2 METHODS

2.1 The multi-model ensemble

The analysis conducted for the second EAT-Lancet commission (Rockström et al. 2025) included a range of global economic models, including CGE, PE, IAMs, and an input-output mode. This paper will focus on the results from the 10 global economic models (excl., DIA-GIO the input-output model). Table 1 lists the eleven models that contributed to the multi-model assessment in the EAT-Lancet report. The structural diversity across the ensemble was a deliberate feature, with the objective of trying to assess a wider range of potential outcomes from an EAT-Lancet style food system transformation.

The ensemble was coordinated under a harmonized modelling framework based on protocols developed for past multi-model intercomparisons as a part of the Agricultural Intercomparison and Improvement Project (AgMIP)(Stehfest et al. 2019; Wiebe et al. 2015; Nelson et al. 2014). Running a multi-model ensemble of this scale is less a single computational exercise and more an extended collaborative expert elicitation process. The ensemble analysis began in October 2023 and continued through July 2025, with teams engaging through monthly virtual meetings attended by representatives of the participating modelling groups, supported by more frequent one-to-one exchanges between coordinators and individual modelling teams to work through model-specific implementation questions.

Table 1 Contributing Models

Model	Full Name	Model Type	Reference
AIM	Asia-Pacific Integrated Model	IAM CGE	(Masui et al. 2011)
CAPRI	Common Agricultural Policy Regionalised Impact	Agricultural PE	(CAPRI 2022)
DIA-GIO	Global Input-Output module of the Dietary Impact Assessment model	Input-Output	(Springmann 2025)
ENVISAGE	Environmental Impact and Sustainability Applied General Equilibrium	CGE	(Mensbrugghe 2019)
FARM	Future Agricultural Resources	CGE	(Sands et al. 2014)
GCAM	Global Change Analysis Model	IAM PE	(Wise and Calvin 2011)
GLOBIOM	Global Biosphere Management Model	Agricultural PE	(Havlík et al. 2014)
IMAGE	Integrated Model to Assess the Global Environment	IAM CGE	(Stehfest et al. 2014)
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade	Agricultural PE	(Robinson et al. 2024)
MAGNET	Modular Applied General Equilibrium Tool	CGE	(MAGNET 2022)
MAgPIE	Model of Agricultural Production and its Impact on the Environment	Agricultural PE	(Dietrich et al. 2019)

Model submissions were processed and compiled into a shared results database, with all outputs converted to relative changes against a common 2020 reference year to facilitate direct comparison across models with different base calibrations and regional aggregations. Comparing results across models was an important diagnostic tool. Divergent results prompted re-examination of results and scenario implementation, leading in some cases to revision of model implementation, as well as broader revision of scenario specification to ensure more consistent representation of the scenarios across the ensemble. The central question when results diverged was always whether the difference reflected genuine structural variation between models or an inconsistent implementation that needed to be corrected.

In total, the ensemble went through six submission rounds. The first was a process check with 7 of the participating models before substantive results were generated. This first round (Round 0 in the figure below) was designed to test the submission and processing workflow. Round 1 harmonized population and GDP growth assumptions applying version 3 of the SSP2 socioeconomic projections. Round 2 harmonized BAU climate policy assumptions. Round 3 focused on incorporating updated healthy reference diets (Springmann 2025), with the 3 final global models in the ensemble joining towards the end of this round. Round 4 revised the agricultural productivity target to better align with an SSP1-consistent growth pathway. Round 5 added food loss and waste sensitivity scenarios with all models resubmitting results. Between formal rounds, individual teams made iterative submissions as they worked through revised inputs or resolved implementation issues, making the overall process closer to a rolling revision cycle than a clean sequence of discrete runs. Figure 1 highlights model submissions over the course of this work, with the relative frequency of submissions highlighting which drivers (i.e., diets) generated the most challenges in representation across the ensemble. This iterative character reflects the actual process of generating the results, and the learning process that facilitates better comparison across structurally diverse models.

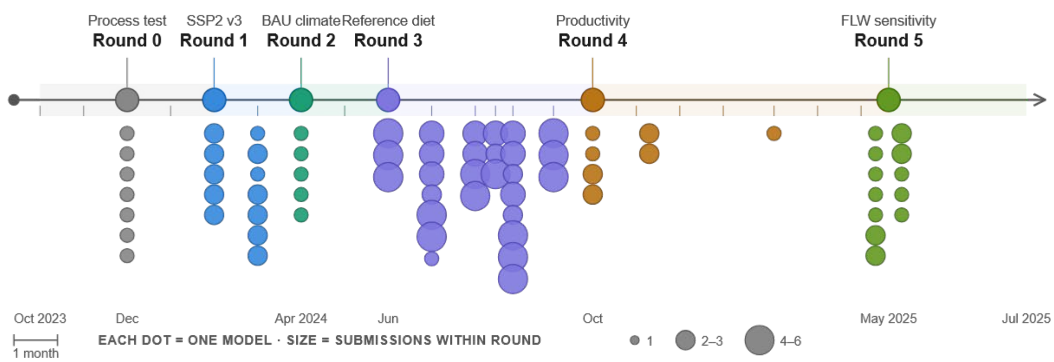

Figure 1 Timeline of submission rounds

2.2 Scenario design and decomposition framework

This analysis built on previously developed food system transformation and climate mitigation scenarios (Willett et al. 2019; Springmann et al. 2018; Stehfest et al. 2019), the shared socioeconomic pathways(van Vuuren et al. 2017; IIASA 2024), and updated dietary recommendations (Springmann 2025).

Key shared inputs included:

- GDP and population projections (SSP1/SSP2)(IIASA 2024),
- climate productivity shocks for crops (GGCMI ensemble under RCP 7.0)(Jägermeyr et al. 2021),
- livestock productivity shocks (Thornton et al. 2022),
- agricultural labor productivity shocks (Nelson et al. 2024),
- a harmonized healthy reference diet derived from Springmann (2025).

Productivity growth assumptions were explicitly harmonized between BAU and EL scenarios to ensure comparability, with

- BAU assuming historically-calibrated productivity trends (yielding approximately 23% yield increases on aggregate by 2050), while
- the EL scenario adds an additional 5–10% productivity gain by 2050 consistent with an SSP1 pathway.

The scenario framework comprises three core scenarios and a structured decomposition set (Table 2). All scenarios share the same GDP and population projections and RCP 7.0 climate productivity shocks, so that differences in outcomes are attributable only to policy and behavioral assumptions.

- **Business-as-Usual (BAU):** Continues current dietary trends, historic agricultural productivity growth, and current food loss and waste levels to 2050, with climate and land-use policies limited to those already implemented nationally. This scenario projects a 9.6 billion world population by 2050 with GDP growing substantially faster than population.
- **EAT-Lancet (EL):** Assumes full global adoption of the EAT-Lancet healthy reference diet by 2050, combined with SSP1-consistent agricultural productivity growth and halving of food loss and waste (consistent with SDG 12.3), without additional climate mitigation policy. The diet is implemented as an exogenous shift in consumer demand preferences, with a linear transition from current diets to the EL2 diet by 2050.
- **EAT–Lancet with Mitigation (ELM):** Adds emission pricing and land-use regulations consistent with a 1.5°C warming pathway to the EL transformation.

The decomposition counterfactuals each activate or remove a single driver relative to the BAU or ELM baseline, enabling systematic attribution of outcomes.

Table 2 Core and decomposition scenario set

Scenario	Diet	Productivity	Food Loss & Waste	Climate Mitigation
Core Scenarios				
BAU	Baseline projections [1]	Baseline projections	Baseline Projections	Currently implemented policies (NPi)
EL	Global transition to a healthy diet by 2050 [2]	Increased Ag productivity [3]	Halved relative to BAU by 2050 [4]	NPi
ELM	Global transition to a healthy diet by 2050	Increased Ag productivity	Halved relative to BAU by 2050	1.5°C-consistent climate and LUC policies [5]
Decomposition Scenarios				
BAU_DIET	Global transition to a healthy diet by 2050	Baseline projections	Baseline projections	NPi
BAU_PROD	Baseline projections	Increased Ag productivity	Baseline projections	NPi
BAU_WAST	Baseline projections	Baseline projections	Halved relative to BAU by 2050	NPi

BAU_MITI	Baseline projections	Baseline projections	Baseline projections	1.5°C-consistent climate and LUC policies
ELM_DIET	Baseline projections	Increased Ag productivity	Halved relative to BAU by 2050	1.5°C-consistent climate and LUC policies
ELM_PROD	Global transition to a healthy diet by 2050	Baseline projections	Halved relative to BAU by 2050	1.5°C-consistent climate and LUC policies
ELM_WAST	Global transition to a healthy diet by 2050	Increased Ag productivity	Baseline projections	1.5°C-consistent climate and LUC policies
ELM_MITI	Global transition to a healthy diet by 2050	Increased Ag productivity	Halved relative to BAU by 2050	NPi

Notes: BAU_* scenarios add a single driver to BAU; ELM_* remove a single driver from ELM

[1] Baseline projections are model specific and are calibrated to population and GDP growth rate for SSP2

[2] Dietary transition assumes a global shift to the EAT-Lancet reference healthy diet by 2050

[3] Increased agricultural productivity is based on productivity trends used for the more optimistic SSP1, and globally are about 10% higher by 2050 compared to BAU

[4] Halving of FLW with respect to BAU FLW coefficients and in line with SDG 12.3

[5] Based on Climate and Land-use change policies used in previous modelling studies (Stehfest et al. 2019) in support of the IPCC Special Report on 1.5C future (IPCC 2018).

2.3 Reporting protocol

Results were collected under a standardized reporting protocol covering more than 40 variables across 13 global regions plus global aggregate (Table 3), and a harmonized agricultural sector classification (Table 4).

Table 3 Regional Aggregation

Code	Details
ANZ	Australia and New Zealand
BRA	Brazil
CAN	Canada
CHN	China (incl Hong-Kong, Macao)
ECC	Eastern Europe, Caucus, and Central Asia
EUR	Europe (excl. Turkey)
IND	India
MEN	Middle East and North Africa (incl. Turkey)
OAS	Other Asia (incl. Other Oceania)
OSA	Other South and Central America and Caribbean (excl. Brazil)
SEA	South-East and East Asia (incl. Japan, Taiwan)
SSA	Sub-Saharan Africa
USA	United States of America
WLD	World

Table 4 Sector Summary

Code	Description
RIC	Rice (paddy equivalent)
WHT	Wheat
CGR	Other cereal grains
OSD	Oilseeds (raw equivalent)
SGC	Sugar crops (raw equivalent)
VFN	Vegetables, fruits, nuts (incl. roots and tubers)
- **VFN|VEG**	Vegetables
- **VFN|FRU**	Fruits
- **VFN|NUT**	Nuts
PFB	Plant based fibers
ECP	Energy crops
OCR	Other crops
RUM	Ruminant meats
NRM	Non-ruminant meats
- **NRM|PRK**	Pork meat
- **NRM|PTM**	Poultry meat
- **NRM|EGG**	Poultry eggs
- **NRM|ONR**	Other non-ruminant
DRY	Dairy (raw milk equivalent)
OAP	Other animal products (wool, honey)
GRS	Grass
OFD	Other feed products
FSH	Fish
FOR	Forestry products
Sectors aggregates	
CRP	All crops
LSP	Livestock products
AGR	All agricultural products
TOT	Total (full economy, population, GDP, calories)

Coverage is heterogeneous across the model ensemble, and not all models reported all variable-sector-region combinations, as such the number (n) of models reporting any particular result is reported throughout.

3 3. RESULTS

3.1 The business-as-usual trajectory: declining food insecurity coupled with growing environmental and health challenges.

Before assessing the transformation scenarios, establishing what the ensemble projects under BAU is essential context. By 2050 under current trends, the world will have approximately 9.6 billion people, with GDP growing substantially faster than population. Ensemble projections for food demand increase by 28–32% globally compared to 2020 (n=9 models), with per capita calorie availability rising approximately 6% to around 3,000 kcal/day globally. The largest increases in per capita calorie availability are projected for South Asia and sub-Saharan Africa, which start from lower baselines; high-income regions see mostly satiated per capita food demand at around 3,500 kcal/day. Importantly, BAU demand growth is disproportionately concentrated in more resource-intensive food categories: livestock products and vegetables, fruits, and nuts (VFN) see larger per capita increases than cereals, reflecting dietary shifts driven by income growth (i.e., Engel's and Bennett's Laws). While food prices across the ensemble vary in their direction of change, with some models projecting a small decline, and others projecting a small increase, all the models agree that given per capita GDP growth assumed in SSP2 food becomes more affordable compared to 2020 in all regions.

Agricultural production increases by approximately 37% compared to 2020, with relatively high level of agreement across the ensemble for both the range and direction of change. This increase is driven by projected yield improvements of 24% (range: 17–46%). Despite these increases in productivity, however, we observe continued increase on natural resource use and increased pressure on several environmental dimensions, with total agricultural land projected to increase by 4% (range: 1–7%). Agricultural greenhouse gas emissions are projected to rise by 33% (range: 20–50%), driven primarily by a 41% increase in ruminant animal numbers. Nitrogen and phosphorus fertilizer application both increase by 41% above 2020 levels, deepening already-transgressed planetary boundaries. Blue water-use increases by a median of 13%, though with a wider ensemble range (−10% to +43%), suggesting different assumptions on future water use and water use efficiency gains.

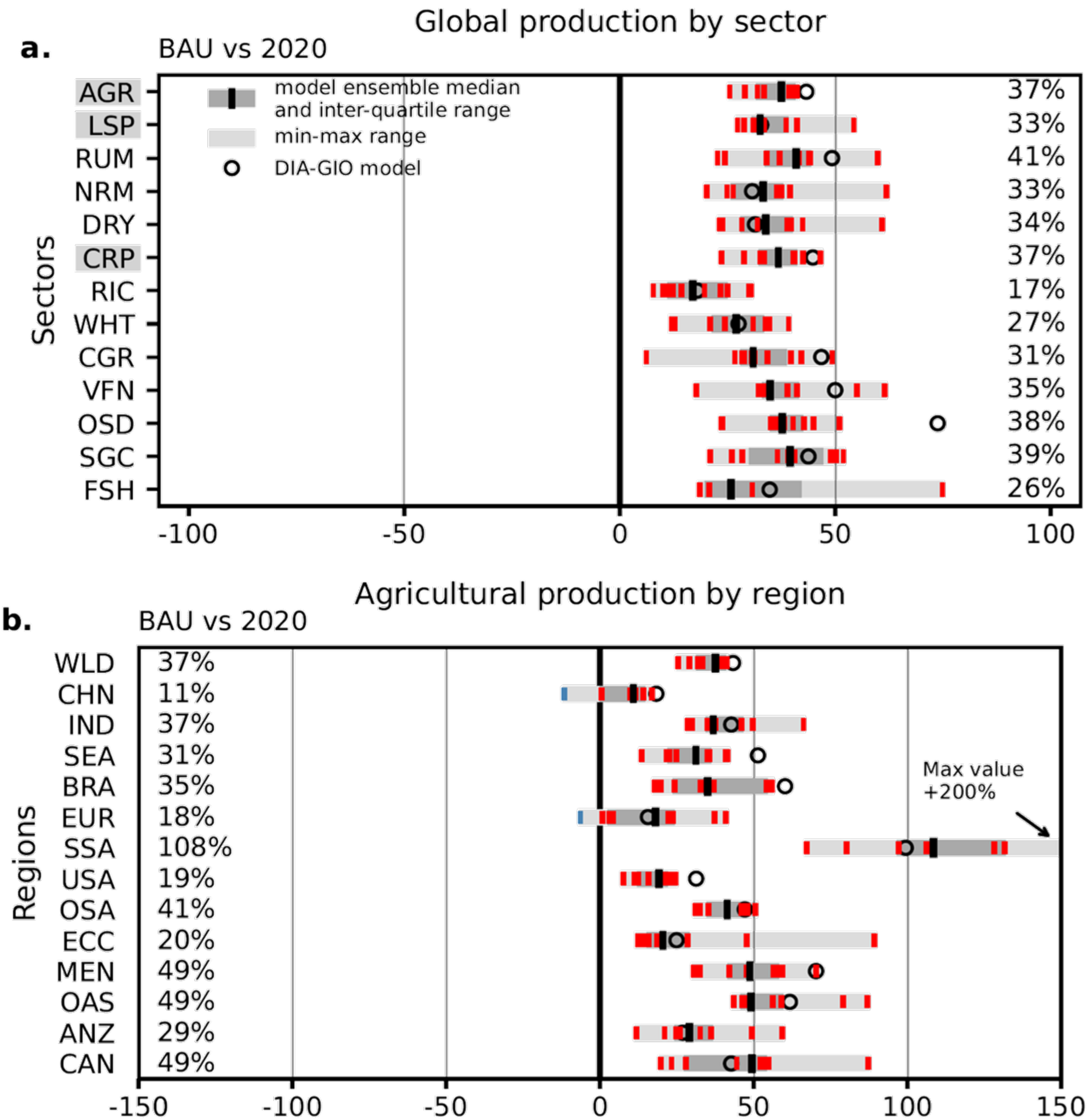

Figure 2 Projected changes in agricultural production summarized (a) by sector globally (a) and (b) by region for total agriculture

Note: Percentage change is for BAU projections in 2050 compared to 2020. Production is reported in mt
Source: Rockström et al. (2025)

3.2 Structural changes in an EAT-Lancet transformed food system.

An EAT–Lancet-aligned transformation would fundamentally reshape the structure of global agriculture, with implications for trade, value chains, and factor markets that are of direct relevance to GTAP users. Under an EL future the global food system would be substantially smaller than under a BAU future, even as most models suggest that global food production would increase with respect to the 2020 starting point. While aggregate global agricultural production in an EL future might be at a similar level to the 2020 starting point, the sector would be substantially restructures driven by the adoption of healthy diets, with large increases projected by most models in global production of vegetables, fruits, legumes, and nuts (VFN) as well as aquatic foods (FSH), whereas there are substantial reductions for livestock products (LSP) and in particular ruminant and non-ruminant meat production (RUM and NRM) and for sugar crops (SGC).

Reorientation of Global Agricultural Production.

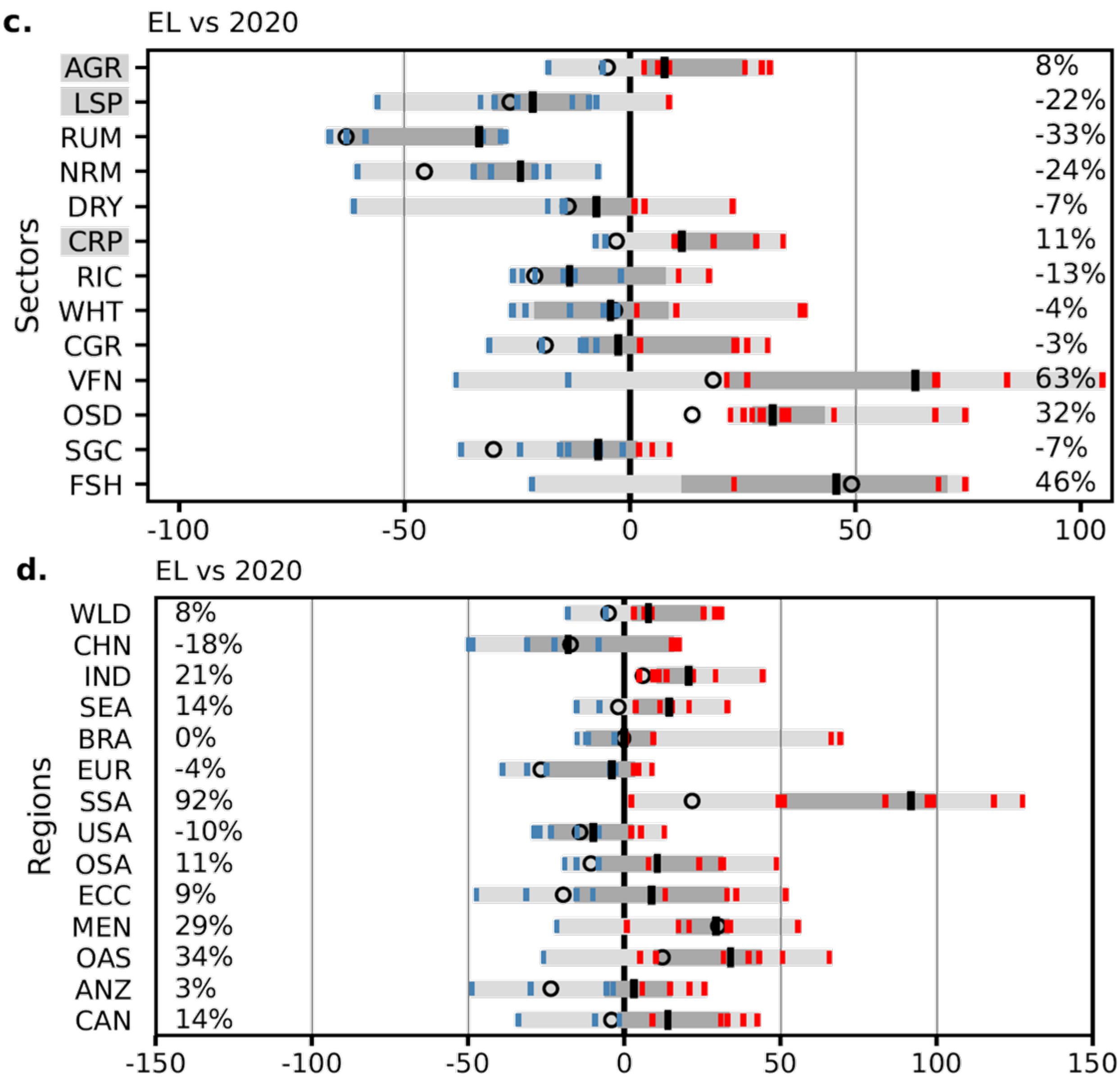

Figure 3 Global production by sector and agricultural production for the EL2 scenario

Note: Percentage change is for BAU projections in 2050 compared to 2020. Production is reported in mt
Source: Rockström et al. (2025)

We can see substantial spread of global projections by sector, for example we see the ensemble straddles the 0-axis for most cereals, highlighting the difficulty of modelling a transition to a healthy diet which would suggest a need to increase the consumption of whole grains, even as over consumption of processed grains need to be reduced, all while global demand for cereals for animal feed would fall, freeing up cereals for both food and industrial uses (e.g., biofuels).

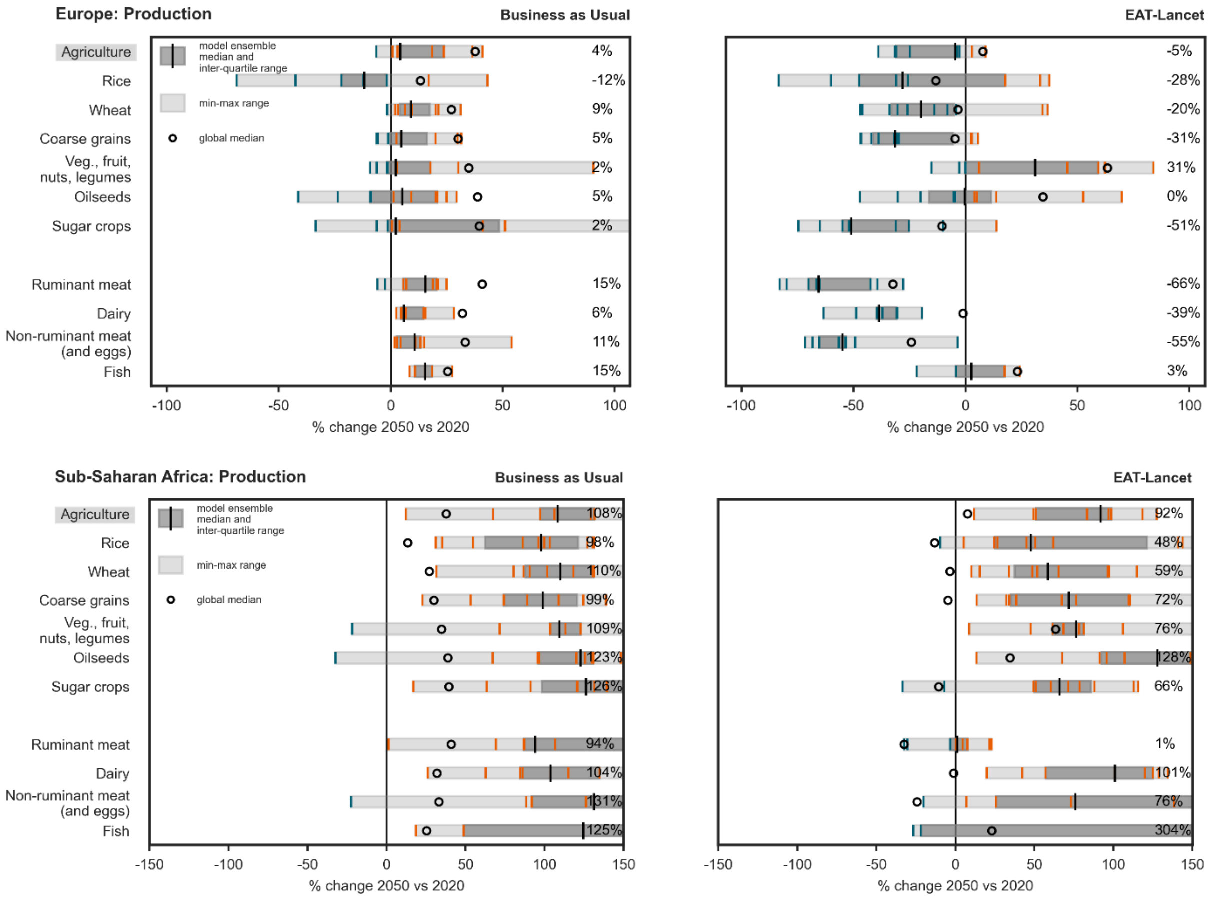

Figure 4 Comparing Europe and Sub-Saharan production by selected sectors

Regionally, in general, high- and upper middle- income regions with slow or declining population growth are projected to see declines in agricultural production compared to BAU, and in some cases models project decline with respect to 2020 (e.g., many models project declines in agricultural production in China, Europe, and the United States). Lower income regions such as sub-Saharan Africa, on the other hand see production trajectories more in line with the BAU Figure 4 Comparing Europe and Sub-Saharan production by selected sectors. However, it is important to note that the spread of model results increases once we move from global aggregates to regional projections, with these spreads broadening even further when we look at region and sector production projections. Much of this wide range of projections is driven by the dietary change component of the EAT-Lancet scenario. This highlights, that the specification of this scenario has very little guidance in how agricultural production should transition towards supplying a healthy diet, with the models presenting different potential pathways regionally and sectorally in supplying healthy diets for all.

3.3 Environmental outcomes: gains that approach but do not fully reach safe operating space.

An EAT–Lancet transformation produces substantial environmental improvements. On emissions, the EL2 scenario reduces agricultural non-CO_2 emissions by a median of 20% below 2020 levels, primarily from reductions in ruminant numbers. The ensemble median approaches the food system emissions boundary of 5 $GtCO_2e$ per year. However, while the ensemble agrees in a reduction, there is less agreement with how large this reduction would be, and if the planetary boundary would be approached. Dietary change alone contributes the largest emissions reduction, but does not reliably reach the 5 Gt target on its own, with that threshold only approached once food loss and waste reduction and increased productivity are included, and reliably reached below the boundary only in the ELM scenario, when ambitious mitigation is included (−34% vs 2020; range: −84% to −18%).

The decomposition analysis suggests that dietary change, productivity improvements, and FLW reduction play complementary but distinct roles across environmental outcomes (Figure 5). Diet change drives most of the reduction in emissions, and agricultural land use. Increased productivity and reduced FLW have limited impacts on emissions and land when applied in isolation. Both productivity increases and reduced food loss and waste contribute to reductions in water, nitrogen, and phosphorus use. Ambitious mitigation contributes similar levels of reduction in emissions globally to dietary change but does much less on reducing bluewater and agricultural land use. When combined with the other 3 drivers under the ELM scenario environmental pressures are reduced the most, but it is important to note that the gains observed for each drive in isolation are not additive when combined in a bundle, as there are some redundancies, for example with emissions dietary change and targeting and pricing agricultural emissions both target ruminant sectors.

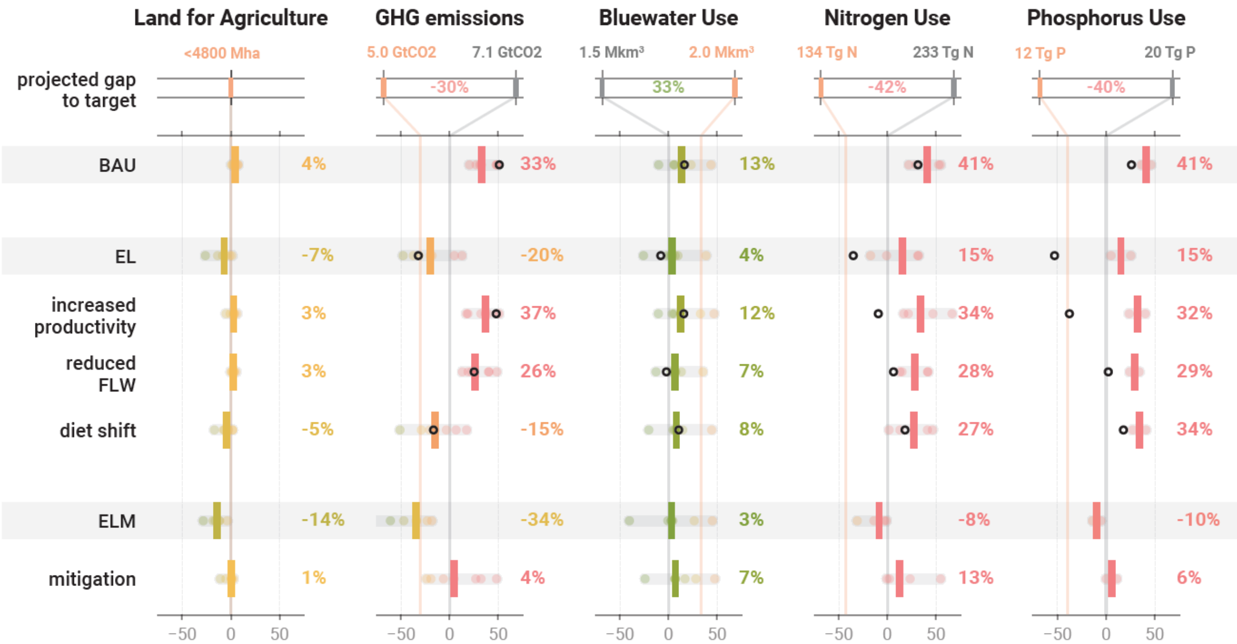

Figure 5 Global environmental outcomes by scenario driver

Source: Rockström et al. (2025)

Nitrogen and phosphorus boundaries remain the most challenging to resolve. Even under ELM, both nitrogen use and phosphorus use remain above current levels and above the planetary boundary thresholds. The DIA-GIO model projects much larger reductions (35% reduction in nitrogen, 53% in phosphorus under EL). This gap between the input-output and dynamic economic model results highlights the impact of rebound effects and factor reallocation in dynamic models, which can offset potential gains from efficiency improvements.

3.4 Agricultural market consequences: prices, trade, and value reallocation

Producer prices. The EL scenario produces a less resource-intensive food system that, across the ensemble, translates to agricultural producer prices that in general are lower than those observed in BAU (a median 8% reduction). This reduction reflects lower demand for resource-intensive animal products and efficiency gains from productivity improvements and FLW reductions. However, the sectoral composition of this aggregate masks important differences in price trajectories by sector. With substantial declines in producer prices for terrestrial animal sourced foods, reflecting declines in demand for red meat (ruminants and non-ruminant meat), increased productivity, and reductions in the cost of animals feeds (coarse grains and oilseeds). Vegetable fruits, nuts, and legumes on the other hand see the opposite tendency with increases in producer prices (median 10% compared to 2020, vs a 15% reduction in BAU) reflecting the challenges that these supply chains might encounter in responding to increased demand (Figure 6).

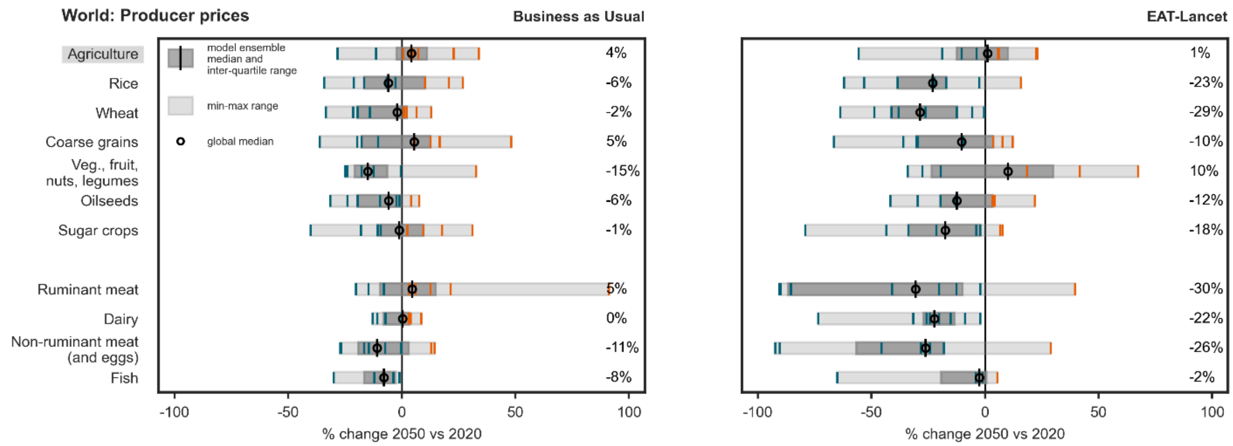

Figure 6 World Producer prices for select commodities under the BAU and EL scenario by 2050

Food Affordability. Globally food affordability improves in an EL world. However, with important regional differences. High-income regions that currently are overconsuming animal sourced foods, sugars, and processed foods, see a shift to a healthy diet reduce food expenditure compared to BAU diets. However, in many lower-income regions currently suffering from persistent food insecurity, and relatively low consumption of animal sourced foods may see increasing cost of food compared to the BAU scenario, although it should be noted that even in these regions food affordability is projected to improve with respect to 2020 levels.

Trade reallocation. The structural reorientation of global food production has substantial trade implications that the ensemble has not yet fully disaggregated. Regions such as Brazil, Australia and New Zealand, and the Southern Cone of South America currently exporting large volumes of livestock products face contracting global markets. Conversely, rapidly expanding VFN and fishery sectors could create new trade opportunities for regions with strong supply chains and established trade relationships such as Southeast Asia, China and the Middle East and North Africa. production.

Agricultural labor A food system transformation would substantially reshape agricultural labor demand. While fewer models were able to report on agricultural labor than other food system dimensions, those that were able to report that on the whole agricultural employment could decline modestly by 2050 compared to the BAU scenario (<5%). However, similar to producer prices the aggregate conceals a structural transformation, with substantial reallocation of labor suggested by the contractions and expansions in sector output highlighted previously.

3.5 Ensemble ranges as a signal: what models agree on

One of the most valuable features of a multi-model ensemble is not the central tendency but the spread of results. This can provide some insights on where mechanisms of change are better understood, and where there remain many plausible transition pathways for future research to be more systematically assessed. Table 5 provides a summary of some key takeaways from the ensemble range.

Table 5 Summary of select ensemble results and model agreement

<table>
<tr><th>Scenario</th><th></th><th>Higher-agreement findings</th><th>Mixed findings</th><th>Lower-agreement findings</th></tr>
<tr><td rowspan="3">BAU 2050 vs 2020</td><td>Environment</td><td>• Non-CO_2 emissions (+32%, +7 to +50) all models same sign; emissions rise.
• Nitrogen use (+41%, +22 to +58) all same sign, bounded magnitude.
• Phosphorus use (+41%, +36 to +46) all same sign and tight clustering.</td><td>• Cropland (+10%, +4 to +25) all models agree on direction but with a wide range of results (range ≈2× the median).</td><td>• Grassland (+2%, −2 to +5) direction split around zero; some models project release, others slight expansion.
• Water withdrawal (+5%, −10 to +13;) direction split with few reporting models.</td></tr>
<tr><td>Food system</td><td>• Agricultural production (+38%, +13 to +41) all models same sign with relatively tight clustering.
• Livestock production (+33%, +18 to +54) all models project increase with relatively tight clustering</td><td>• VFN production (+37%, −17 to +62) direction mostly positive; but a wide range of production increases
• Food demand (+32%, +4 to +38) all same sign but one model is much lower than the rest.</td><td>• Agricultural producer price (+4%, −28 to +34) direction split across the ensemble with magnitude spread an order of magnitude larger than the median.
• Ruminant price (+5%, −20 to +91) same pattern.</td></tr>
<tr><td>Regional</td><td>• Sub-Saharan Africa agricultural production (+108% median) all models agree on direction; SSA shows the largest regional expansion.
• China production growth (+11%) similarly consistent in direction.</td><td>• Brazil and OSA show moderate expansion with substantial magnitude spread, reflecting differing assumptions about export-oriented livestock growth pathways.</td><td>• Middle-income transition regions show wide ranges driven by divergent assumptions about dietary transition pace and demand satiation thresholds.
• India and China food demand trajectories show a wider range of potential outcomes.</td></tr>
<tr><td rowspan="2">DIET vs BAU 2050</td><td>Environment</td><td>• Non-CO_2 emissions (−29%, −46 to −16) all models same sign; tight clustering relative to magnitude.
• Phosphorus use (−4%, −5 to −4) tight cluster among reporting models.
• Grassland (−9%, −47 to −2) all models reduce.</td><td>• Total agricultural land (−7%, −23 to +1) direction mostly consistent with one model near zero, but wide magnitude
• . Nitrogen use (−8%, −21 to −4) all same sign but range ≈2× median.</td><td>• Cropland (+7%, −13 to +23) direction splits roughly evenly across the ensemble, with some models projecting expansion and others contraction
• Water withdrawal (−3%, −12 to +1) direction near zero, low coverage.</td></tr>
<tr><td>Food system</td><td>• Ruminant production (−53%, −76 to −24) all models project substantial contraction
• Ruminant price (−18%, −90 to −11) all same sign.</td><td>• VFN production (+21%, −39 to +72) direction mostly positive but with relatively wide spread
• VFN price (+39%, +2 to +189) all positive but large magnitude spread.
• Agricultural production (−13%, −27 to −2) also relatively wide spread in magnitude.</td><td>• Agricultural producer price (+1%, −30 to +23) direction split across the ensemble; some models show DIET as net price-raising (reflecting VFN dominance) while others show net price-falling (reflecting livestock dominance).
• Food demand (+2%, −25 to +10; n=9) similarly split.</td></tr>
</table>

	Regional	• High-income animal-product regions face steepest dietary transitions with consistent ensemble agreement. Declines in demand push down production, but also increased exports	• Brazil and OSA producer price declines direction consistent across models but magnitude variable. • SSA dairy expansion (+76% median) consistent direction with wide range.	• India producer price effect splits in direction: some models project DIET as raising prices while others project declines.
PROD vs BAU 2050	Environment	• Phosphorus use (−7%, −10 to −4) tight cluster among reporting models. • Water withdrawal (−1%, −2 to −1) all near zero, low coverage but consistent.	• Cropland (−2%, −5 to +7) direction split with general agreement in modest changes • Total agricultural land (−1%, −12 to +1) most models near zero but one outlier model suggest a larger decline.	• Non-CO_2 emissions (0%, −11 to +4) direction split around zero; some models show net reduction from productivity, others slight rebound from increased output. • Nitrogen use (−2%, −10 to +8) similarly split around zero.
	Food system	• Producer prices (−5%, −17 to +1) direction mostly consistent • Ag production (+1%, −1 to +8; n=9) and livestock production (+1%, 0 to +4) small positive effects, near-zero with tight clustering.	• VFN price (−6%, −17 to 0) and ruminant price (−4%, −20 to +15) both show consistent direction overall but magnitude varies substantially.	• Several indicators near zero with direction split: VFN production (+1%, −1 to +4), food demand (+1%, 0 to +4; n=9). Small effects with mixed signs across models.
	Regional	• Productivity gains contribute to lower producer prices in all regions. Direction is consistent across the ensemble at the regional level.	• Magnitude of regional price reductions varies more than the global aggregate suggests, with model ranges spanning roughly −18 to +5 percentage points across regions.	• India's production (+12%, −8 to +28) direction split with relatively wide range of results.
FLW vs BAU 2050	Environment	• Non-CO_2 emissions (−5%, −7 to −1) direction consistent; tight clustering around the median. • Cropland (−3%, −6 to −2;) all same sign, and relatively tightly clustered.	• Nitrogen use (−8%, −12 to −7) and phosphorus use (−9%, −9 to −8) are consistent across the ensemble, but with fewer reporting models. • Grassland (0%, −3 to +1) and water withdrawal clusters around zero (−3%, −3 to 0), but with some models increasing and others decreasing grasslands.	• Mostly consistent results at the global level
	Food system	• VFN price (−6%, −20 to −3), ag producer price (−5%, −14 to −2), and ruminant price (−4%, −31 to −1) all same sign across the ensemble; consistent downward pressure on prices.	• Food demand (−9%, −13 to +1) direction mostly consistent (most models reduce) but one model near zero; spread ≈1.6× median. • Ag production (−7%, −10 to −1; n=9) and VFN production (−11%, −17 to −1; n=8) direction consistent but with wider spread of results	• Ruminant production (−3%, −9 to 0) direction split between negative and near-zero models; effect small but direction not unanimous.

	Regional	• Food affordability gains from FLW reduction concentrate in lower-income regions.	• Middle-income regions show consistent direction but variable magnitudes depending on consumer-side waste behavior assumptions in dietary transitions.	• China food demand under FLW (−7%, −14 to +2) direction split with one model showing demand expansion.
EL vs BAU 2050	Environment	• Non-CO_2 emissions (−34%, −53 to −10) all models same sign with bounded magnitude relative to median • Nitrogen use (−17%, −36 to −14) all same sign with tight clustering.	• Total ag land (−9%, −31 to 0) direction mostly consistent (one model near zero); magnitude spread ≈3×. • Grassland (−10%, −61 to −2) all same sign but wide magnitude range.	• Cropland (+3%, −19 to +24) direction splits across the zero line. The disagreement reflects the tension between competing land use reducing need for feed crops, increasing demand for VFN, and the contribution of productivity gains.
	Food system	• Ruminant production (−53%, −77 to −15) DIET's consistent dietary shift dominates the bundle outcome across all models. • Livestock production (−36%, −57 to −18) all same sign with bounded clustering.	• Agricultural production (−17%, −32 to −2) all models contract but magnitude varies as DIET's demand contraction interacts differently with PROD's supply expansion across models. • VFN price (−2%, −15 to +103) most models show modest changes but one model is an outlier driving the range. • Ruminant price (−29%, −92 to −5) all same sign though magnitude spread wide.	• VFN production (+20%, −45 to +53) and food demand (−5%, −32 to +9) split in direction across the ensemble. • Agricultural producer price (−8%, −38 to +14) also splits, as models weigh the upward pressure on VFN prices (from DIET) against the downward pressure across all sectors (from PROD) in different proportions. • FLW reduction contributes a smaller and more uniform downward push that does not resolve these splits.
	Regional	• Food expenditure in high income regions declines, as healthy diets are cheaper the BAU diets • Food expenditure in low-meat eating regions (India and Sub-Saharan Africa) increases, driven by increasing VFN prices • Environmental pressure declines across all dimensions in all regions, except for Sub-Saharan Africa, where EL results resemble BAU results	• Food expenditure in Latin America tends to see declining prices due to reductions in ruminant consumption and prices, but some models suggest prices could increase	• Prices in sub-Saharan Africa vary substantially with limited agreement across the ensemble (13%, −46 to +23)

Across the ensemble there remains work to better understand what model specific factors might be contributing to the wide range of results. This could include base data sources (GTAP vs FAO), starting year, as well as model structure (PE vs CGE). An initial analysis of PE and CGE results suggest that these different approaches may partially explain some of the difference in results (Figure 7). For example we can observe varying results for land use, highlighting differences in how land type conversion is captures, with PE models with more biophysical constraints suggesting less opportunity to reduce grassland and convert it to other uses, while similarly less expansion of cropland in response to greater demand for horticultural crops and legumes.

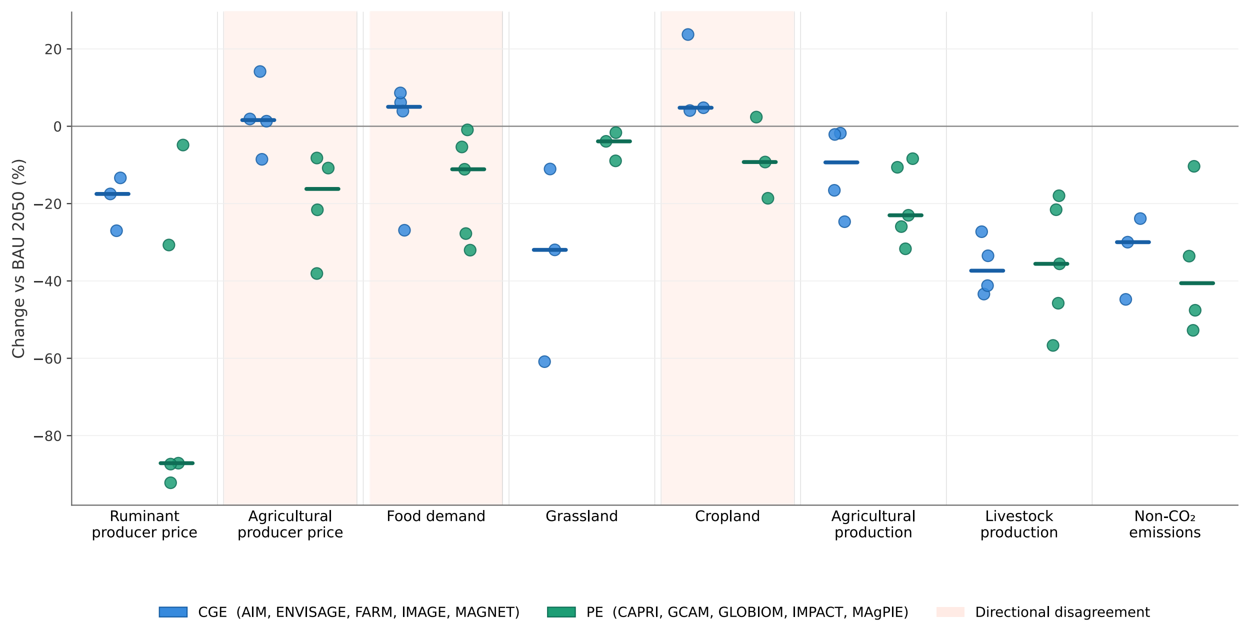

Figure 7 Comparing PE and CGE model EL global results for select variables

4 Discussion

The multi-model ensemble suggests that a food system transformation consistent with the EAT–Lancet vision could substantially improve environmental outcomes while maintaining broad improvements in food availability and affordability at the global scale. These findings are broadly aligned with the conclusions of the first EAT–Lancet Commission (Willett et al. 2019), while providing additional insight into the economic and distributional dimensions of transformation.

The ensemble projects that under current trends, food demand, agricultural production, emissions, fertilizer use, and land pressures continue to increase through 2050. In contrast, the EAT–Lancet transformation scenarios produce a substantially different agricultural system characterized by lower livestock production, expanded production of vegetables, fruits, nuts, legumes, and aquatic foods, and lower aggregate agricultural resource use. Dietary change emerges as the dominant driver of reductions in agricultural emissions and land demand, while productivity improvements and food loss and waste reduction provide complementary gains, particularly for water, nitrogen, and phosphorus use. At the same time, the results suggest that environmental sustainability objectives are not equally easy to achieve. While reductions in agricultural greenhouse gas emissions and land use are observed consistently across the ensemble, nitrogen and phosphorus use remain above planetary boundaries. No individual intervention fully achieves the environmental improvements observed in the combined scenarios. Dietary change contributes most strongly to reductions in emissions and land use, productivity growth moderates resource requirements and food prices, and food loss and waste reduction improves efficiency throughout the system. When implemented together, these interventions generate outcomes that are larger and more robust than any single driver in isolation, although the benefits are not strictly additive because multiple interventions often affect the same underlying production systems.

The economic results are directionally more complicated than the environmental results. Globally, food affordability improves relative to 2020 under both BAU and EL scenarios due to projected income growth. However, the transition restructures agricultural sectors, with implications on labor as well as regional food affordability. Producer prices and output decline for many livestock sectors while demand and prices increase for horticultural products and other foods emphasized in healthy diets. Regions that currently specialize in livestock exports may face contracting markets, whereas regions with competitive advantages in fruits, vegetables, nuts, legumes, and fisheries may benefit from expanding demand. These adjustments imply significant reallocation of production, trade, and labor even where aggregate impacts appear modest.

Several broad patterns are worth highlighting. First, model agreement on the direction of structural change is higher than for the magnitude of change. For example, all models agree that dietary transformation implies less livestock and more VFN, lower emissions and land use, and lower average producer prices. There is greater agreement in aggregate than at the regional and sectoral results, suggesting that there is some agreement on how things might look at the global level, but less agreement in terms of the relative regional and sectoral contribution. Additionally, there also is much greater agreement across the ensemble for the BAU, Mitigation, and PROD scenarios. Highlighting previous multi-model studies focusing on these topics. While there is a fair amount of agreement on FLW results, there remains substantial questions in how different models currently represent food losses and waste, and additional efforts to understand these differences could be beneficial for future work targeting FLW reduction. The greatest range of outcomes are observed for the diet scenario. This can be explained in part in that this is by far the largest change of the 3 drivers comprising the EL scenario. It is also important to note, that the EL scenario had very little specification on the production side in terms of how supply chains could transition. As such the results are endogenous and based on each models assumptions on the responsiveness of producers to changes in market demand. A food system transformation would likely require supply- and demand- side interventions, and future work developing a range of transition pathways that could be modelled would be important with respect to informing efforts to achieve more sustainable and healthy food systems.

4.1 Caveats and limitations

Several important caveats must frame the use of these results. All models in the ensemble operate at a macro scale using neoclassical frameworks that assume profit-maximizing firms and utility-maximizing consumers, with limited representation of market imperfections, subsistence agriculture, or the distributional consequences of transformation within regions. The finding that global food expenditure declines should not be interpreted as evidence that affordability challenges are solved: within regions with large subsistence populations or poorly integrated rural markets, aggregate results can be deeply misleading. The ensemble cannot tell us how the transition would actually unfold. The models simulate an end state in 2050 and implies a smooth linear transition, abstracting away from stranded assets, political economy constraints, and adjustment costs that will likely dominate the transition experience.

Additionally, the scenario design implements dietary change as an exogenous demand shift without a policy narrative for how it is achieved. Different policy instruments (i.e., food taxes, subsidies, labelling, education) would produce very different price and distributional effects

Finally, coverage heterogeneity in the ensemble reporting means that some key findings, particularly on food expenditure and nitrogen and phosphorus outcomes, are based on a smaller number of reporting models. These results should be treated as indicative rather than definitive.

4.2 Implications for the GTAP community

Several opportunities for the GTAP modelling community for future research topics to inform food system transformation stand out. First, the trade reallocation analysis is only partially developed in the published Commission results and represents a significant gap that CGE and PE models could explore. The structural shift away from livestock, concentrated in current major exporters like Brazil, Australia-New Zealand, and North America, toward VFN and fisheries will generate substantial bilateral trade flow changes that the Commission's reporting protocol captured only at a regional aggregate level. Detailed bilateral trade analysis is a natural next step. Second, the labor market adjustment dynamics deserve deeper investigation using models with more detailed household accounts and factor market representation. The aggregate result of modest employment change conceals substantial sectoral adjustment, and translating this into household welfare and distributional impacts requires more detailed modelling, perhaps with CGE models linked to microsimulation models.

The wide range of results for many variables may itself be a useful resource, as there is substantial future uncertainty about what a transformed food system might look like. The wide range of results can therefore continue to serve as a useful resource to consider many potential consequences, and to begin informing anticipatory governance efforts. Nevertheless, this wider range also suggest that we could benefit from further exploration of the causes of regional and sector divergences, to better understand what assumptions are most critical in explaining the differences between models.

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