GTAP CONFERENCE 2024

Assessing the Individual and Cumulative Impacts of Drivers in Food Systems Transformation through a Multi-Model Ensemble Paradigm

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FOOD SYSTEMS & GLOBAL CHANGE

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Part of Cornell's work on leading the modelling assessment for EAT-Lancet Commission 2.0

NOTE: THIS IS AN ON-GOING RESEARCH PROJECT

RESULTS PRESENTED TODAY ARE PRELIMINARY AND ARE NOT FOR CITATION

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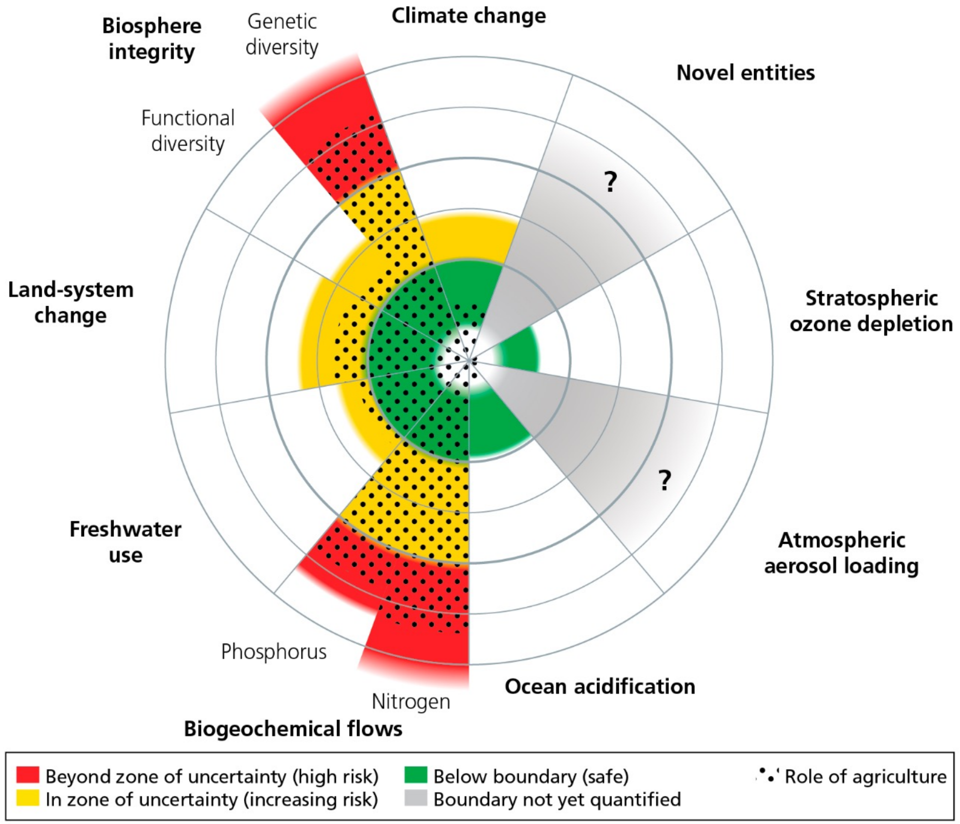
Assessing the Individual and Cumulative Impacts of Drivers in Food Systems Transformation through a Multi-Model Ensemble Paradigm

- The current food system significantly contributes to the transgression of several safe and just planetary boundaries (Vermeulen, Campbell, and Ingram 2012; Campbell et al. 2017; Springmann et al. 2018; IPCC 2023)
- Despite producing enough food for 10 billion people, it is unevenly distributed, leaving one in ten people at risk of hunger (FAO 2023)
- **There is an urgent need to investigate the range of options available**



From Campbell et al 2017

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- The EAT-Lancet report in 2019 suggested that it was possible to simultaneously improve health and environmental outcomes by **shifting to a healthy flexitarian diet, reducing food loss and waste, and improving production practices**.

- Moreover, we evaluate the potential synergies and trade-offs of coupling FST with **climate mitigation**

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AgMIP

Model	Full name	Model type	Institution	Country
AIM	Asia-Pacific Integrated Model	CGE	National Institute for Environmental Studies & Kyoto University	Japan
ENVISAGE	ENVironmental Impact and Sustainability Applied General Equilibrium	CGE	Purdue University	USA
FARM	Future Agricultural Resources Model	CGE	U.S. Department of Agriculture	USA
IMAGE	Integrated Model to Assess the Global Environment	CGE	Netherlands Environmental Assessment Agency (PBL)	Netherlands
MAGNET	Modular Applied GeNeral Equilibrium Tool	CGE	Wageningen University	Netherlands
CAPRI	Common Agricultural Policy Regional Impact	PE	European Commission Joint Research Centre	EU
GLOBIOM	Global Biosphere Management Model	PE	International Institute for Applied Systems Analysis (IIASA)	Austria
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade	PE	International Food Policy Research Institute (IFPRI)	USA
MAgPIE	Model of Agricultural Production and its Impact on the Environment	PE	Potsdam Institute for Climate Impact Research (PIK)	Germany

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AgMIP

- Leveraging the **AgMIP consortium**, which have been involved in several multi-model assessments:
  - Climate change (Nelson et al, 2014)
  - Mitigation and food security (Hasegawa et al 2018)
  - Land use-change (Stehfest et al 2019)
  - ..and more

- **Harmonized input data**
  - Diet (updated from EAT-Lancet 1.0)
  - Productivity shocks:
    - Crops from GGCMI (Jägermeyr et al, 2021)
    - Livestock (Thornton et al, 2022)
    - Labor (Nelson et al, 2024)

Food Group	Range in grams	
	Min	Max
Vegetables	300	
Legumes	75	
Nuts & Seeds	50	
Fruits	200	
Starchy Fruits		100
Roots		100
Red Meat		14
Poultry		29
Fish	28	
Milk		250
Eggs		13
Sugar		31
Palm Oil		7
Veg oil	40	80

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Scenario	Description	Food Systems Transformation Dimensions			Climate Mitigation and Land-use Policies
		Diet	Productivity Assumptions	Waste	
BAU	Business as usual scenario based on SSP2 with a higher climate impact reflected by RCP 7.0	Model BAU assumptions on diets to 2050	Model BAU assumptions on crop and livestock productivity.	Model BAU assumptions on FLW	Model BAU assumptions on climate mitigation and LUC policies
DIETARY PREFERENCE SHIFT	Adds **EAT-Lancet Diet** to BAU	Globally achieves EAT-Lancet diet by 2050			
IMPROVED PRODUCTIVITY	Adds **high productivity** to BAU		High productivity growth rate similar to productivity trends associated with SSP1		
REDUCING FLW	Adds a **reduction of food loss and waste** to BAU			Reduction of FLW	
EAT-Lancet 2.0 (EL2)	**Full EL2** (diet, productivity, FLW) **without mitigation** and higher climate impacts based on RCP 7.0	Globally achieves EAT-Lancet diet by 2050	High productivity growth rate similar to productivity trends associated with SSP1	Reduction of FLW	Model BAU assumptions on climate mitigation and LUC policies

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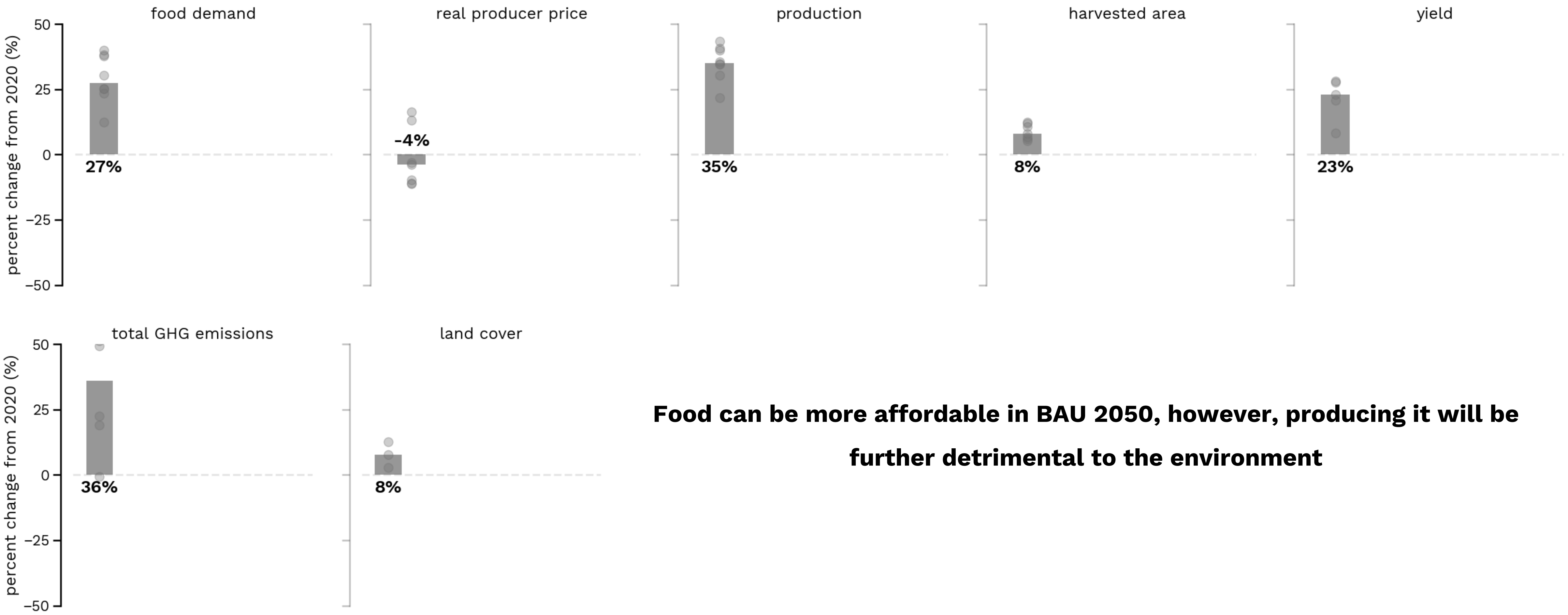
Scenario	Description	Food Systems Transformation Dimensions			Climate Mitigation and Land-use Policies
		Diet	Productivity Assumptions	Waste	
Mitigation	Adds **mitigation and land-use policies** consistent with 1.5C by 2050 to **BAU**				Mitigation and LUC policies consistent with 1.5C
EL2 with Mitigation (ELM)	**Full EL2** (diet, productivity, FLW) **with mitigation** policies consistent with 1.5C. Climate based on a lower climate impacts with **RCP 2.6**	Globally achieves EAT-Lancet diet by 2050	High productivity growth rate similar to productivity trends associated with SSP1	Reduction of FLW	Mitigation and LUC policies consistent with 1.5C

Assessing the Individual and Cumulative Impacts of Drivers in Food Systems Transformation through a Multi-Model Ensemble Paradigm

- What does the world look like in 2050 without food systems transformation (FST)?
- What are the individual impacts of key drivers of food systems transformation?
- What are the co-benefits and trade-offs of bundling key drivers?
- Can the food system have a heavier lift on climate mitigation?

What does **business-as-usual (BAU) 2050** look like?



Food can be more affordable in BAU 2050, however, producing it will be further detrimental to the environment

BAU with **improved productivity**

Increasing efficiency without limits on sufficiency, has limited environmental gains due to rebound effects

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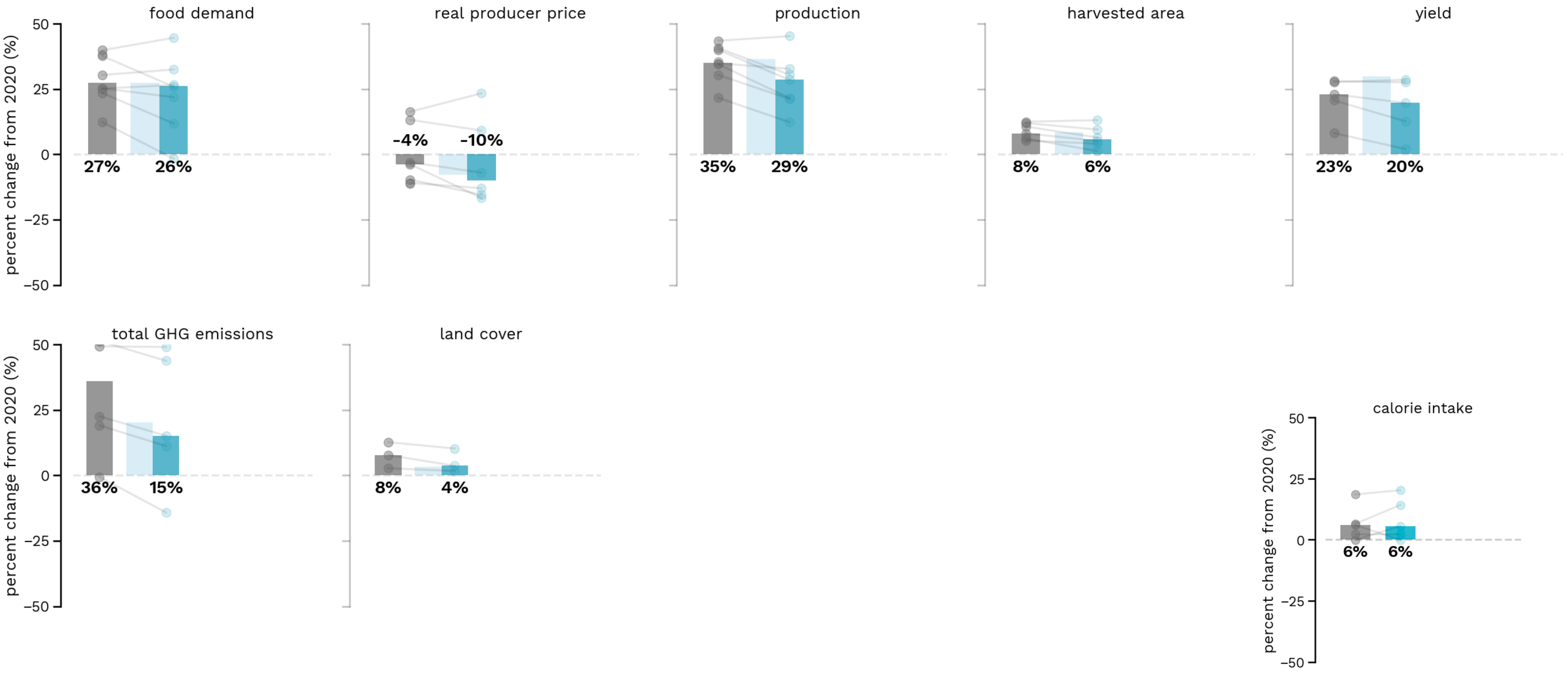
BAU with **reduced food loss and waste**



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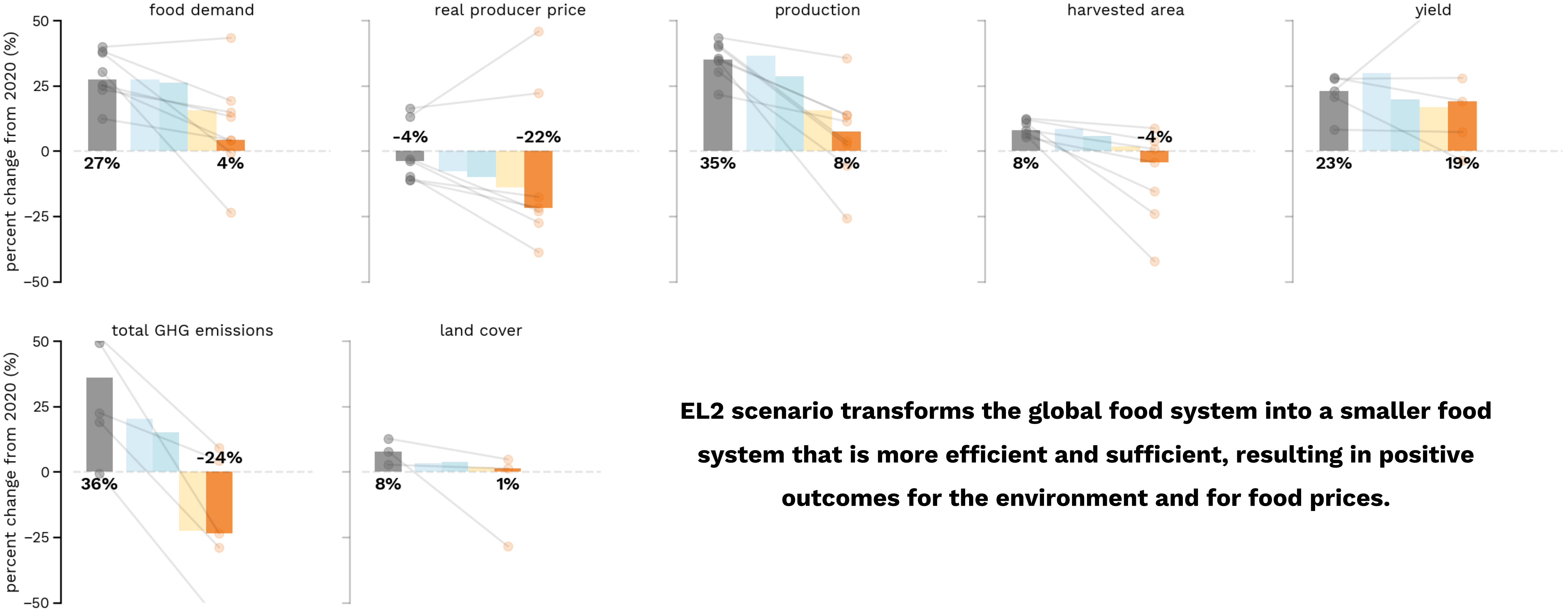
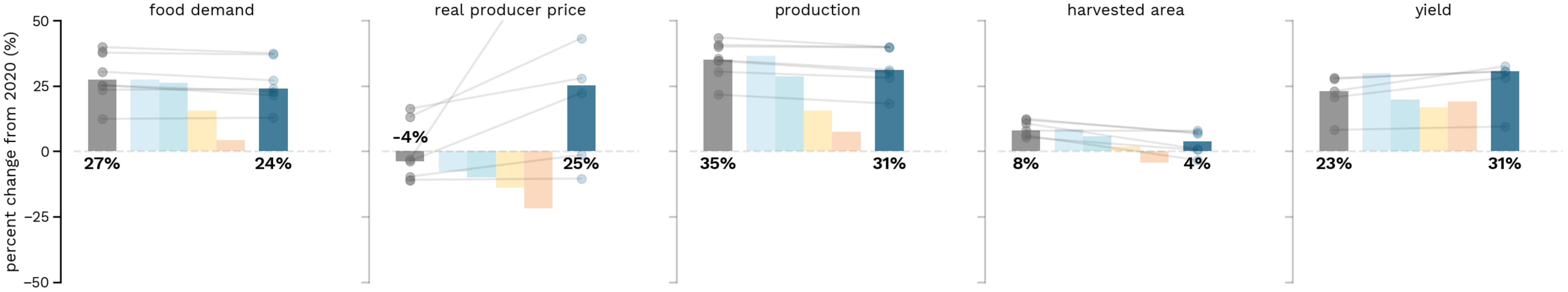
BAU with dietary preference shift

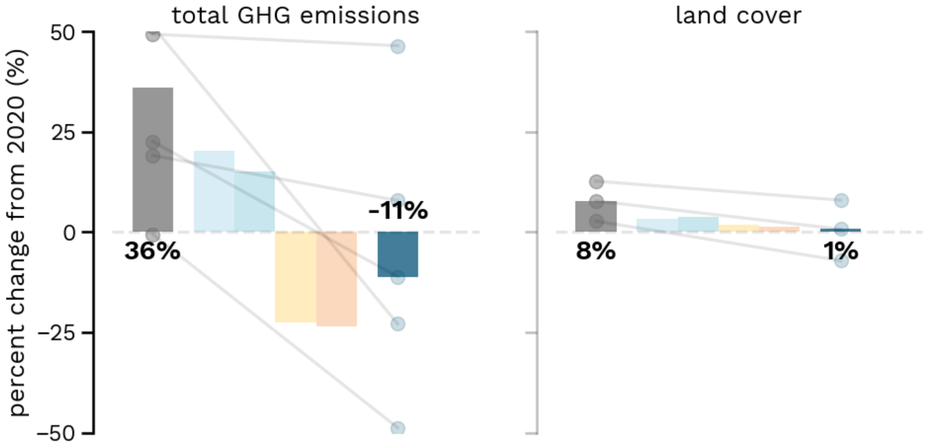
EAT-Lancet 2.0: **improved productivity, reduced FLW, diet shift**



EL2 scenario transforms the global food system into a smaller food system that is more efficient and sufficient, resulting in positive outcomes for the environment and for food prices.

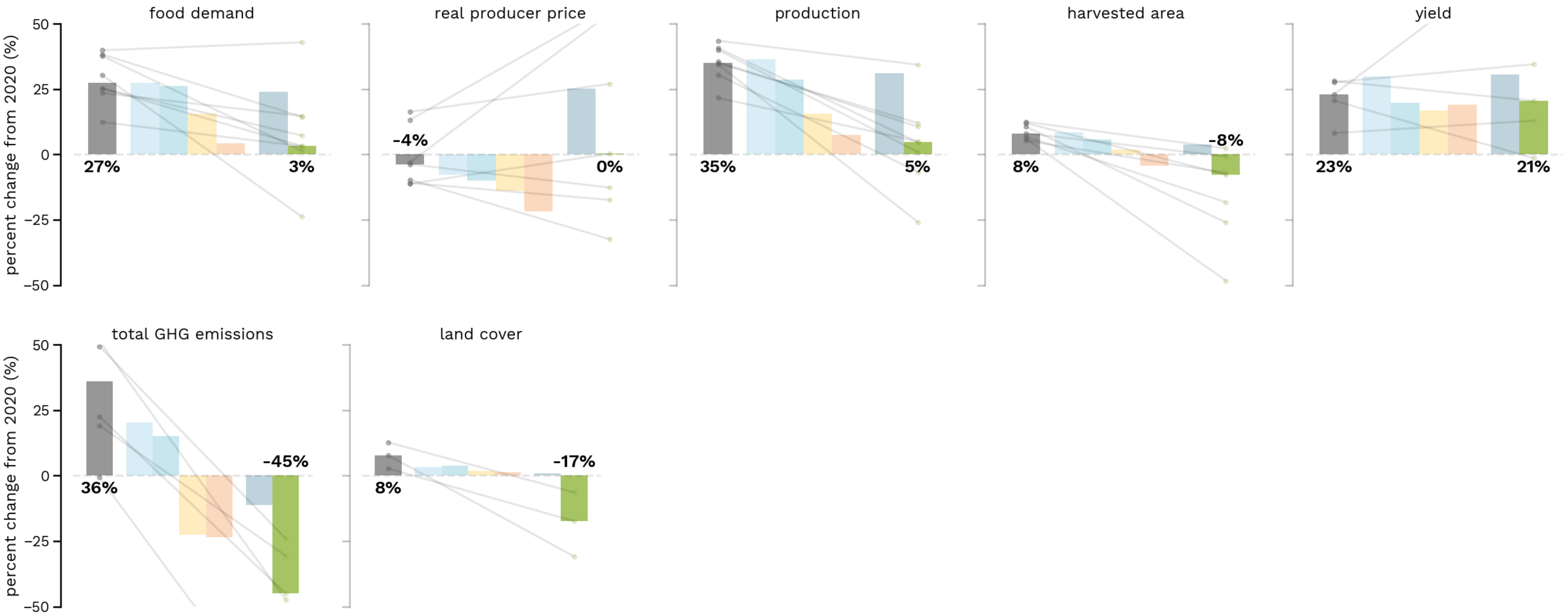
BAU with **mitigation**





- Increasing efficiency

EL2 with mitigation (ELM)



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- A comprehensive food system transformation that combines efficiency and sufficiency reduces negative rebound effects and maximizes environmental benefits, above and beyond employing a single intervention by itself.
- It is within the possibility space of EL2 for the food systems to satisfy agricultural demands within our resources today, thus avoiding further land conversion and increased yearly GHG emissions, without increasing prices
- Coupling EL2 with additional climate mitigation scenario further amplifies the environmental outcomes for the agricultural sector and dampens the increase in the prices of agricultural commodities.

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Thank you

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Global Development

	Percentage Change from BAU 2020 (%)																							
	Food Demand			Real Producer Price			Production			Harvested Area			Yield			Total GHG Emissions			Land Use			Water Withdrawals		
	median	min	max																					
BAU	27	12	40	-4	-11	16	35	22	44	8	5	13	23	8	28	36	-1	107	8	3	13	1	-12	13
Increased Productivty	26	13	45	-8	-13	8	36	22	52	8	-9	11	30	9	50	20	-7	52	3	-5	12	0	-13	12
Reduced FLW	26	-2	45	-10	-17	23	29	12	45	6	1	13	20	2	29	15	-14	49	4	2	10	-1	-16	13
Dietary Shift	23	-26	34	-14	-30	50	16	-21	28	2	-30	10	17	-1	40	-23	-48	13	2	-19	5	-13	-36	11
EL2	9	-23	43	-22	-39	46	8	-26	36	-4	-42	9	19	-3	64	-24	-57	9	1	-28	5	-15	-41	11
Mitigation	24	13	38	25	-10	95	31	18	40	4	-3	8	31	9	33	-11	-49	46	1	-7	8	-2	-10	6
ELM	5	-23	43	0	-32	57	5	-26	34	-8	-48	2	21	-1	81	-45	-97	-24	-17	-31	-6	-17	-35	2

	Percentage Change from BAU 2050 (%)																							
	Food Demand			Real Producer Price			Production			Harvested Area			Yield			Total GHG Emissions			Land Use			Water Withdrawals		
	median	min	max																					
Increased Productivty	1	0	3	-4	-15	-1	1	0	8	-1	-14	-1	2	1	22	-2	-7	1	-1	-11	1	-1	-2	-1
Reduced FLW	-3	-12	3	-4	-13	6	-7	-10	1	-2	-5	1	-3	-6	1	-6	-14	0	-2	-4	-1	-2	-4	0
Dietary Shift	-10	-43	9	-7	-23	32	-14	-41	-4	-6	-34	-1	-7	-18	14	-37	-48	-15	-6	-25	-1	-15	-28	-2
EL2	-12	-40	2	-12	-32	29	-21	-45	-6	-9	-46	-3	-1	-19	33	-40	-57	-15	-7	-34	-1	-18	-33	-2
Mitigation	-2	-3	0	18	1	101	-3	-3	0	-5	-9	0	2	1	8	-28	-49	-2	-7	-10	-4	-2	-6	2
ELM	-16	-41	2	9	-25	59	-22	-45	-6	-18	-51	-8	4	-17	47	-55	-97	-42	-20	-36	-17	-18	-27	-10

	GHG Emissions in 2050 (Gt CO_2eq)												Land Use in 2050 (Billion ha)		
	total emissions			CH_4			N_2O			CO_2					
	median	min	max										median	min	max
BAU	9.9	6.3	15.8	6.6	3.9	9.5	2.8	2.4	5.7	0.2	0.0	3.3	5.3	5.1	5.5
Increased Productivty	9.6	6.2	12.2	6.0	3.9	7.0	2.6	2.3	3.3	0.0	0.0	3.5	5.1	4.9	5.2
Reduced FLW	9.4	5.9	11.3	6.1	3.7	6.7	2.3	2.2	3.1	0.0	0.0	2.3	5.1	5.0	5.3
Dietary Shift	5.9	4.0	7.7	3.2	2.4	4.6	1.8	1.6	3.1	0.0	0.0	2.0	4.9	4.1	5.0
EL2	5.6	3.7	7.4	2.9	2.3	4.5	1.7	1.4	3.0	0.0	0.0	1.4	4.9	3.7	5.0
Mitigation	5.7	5.0	9.3	3.5	3.1	5.9	2.0	1.9	3.1	0.0	-0.9	0.3	5.0	4.6	5.2
ELM	3.6	0.4	4.8	1.9	1.5	2.8	1.4	1.2	1.8	0.0	-2.3	0.2	4.1	3.5	4.4