Resilience of the UK
Food System
to Global Shocks

Insights from modelling global shocks for the UK food system

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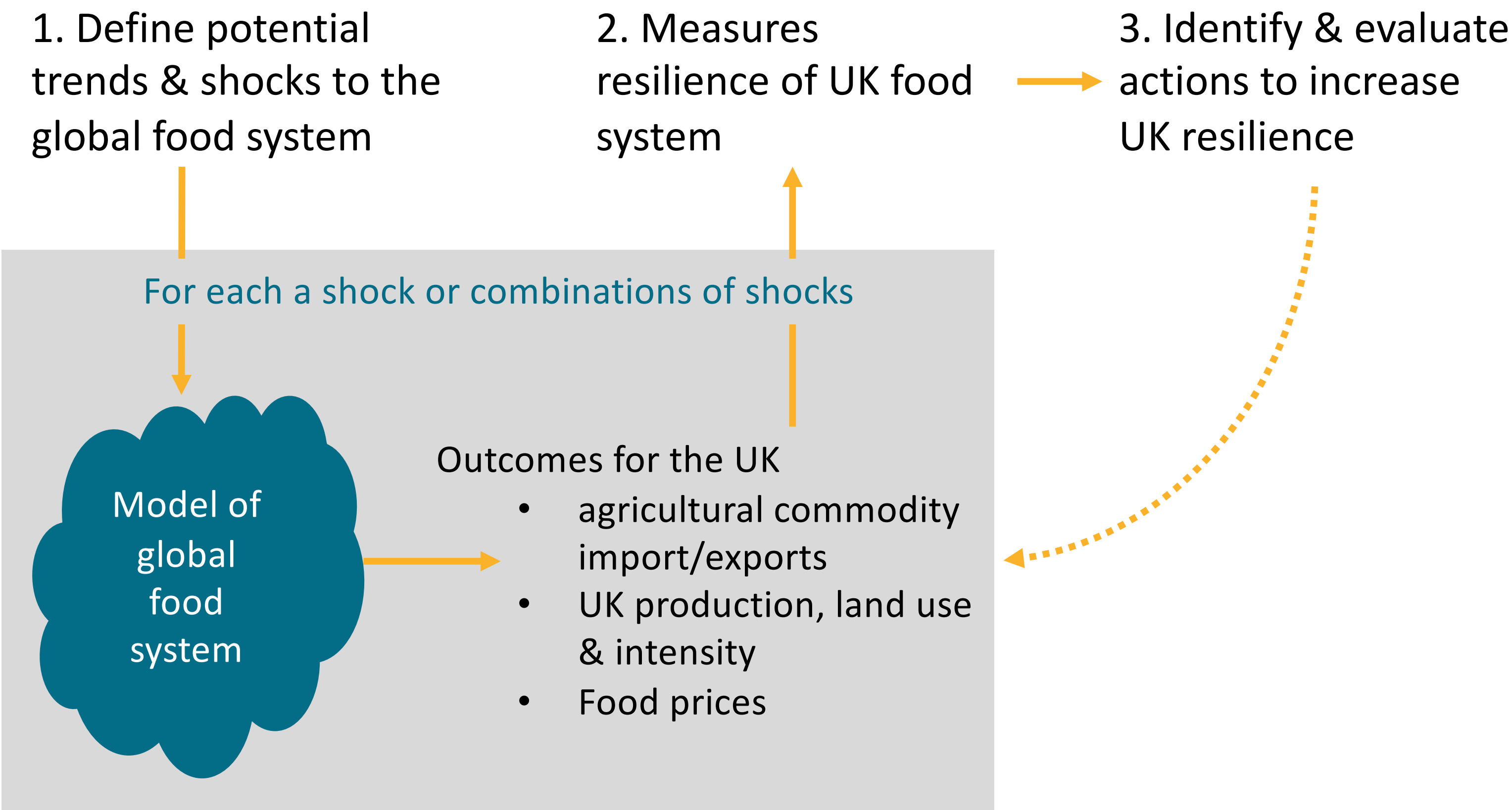
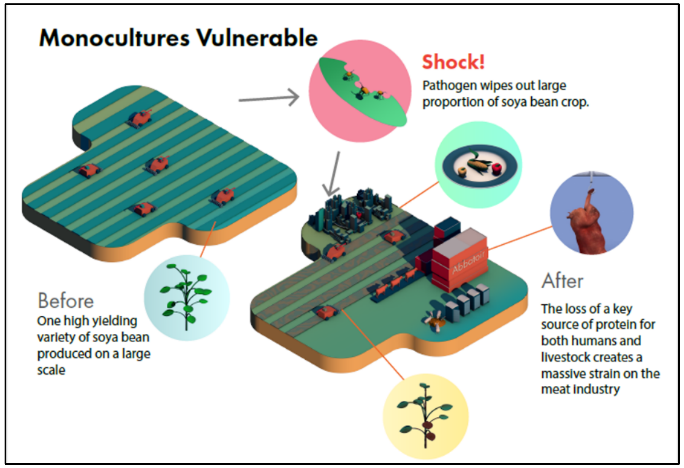
Project aims and objectives

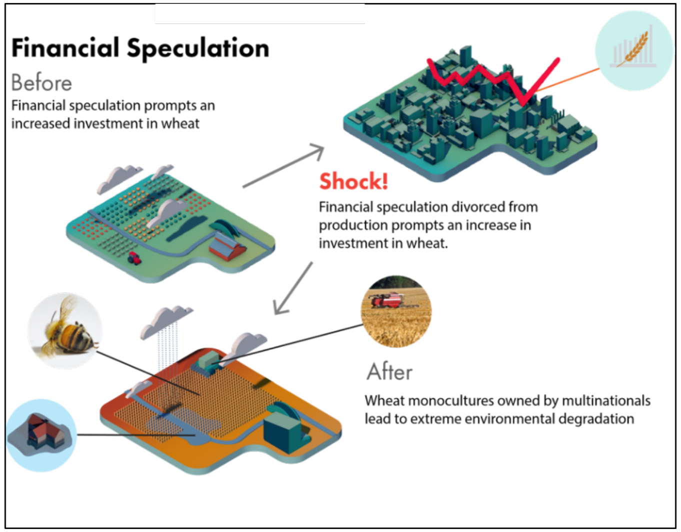
- Explore vulnerability & resilience of UK food system in a global context
  - to better understand the relationships to potential global shocks and trends
  - take a food systems approach that integrates biological systems, human behaviours, and the environment
  - to identify actions that increase UK resilience

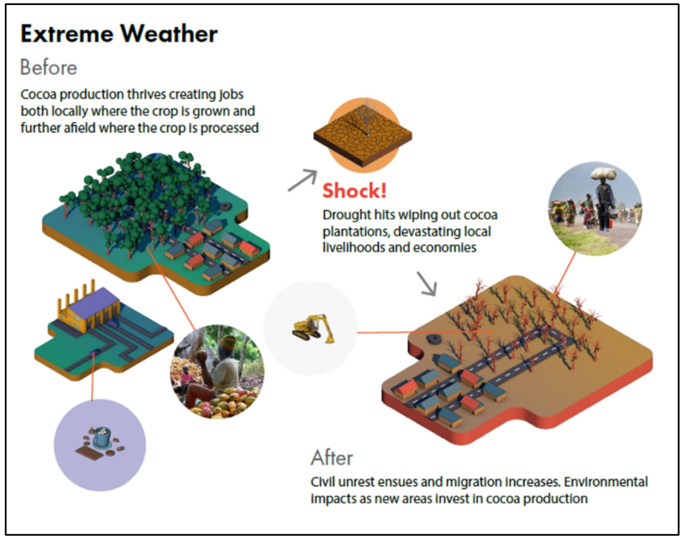
Conceptual approach

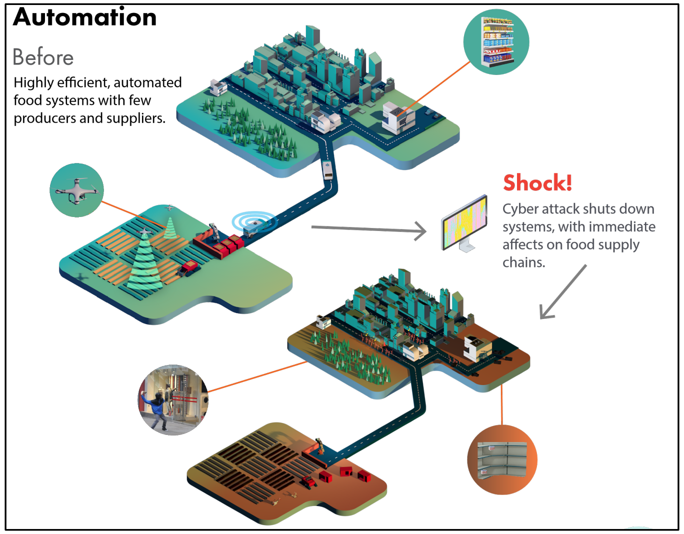


Scenario development examples









Hamilton, H. *et al.* Exploring global food system shocks, scenarios and outcomes. *Futures* **123**, (2020).

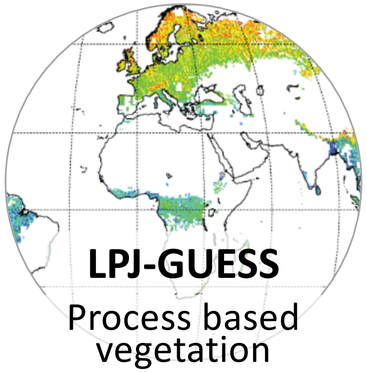
Land System Modular Model (LandSyMM)

Input scenarios, e.g.,

- ❖ **Climate change**
- ❖ **Population & GDP**
- ❖ **Policies,** **e.g. tariffs and subsides**
- ❖ **Dietary preferences**
- ❖ **Shocks**

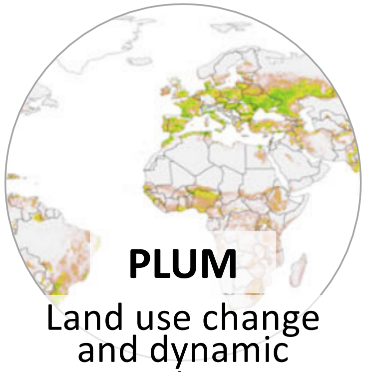
Modelled outcomes, e.g.,

- **Food prices & trade**
- **Land use**
- **Agriculture intensity**
- **Ecosystem inidactors**
- **Diet & nutritional health**



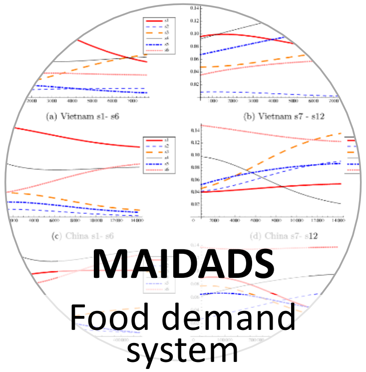
LPJ-GUESS

Process based vegetation system



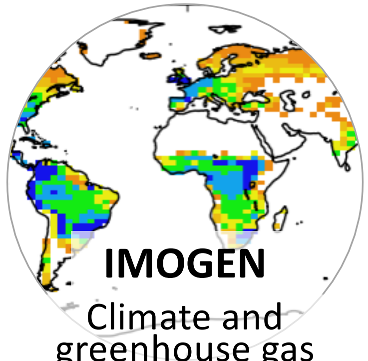
PLUM

Land use change and dynamic economic system



MAIDADS

Food demand system



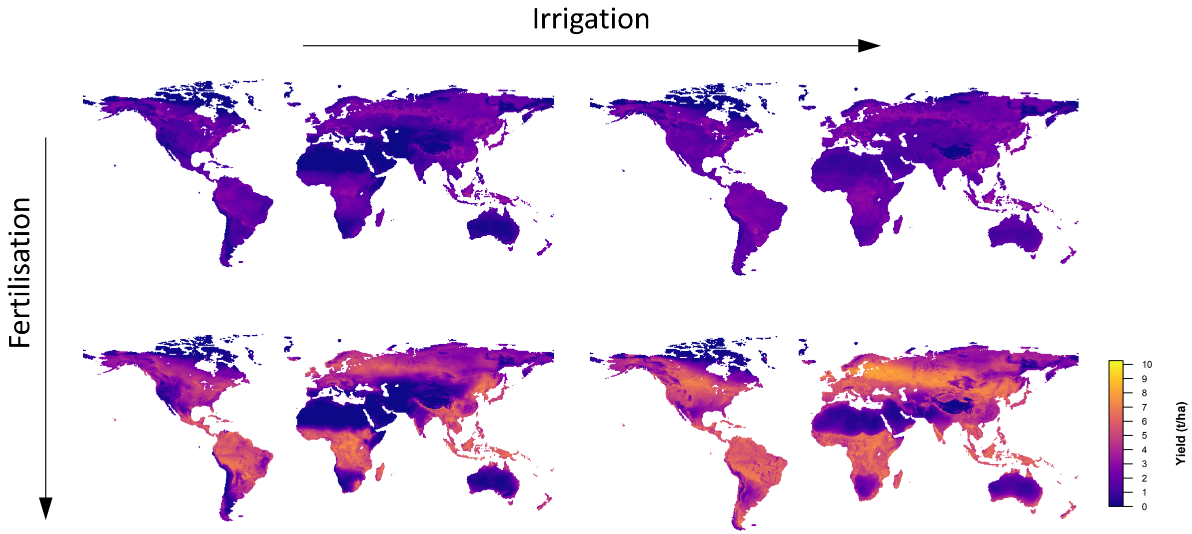
IMOGEN

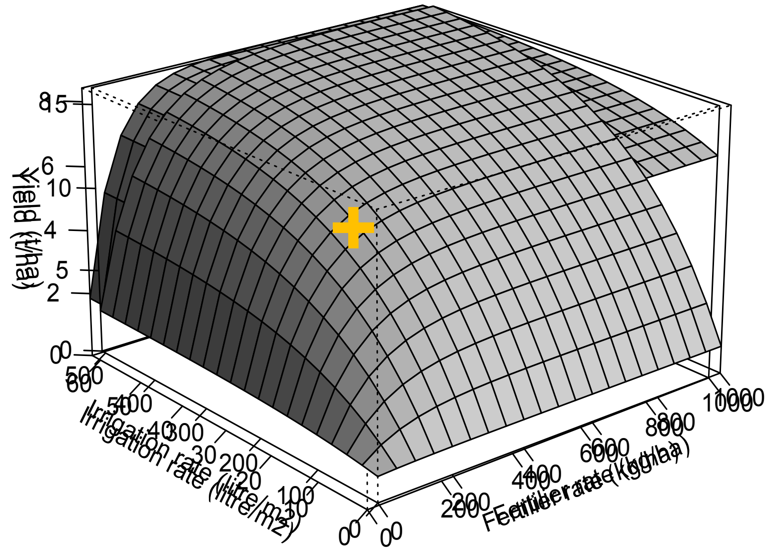
Climate and greenhouse gas forcing (in progress)

Model implementation example:
Land use and commodity production representation

Yield potential maps for each crop, fertilizer rate and irrigation/rainfed.

Used to create yield response to intensity for each crop and grid cell



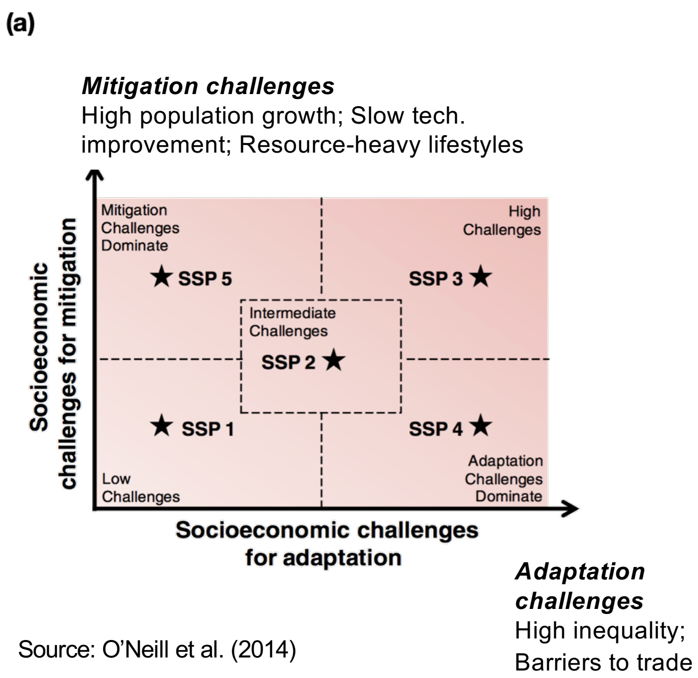


Maize, California Central Valley, US
(37ºN, 120ºW)

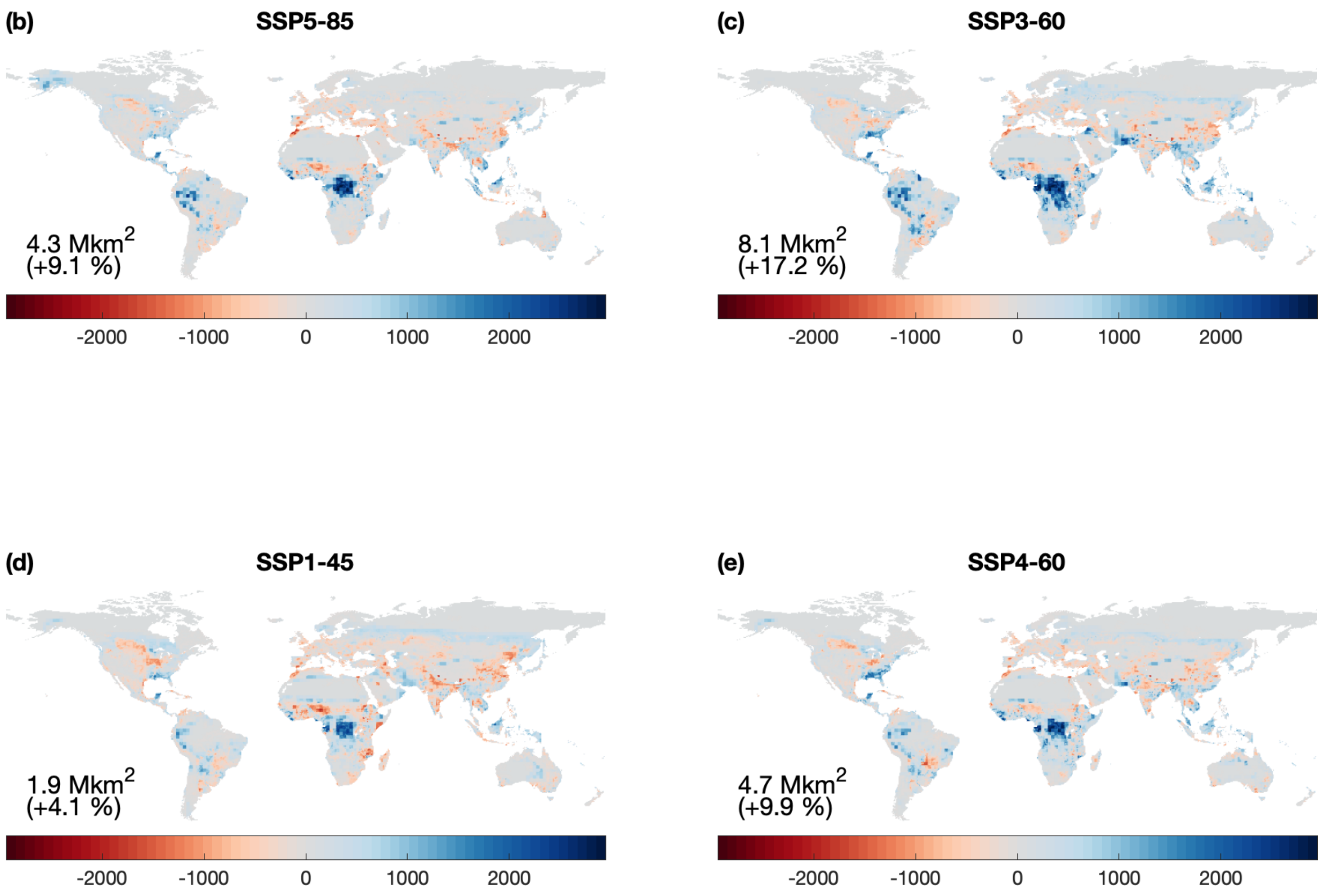
Alexander, P. *et al.* Adaptation of global land use and management intensity to changes in climate and atmospheric carbon dioxide. *Glob. Chang. Biol.* **24**, 2791–2809 (2018).

For each crop, year and climate scenario

Projected agricultural expansion at 2100



Source: O’Neill et al. (2014)

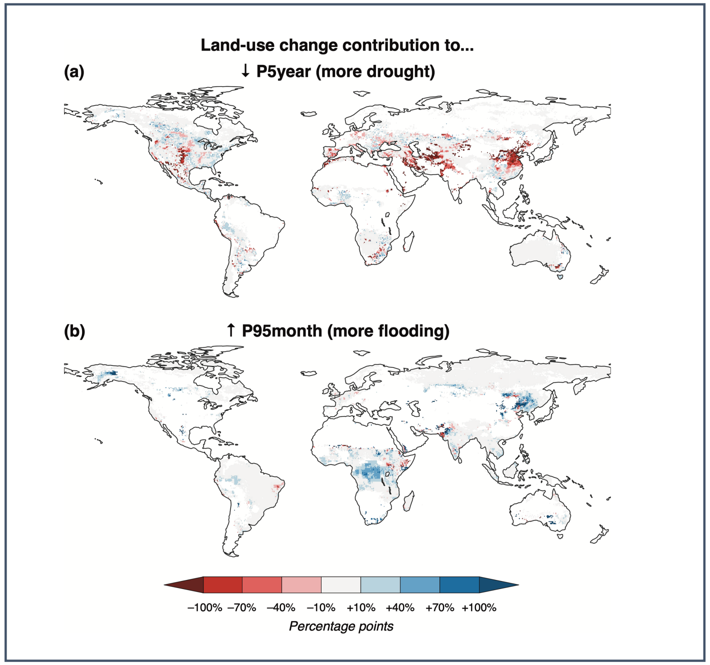


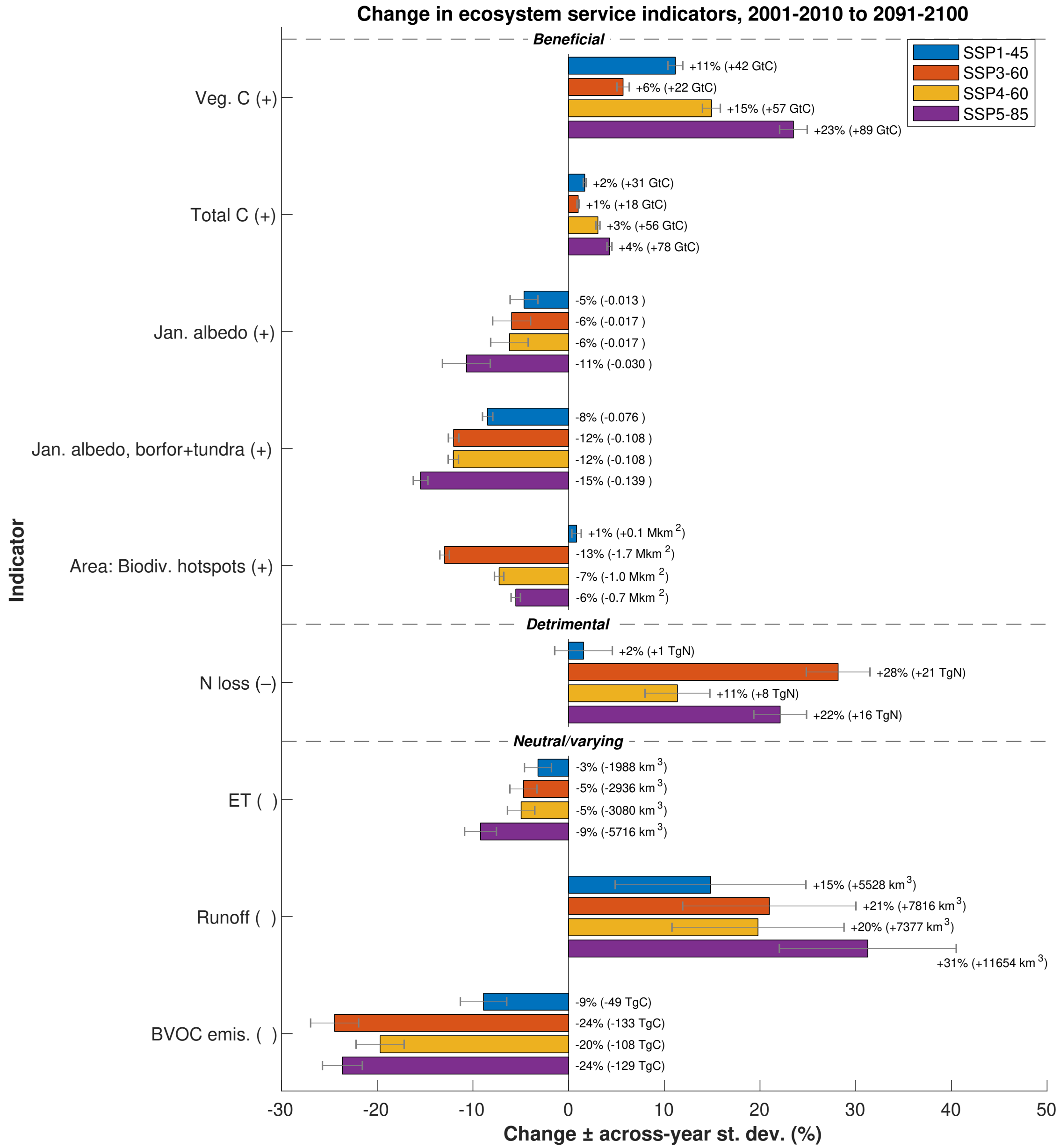
Socioeconomic
Shared Socioeconomic Pathways (**SSPs**)

probabilistic mapping to →

Climate
Representative Concentration Pathways (**RCPs**)

Ecosystem service indicators

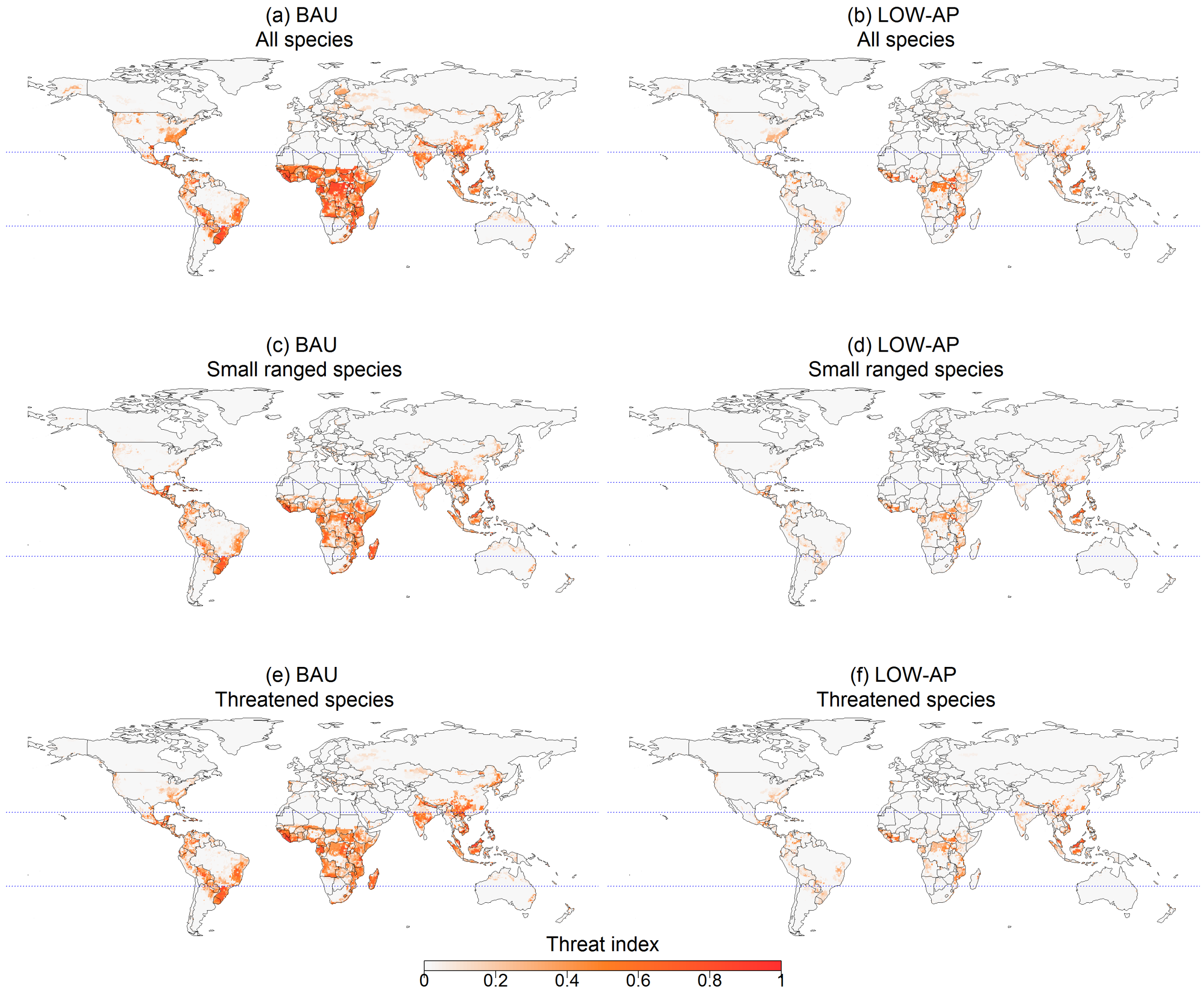




Rabin, S. S. *et al.* Impacts of future agricultural change on ecosystem service indicators. *Earth Syst. Dyn.* **11**, 357–376 (2020).

Dietary transitions for safeguarding biodiversity

Comparing regions with high biodiversity under pressure from agricultural expansion. The left column (a,c,e) is the business-as-usual (BAU) scenario and the right column (b,d,f) is the diet low in animal products (LOW-AP) scenario for the different types of species richness



Henry, R. C. *et al.* The role of global dietary transitions for safeguarding biodiversity. *Glob. Environ. Chang.* **58**, 101956 (2019).

How can the UK food system be managed to reduce the impact of global shocks?

- Potential changes to policy considered…
  a. Raise trade barriers on food imports?
  b. Increase subsidies to agricultural production?
- Resilience of the food system should consider…
  i. Food security (households)
  ii. Viability of agricultural sector
  iii. Environmental impact of the production

1. What impact do different policy option have on UK food system?
2. Are some policy options better than others in mitigating the impact of global shocks for food security?
3. What are the implications for viability of production section & environmental sustainability?

Methods – Scenarios tested

- Simulation run with and without shocks to 2060
- **Historical patterns of global production shocks** used to randomly generate shocks to global production system
- **Three policy scenarios** used to explore outcomes for UK food system under shocks.

Policy regime	Subsidy Rate (% of unit cost per ha)	Trade Barrier (% of tariff-free price)
Business as usual (BAU)	6%	12%
Higher UK subsidy	12%	12%
Higher UK import tariffs	6%	23%

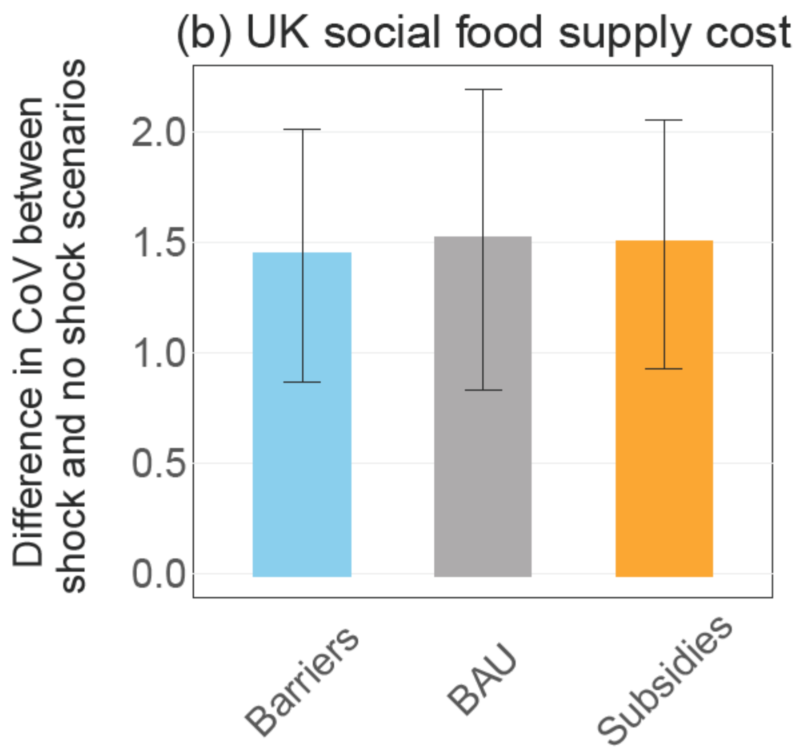
Household Food Security

- Across all policy regimes scenarios, the impact of modelling global shocks is to increase price volatility

- But, neither policy options dramatically impacts price volatility

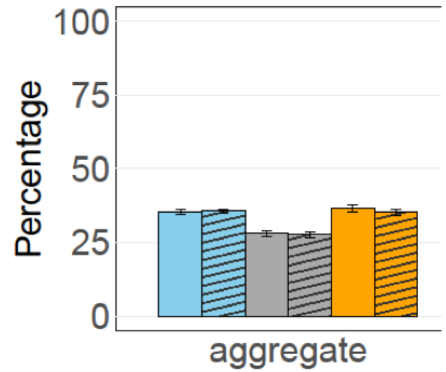
- Consumer food spending reduces with higher subsidies (~4% overall) compared to BAU.

- But, conversely, consumer costs increase under trade barriers

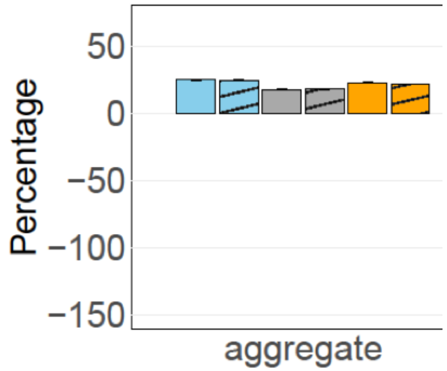


Agricultural viability

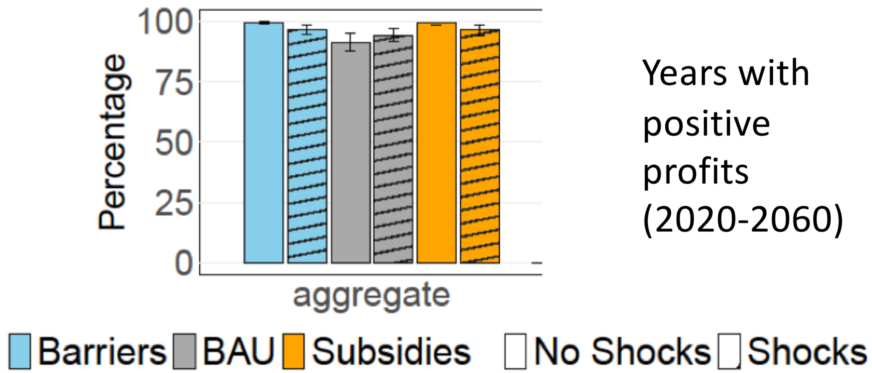
- Self-sufficiency is improved by both protectionist policies and subsidies (by around 10%)
- Higher trade barriers & subsidies improve profit margins, particularly for ruminants
- Years of negative profits are reduced by protectionist policies, especially for oilcrops, pulses, starchy roots, and wheat.



Mean % of demand met from domestic production (2020-2060)



Average profit margin (2020-2060)



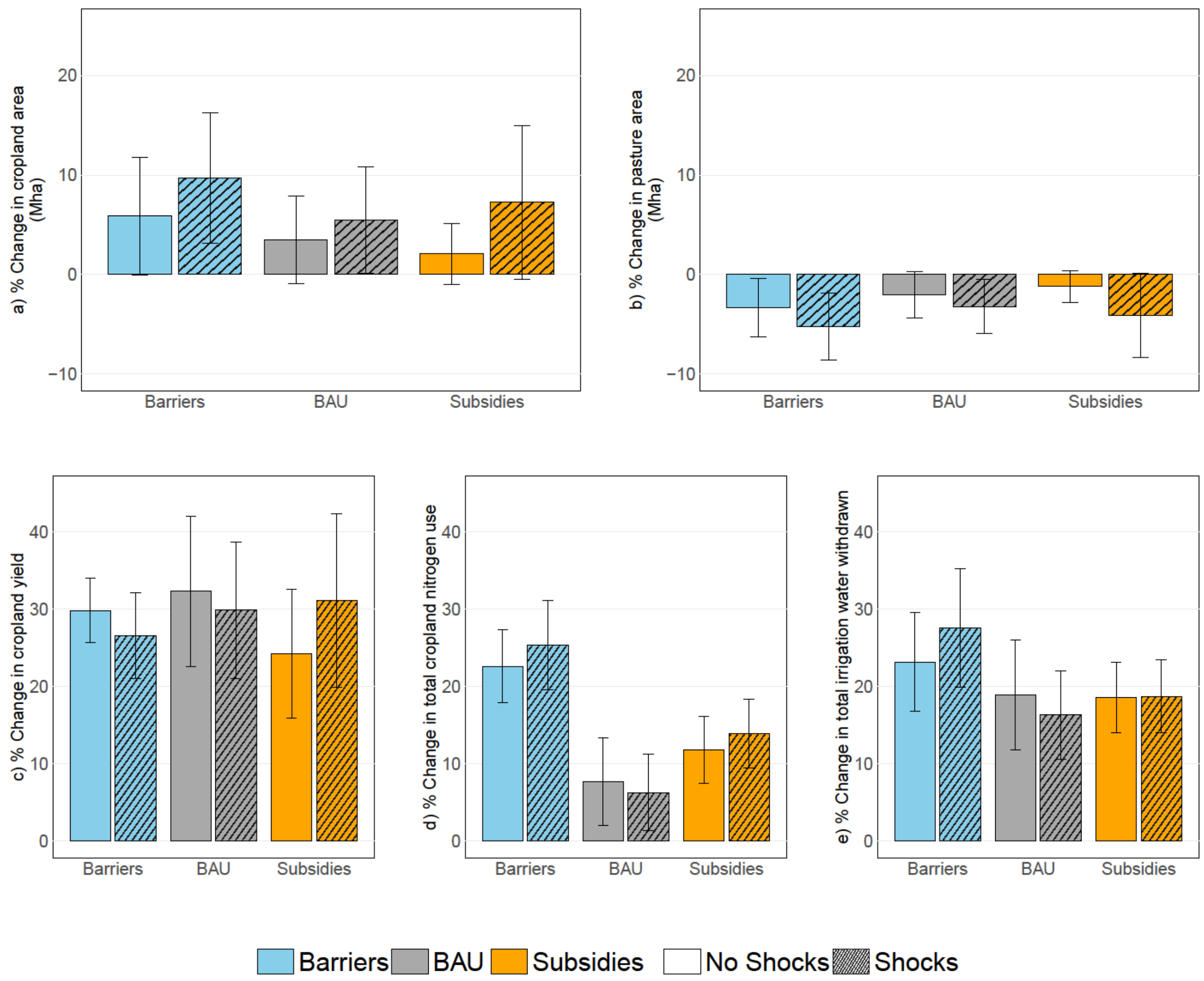
Years with positive profits (2020-2060)

Environmental Footprint

Both subsides and trade barriers create an intensification of production and expansion of UK cropland.

Trade barriers scenario having a greater effect than subsides scenario.

Total agricultural area remains unchanged, but shift from pasture to cropland.



Trade-offs for managing food system resilience

Indicator	Trade barriers	Subsidy
Food Security		
Household food spending	-1	1
Consumer price volatility	0	0
Viability of agriculture sector		
Profit margins	1	1
Profit volatility	2	1
Agricultural GDP growth	-1	-1
Food self-sufficiency	-1	-1
Environmental impact		
Natural land lost	0	0
Land use change	-1	1
Nitrogen use	-2	-1
Water use	-1	0
Livestock production	1	1

Higher trade barriers
- Good for viability of agricultural production sectors
  - increased profitability and lower price volatility.
- But…
- Environmental impacts
- Raises food prices for consumers

Higher subsidies
- Good for consumer prices
- Good for viability of agricultural sectors

How does market power affect food system resilience?

- Power imbalances are assumed to be detrimental to food security and to economic welfare
- We consider how previous shocks have been mitigated or amplified by the consolidation of market power
- Impact of market power on food system resilience found to be mixed

Low functional diversity levels, inflexible contracts and homogenous processes may increase supply chain vulnerability Example: Outbreak of E coli O157:H7 in Spinach from California in 2006 due to concentrated production and processing	**Financial capacity, robust logistics and cooperation can enable firms to better mitigate shock impacts** Example: European vegetable shortage in 2017, powerful UK retailers diverted to US lettuce at higher cost

Final comments

- Project work and analysis still going on…
  - including on the impacts of other shocks, including post-COVID recovery scenarios.

- Global food system is complex, but this can make the system (at least for consumers) more resilient to shocks
  - Complexity or long supply chains are not in themselves a source of vulnerability as some suggest
  - Disruptions to international trade is a notable exception
  - Globalisation concentrates impacts poorest

Thank you. Questions?

Agnolucci, P. *et al.* Impacts of rising temperatures and farm management practices on global yields of 18 crops. *Nat. Food* **1**, 562–571 (2020).

Alexander, P. *et al.* Adaptation of global land use and management intensity to changes in climate and atmospheric carbon dioxide. *Glob. Chang. Biol.* **24**, 2791–2809 (2018).

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