

Adaptation or Reallocation?

Climate and Trade Drivers of Agricultural Intensification

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Motivation

- ▶ Climate change alters yields, water use, and nutrient demand.
- ▶ Irrigation and fertilizer responses are visible, but they do not necessarily reflect the same mechanism.
- ▶ Markets can amplify, offset, or redirect climate responses through trade.

Core question

When intensification changes, are we seeing local adaptation to climate, or reallocation through trade?

Adaptation vs. Reallocation

Biophysical
response or
market response?

Approach

- ▶ GLOBIOM global partial equilibrium model
- ▶ Endogenous land use, production, and trade
- ▶ Focus on U.S. outcomes in 2050

Scenario design

- ▶ **Baseline:** historical climate and baseline trade
- ▶ **Climate (fixed trade):** climate shock with U.S. trade held fixed
- ▶ **Climate + trade:** climate shock with endogenous trade adjustment

Interpretation

- ▶ Climate effect = change from baseline under fixed trade
- ▶ Trade effect = difference between fixed-trade and endogenous-trade outcomes

Scenario Design

Scenario	Climate shock	Trade
Baseline	No	Baseline trade pattern
Climate (fixed trade)	Yes	U.S. trade held fixed
Climate + trade	Yes	Adjusts endogenously

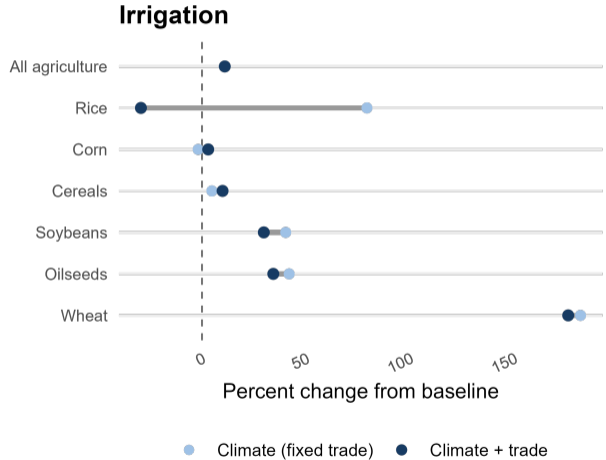
Trade effect = difference between fixed-trade and endogenous-trade outcomes

Results

Climate and trade shape irrigation use

USA, 2050; RCP7p0_MRI percent change from baseline

- ▶ Wheat shows the strongest increase, at about **+176% combined**.
- ▶ Rice moves in the opposite direction, shifting from **+79% climate-only** to about **-29% combined**.
- ▶ Aggregate irrigation changes remain modest, indicating reallocation across crops rather than system-wide expansion.



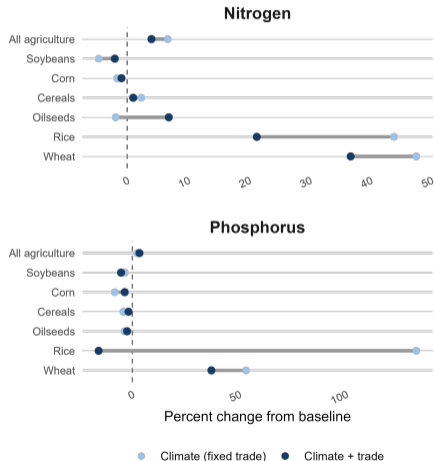
Interpretation: Climate drives irrigation pressure, and allowing

Nutrient responses are smaller and more crop-specific

USA, 2050; RCP7p0_MRI percent change from baseline

- ▶ Wheat nutrient use rises in both cases, about **+37%** for nitrogen and phosphorus.
- ▶ Rice rises for nitrogen but falls for phosphorus, showing more mixed adjustment than irrigation.
- ▶ Other crops remain near zero or shift only modestly.

Interpretation: Nutrient responses are more mixed and crop-specific, allowing trade to adjust offsetting climate pressure but not uniformly.

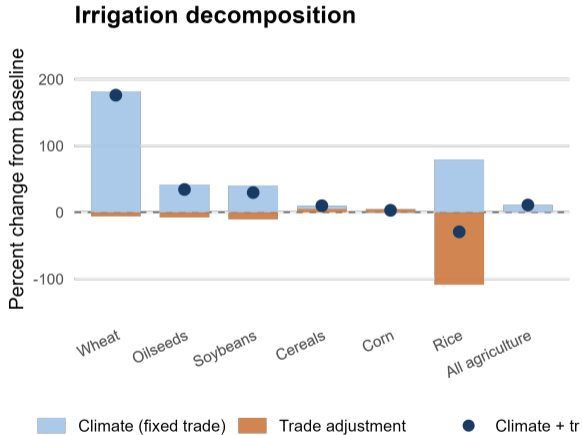


Irrigation is the clearest adaptation signal

Decomposition of irrigation response, USA 2050

- ▶ **Wheat:** irrigation rises sharply under climate (+182%) and remains high with trade (+176%), alongside +84% production.
- ▶ **Rice:** climate increases irrigation (+79%), but trade more than offsets it (-109%), yielding -29% combined even as production rises +43%.

Takeaway: Water responses still look primarily climate-driven, but trade changes where that pressure shows up.



Adaptation or reallocation?

What looks like adaptation is often reallocation

More climate-driven	More trade-mediated (through adjustment)
Irrigation response	Nutrient intensity by crop
Water withdrawals	Crop specialization
Local adjustment	Redistribution of pressure

Main takeaway

- ▶ Climate is the main driver of irrigation response.
- ▶ Allowing trade to adjust offsets rice strongly, but nutrient responses are more mixed and crop-specific.
- ▶ The combined outcome is not just about more or less input use; it is about *where* intensification occurs.

**Climate changes
the signal**

**Trade changes
the location**

Bottom line

Adaptation and trade are interacting channels, not competing explanations.

Implications

- ▶ Allowing trade to adjust can buffer some production losses under climate stress.
- ▶ But it also redistributes water and nutrient pressures across crops rather than eliminating them.
- ▶ Wheat becomes much more input-intensive, while rice shows how trade can offset domestic irrigation pressure even as production rises.

Implication

Trade adjustment redistributes environmental pressure rather than eliminating it, so evaluating adaptation requires tracking both biophysical and market responses.

Thank you

Questions?

Appendix

Land outcomes are secondary

USA, 2050; RCP7p0_MRI percent change from baseline

- ▶ Managed forest declines about **9%**, while primary forest increases about **3%**.
- ▶ Cropland declines about **3%**, while other natural vegetation increases about **1%**.

Interpretation

This is not mainly an extensive land expansion story; the stronger signal is intensification.

