

GROUP OF FRIENDS OF SCIENCE & INNOVATION · 9 OCTOBER 2026

Utility and limitations of economic modelling for El Niño

Consequences for agrifood systems and proposed responses

Máximo Torero Cullen

Chief Economist, Food and Agriculture Organization of the United Nations (FAO)

With contributions from

David Laborde and the Agrifood Economics and Policy Division (ESA) of FAO



Four messages for decision-makers

1

A very strong El Niño is under way

NOAA puts the odds of a very strong event this winter above 90%, and of the strongest event since 1950 at 75%.

2

No two El Niño events are alike

Impacts differ by location, crop calendar and starting conditions; averages of past events mislead.

3

Weather is only the first-round shock

Final agrifood outcomes depend on fertilizer costs, trade routes, water availability and policy responses.

4

Integrated modelling turns forecasts into decisions

Linking these channels in one framework supports anticipatory action before losses materialize.

El Niño 2026 is on track to be one of the strongest on record

>90%

chance of a very strong El Niño in Northern Hemisphere autumn–winter 2026–27

75%

chance of a historic event in Oct–Dec 2026, stronger than any since 1950 (relative Niño-3.4 $\geq +2.5^{\circ}\text{C}$)

+3.4°C

Niño-1+2 anomaly in August 2026 (Niño-3.4: $+1.8^{\circ}\text{C}$), with eastern Pacific SSTs above $+3^{\circ}\text{C}$

Already visible

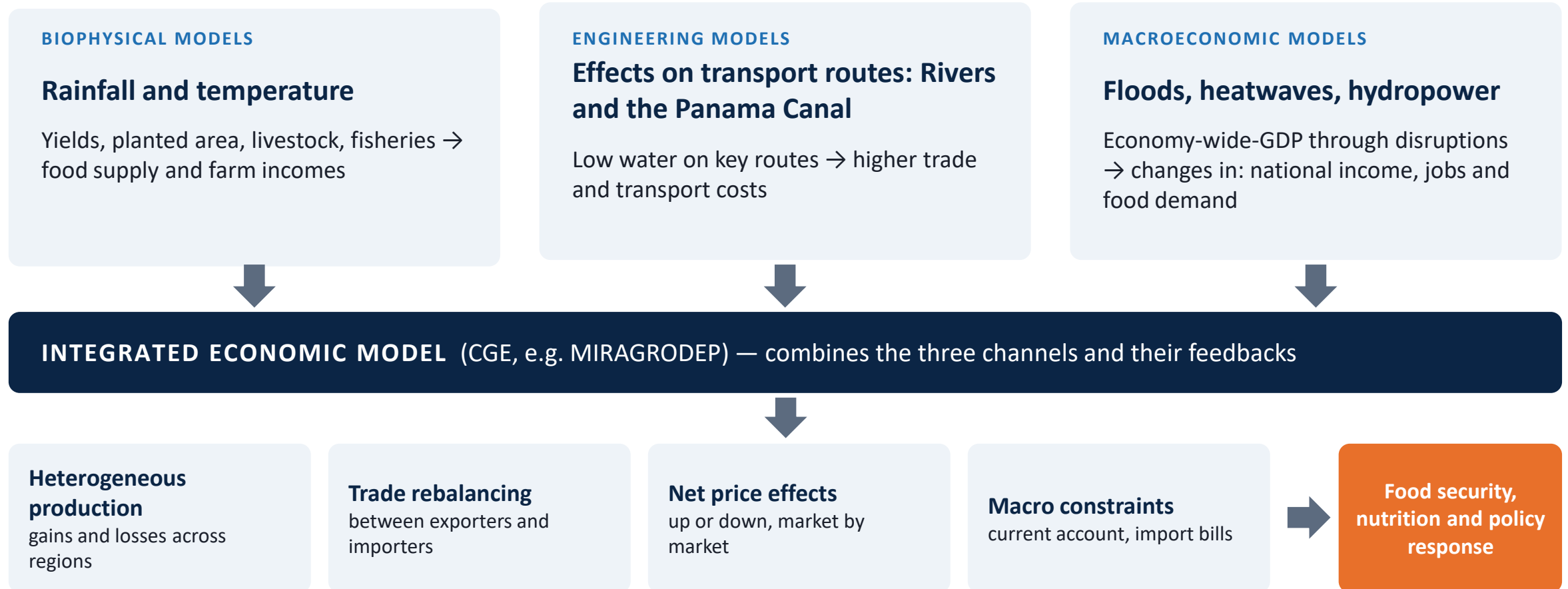
The Panama Canal Authority has cut the Neopanamax draft limit five times in 2026, to 47.5 ft from 3 September, as Gatún Lake falls.

But strength is not destiny

A stronger event raises the odds of typical El Niño impacts; it does not guarantee them. Local outcomes still have to be forecast, not assumed.

Sources: NOAA Climate Prediction Center, ENSO Diagnostic Discussion, 10 September 2026; Panama Canal Authority, Advisory to Shipping A-25-2026.

El Niño is not ‘just’ weather: economic feedbacks determine the final impact on food security



Policy responses feed back into prices and incentives (Lesson 4). MIRAGRODEP: IFPRI/AGRODEP multi-region computable general equilibrium model.

Biophysical channel: first-round yield losses concentrate in a few crop–country pairs – but still strong limitations

MAJOR PRODUCERS AT RISK area > 500k ha · yield attribution < –3%

COUNTRY	CROP	AREA	YIELD IMPACT
Malawi	Maize	1.3 Mha	-18.2%
South Africa	Maize	3.8 Mha	-15.1%
India	Soybeans	4.8 Mha	-14.7%
Argentina	Maize	3.6 Mha	-12.9%
Brazil	Wheat	2.1 Mha	-12.0%
Nigeria	Maize	3.3 Mha	-11.5%
Zambia	Maize	0.8 Mha	-9.8%

- **Southern Africa maize is most exposed:** Malawi –18%, South Africa –15%, Zambia –10%.
- **India soybean –15%** on 4.8 Mha, the largest area at risk in the table.
- **These are gross, first-round shocks.** Gains elsewhere (e.g. soybean in the Americas) offset part of them in world markets.

Major producers at risk, 2026 forecast: harvested area > 0.5 Mha and yield impact below –3%

Final production and price effects depend on area reallocation, trade and policy, which is what the integrated model adds.

Source: production forecasts by country and crop (model source to be stated).

Mapping cropland with almost no ground data



The limitation

Traditional EO crop mapping needs extensive ground-truth training data, region by region. Smallholder fields are smaller than most satellite pixels — a single pixel mixes crop, soil, and noise.

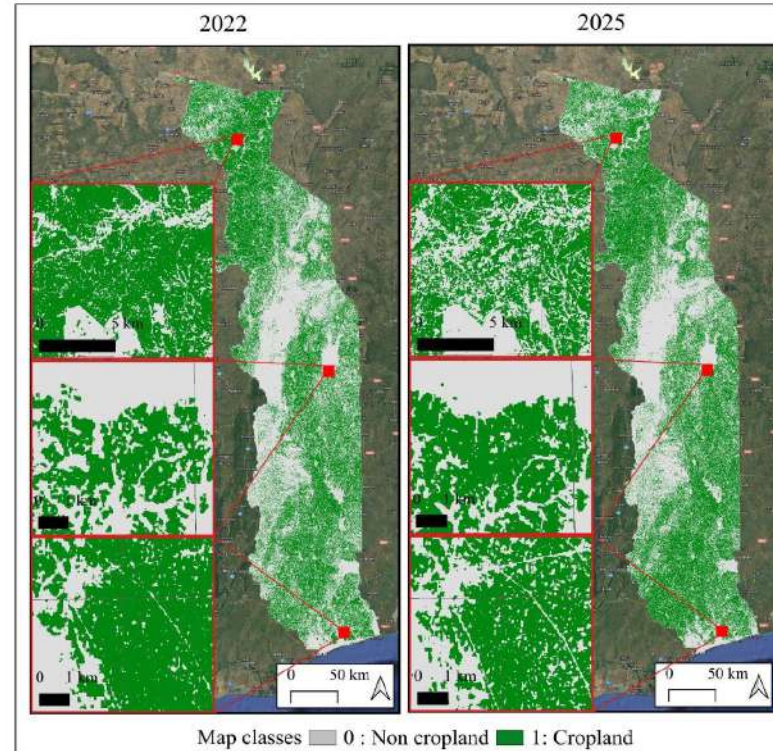


The innovation

Gaussian Mixture Models (GMM) separate crop signal from background using vegetation dynamics alone — no labeled samples required. Geospatial foundation models like OlmoEarth, Presto, Clay trained on optical, RADAR, and canopy-height data, extend this into places where reference data is sparse or impossible to collect.

In Zimbabwe, the SITS package also automatically filters spectrally inconsistent ground samples — cleaning the training data before the model ever sees it.

Example — Northern Togo, 2022 vs. 2025



A 2019 reference dataset (1,319 points)

fine-tuned the OlmoEarth foundation model to map active cropland in 2022 and 2025 — six years later — with **zero new field data collected**.

Cost: under \$100 per season, an in-kind contribution from the Allen Institute for AI.

This matters because Northern Togo is conflict-affected — field surveys were not a safe option.

Forecasting yield on physiological time, not the calendar



The limitation

Traditional EO yield models track vegetation greenness against calendar days, and miss thermal stress entirely. In fragmented smallholder fields, mixed pixels further weaken the signal.



The innovation — ARYA

- Growing Degree Days instead of calendar days — a physiologically consistent timeline regardless of when planting happened.
- A Temperature Difference (TDif) metric, combining land surface and air temperature, to catch water deficit and frost that greenness alone misses.
- Mathematical signal unmixing (matrix inversion) to extract the theoretical 100%-pure crop signal from fragmented pixels.

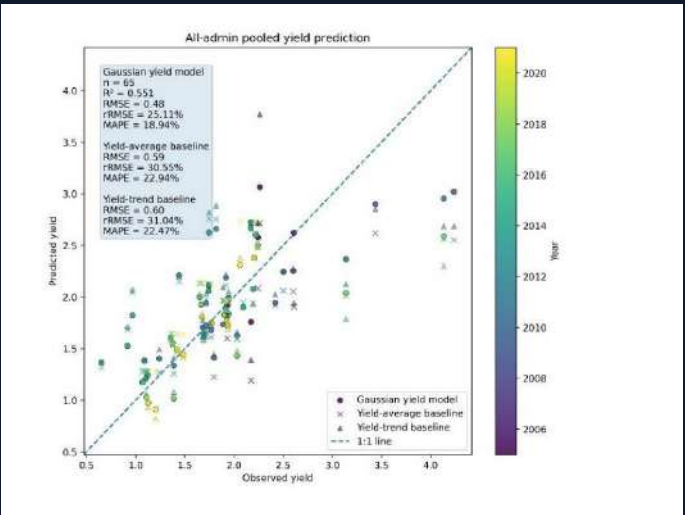
$r^2 = 0.94$ national production (10.5% error)

$r^2 = 0.91$ subnational yield (15.8% error)

ARYA validated against major wheat- and maize-exporting countries

Now applied to ESTELLA countries

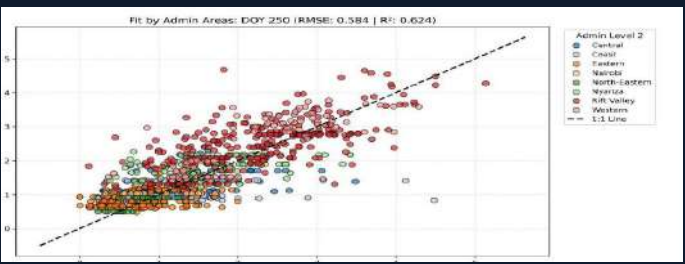
Togo — maize, admin-1 pooled



MAPE = 18.94%

Beats yield-average (22.94%) and yield-trend (22.47%) official statistics baselines by ~4 points.

Kenya — maize, admin-2 (county) level

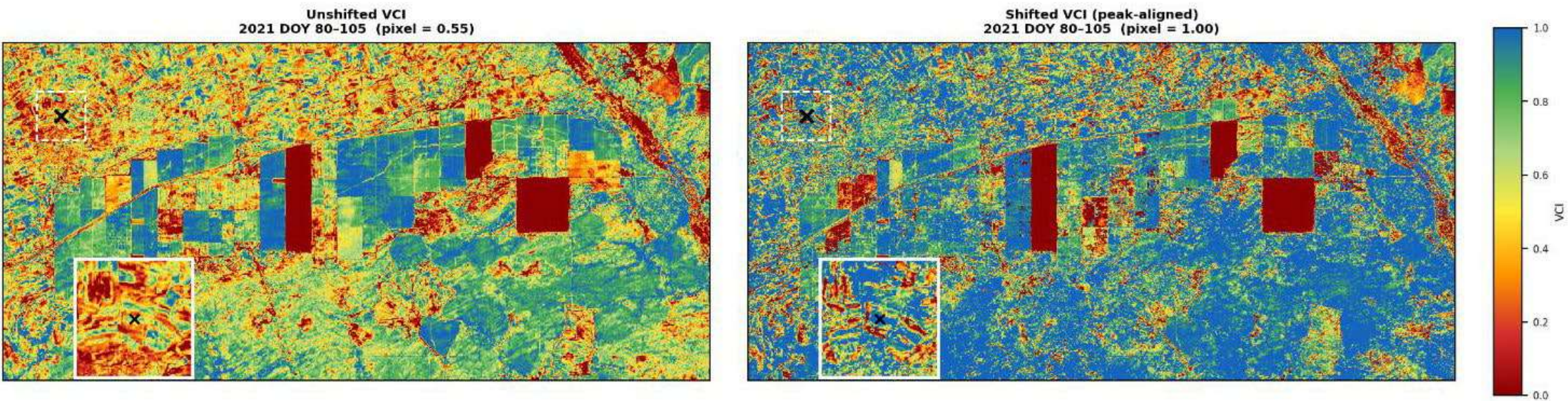
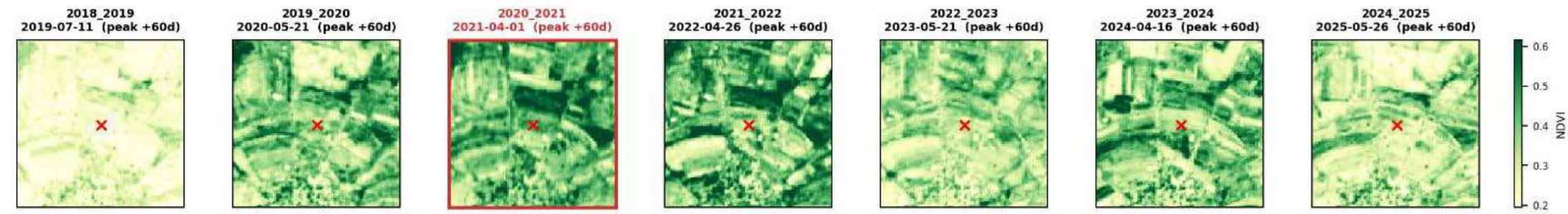


$R^2 = 0.624$

Tighter at the county level than Zimbabwe's early result ($R^2=0.33$) — a sign ARYA improves with denser registry data.

INNOVATION 3 — DROUGHT MONITORING & RISK PREPAREDNESS

FAO's phenological-shift method for Zimbabwe (ESTELLA) — directly feeding back into ARYA itself

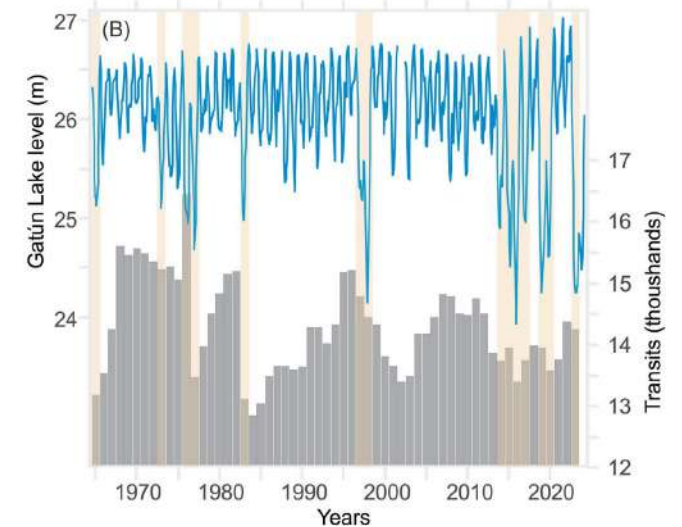
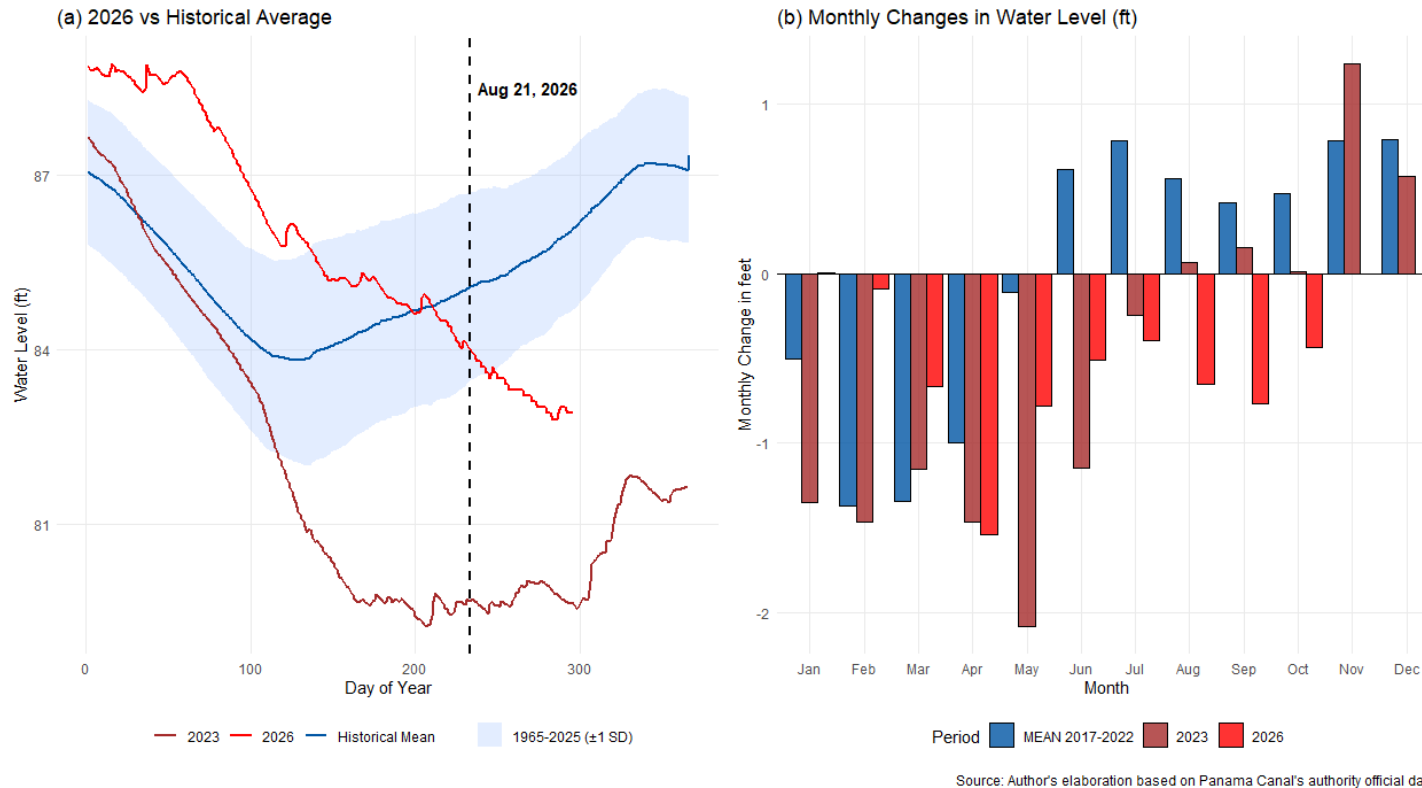


Honest trade-off

Season-by-season shifting is more computationally intensive than one global average — best for national/subnational use, not yet a global default. ARYA is now adopting this approach.

Engineering channel: falling water in Gatún Lake is already constraining Panama Canal trade – but this is one element

Supplying the Panama Canal: Gatun Water Level



Lake level and annual transits, 1965–2024; shaded = El Niño episodes

- 2026 began well above the historical range but fell below the mean in August.
- Draft limit cut five times in 2026, to 47.5 ft; carriers are adding surcharges.
- Past El Niño episodes coincide with lake drawdowns and fewer transits.

Sources: FAO elaboration on Panama Canal Authority data (left); historical series as in original deck, citation to be added (right); ACP Advisory A-25-2026.

Macroeconomic channel: El Niño creates winners and losers, and GDP effects build over a year

Table 3. The Effects of an El Niño Shock on Real GDP Growth (in percent)

Country	Impact	Cumulated Responses After			
		1 Quarter	2 Quarters	3 Quarters	4 Quarters
Argentina	-0.08	0.03	0.29*	0.64**	1.08**
Australia	-0.03	-0.18**	-0.30**	-0.37*	-0.41
Brazil	-0.06	0.04	0.20	0.42*	0.68*
Canada	0.00	0.13**	0.33*	0.58**	0.85**
China	-0.01	0.03	0.16*	0.36*	0.56*
Chile	-0.19*	-0.10	0.16*	0.42*	0.70*
Europe	0.02	0.09	0.27**	0.49**	0.69**
India	-0.03	-0.15*	-0.23	-0.25	-0.25
Indonesia	-0.35**	-0.61*	-0.91*	-1.02	-1.01
Japan	-0.10*	-0.12	0.01*	0.20*	0.37*

Losers

- Indonesia: -0.9 pp after 2 quarters
- Australia: -0.3 pp after 2 quarters
- India: -0.15 pp after 1 quarter

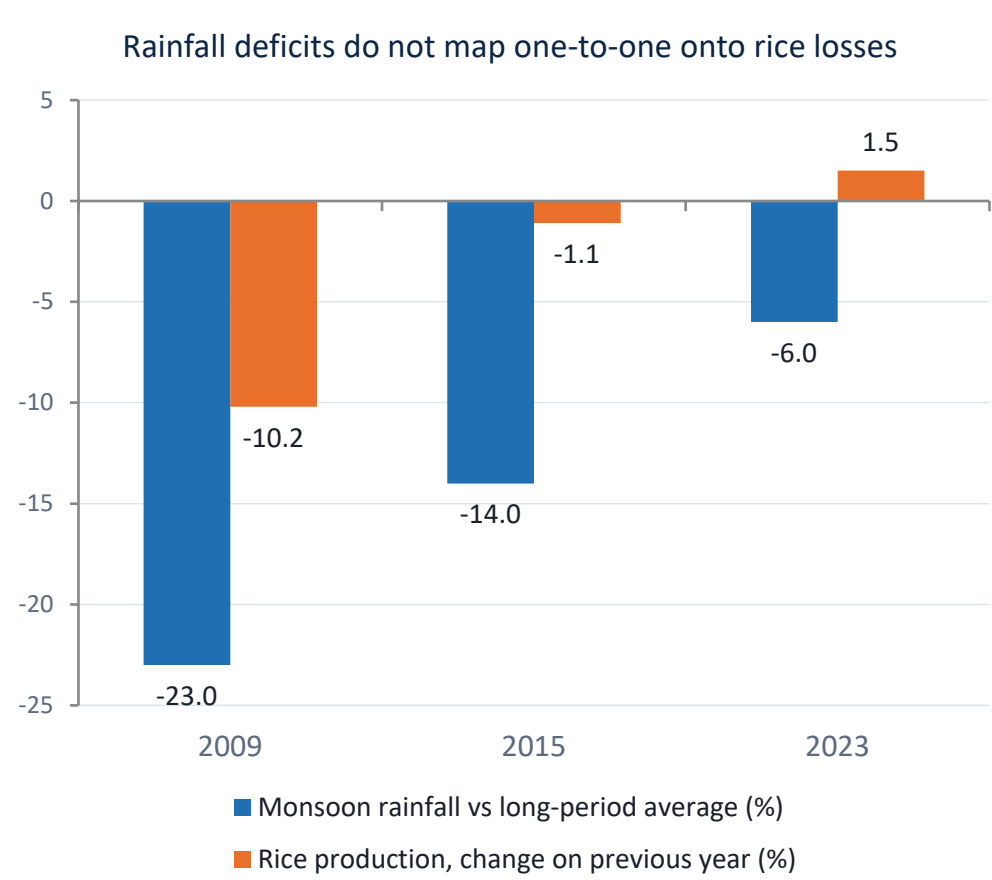
Winners

- Argentina: +1.1 pp after 4 quarters
- Canada: +0.85 pp after 4 quarters
- Chile, Europe: +0.7 pp after 4 quarters

Effects accumulate over three to four quarters: fiscal and balance-of-payments planning must look beyond the next harvest.

Source: Cashin, Mohaddes & Raissi (2017), 'Fair weather or foul? The macroeconomic effects of El Niño', Journal of International Economics 106: 37–54, Table 3. Cumulative response of real GDP growth, pp; only statistically significant values cited.

No two El Niño events are alike: India’s rice harvest in 2009, 2015 and 2023

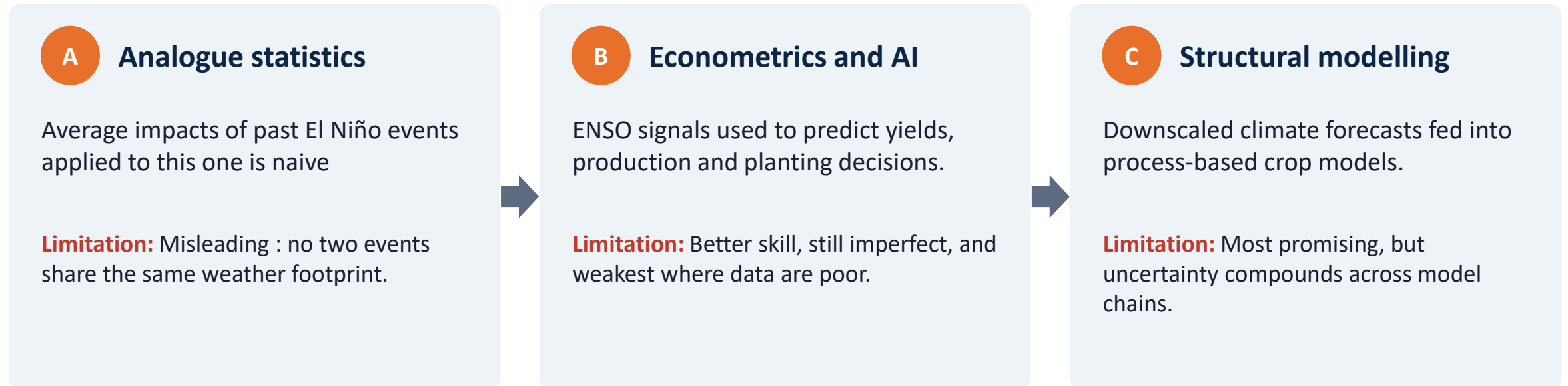


El Niño year	Monsoon (Jun–Sep)	Rice outcome	Economic and policy outcome
2009	77% of LPA; northwest India 64%	Kharif rice –11%; total –10%	High food inflation; income losses for rainfed farmers without irrigation
2015	86% of LPA; second drought year after 2014 (88%)	Total –1%; losses concentrated in rainfed districts	Rural distress; higher pumping costs and household debt
2023	94% of LPA; driest August since 1901	Record 137.8 Mt, supported by irrigated and rabi crops	Export ban on non-basmati white rice protected supply, capped farm prices and lifted world prices

Four takeaways: weather varies within countries; starting conditions matter; the next harvest matters too; policy responses change market outcomes and farmer welfare.

Sources: India Meteorological Department, end-of-season monsoon reports; Ministry of Agriculture & Farmers Welfare (DES), production estimates. Crop years 2009-10, 2015-16, 2023-24. LPA = long-period average.

Lesson 1 — Economic models need better agro-climatic projections, used probabilistically



1 LESSON 1 Each El Niño hits each location differently. Feed economic models with ensembles of agronomic projections and report outcomes as probabilities, not single numbers.

Increasing sophistication and skill from left to right; none yet removes the need for scenario ranges.

Lesson 2 — Starting conditions shape the damage: high input costs amplify weather risk

Farmers manage weather and economic risk jointly

- 1 What to plant?** Weather sensitivity and relative prices both matter
- 2 How much to apply?** Fertilizer, seed and labour are cut when cash is short
- 3 How long to wait?** Delaying planting buys information but shortens the season

Example: fertilizer costs and El Niño

- **Afghanistan:** El Niño usually brings a wetter winter, but the extra rain does not become higher yields if farmers cannot afford urea.
- **Brazil soybean:** costly phosphate means less applied at planting, weaker root development and lower drought tolerance.
- **2026 context:** FAO expects fertilizer prices to remain historically high through late 2026.

2 LESSON 2 This year combines high weather risk with high economic risk. That narrows farmers' options to limit losses now and can depress investment in the next planting cycle.

Source: FAO fertilizer market outlook, 2026. The more risky the economic environment, the larger the effective weather shock.

Lesson 3 — Markets rebalance El Niño shocks, so trade must be allowed to flow

22–24%

of global harvested area shows significant yield losses in El Niño years

30–36%

shows significant yield gains, so shocks partly offset globally

+2.9–3.5%

global soybean yield in El Niño years; maize, rice and wheat are mostly below normal

Wheat is the swing crop: the outcome depends on losses in Australia against gains in Argentina and Kazakhstan.

On wheat trade:

- Moderate versus strong El Niño does not have a fixed percentage effect on global wheat trade.
- Stronger events generally increase the magnitude of production and trade disruptions, but the net effect on world wheat trade depends critically on which exporting regions are affected and whether production losses are offset by gains elsewhere.

3

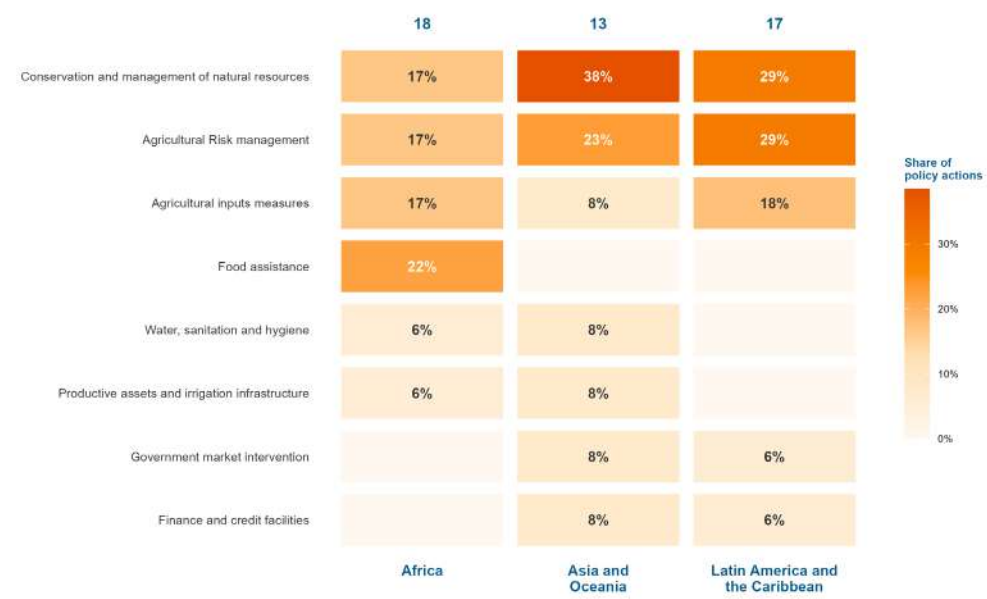
LESSON 3 Markets absorb El Niño shocks locally, regionally and globally by rebalancing across crops and regions. High energy and freight costs, conflict and export restrictions slow that adjustment or make it costlier.

Sources: Iizumi et al. (2014), Nature Communications 5: 3712 (yields, 1984–2004); wheat trade: FAO analysis (citation to be added).

Lesson 4 — Policy responses can mitigate or amplify the shock and must be modelled explicitly

30 countries have adopted measures in 2026 to prevent or respond to El Niño impacts on agrifood systems

- Since 2015, a shift from reactive crisis management to packages combining relief, preparedness, market stabilization and risk management.
- Africa leads on food assistance (22% of actions); Asia and Latin America focus on natural-resource and risk management.



Share of 2026 El Niño policy actions by region; column totals = number of actions

4

LESSON 4 Policies shape farmer and trader incentives before the shock and change again in response to it. Economic models can represent these instruments explicitly, endogenize them and show the trade-offs.

Source: FAO Food and Agriculture Policy Decision Analysis (FAPDA), 2026.

This El Niño is not over, and it will not be the last: we need better systems

Remaining gaps

- 1** We know less than we think we know about local impacts.
- 2** Climate, agricultural and socio-economic information systems remain fragmented.
- 3** Decisions are rarely tied to triggers, so action comes after the losses.

FAO's response



Monitor integrated climate, agriculture, water, market and vulnerability intelligence



Forecast impacts on production, prices, livelihoods and food security with scenarios and models



Act early translate risk signals into triggers, contingency plans and decision-support tools



Inform governments with evidence on effective El Niño responses and resilience strategies

Sources

- Cashin, P., Mohaddes, K. & Raissi, M. (2017). Fair weather or foul? The macroeconomic effects of El Niño. *Journal of International Economics*, 106, 37–54.
- FAO Food and Agriculture Policy Decision Analysis (FAPDA) (2026). El Niño policy responses database.
- Iizumi, T. et al. (2014). Impacts of El Niño Southern Oscillation on the global yields of major crops. *Nature Communications*, 5, 3712.
- India Meteorological Department. Southwest monsoon end-of-season reports, 2009, 2014, 2015, 2023.
- Ministry of Agriculture & Farmers Welfare, Directorate of Economics & Statistics. Estimates of production of foodgrains, 2009-10, 2015-16, 2023-24.
- NOAA Climate Prediction Center (2026). ENSO Diagnostic Discussion, 10 September 2026.
- Panama Canal Authority (2026). Advisory to Shipping No. A-25-2026; Gatún Lake level data.