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Global Food Systems and Agricultural Input Risks

Energy and Fertilizer Markets, Country Evidence, and Conditional Economic and Strategic Scenarios for 2027-28

Research coverage: commodity prices / three country case studies / global grain balances / economic and strategic scenarios

Information cut-off: 19 October 2026

Executive Summary

Energy and fertilizer prices diverged sharply in 2026. In September, the European natural-gas benchmark rose 128.6% year on year, while urea fell 11.6% and diammonium phosphate (DAP) increased 2.6%. The rise in energy prices was not mirrored across fertilizer products. Assessing agricultural-input risks therefore requires separate attention to international input costs, prices actually paid by farmers, and physical availability, rather than treating any single energy benchmark as a proxy for production costs.

Country evidence points to distinct transmission channels. In Kenya, public records document fertilizer delivery delays that overlapped with planting schedules. In India, administered urea prices, subsidies for phosphatic and potassic fertilizers, and public stocks influence who bears input costs. In Brazil's 2025/26 second maize crop, yields declined 2.66% while planted area expanded 2.28%, leaving second-crop output down only 0.44%; total maize production across all seasons rose 2.37%. Crop calendars, cost structures and institutional buffers mediate the link between international shocks and agricultural outcomes.

At the aggregate level, the USDA's October 2026 projection placed the world grain stocks-to-use ratio for 2026/27 at 26.43%, down from an estimated 27.74% the previous year, but still indicating some global supply buffer. Local risks could be more severe than aggregate measures suggest where fertilizer shortages, missed planting or application windows, adverse weather and diminished import capacity coincide. The 2027-28 scenarios in this report examine the consequences of these interacting conditions.

Beyond economic shocks, the research examines how governments, export regulators and suppliers adjust their decisions over time. India's 2022 wheat export restrictions illustrate what happened to contracts, shipments and government-to-government coordination after a sudden policy change. Conditional scenarios for 2027-28 compare how differences in policy priorities and supplier acceptance affect outcomes in Kenya, India and Brazil. This extension links supplier decisions and policy implementation delays with the existing crop-calendar and market framework.

Policy analysis covers four distinct channels: targeted input subsidies, public-stock releases, diversification of fertilizer procurement, and food assistance to households. Their effects and implementation times differ. A useful policy choice starts by locating the binding constraint: agricultural inputs, market supply or household purchasing power.

128.6%	26.43%	3
European gas, Sep. 2026 YoY	USDA world grains stocks/use, 2026/27	Country case studies

> How to read this study. The report separates recorded market and policy events, forecasts issued by external institutions, and modeled economic or strategic scenarios under specified assumptions. The latter compare mechanisms and choices rather than offer calibrated event probabilities.

Principal sources: World Bank Pink Sheet; USDA WASDE (October 2026); Conab (October 2026); national and international public releases.

Contents

Chapter One	International Energy and Fertilizer Prices	03
Chapter Two	Country-Level Agricultural Risks	06
Chapter Three	Global Grain Balances and Trade Exposure	11
Chapter Four	Transmission Mechanisms and Conditional Scenarios	13
Chapter Five	Strategic Behavior and Economic Feedback	18
Chapter Six	Policy Tools, Execution and Risk Monitoring	24
Appendix	Data Sources and Research Methods	29

Chapter One

International Energy and Fertilizer Prices

1.1 International Energy and Fertilizer Prices

International commodity markets moved in different directions in September 2026. The European natural-gas benchmark averaged 128.6% above its level a year earlier, while US natural gas was broadly unchanged. Over the same period, urea fell 11.6%, DAP rose 2.6%, and muriate of potash (MOP) gained 4.3%. The divergence reflects different supply-and-demand conditions across energy markets and fertilizer products.

Natural gas is a major input into ammonia and some nitrogen fertilizer production, but gas contracts, coal-based ammonia capacity, regional energy costs and plant utilization differ. Phosphate fertilizer costs also reflect phosphate rock, sulfuric acid and trading arrangements; potash is more strongly shaped by mining capacity and transport networks. Even a sharp movement in energy costs need not produce a uniform adjustment in internationally quoted fertilizer prices.

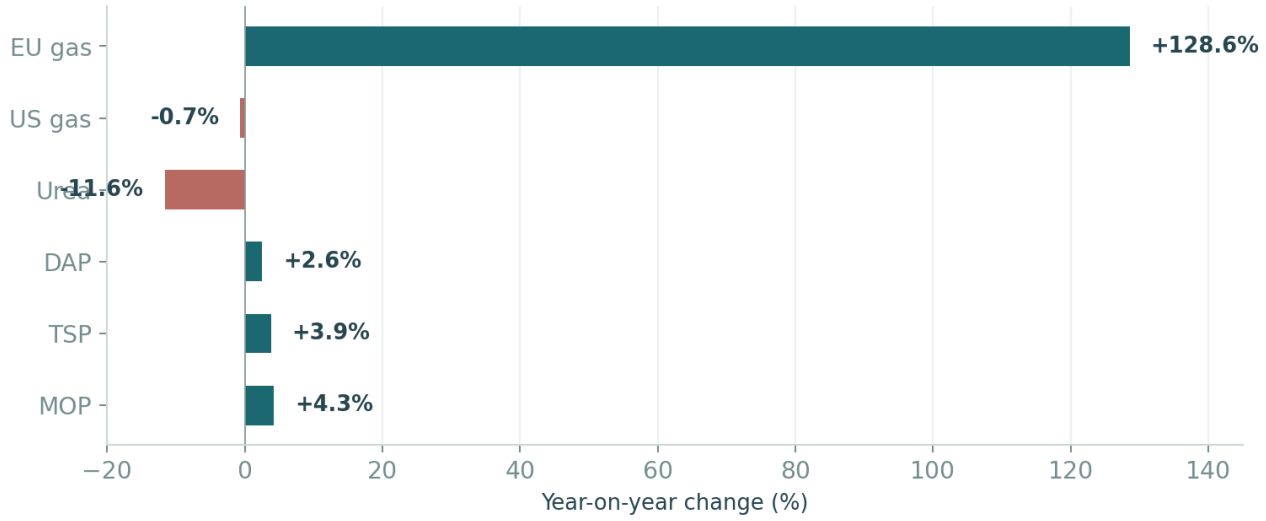


Figure 1-1. Year-on-year changes in international commodity benchmarks, September 2026 (%). Each series reflects its own nominal US-dollar quotation.

Urea had also fallen about 52.4% from its April 2026 peak. Comparing September year-on-year prices and measuring the decline from the year's high can therefore tell different stories. Agricultural-risk monitoring should consider costs, available quantities and purchase timing together, with local prices assessed separately from international benchmarks.

Source: World Bank Pink Sheet, October 2026 commodity release; calculations from the published monthly series.

1.2 Historical Price Cycles and Benchmark Definitions

Viewed against monthly data since 2008, energy and fertilizer prices exhibit several periods of common movement, though not always at the same magnitude. The global commodity cycle in 2008 and the energy and trade disruptions of 2021-22 affected a broad range of products. In the subsequent adjustments, however, fertilizer prices moved and receded at different speeds.

Short-run co-movement does not establish a fixed long-run pass-through rate. Urea production has a relatively direct connection to natural-gas costs, while DAP and MOP prices depend on different inputs and regional market conditions. Index charts express each series relative to its own base period; their levels should not be treated as directly comparable unit costs.

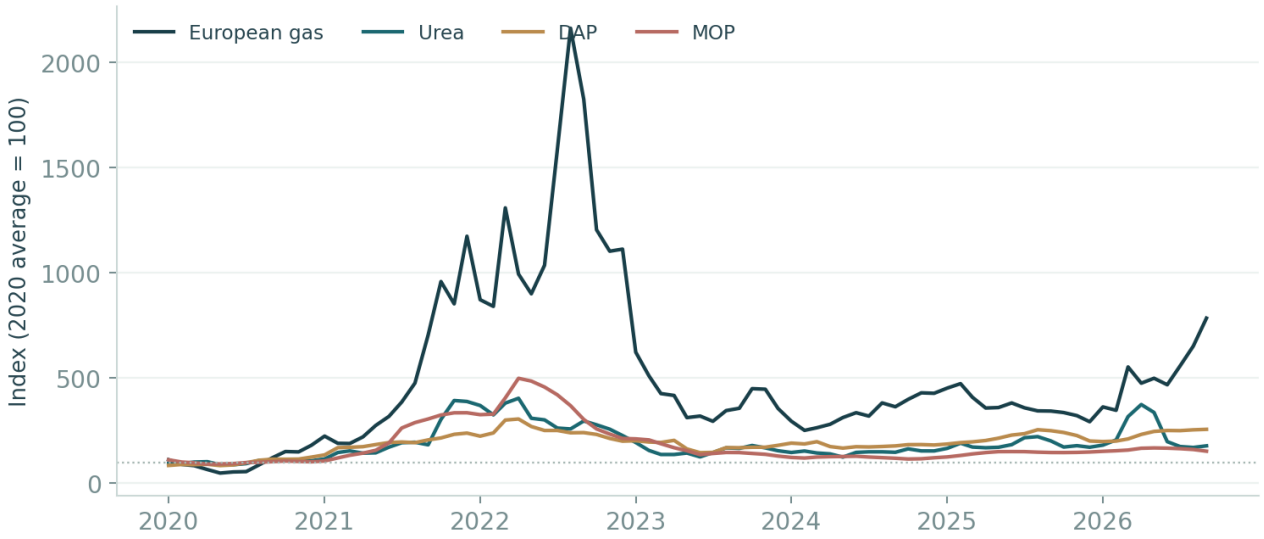


Figure 1-2. International natural-gas and fertilizer price indices (2020 average = 100), 2020-26.

The principal statistical estimation window covers 216 months from 2008 to 2025. January-September 2026 is used for the current market assessment. Several commodity benchmarks changed definition over time, including the urea export-price basis in March 2022. The historical analysis therefore includes checks for sensitivity to changes in underlying quotation series.

Source: World Bank historical monthly commodity prices. Some fertilizer benchmark definitions change within the sample.

1.3 Statistical Estimates of Price Transmission

To examine delayed relationships between energy and fertilizer prices, the study estimates monthly distributed-lag regressions. Changes in fertilizer prices are related to contemporaneous and lagged movements in European gas prices, alongside controls for US gas, crude oil, a copper-price proxy and seasonal effects. The estimation uses 216 monthly observations over 2008-25 and adjusts inference for serial correlation.

Within this specification, a hypothetical permanent 10% increase in European gas prices is associated with an estimated cumulative fertilizer-price response over the following six months of approximately 4.28% for urea, 2.60% for DAP, 2.97% for triple superphosphate (TSP) and 3.47% for MOP. These are conditional statistical responses with other included variables held constant; the chart's ranges reflect uncertainty in estimated coefficients.

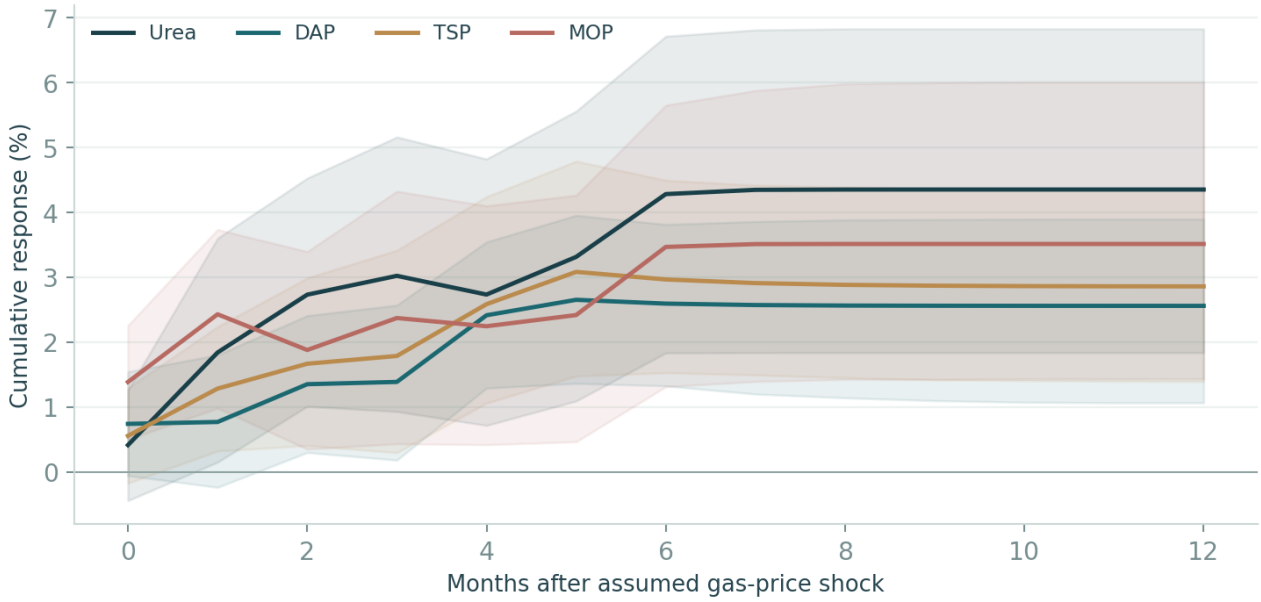


Figure 1-3. Estimated cumulative six-month fertilizer-price responses to a hypothetical 10% increase in European gas prices, with 95% estimation intervals.

Table 1-1. Summary of estimated price responses

Product	Six-month cumulative response	Robustness note
Urea	+4.28%	Remains positive excluding 2021-22
DAP	+2.60%	Interval approaches zero excluding crisis months
TSP	+2.97%	Positive in principal alternative specifications
MOP	+3.47%	Sensitive to replacing European with US gas

Gas and fertilizer prices may both respond to trade policy, aggregate demand and production interruptions. The regressions do not isolate a purely causal natural-gas supply shock. Their purpose is to assess the direction and possible timing of historical price relationships, not to calculate crop-production losses.

Source: Study estimates and sensitivity checks. The 95% ranges refer to regression estimation uncertainty, not forecast bands.

1.4 Domestic Grain Prices and Downstream Transmission

Between an international fertilizer quotation and the food price paid by a household lie domestic procurement, cultivation, harvest, trade, transport and retail distribution. Observations from August-September 2026 show no common direction of change in local grain prices following the sharp increase in European gas prices.

In Kenya, the national retail price of maize grain rose 1.83% year on year in August. White maize increased 8.16% in Garissa but fell 1.79% in Makueni, while maize flour in Nairobi increased 10.20%. Over the relevant September observations, India's nationwide retail wheat price rose 1.35%, and wholesale yellow maize in São Paulo, Brazil, rose 16.63%. Each percentage measures a change within its own market and product series, not a cross-country comparison of price levels.

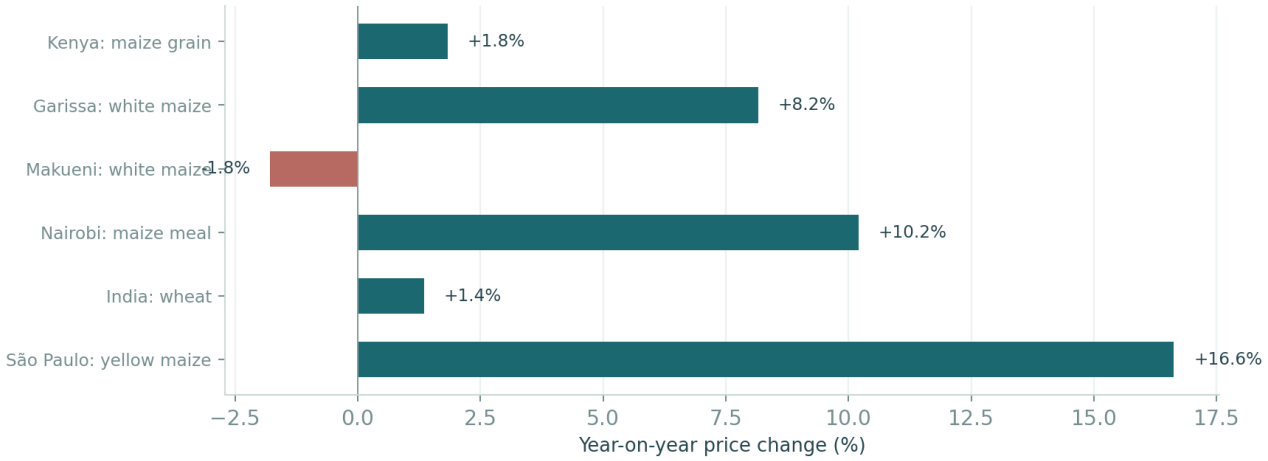


Figure 1-4. Year-on-year changes in selected FAO FPMA market quotations (%). Products, countries and transaction stages differ.

The differences across regions and processing stages underline the importance of local price formation. Garissa and Makueni are both retail white-maize markets, yet they differ markedly in level and annual direction. Food availability and household affordability should therefore be examined by location, product and market stage; a national mean is not necessarily the price any particular household pays.

Sources: FAO FPMA / FEWS NET and official national market observations; latest data from August-September 2026.

Chapter Two

Country-Level Agricultural Risks

2.1 Kenya: Fertilizer Logistics and Input Timing

Kenya illustrates a risk that cannot be captured by price data alone: whether fertilizer reaches the point of use when farmers need it. On 31 March 2026, an official report described several-week delays associated with transport diversions. Authorities began dispatching around two million bags of subsidized fertilizer from Mombasa for nationwide distribution, while planting was already under way in some areas.

FAO reporting in early May continued to identify delayed fertilizer imports. On 24 August, the government announced a reduction in the subsidized fertilizer price from KES 2,500 to KES 2,000 per 50-kg bag. Port dispatch, regional transport, distribution through county depots, farmers' purchases and actual application are distinct stages; announcing a lower price or sending a shipment does not make them simultaneous.

31 Mar 2026	Authorities acknowledged transport delays and began dispatching approximately two million bags of subsidized fertilizer.
4 May 2026	FAO continued to report delayed imports and risks around seasonal input timing.
24 Aug 2026	Government announced a lower subsidized fertilizer price; implementation may vary by locality.

Delivery Timing and the Growing Season

Agricultural inputs are time-sensitive. Delayed basal or top-dressing fertilizer may reduce the quantity applied or shift its timing. The effect depends on crop variety, soil nutrients, rainfall and whether later applications remain effective. Market availability and timely arrival should be monitored separately: the first describes supply, while the second determines whether the input can still influence that season's harvest.

Available evidence establishes a reason to monitor logistical mismatches. Quantifying any reduction in fertilizer application or net output requires county-level delivery records and farm-level input observations.

Sources: Kenya News Agency, 31 March and 24 August 2026; FAO GIEWS Kenya, 4 May 2026.

2.2 Kenya: Regional Grain Prices and Crop Calendars

Retail white-maize prices vary considerably across Kenyan markets. In August 2026, the price in Garissa reached KES 106 per kilogram, up 8.16% year on year; in Makueni it was KES 55 per kilogram, down 1.79%. Prices for the same product at the same trading stage were almost twice as high in one market as in the other. Household food purchasing conditions cannot be adequately represented by a single national indicator.

Agricultural calendars also differ within Kenya. Main long-rains planting in western and Rift Valley regions is concentrated around March-April, while southeastern and coastal areas also have short-rains cropping patterns. Relating a March transport delay directly to the country's entire annual harvest would overlook regional differences in input and harvest timing.

106	55	9.95 pp
Garissa white maize / KES per kg	Makueni white maize / KES per kg	Difference in YoY rates

Table 2-1. Indicative maize crop windows in Kenya

Region / season	Planting and key input window	Typical harvest
Western and Rift Valley main season	March-April	October-November
Southeastern and coastal long rains	Around March-May	Around July-August
Southeastern and coastal short rains	Around October-December	January-March, following year

Monitoring the effects of 2026 transport disruptions requires delivery dates matched to crop growth stages. The declaration that fertilizer has been dispatched is not itself evidence that it reached farmers in time. Local supply sources, interregional transport costs and household incomes are also needed to explain why food spending differs across markets.

Sources: FAO FPMA / FEWS NET, USDA GAIN Kenya (March 2026), and FAO crop-calendar information.

2.3 India: Administered Prices, Subsidies and Stocks

India's fertilizer market is characterized by administered prices and substantial fiscal support. Government information lists a maximum retail price of INR 242 per 45-kg bag of urea, excluding specified taxes, while phosphatic and potassic fertilizers receive nutrient-based subsidies. Higher import costs therefore need not translate into an equivalent increase in farmers' purchase prices; they can instead change public subsidy outlays and procurement requirements.

In April 2026, the government announced an estimated INR 41,533.81 crore subsidy requirement for phosphatic and potassic fertilizers during Kharif 2026, around 11.6% more than in the comparable season a year earlier. The figure describes a fiscal buffer for that crop season; it should not be presented as the direct cost of the 2027 Rabi wheat crop.

Table 2-2. Fertilizer pricing and inventory indicators in India

Item	Public record	Interpretation
Urea administered retail price	INR 242 / 45 kg	Regulated farm-gate price
Phosphatic and potassic fertilizer subsidy	INR 41,533.81 crore	Kharif season, April-September 2026
National urea inventory	53.08 LMT	Recorded 23 March 2026
National DAP inventory	21.80 LMT	Recorded 23 March 2026

Administered prices shift part of international cost fluctuations toward public finances or the supply system. They can ease farmers' immediate cash burden, but do less to overcome localized shortages, transport bottlenecks or delivery arriving after the relevant application period. National stocks constitute a potential buffer whose practical effect depends on distribution by region and season.

Comparing input risks in India and Kenya therefore calls for more than asking which country faces the higher international fertilizer bill. Delivery conditions, fiscal absorption and the price ultimately borne by the farmer are all material.

Sources: Government of India PIB (March 2026) and release of 8 April 2026. One crore = 10 million rupees; one LMT = 100,000 tonnes.

2.4 India: The Rabi Wheat Production Cycle

India's 2026/27 Rabi wheat crop is principally sown in October-November 2026 and harvested in March-April 2027. Fertilizer and irrigation requirements differ between sowing, tillering, stem elongation and grain filling. The impact of delivery or water constraints depends on when they occur. The relevant prospective harvest is spring 2027, not the crop already harvested in spring 2026.

Three checkpoints are useful for assessing the 2027 crop: availability of DAP, urea and finance ahead of autumn sowing; water, fertilizer and energy supplies during winter tillering and top dressing; and heat exposure and irrigation during spring grain filling. Stable local delivery, subsidy support and irrigation may cushion international price shocks. Conversely, local input shortages coinciding with heat stress would put greater pressure on yields.

Oct-Nov 2026	Sowing and basal fertilization; monitor local DAP/urea, planted area and farmers' ability to pay.
Dec 2026-Feb 2027	Winter growth and top dressing; track irrigation, electricity and actual input application.
Mar-Apr 2027	Grain filling and harvest; evaluate yield against heat, irrigation and observed output.

Interpreting Fertilizer Sales and Weather Indicators

Table 2-3. Selected fertilizer and weather indicators

Observation	Reported value	Analytical use
Urea sales, March 2026	196.42 LMT	Fertilizer distribution across crops nationwide
DAP sales, March 2026	52.74 LMT	Fertilizer distribution across crops nationwide
2026 monsoon rainfall	87% of long-period average	National context, not wheat-region irrigation

The available observations describe parts of the fertilizer distribution system and the national climate background. Assessing the 2027 wheat harvest requires allocation of all-crop fertilizer sales to regions, crops and application windows, and matching weather data to the wheat growth cycle.

Sources: India PIB (March and July 2026); India Meteorological Department; USDA GAIN India (April 2026).

2.5 Brazil: Composition of the Second Maize Harvest

Brazil's 2025/26 second maize crop had already been harvested. In its October 2026 survey, Conab estimated that planted area expanded 2.28% year on year while yield fell 2.66%, leaving production down only 0.44%. The opposing movements in area and yield made output more stable than the yield measure alone would suggest.

Production reflects both harvested area and output per unit of land. Looking only at yield can overstate the decline in aggregate output; looking only at total production can conceal a deterioration in productivity. Decomposing both components helps identify how far acreage growth offset yield pressure.

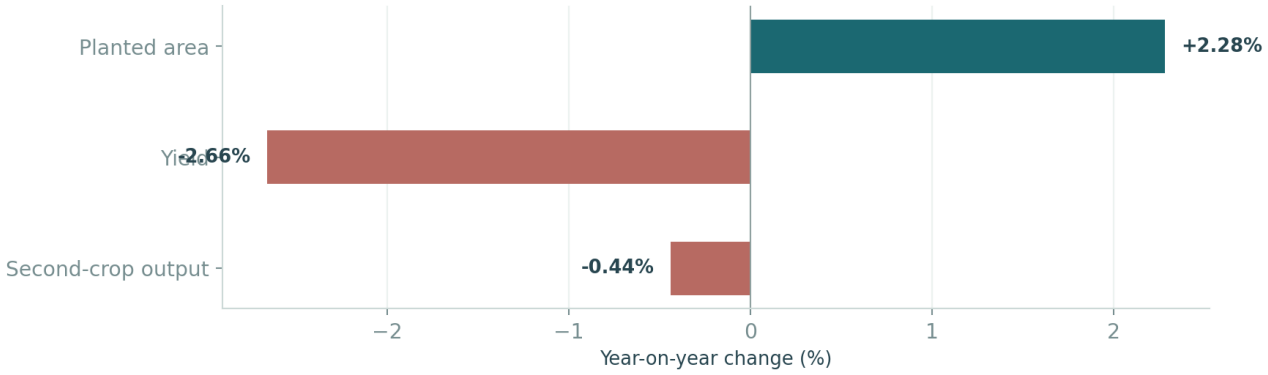


Figure 2-1. Brazil 2025/26 second maize crop: year-on-year changes in planted area, yield and output. Source: Conab, October 2026.

Table 2-4. Second maize crop production and acreage

Indicator	2024/25	2025/26	Change
Planted area (million ha)	17.43	17.82	+2.28%
Second-crop output (million tonnes)	113.27	112.77	-0.44%
Second-crop yield	Base = 100	Approx. 97.34	-2.66%

Weather, planting dates, soil conditions and input costs can all affect yields. This accounting of an observed harvest provides a reference point for later risk scenarios, but attributing each contribution requires more detailed regional production records.

Source: Conab survey published 15 October 2026.

2.6 Brazil: The Next Crop Cycle and National Balances

Brazil's second maize crop is usually planted after the soybean harvest, creating a strong dependence on the preceding crop's calendar. A delayed soybean harvest compresses the maize planting window and can shift key growth stages into less favorable temperature and rainfall conditions. Fertilizer procurement and planting risk therefore involve more than a single market price.

Conab estimates that total maize production across all three Brazilian cropping seasons rose 2.37% in 2025/26 even as second-crop output edged lower. Because all three crops contribute to national supply, analysis of export availability and domestic feed and ethanol demand should not be based on the second crop alone.

Soybean harvest Jan-Mar → Second-crop maize planting window → Critical weather Apr-May → Maize harvest Jun-Sep

Table 2-5. Brazil: national maize supply and use

All maize (million tonnes)	2024/25	2025/26	2026/27 outlook
Production	141.16	144.50	148.02
Domestic use	91.08	98.30	104.81
Exports	41.63	43.92	46.02
Ending stocks	12.06	16.04	14.93

Conab's 2026/27 projections envisage growth in both production and domestic use, accompanied by lower ending stocks than in 2025/26. Realized outcomes will depend on the soybean harvest, the subsequent maize planting window, weather and input deliveries. For international trade, Brazil's exportable surplus matters more than a single month's fertilizer quotation.

Source: Conab October 2026 harvest and national supply-use tables; 2026/27 values are agency projections.

2.7 Comparing Country-Level Risk Structures

The comparison of Kenya, India and Brazil reveals three distinct transmission structures. Kenya draws attention to physical delivery and input timing; India shows how administered prices, subsidies and stocks redistribute cost exposure; and Brazil illustrates the calendar constraints of sequential cropping and the offsetting movements of area and yield.

All three countries can be affected by shifts in international energy, fertilizer and logistics markets, but the variables determining their exposure differ. Applying a common crop-output elasticity to the same international price increase would ignore agricultural institutions and potentially misdirect intervention resources.

Table 2-6. Comparing country-level transmission channels

Dimension	Kenya: maize	India: Rabi wheat	Brazil: second maize crop
Main transmission channel	Port - county depot - farm use	Subsidies - local availability - irrigation	Soybean harvest - maize planting - weather
Principal buffers	Subsidy and supplementary imports	Administered prices, stocks, irrigation	Acreage adjustment and trade channels
Key monitoring	Deliveries, distribution and actual application	Local prices paid, top dressing, spring heat	Planting delay, yield, exportable surplus
Policy emphasis	Timely distribution and vulnerable households	Local supply and cost sharing	Alternative sourcing and planting windows

Economic Implications of Country Comparisons

Input subsidies, public grain stocks and diversified international sourcing address different problems: affordability, immediate availability and medium-term supply resilience. Policy design should begin by establishing whether the binding constraint is the ability to pay, the physical quantity available or the timing of production. Later policy scenarios examine these distinctions within a common analytical framework.

The three countries are contrasting case studies, not a representative sample of all food systems. Their value lies in identifying distinct policy margins, not ranking countries by the magnitude of a single international price movement.

Sources: National case evidence, including Kenya News Agency, FAO, India PIB, Conab and USDA GAIN.

Chapter Three

Global Grain Balances and Trade Exposure

3.1 Global Grain Stocks and Supply-Demand Balances

Global grain balances provide an important backdrop to local risk analysis. The USDA's October 2026 outlook placed the world grain ending-stocks-to-use ratio for 2026/27 at 26.43%, down from an estimated 27.74% in 2025/26. The stock buffer has narrowed, although the aggregate balance remains different from periods of exceptional tightness.

Stock positions also differ across crops. For 2026/27, the projected global stocks-to-use ratio is 21.24% for maize and 33.34% for wheat. A single grains aggregate can obscure important differences in inventories, trade exposure and end uses.

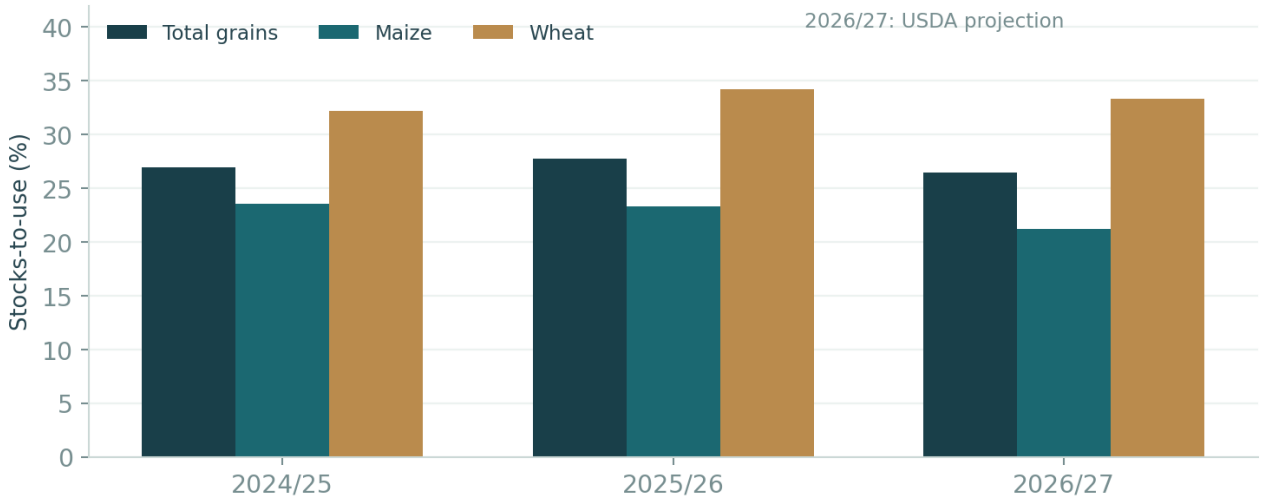


Figure 3-1. USDA world stocks-to-use ratios for grains, maize and wheat, 2024/25-2026/27 (%); 2026/27 is a projection.

Stocks-to-use compares inventory carried forward with the scale of consumption; it indicates relative buffers but does not directly measure hunger or the probability of shortages in any particular locality. FAO-AMIS presents a comparatively stable view of maize inventories over the same period, reflecting differences in statistical vintages and estimation methods. Market monitoring should keep each source's estimates together rather than splice isolated figures from different agencies.

Sources: USDA WASDE, 9 October 2026; FAO-AMIS Market Monitor No. 142, October 2026.

3.2 Trade Exposure and National Buffers

Even where global inventories are sizable, grain is not evenly distributed across countries and regions. Importers need foreign exchange, funding, procurement channels and port capacity; exporters face domestic demand, reserve and policy constraints. Global stocks can ease aggregate scarcity without guaranteeing that every importing country can obtain grain at the same price or at the same time.

Kenya, India and Brazil illustrate three different dimensions: import reliance, domestic inventory buffers and influence on export supply. In USDA's 2026/27 data, maize imports equal 43.9% of Kenya's utilization; India's wheat stocks-to-use ratio is around 26.48%, while imports represent just 0.09% of use; and Brazil accounts for approximately 20.41% of world maize exports. These figures have different denominators and should be interpreted as distinct measures rather than ranked together.

Table 3-1. Trade exposure and national inventory buffers

Market	Key 2026/27 indicator	What it measures
Kenya / maize	Imports / utilization: 43.9%	Exposure to foreign supply and logistics
India / wheat	Stocks / use: 26.48%	Domestic inventory buffer
India / wheat	Imports / utilization: 0.09%	Limited import dependence
Brazil / maize	Share of world exports: 20.41%	Influence on international export supply

Supply Security and Purchasing Power

Physical availability and purchasing power are separate constraints. Grain reaching a port but remaining unaffordable to households is not the same problem as grain failing to reach the port at all. During trade stress, exchange rates and freight costs affect procurement prices; domestic distribution and food assistance further determine what families can obtain.

Effective monitoring should bring together global inventory balances, exportable surpluses, import delivery and household affordability. Combining them into one opaque composite score would conceal the mechanisms policy needs to address.

Source: USDA PSD, October 2026. Import, stock and export shares are measured against different denominators.

Chapter Four

Transmission Mechanisms and Conditional Scenarios

4.1 Transmission Mechanisms in the Food System

The link between agricultural inputs and food security runs through more than prices. Fertilizer availability, farmers' input choices, cropped area and yield, weather and irrigation, harvested inventories, trade, and households' nominal purchasing capacity all play roles. The framework uses crop-specific planting and harvest windows and monthly state updates to connect input decisions with subsequent output and food use.

Higher prices can reduce quantities farmers can afford, but a physical supply cap may bind first: lowering the price will not produce more fertilizer if none is available. Weather shocks can directly affect yields while also changing the marginal benefit of inputs. Public-stock releases may improve near-term market availability; cash transfers can support household purchases. Neither directly increases the current harvest.



Three Basic Constraints

Table 4-1. Constraints and potential policy levers

Constraint	What is observed	Potential response
Input affordability	Actual fertilizer cost and financing	Subsidies, procurement, credit
Physical input availability	Fertilizer volumes and deliveries	Alternative imports, ports, distribution
Production calendar	Planting, fertilization and weather windows	Timing, irrigation, supplementary application

The framework is designed to compare system responses under different conditions. Inventory and policy accounts can be checked for consistency, while some cross-country agronomic responses and opening monthly stocks necessarily rely on assumptions where evidence is limited. It is therefore most useful for examining conditional mechanisms and policy choices rather than as a fully externally validated forecasting model for national harvests.

Source: Study framework using crop calendars, inventory balances, input responses and policy channels.

These channels also underpin the strategic-behavior analysis that follows. Prices, stocks and planting calendars shape government and business decisions, while those decisions in turn change the conditions faced in the next period. Chapter Five distinguishes policy announcements, supplier responses and dates when measures actually take effect, allowing the importance of sequencing to be assessed.

4.2 Scenario Design for 2027-28

Five scenarios are examined across three countries, each with five policy conditions, for a total of 75 country-scenario-policy combinations. The exercise compares annual crop outcomes for 2027 and 2028. Its purpose is to examine how risk factors compound, not to assign real-world probabilities to particular scenarios.

The initial comparison holds policy options fixed to distinguish changes in prices, weather and physical supplies. The subsequent strategic exercise retains the same external shocks but allows selected policies to respond to previous-period prices, inventories and available supply. These exercises address different questions and should not be conflated.

The normalization case assumes relatively moderate input-price adjustment; the input-cost shock raises fertilizer prices while restricting physical supply. The seasonal-compounding case adds adverse weather and planting conditions. The supply-recovery case allows more effective sourcing and import capacity. Finally, the compound-stress case combines still higher fertilizer prices, tighter supplies, weaker import capacity, adverse weather and fiscal constraints.

Table 4-2. Scenario assumptions

Scenario	Fertilizer supply and prices	Weather and trade assumptions
Normalization	Early-2027 urea = 1.10x Sep. 2026 price	Neutral weather; import capacity 1.00x
Input-cost shock	Urea 1.65x; mild physical constraint	Neutral weather; import capacity 0.90x
Seasonal compounding	Higher inputs and production constraints	Kenya / India / Brazil weather: -12% / -8% / -10%
Supply recovery	Urea 1.05x; alternative supply improves	Neutral weather; import capacity 1.10x
Compound stress	Urea 2.10x; stronger supply/fiscal pressures	Weather: -18% / -12% / -15%; imports 0.65x

Fertilizer price multipliers are anchored to September 2026 in the model, which also distinguishes DAP, MOP, planting delays and country-specific application windows. The compound-stress case is a deliberately severe combination: without simultaneous deterioration in weather, trade access and subsidy systems, its modeled losses should not be read across to actual production.

Outcome Measures and Baselines

Crop-output indices are measured against a static model reference set to 100; a negative number denotes a deviation from that reference state. The reference is not a forecast of actual 2027 production. Even a slightly negative result in the normalization case does not imply an expected national harvest decline. The following section reports the annual comparisons.

Source: Study scenario assumptions and annual outcomes. “No additional policy” retains existing policy arrangements.

4.3 Scenario Comparisons of Crop Output

The simulations suggest that fertilizer prices and moderate quantity restrictions alone produce relatively limited deviations in crop output. Losses become substantially larger when poor weather, unfavorable planting conditions and reduced import capacity are combined. The differences between the seasonal-compounding and compound-stress cases reflect the joint effect of constraints within the specified model.

Under compound stress with no additional policy intervention, modeled output in 2027 deviates from the static reference by -26.07% for Kenyan maize, -15.90% for Indian wheat and -24.27% for Brazil's second maize crop. These figures measure modeled stress responses across crop calendars; they are not forecasts of year-on-year changes in national grain production.

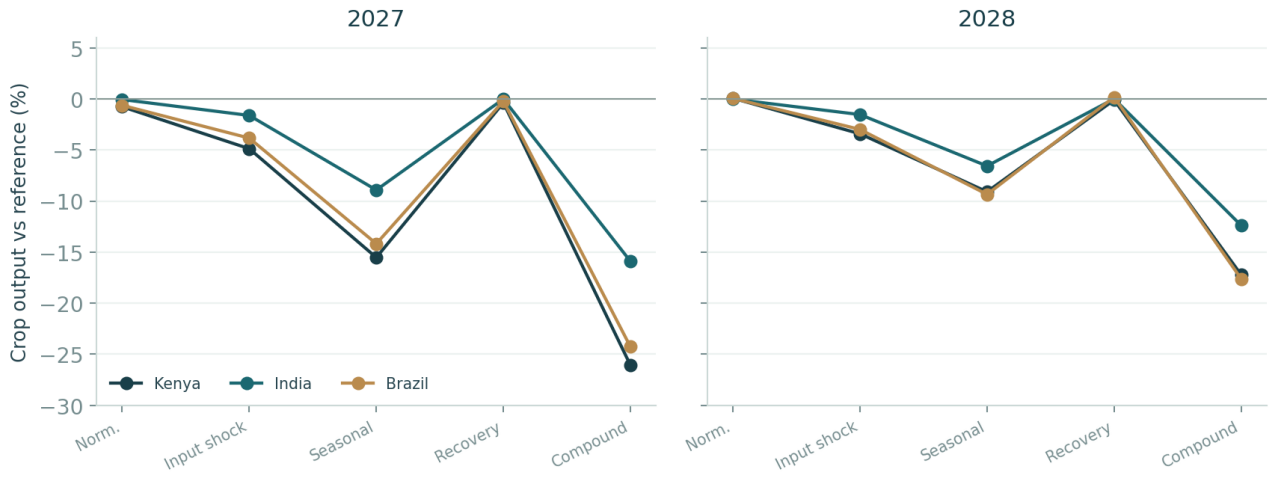


Figure 4-1. Simulated 2027 and 2028 crop-output deviations relative to the static reference under five scenarios, with no additional policy (%).

Table 4-3. Modeled output deviation in 2027, no additional policy

Country / crop	Input shock, 2027	Seasonal stress, 2027	Compound stress, 2027
Kenya / maize	-4.88%	-15.53%	-26.07%
India / wheat	-1.62%	-8.92%	-15.90%
Brazil / second maize crop	-3.84%	-14.18%	-24.27%

Differences in modeled country responses arise from the crop calendars, institutional buffers and parameter choices represented in the system, not from an independent empirical ranking of global food risks. The useful policy question is which points in the production and supply chain would require additional resilience if several adverse conditions occurred together.

Source: Conditional annual simulations for Kenyan maize, Indian Rabi wheat and Brazil's second maize crop.

4.4 Persistent Stress, Inventories and Consumption

In the compound-stress simulations, output deviations in 2028 are smaller than in 2027. This partly reflects assumed easing in weather stress, adjustments in input prices and the response of planted area. It is not an independently identified recovery trajectory; changing those assumptions would change the size of the second-year improvement.

Inventories add another dimension beyond annual output. A monthly framework can show stocks falling and use becoming constrained before harvest, even if year-end balances recover when new production arrives. An ending-stock observation alone may miss pressure between planting and harvest.

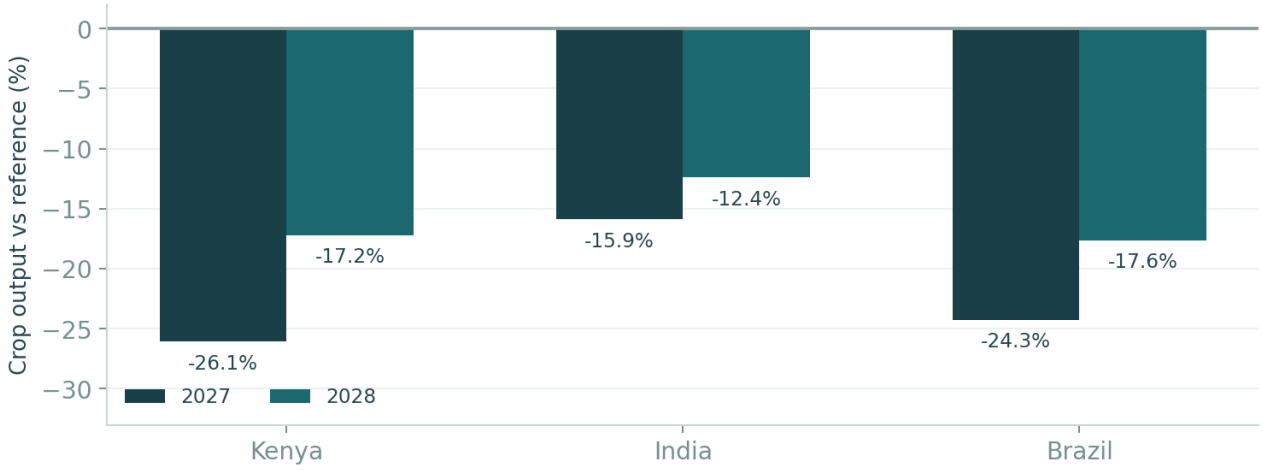


Figure 4-2. Compound-stress crop-output deviations in 2027 and 2028 with no additional policy (%).

Table 4-4. Compound-stress output comparison, 2027-28

Country	Compound stress 2027	Compound stress 2028	Direction
Kenya	-26.07%	-17.22%	Smaller modeled shortfall
India	-15.90%	-12.39%	Smaller modeled shortfall
Brazil	-24.27%	-17.62%	Smaller modeled shortfall

Prices and effective access to food must also be distinguished. The model's price-pressure index is constructed from inventories and unmet-use measures; it is not an observed consumer price index. Unmet use includes feed and other applications as well as human consumption, and cannot be equated with the number of people facing food insecurity. Real-world monitoring still requires retail prices, household incomes and physical-delivery data.

Source: Seasonal dynamic simulations, using an assumed monthly inventory starting point.

4.5 Sensitivity to Core Assumptions

The study performs 128 one-at-a-time sensitivity tests, varying weather conditions, fertilizer availability, crop responsiveness to inputs, harvested-area reactions, and inventory and price feedback. The accompanying figure shows the change in simulated Kenyan maize output in 2027 under the compound-stress case as selected assumptions are varied.

Weather and physical fertilizer availability can materially change the modeled loss. Where the available quantity of fertilizer is already capped, changing farmers' price responsiveness has less influence. Price and quantity constraints therefore operate through different channels; a large international fertilizer-price increase alone cannot determine crop outcomes.

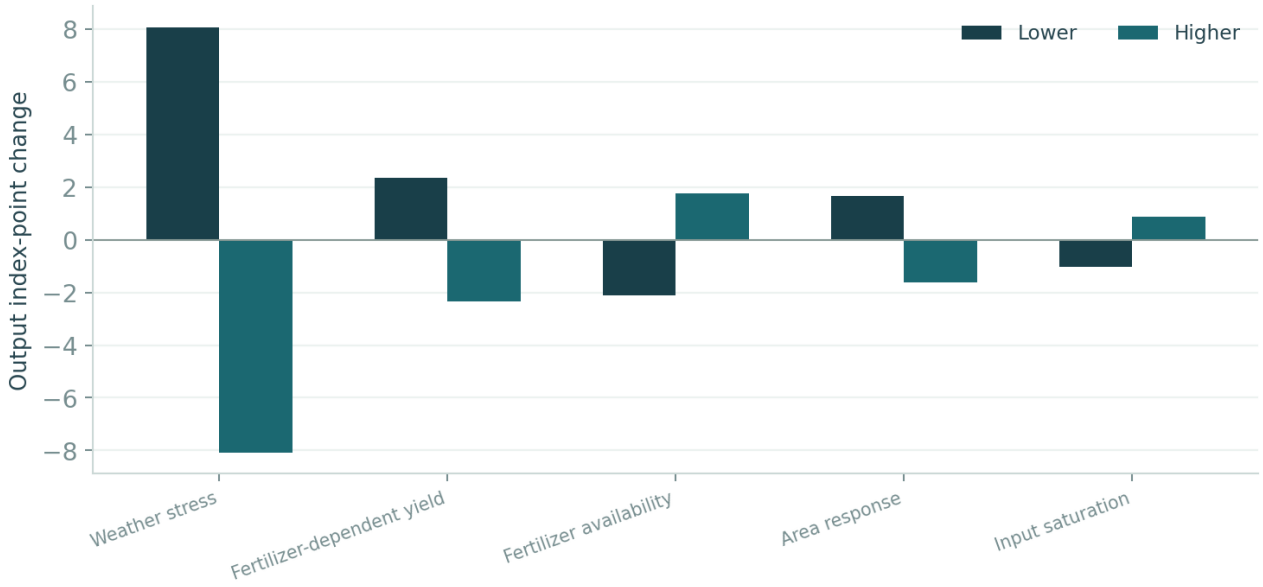


Figure 4-3. One-at-a-time sensitivity: Kenyan maize output under compound stress in 2027 (index-point change from central run).

The tests identify priorities for further observation: growing-season weather, fertilizer quantities actually applied, delivery timing and the capacity to release stocks. Parameter ranges are analytical choices for testing robustness, not estimates of the probability that each condition will occur. New observations should be used to revise both assumptions and scenario boundaries.

Source: One-at-a-time model sensitivity tests. Assumed parameter intervals are not statistical confidence intervals.

4.6 Historical Tests of Price-Forecasting Models

The research also tests whether energy and fertilizer information improve short-horizon commodity-price forecasts relative to a simple benchmark. The naïve forecast carries forward the previous month's price. An extended autoregressive specification adds lags of the commodity itself and lagged energy, crude-oil and copper indicators; fertilizer information is also tested for grain prices.

In retrospective tests covering 2019-22 and 2023-24, the more complex models did not consistently outperform the naïve benchmark. The strictly held-out period with verifiable historical data versions contains only four forecast origins, September-December 2025, for each commodity. In that limited window, the extended model's root-mean-square error was approximately 0.854 times the naïve benchmark for MOP but 1.160 times it for maize. Performance varied substantially by target.

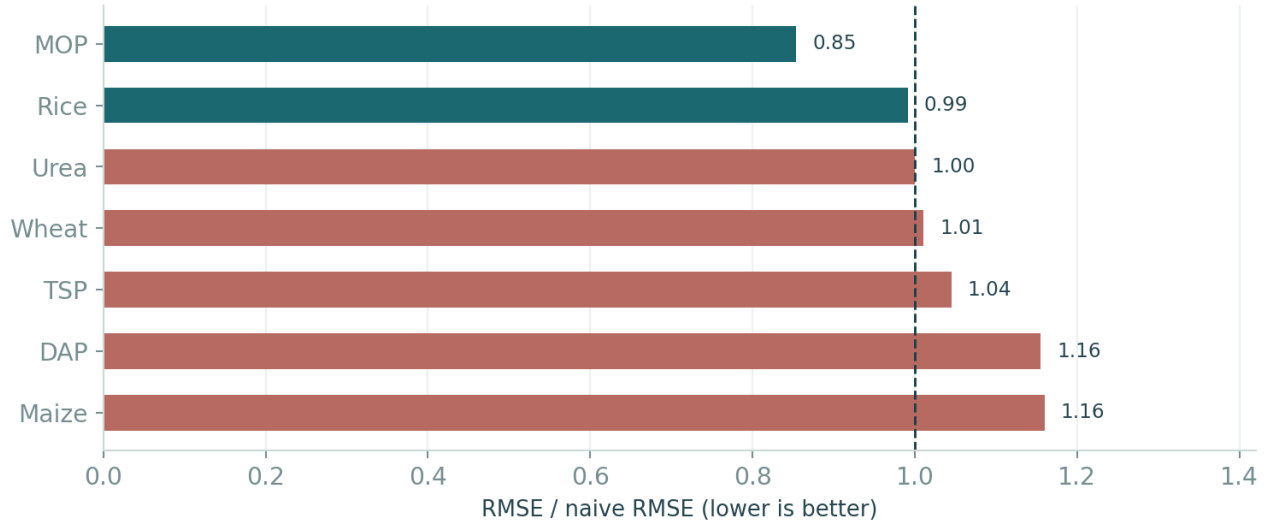


Figure 4-4. Extended model RMSE relative to the naïve benchmark, using the September-December 2025 real-time data vintages (values below 1 indicate lower error).

Adding predictors does not necessarily improve out-of-sample accuracy. The crop model passes internal accounting and reproducibility checks, yet its national output projections have not been validated against independent multi-year country data. The simulations in Chapters Four to Six are consequently presented as conditional experiments in mechanisms and policy responses.

Source: Historical price-forecast comparisons. Earlier retrospective tests are affected by revised data vintages.

Chapter Five

Strategic Behavior and Economic Feedback

5.1 Historical Trade Policy and Market Responses

Trade policy affects both domestic supply and contracts already signed across borders. An export restriction may be announced overnight, but international trade does not stop instantaneously. Cargoes may already have been purchased, supported by letters of credit or booked for shipment. Once a restriction takes effect, exporters, importers and governments must decide how to handle these commitments. India's wheat export policy in 2022 provides a traceable example of this sequence.

In February 2022, India estimated wheat output at roughly 111.32 million tonnes. During April, official communications continued to discuss access to overseas markets and export ambitions; as late as 4 May, the public position was that no wheat export restriction was planned. On 13 May, normal wheat exports were restricted, with exceptions for qualifying letters of credit and certain government-to-government arrangements. For exporters, an opportunity to sell wheat became a question of contract performance: whether the shipment qualified for an exception, whether loading could proceed and whether official permission was needed.

Table 5-1. India's 2022 wheat policy and subsequent responses

Date	Observed action	Issue that followed
4 May 2022	No export restriction was planned at that time, per public statement	Traders continued under existing expectations
13 May 2022	Ordinary wheat exports restricted with exceptions	Contracts and arranged shipments needed new clearance
17 May 2022	Cargo owner requested completion of wheat loading for Egypt	Exception requested to perform existing shipment
17 May 2022	Egypt requested release of the cargo; India approved	Administrative exception allowed the transaction

The transaction concerned 61,500 tonnes of wheat bound for Egypt, of which 44,340 tonnes had already been loaded and 17,160 tonnes remained to be loaded. The cargo owner sought to complete shipment; the Egyptian government wanted to secure the contracted supply; and the Indian regulator had to reconcile the domestic policy with the exception framework. The official record indicates that permission was granted. Not every importing country can expect the same outcome, but the case demonstrates that export restrictions may be followed by significant contract-level applications, diplomatic coordination and administrative decisions.

The research also tests what could have been anticipated using only information available before 11 May 2022. The model ranked continuation of ordinary exports first, whereas the actual decision was to restrict them. That first-choice prediction failed. Once the restriction was treated as given, the model's expectations about the cargo owner's application and the Egyptian government's request were closer to the later record. Predicting a policy reversal and anticipating actors' responses after that reversal are distinct tasks.

The 2027-28 scenarios do not treat this history as a script bound to repeat. Instead, they retain an observable logic: policy announcements alter commercial choices; those choices can generate further governmental responses; and economic outcomes depend on when each decision is implemented.

5.2 Supply Constraints and Policy Choices

Chapter Four compares crop outcomes under different price, weather and supply conditions. This chapter asks an additional question: as pressure persists, will governments and market participants change course? Will a supplier accept a new fertilizer order or defer it? If rising grain prices prompt an export adjustment, what price conditions will domestic growers face in the next planting cycle? Even with the same external shock, the order of decisions can change the outcome.

The simulations use compound stress as a shared background and allow selected policies to respond to information from the previous period. An external restriction first reduces fertilizer availability. Governments then choose among input subsidies, alternative sourcing, stock releases and household support. Suppliers decide whether to accept new procurement requests; grain export regulators may adjust trade conditions as the domestic market evolves. There are delays between announcement and implementation, while cultivation and consumption continue on their own calendars.

Table 5-2. Actors, choices and implementation conditions

Participant	Available actions	What affects effectiveness
Fertilizer exporters / supply regulators	Adjust additional supply or export conditions	Capacity and domestic policy limits
Importing-country government	Subsidies, alternative purchasing, stock release, household aid	Budget, reserves, procurement, crop calendars
International supplier	Accept, defer or fulfill orders	Contract terms, shipping capacity, feasibility
Grain export authority	Maintain, restrict or restore export conditions	Domestic market stress and existing contracts
Farm producers	Adjust input quantities and future cropping	Delivery timing, actual costs, expected returns

Time is not merely a reporting interval. Subsidies can alter what farmers pay relatively quickly, but cannot create fertilizer that is physically unavailable. New sourcing can strengthen later supplies but first requires supplier acceptance and contract execution. Stock releases may affect the current grain market sooner, yet use inventories that might be needed again. Both the target and timing of an intervention determine whether it works.

Two broad policy packages are compared. The production-first approach addresses farmers' input costs initially, then considers alternative purchasing and consumer measures in response to market developments. The trade-adaptation approach starts searching for new sources earlier, under assumptions that make suppliers more willing to accept an order. Neither path is an announced government program. Their outcomes represent combinations of government decisions and supplier behavior, not the isolated effect of one policy instrument.

5.3 Kenya: Fertilizer Procurement and the Crop Calendar

Kenya's input risk is unusually sensitive to timing. Fertilizer may already be under procurement or in domestic transit, yet delivery at the farm still depends on local distribution and accessible inventories. For the government, reducing a purchase price and increasing physical supply are separate tasks. For farmers, fertilizer delivered after the relevant application window may be of limited value for that season.

In the production-first compound-stress simulation, an external fertilizer supply restriction is announced in November 2026 and takes effect in December. Kenya announces an input subsidy in the same month, but it does not begin affecting costs until February 2027. Farmers' modeled payment burden eases somewhat without an immediate increase in the quantity available for purchase. With supply still constrained, the government begins seeking alternative sources in May 2027.

Suppliers do not confirm the new order immediately. Acceptance is deferred in May and granted in June, after which contracting and transport still take time. The additional supply becomes effective only in November. Meanwhile, a domestic grain export authority decides in August to tighten export conditions, implemented in September. Rather than a pre-written annual policy program, this is a sequence of responses to successive market conditions.

Table 5-3. Kenya: simulated action sequence under compound stress

Period	Action sequence	Economic channel
Nov. 2026-Feb. 2027	Fertilizer imports tighten; input subsidy announced and implemented	Payment burden eases first; physical supply still constrained
May-Jul. 2027	New sourcing sought; supplier accepts after a delay	Procurement feasible, but not yet delivered
Aug.-Nov. 2027	Grain export conditions tighten; alternative inputs arrive later	Different effects on consumers and farm inputs
Jun.-Jul. 2028	Public-stock release announced and implemented	Focus shifts to immediate grain-market supply

The path illustrates how policy priorities can create mismatches with the agricultural calendar. Subsidies provide earlier relief from affordability constraints, but cannot overcome shortages if fertilizer has not arrived. Alternative suppliers increase availability later, potentially in a different crop window. By the next year, as attention shifts toward immediate pressure in grain markets, the government turns to a public-stock release.

The trade-adaptation path seeks new suppliers as early as November 2026 and, under more permissive acceptance assumptions, secures agreement that month. Additional supply therefore becomes effective in May 2027. The two paths produce different 2028 output and household-affordability outcomes: trade adaptation raises the maize production index, while average price pressure is slightly higher and the targeted household purchasing-power index slightly lower. It is a trade-off between upstream production support and downstream consumer protection, not proof that earlier procurement is invariably better.

5.4 India: Farm-Input Protection and Market Stability

When fertilizer costs and international supplies are under simultaneous pressure, India faces problems operating on different timelines. Farmers need inputs during sowing and fertilizer application; household food expenditure can deteriorate long before a better harvest arrives. Production support and market stabilization can complement each other, but a single intervention rarely addresses both at the same moment. The starting point of policy matters for the choices that follow.

The production-first path begins with an effort to reduce farmers' fertilizer expenses. An input subsidy is announced in November 2026 and takes effect in December, lowering modeled farmer purchase costs. It improves affordability but does not immediately increase the available quantity. As supply pressures persist, the government starts looking for alternative suppliers in February 2027. Confirmation is deferred until April, and the new sourcing arrangement becomes effective in August after contracting and delivery delays.

That delay shifts which agricultural stages benefit from the intervention. Even an early subsidy may not secure sufficient fertilizer within the relevant application window. Later, as market prices and stocks evolve, the government uses a combination of further input support, public-stock management and food assistance. Pressures on farm production and household consumption differ, and the policy emphasis adjusts accordingly.

Trade adaptation starts elsewhere in the supply chain. The government begins diversifying procurement in November 2026 and secures supplier acceptance that month. Supply becomes available in May 2027, roughly three months earlier than under production first. This difference does not arise solely from government timing: the simulations also assume different supplier acceptance conditions. Earlier supply should therefore be attributed to the combined policy-and-supplier configuration.

The two paths do not produce a uniform ranking of economic outcomes for 2028. The wheat production index reaches 89.62 under trade adaptation versus 86.32 under production first. Yet average domestic price pressure is higher and purchasing power among targeted households is weaker. Stronger agricultural output does not ensure lower retail pressure or a lighter near-term food burden.

Table 5-4. India: simulated 2028 outcomes under compound stress

2028 model indicator	Production first	Trade adaptation
Rabi wheat production index	86.32	89.62
Mean domestic price-pressure index	144.77	155.01
Targeted household purchasing-power index	70.10	66.55
Annual cash spending / reference crop revenue	0.72%	0.18%

These differences reflect where the policies operate. Earlier sourcing mainly improves inputs for subsequent production, while later stock releases and household transfers under the production-first path support the near-term grain market and consumers. The two approaches also entail different cash requirements, but the table's spending figures are normalized model measures, not India's actual national budget. Policy sequencing must consider when farmers need inputs and when households need a buffer against food prices and income pressure. Output alone cannot judge the result.

5.5 Brazil: Export Management and Production Incentives

Brazil's second maize crop depends on preceding crop schedules and is closely connected to international trade. Growers commit to many input decisions before sowing, whereas export policy and domestic grain prices can change repeatedly afterward. Retaining more grain for the domestic market may ease immediate availability pressure; if prices remain suppressed, however, incentives for the next round of planting and input spending may weaken. Export management thus has both near-term market and medium-term production effects.

Under the constructed compound-stress scenario, the trade-adaptation path opens additional fertilizer procurement channels in November 2026. Suppliers accept that month, and the resulting supplies become effective in May 2027. A domestic grain export authority then decides in August 2027 to tighten export conditions, lowering the modeled export ceiling to 70% of its initial level in September. The measure shifts quantities between domestic circulation and overseas sales, and subsequent market developments inform the next decision.

In 2028, the simulated export cap does not remain fixed. A decision in July lifts the restriction and restores the initial ceiling in August. New market conditions in August then prompt another tightening decision, returning the ceiling to 70% in September. A snapshot at year-end would show only a restricted export regime. The monthly sequence reveals relaxation, feedback and renewed tightening.

The immediate policy objective and growers' subsequent incentives are not necessarily aligned. Under current assumptions, the 2028 second-maize production index is 84.56 under trade adaptation versus 81.35 under production first, while average domestic price pressure falls from 127.64 to 123.12 and targeted household purchasing power improves modestly. This differs from India: similar policy labels can produce different production-price trade-offs under different crop calendars, trade positions and accompanying measures.

The Brazil model does not yet connect export policy to partner-country imports through a single cross-border supply network. It can reproduce domestic policy adjustments as market conditions evolve and compute domestic indicators, but it cannot determine how much grain an overseas importer would consequently lose. Modeling those responses would require trade partners, shipping capacity and substitute suppliers within shared market constraints.

5.6 Comparing Strategic Paths and Economic Outcomes

Across Kenya, India and Brazil, governments do not respond to food-system stress in identical ways. Kenya confronts the timing of agricultural-input distribution; India alternates between farm support, domestic price stability and household burden; Brazil adjusts trade conditions against domestic prices and production incentives. Strategic modeling is useful not because it assigns a different policy label to each country, but because it links the timing of decisions, participation by other actors and the economic outcomes that follow.

The study retains two comparison paths: the original model with no additional intervention, and a case in which initial external restrictions occur without subsequent strategic responses. In all three countries, the latter yields a lower 2028 production index than the first. Allowing governments, suppliers and regulators to adjust reduces some modeled losses, with the degree of relief depending on implementation dates and supplier cooperation.

Table 5-5. 2028 crop-output indices under alternative strategic paths

Country / crop	Fixed-policy reference	Initial restriction only	Production first	Trade adaptation
Kenya / maize	82.78	81.14	84.06	85.78
India / Rabi wheat	87.61	86.24	86.32	89.62
Brazil / second maize crop	82.38	81.07	81.35	84.56

Within the tested configurations, trade adaptation yields the highest production index in each country. But the intervention timing and supplier acceptance assumptions change together. Differences in the table cannot be attributed to earlier procurement alone. Tightening supplier acceptance conditions substantially erodes the advantage in all three cases. A realistic proposal must address not only whether a government should look for alternative supply, but whether suppliers will sign, when goods will arrive and whether the relevant application window will still be open.

Production is also not a substitute for household food outcomes. India's trade-adaptation path raises output but results in greater price pressure and weaker purchasing power. Under the tested Brazil configuration, higher output coincides with lower price pressure. These differences caution against evaluating food policy by production alone or applying one country's preferred simulated path mechanically to another. The next chapter separates farm inputs, market supply and household support before examining the conditions necessary for delivery.

Chapter Six

Policy Tools, Execution and Risk Monitoring

6.1 Policy Tools and Transmission Channels

The country studies and strategic scenarios show that agricultural risk is not a single problem solved by one subsidy. Farmers may be unable to afford fertilizer, or they may be able to pay but unable to obtain any. Grain prices may rise before the next harvest can respond, while the stock available to the government determines whether it can increase near-term market supply. Policy measures should therefore match specific constraints.

Input subsidies reduce what farmers pay for fertilizer, but only if supplies exist and the relevant application window remains open. Public-stock releases bring existing grain into the market and can address immediate availability. Diversified sourcing reduces exposure to future procurement interruptions, but it takes time to contract and deliver. Food assistance helps bridge gaps between household income and prices without replacing physical grain in the market.

Table 6-1. Policy instruments and delivery requirements

Policy	Main transmission channel	Implementation lag (model)	Key requirement
Input subsidies	Actual fertilizer cost, later farm inputs	Around 1-3 months	Product available during crop window
Public-stock release	Near-term grain availability, price pressure	Around 1 month	Releasable reserves and delivery network
Diversified sourcing	Future fertilizer supply gap	Around 6 months	Suppliers, transport and financing arranged
Food assistance	Nominal household purchasing power	Around 1 month	Food available and assistance delivered

Implementation timing determines which part of the system a measure can affect. Farm support may change the harvest only if it arrives during a relevant crop stage. New procurement delivered too late may primarily help the next season. For households facing food inflation now, better production next year cannot replace immediate purchasing-power support. Comparisons therefore need to examine production, prices, household affordability and resource use together.

Source: Economic and strategic scenario assumptions; implementation lags are modeled, not empirical country estimates.

6.2 Conditional Policy Outcomes

Under compound stress, the original economic framework compares four policy tools and their outcomes in 2028. The objective is not to declare one universally optimal program but to understand which tool acts on the binding constraint: agricultural inputs, near-term grain availability or household purchasing power.

In Kenya, diversified fertilizer sourcing raises the 2028 maize production index by 3.32 points relative to no additional intervention. In India, a public-stock release raises the purchasing-power index of targeted households by 9.62 points. In Brazil, food assistance increases that index by 2.34 points. These effects occur at different levels of the food system and cannot be ranked on a common benefit measure without additional assumptions.

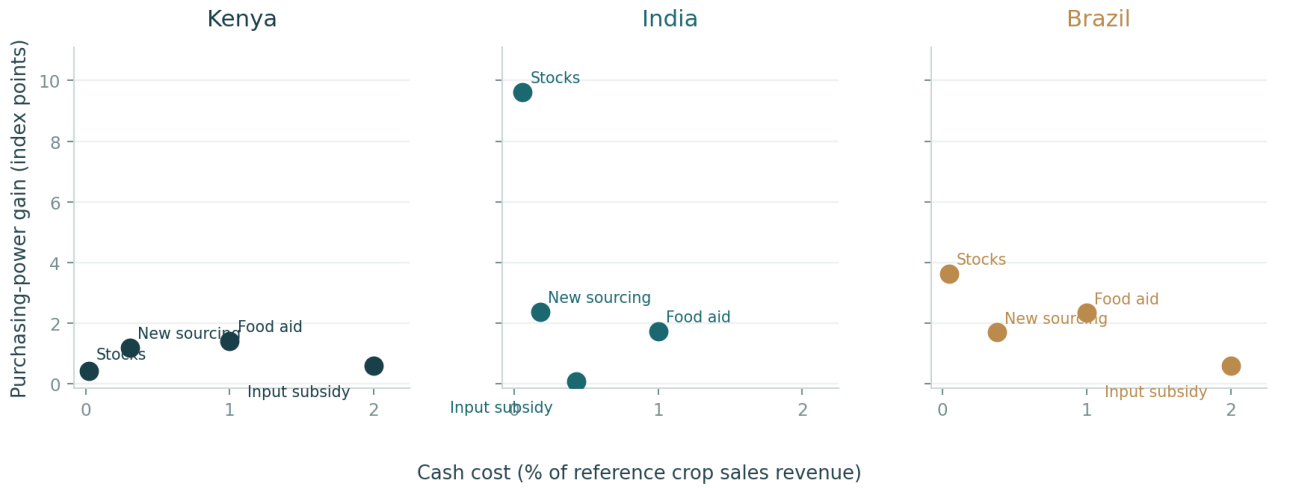


Figure 6-1. Incremental cash spending and targeted household purchasing-power gains, compound-stress policy experiments, 2028.

The resource costs also differ. A stock release may involve little cash expenditure but uses publicly held grain that may be needed later. Input subsidies and food assistance chiefly require current cash transfers. New sourcing also involves procurement, freight and delivery arrangements. Even where the model shows benefits, execution constraints and timing can materially change the outcome of a policy package.

Source: Conditional policy outcomes and normalized annual resource accounts. Reserve-asset use is recorded separately.

6.3 Execution, Supplier Acceptance and Robustness

Strategic interaction adds a further layer to the question of policy effectiveness. A government decision to seek alternative fertilizer does not guarantee that farms receive additional inputs. International suppliers may decline or delay an order. Contract execution and physical delivery follow, and the shipment may arrive after the application window. Between a government announcement and a farmer's actual access to fertilizer stand several independent hurdles.

Supplier acceptance assumptions have a material effect on the results. Under stricter acceptance conditions, the gains in the trade-adaptation configuration weaken. Compared with the more permissive central case, the 2028 production indices fall by 4.64 points in Kenya, 3.38 in India and 3.73 in Brazil; price pressure rises and targeted household purchasing power declines. The effects extend beyond crop production into grain markets.

Table 6-2. Impact of stricter supplier acceptance assumptions, 2028

Country	Production-index change	Price-pressure-index change	Purchasing-power-index change
Kenya	-4.64	+6.18	-2.39
India	-3.38	+7.71	-3.30
Brazil	-3.73	+4.66	-2.47

Progress in procurement should therefore not be measured solely by whether a new supply channel has been announced. The operational sequence is whether alternative suppliers accept the order, when contracts can be performed, when transport is completed, and whether delivery is still timely for crop needs. A delay at any stage can reduce the anticipated improvement in production.

Faster is not automatically better in every simulated configuration. Changing government and supplier response lags can also alter the sequence of policy choices and the cropping windows they affect; some combinations do not produce a uniform direction of output change. The actionable issue is not a single optimal administrative date, but coordination of policy, supplier execution and crop calendars against domestic market pressure.

Note: Changes are relative to the central trade-adaptation configuration under compound stress, expressed in index points.

6.4 Policy Costs and Resource Allocation

For model accounting, policy expenditure is expressed as a percentage of reference-year farm sales revenue for the target crop: maize in Kenya, Rabi wheat in India and second-crop maize in Brazil. This common normalization helps check budget consistency within each country model. It does not measure the countries' actual fiscal capacity on a directly comparable basis.

Resource use is broader than government cash payments. Releasing reserves draws down public inventories; diversifying procurement entails contracting and delivery; input subsidies and household transfers mainly involve cash spending. Policy paths should therefore be evaluated in terms of both annual payments and the future resource value of stocks used, rather than treating low immediate cash outlay as low total cost.

Table 6-3. Policy outcomes and resource use, 2028, compound stress

Country and policy	Output change[1]	Purchasing power[1]	Cash cost[2]	Stock depletion[2]
Kenya: input subsidy	+0.62	+0.60	2.00%	0
Kenya: stock release	-0.12	+0.43	0.02%	1.10%
Kenya: diverse sourcing	+3.32	+1.19	0.31%	0
Kenya: food assistance	0	+1.40	1.00%	0
India: input subsidy	+0.08	+0.08	0.43%	0
India: stock release	-0.18	+9.62	0.06%	2.96%
India: diverse sourcing	+2.41	+2.36	0.18%	0
India: food assistance	0	+1.73	1.00%	0
Brazil: input subsidy	+0.47	+0.60	2.00%	0
Brazil: stock release	-0.71	+3.63	0.05%	2.28%
Brazil: diverse sourcing	+2.62	+1.70	0.38%	0
Brazil: food assistance	0	+2.34	1.00%	0

[1] Differences in model index points. [2] Percent of reference-period farm sales revenue of the target crop. Cash expenditure is recorded by calendar year; crop output is recorded by harvest year.

The table's changes in output and purchasing power represent different policy objectives and should not simply be added together. Cash costs are measured in calendar years while harvest outputs belong to crop years; both need not relate to the same growing season. Actual policy budgets would additionally require beneficiary coverage, delivery costs, reserve replenishment and financing conditions.

Source: Conditional 2028 policy simulations; financial ratios are model-normalized, not actual national fiscal outlays.

6.5 Risk Monitoring and Policy Conclusions

Taken together, the economic and strategic results suggest that monitoring should extend beyond international price indices. The most useful signals sit at different stages of implementation: whether import contracts are executable, when fertilizer reaches local depots, whether farmers can apply it on time, how much public grain can be released, and whether households can afford local retail prices. Putting these observations on a common timeline makes it easier to identify what each intervention is achieving.

For Kenya, priorities include county-level fertilizer receipts and disbursement, local maize prices, and the gap between imported cargo arrival and farm delivery. India requires joint monitoring of subsidy implementation, local stocks, irrigation and spring wheat weather. Brazil's indicators should connect soybean-harvest timing, second-maize planting, fertilizer supply and export decisions. These sets differ because the mechanisms transmitting risk to production and consumption differ.

Table 6-4. Country monitoring priorities

Research focus	Indicators to update	Conditions to watch in combination
Kenyan maize	County deliveries, fertilizer use, local prices, stocks, harvest	Timing mismatch + low stocks + delayed imports
Indian Rabi wheat	Local fertilizer, subsidies, irrigation, spring weather	Local shortages + inadequate irrigation + heat
Brazilian second maize	Soybean harvest, late planting, weather, fertilizer, exports	Delayed sowing + adverse weather + tighter exports

Overall Assessment

Available evidence does not show the disappearance of global grain buffers, although local markets already exhibit differences in transport conditions, input timing and household affordability. The 2027-28 compound-stress scenarios indicate that even under the same external shock, the order of government actions and supplier cooperation can alter subsequent output and price conditions. Risk analysis should therefore be updated with actual behavior and market data, not simply extend a predetermined forecast path.

Policy should be targeted at the location of the constraint. Farmers unable to afford inputs need financial relief; markets lacking physical supply need inventories or new procurement; households overwhelmed by food prices may need direct consumption support. When these constraints coincide, the order of measures matters as much as their names. A next step for research is to connect supplier quotes, contract performance and bilateral trade flows in a verifiable cross-border system.

Monitoring priorities combine official market observations, fixed-policy experiments and conditional strategic scenarios.

Appendix

Data Sources and Research Methods

Source Coverage and Scope

The study uses international statistical releases, public market observations and information published by governments and agricultural institutions available as of 19 October 2026. Sources differ in product specification, quotation currency, stage of trade and reporting date. The analysis retains these distinctions and focuses on price trends, local disparities and channels of economic transmission.

Table A-1. Principal data and documentary sources

Material category	Principal source	Use in this study
International energy and fertilizer prices	World Bank commodity price data (Pink Sheet)	Historical changes and diverging commodity prices
Local and regional grain prices	FAO Food Price Monitoring and Analysis (FPMA), FEWS NET, national price data	Trends and regional differences in selected markets
Global grain balances and stocks	USDA WASDE and PSD; FAO-AMIS market information	World supply-demand balances, inventories and trade buffers
Country agriculture and policy	Brazil Conab; Kenyan government agriculture data; Indian government and agricultural releases; USDA GAIN	Crop calendars, farm inputs, stocks, subsidies and trade rules
Policy behavior and trade episodes	Official government notices, policy documents and public trade-event records	Reconstruct historical decisions and examine actor responses

Research Methods

The study first compares historical movements in energy, fertilizer and grain prices, including potential lagged relationships among products and regions. It then examines Kenya, India and Brazil through their crop calendars, input availability, public support and market distribution arrangements. Global supply, demand and stock data provide a benchmark for interpreting overall buffers and the relative significance of local exposure.

Building on the country cases, the analysis compares agricultural-input, weather, supply and trade conditions and their modeled effects on production, inventories, price pressure and household purchasing power. Historical policy episodes inform the study of government responses, supplier decisions and implementation timing. These behavioral paths are assessed against observed historical events and compared across conditional scenarios.

Interpretation of Results

The report distinguishes historical observations, agency projections and results from conditional scenarios. Historical figures describe recorded developments; projections reflect the issuing institution's view at a given release date. Scenarios compare pathways and policy choices under stated assumptions, rather than predicting a precise future outcome or an estimated probability of occurrence.

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