

FOOD SYSTEMS UNDER STRESS: BUILDING RESILIENCE FROM THE FIRST MILE

IFAD
Investing in rural people

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE
AND FORESTRY

COP31
TÜRKİYE
ANTALYA

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KEY ABBREVIATIONS AND ACRONYMS

AGPM	General Association of Maize Producers
APR	Asia and the Pacific
ASI	Agricultural Stress Index
AYII	Area yield index insurance
COP31	31st Conference of the Parties to the United Nations Framework Convention on Climate Change
ECB	European Central Bank
ENSO	El Niño–Southern Oscillation
ESA	East and Southern Africa
EUR	Euro
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GDP	Gross Domestic Product
GTWDP	Göksu-Taşeli Watershed Development Project
IFAD	International Fund for Agricultural Development
IFAD12	Twelfth Replenishment of IFAD's Resources
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
KCEP-CRAL	Kenya Cereal Enhancement Programme – Climate-Resilient Agricultural Livelihoods Window
LAC	Latin America and the Caribbean
MoAF	Ministry of Agriculture and Forestry, Türkiye
NAM	North America
NEN	Near East, North Africa, Europe and Central Asia
NOAA	United States National Oceanic and Atmospheric Administration
NPK	Nitrogen, Phosphorus and Potassium
OECD	Organisation for Economic Co-operation and Development
ONI	Oceanic Niño Index
PAPFA	Agricultural Value Chains Promotion Project
PCR	Project Completion Report
READSI	Rural Empowerment and Agricultural Development Scaling-up Initiative
RMTP	Rural Microenterprise Transformation Project
RONI	Relative Oceanic Niño Index
UNDRR	United Nations Office for Disaster Risk Reduction
WCA	West and Central Africa
WFP	World Food Programme
WMO	World Meteorological Organization

FOREWORD



BY THE MINISTER OF AGRICULTURE AND FORESTRY OF THE REPUBLIC OF TÜRKİYE

Agriculture and food today extend far beyond the bounds of an ordinary economic activity. Climate change, extreme weather events, geopolitical tensions, supply chain disruptions and rising input costs have turned food supply security into a strategic, economic and geopolitical issue. Against this backdrop, the real question is not whether crises will come. It is how prepared we are to meet them.

Preparedness means acting before a crisis strikes. Support mechanisms put in place after a shock has hit are often too late. A producer's resilience is determined by the steps taken beforehand: access to water, affordable inputs, finance and insurance, and reliable links to markets. These elements reinforce one another. When one is missing, the others cannot hold on their own.

This is the central message of this report. Inputs, markets and finance must be addressed through an integrated approach, not through disconnected programmes. The field experience examined in this report shows that where these three elements move together, producers stand far stronger in the face of shocks.

In Türkiye, we are placing this understanding at the heart of our policies. Agriculture cannot be sustainable without water. That is why we have placed water at the centre of our agricultural policy. We are aligning production planning with our water resources, expanding the use of drought-tolerant varieties and strengthening early warning systems. Our work with IFAD in the Göksu-Taşeli watershed has likewise shown that lasting results can be achieved when efficient irrigation technologies, finance and producer organization are delivered together.

Yet no country can meet these challenges alone. Strengthening regional cooperation, diversifying trade, and safeguarding producers' incomes while meeting consumers' needs are our shared responsibility. A sustainable future is not an option. It is a necessity.

As we prepare to welcome the international community to Antalya for COP31 this November, we are pleased to share this report together with IFAD. We regard rural resilience and food security as an integral part of climate action. We commend the report's findings to policymakers, financial institutions and development partners, and invite them to join us in building food systems that are prepared for, and resilient to, the shocks ahead.

HIS EXCELLENCY İBRAHİM YUMAKLI

Minister of Agriculture and Forestry
Republic of Türkiye

FOREWORD



BY THE PRESIDENT OF THE INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT (IFAD)

Resilient food systems begin with resilient rural economies. When small-scale producers can withstand shocks, keep businesses operating, and local economies growing, they sustain more than their own livelihoods. Resilience is therefore not only about protecting against losses. It is about securing the foundations of lasting rural transformation.

This report makes an important argument about how we achieve that resilience, based on evidence from our IFAD investments: resilience is not built by investments in single interventions, but by connecting investments in inputs, markets and finance so that gains in one area are not lost in another. Where we have invested in these pillars together, such as in Türkiye's Göksu-Taşeli watershed or Burkina Faso's rice, sesame and cowpea value chains, the results are transformational. Better seeds and water-saving technologies cannot deliver their full value if farmers cannot afford to adopt them. Higher production does not necessarily translate into higher incomes without reliable buyers, storage and transport. And credit alone cannot create a viable investment if production remains exposed to shocks and markets remain out of reach. The evidence from Türkiye or Burkina Faso is transformational: incomes have increased by more than 40 per cent, nearly all households report gains, technology adoption is up by three-quarters.

The year 2026 has tested that principle at speed. Multiple global energy and fertilizer shocks moved through rural economies within a single planting season – too fast for the credit, insurance and subsidy mechanisms to respond. A severe El Niño is now compounding it, with the potential to push tens of millions more people into acute food insecurity by the end of 2027. For the smallholders and rural agri-enterprises IFAD serves, these are not sequential challenges to be met one at a time. They arrive together, and they must be addressed together.

For IFAD and our partners, the challenge is not simply to mobilize more finance for resilience, but to make investments work better together. Drawing on evidence from across our investment portfolio, this report makes the case for bundled, systems-level investment. This approach is central to IFAD's next investment cycle. Resilience financed in silos cannot keep pace with interconnected shocks.

I thank the Government of Türkiye and all partners and contributors to this report for the evidence and the collaboration behind the analysis presented.

ALVARO LARIO

President
International Fund for Agricultural Development

INTRODUCTION

As 2026 draws to a close, smallholders and rural economies are facing a convergence of climate, economic and geopolitical shocks. Energy and fertilizer price volatility is colliding with drought and water stress, while the expected 2026/2027 El Niño could place further pressure on agricultural production and food systems.

The development challenge is not any one of these shocks individually, but how they interact together. For example: when drought coincides with rising energy and fertilizer costs, farmers can face higher irrigation and production costs precisely when water demand is increasing and yields are under pressure. At the same time, disruptions to transport, markets and finance can transmit shocks across rural economies. Each pressure can therefore reduce the capacity of households and food systems to absorb the next.

This changes how resilience needs to be understood and financed. Resilience cannot be built through isolated interventions alone. Farmers need the capacity to maintain production through disruptions (climate and economic), be able to access markets that protect the value of what they produce, and draw on finance that allows them to invest, manage risk and recover. These functions are mutually reinforcing: inputs sustain production, markets turn production into income, and finance enables households and rural enterprises to act before, during and after a shock.

Evidence from five IFAD-financed investments shows how these connections can work in practice. Across different contexts, linking inputs, markets and finance has addressed constraints that individual interventions could not resolve alone. This report's illustrative modelling reaches the same conclusion: under modelled compounding shocks, interventions that bundle input, market and finance pillars avoid 18.7 per cent of net farm income losses, compared with 9.8 per cent if the investment was focused solely on the strongest individual lever (finance).[1]

For governments, investors and development practitioners, the implication is clear. As risks become more interconnected, resilience investments must become more interconnected too. This report examines how compound shocks travel through rural food systems, what experience from IFAD-financed investments tells us about connecting inputs, markets and finance, and how development actors can programme more integrated responses that protect livelihoods and strengthen resilience under the threat of the increasing frequency of compounding shocks.

For IFAD: Resilience is the capacity of rural households and communities to prevent, resist, absorb, adapt and respond to a range of shocks, risks and stressors, while maintaining or improving their well-being.

Consistent with the United Nations definition here: UN Common Guidance on Helping Build Resilient Societies 2020.

[1] See Annex C for details of the modelling.



01 THE EVIDENCE

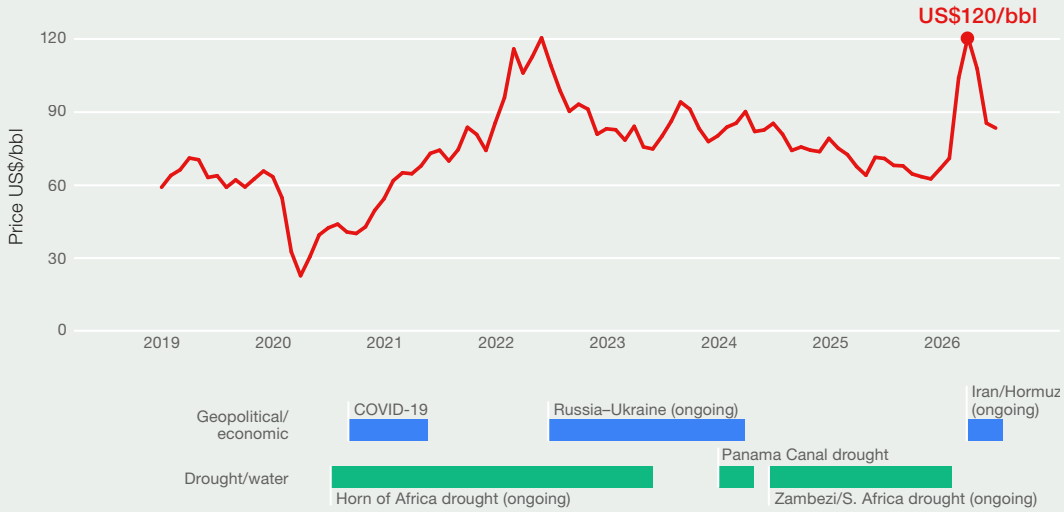
Geopolitical and climate shocks damage rural resilience through system-wide impacts, not isolated local events, and the pattern is intensifying

RECENT YEARS HAVE BROUGHT REPEATED, OVERLAPPING SHOCKS THAT IMPACT SMALL-SCALE PRODUCERS

Rising or unreliable input costs directly affect rural livelihoods, especially when they coincide with climate shocks. Oil prices shape irrigation and transport costs, while gas prices drive fertilizer costs. These pressures are interconnected: a shock in one sector can trigger knock-on effects across others, often hitting the same households at the same time. Recent shocks in disparate parts of the globe have overlapped, with the 2026 Iran/Strait of Hormuz crisis arriving as the Zambezi River basin and southern Africa drought was already under way and longer-term Russia-Ukraine disruptions continued to affect supply chains. These pressures fall hardest on smallholder and import-dependent producers, who have the least capacity to absorb higher input and transport costs.

Furthermore, smallholder farmers often still pay near-peak fuel prices well after the headline price has eased: while crude oil prices spike right away, the full impact on consumer prices usually peaks about six months later – and these spikes transmit faster and more fully than the falls do (Kpodar and Abdallah, 2016). Lower-income economies often see a smaller domestic price peak than higher-income ones, largely because their governments absorb part of the shock through subsidies and price controls. This is a partial and temporary cushion that shifts the cost to the government budget rather than removing it, with the fuel subsidies benefiting whoever buys the most fuel. As a consequence, the richest fifth of households in these economies typically receive around six times as much benefit from subsidies as the poorest (Arze del Granado, Coady and Gillingham, 2012).

FIGURE 1 Brent crude, US$/barrel (bbl), with drought and geopolitical shocks overlaid, 2019–2026

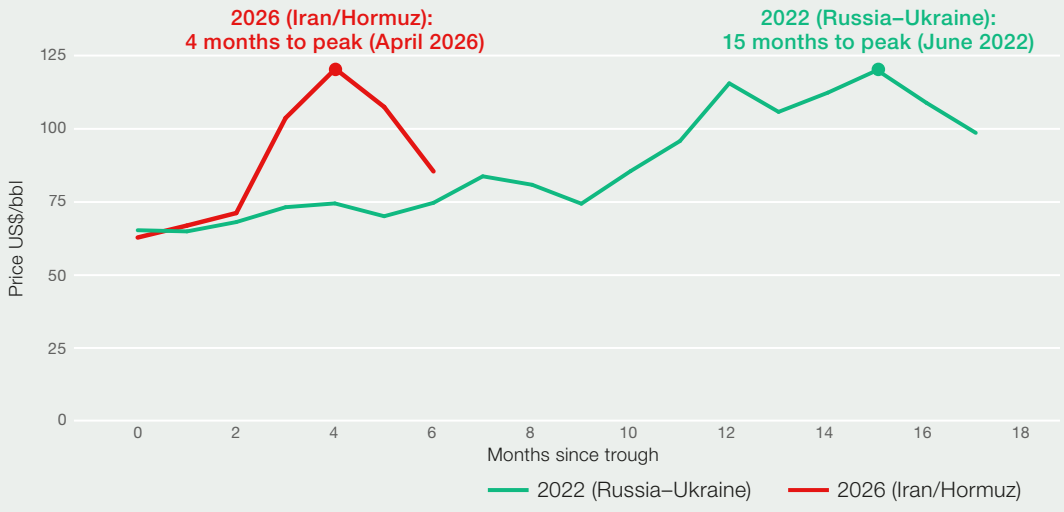


Source: World Bank Commodity Markets Outlook.

SPEED IMPACTS RESILIENCE - CRUDE OIL REACHED US$120 A BARREL FOUR TIMES FASTER IN 2026 THAN IN 2022

Diesel accounts for nearly three-quarters of the energy used for irrigation pumping globally (REN21, 2025), as well as for machinery, processing, storage and transport. When diesel supply shocks land within a single cropping cycle, the reaction time window is far too short for seasonal credit, insurance or subsidy mechanisms to adjust. Impacts are particularly severe when compounding on pre-existing shocks. While Brent crude eased to around US$85 a barrel by July 2026 – i.e. within two to three months after the peak – the slower recovery time on consumer prices means small-scale producers will continue to experience higher prices for six or more months, extending pressure into subsequent planting seasons. As is shown in **FIGURE 2**, Brent crude prices in 2026 (Iran/Hormuz) reached their trough-to-peak high roughly four times faster than in 2022 (Russia-Ukraine): December 2025 (~US$62.7/bbl) to April 2026 (~US$120.4/bbl) = 4 months; versus March 2021 (~US$65.2/bbl) to June 2022 (~US$120.1/bbl) = 15 months.

FIGURE 2 Trough-to-peak: how fast Brent crude rose in 2026 vs. 2022



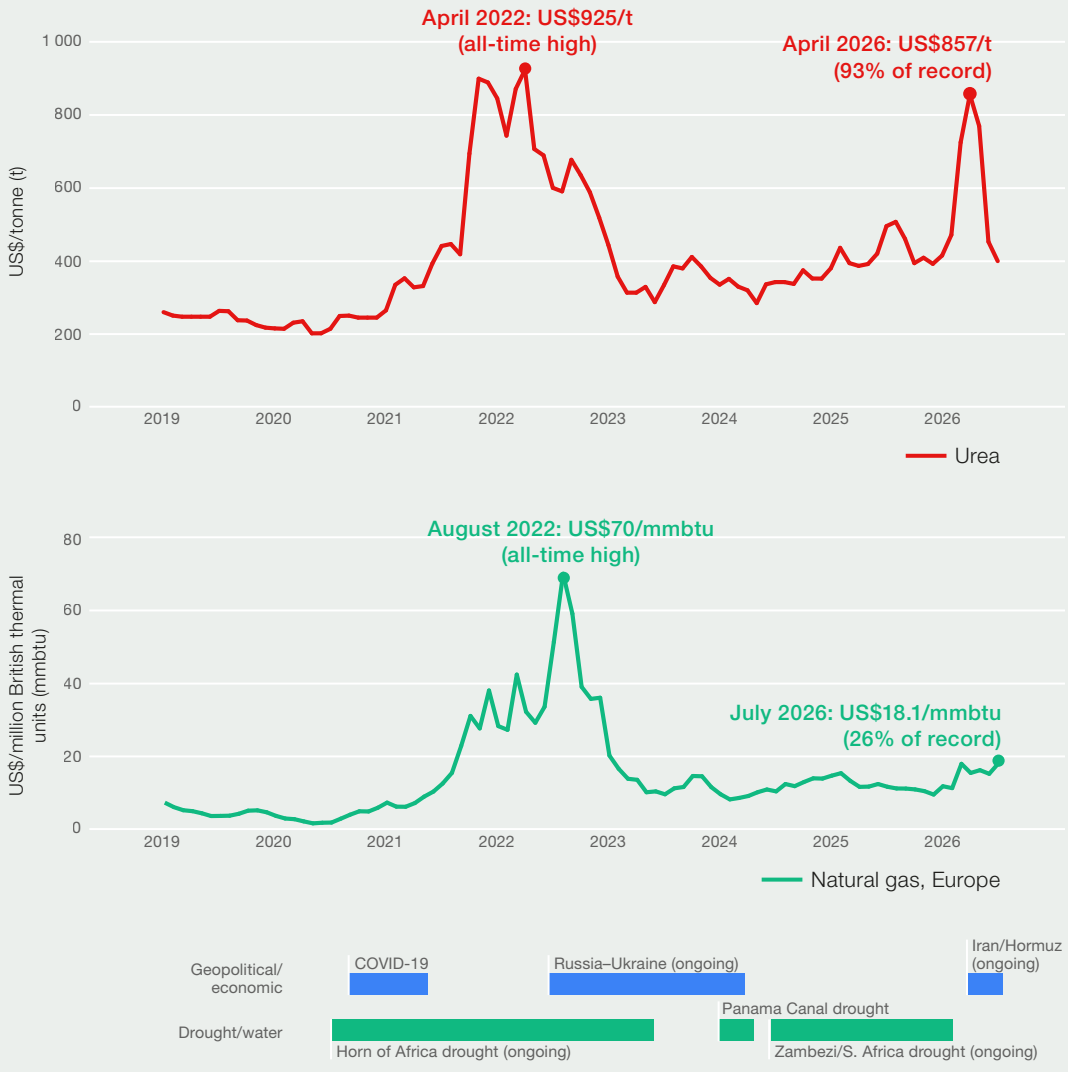
Sources: World Bank Commodity Markets Outlook; REN21 Renewables 2025 Global Status Report.

NATURAL GAS SHOCKS LEAD TO REDUCED PRODUCTION

Natural gas is a key ingredient in the production of ammonia and makes up 70 to 80 per cent of the cost. Ammonia is a key component of urea – a globally used synthetic fertilizer. So a gas price shock is also, by default, a fertilizer shock. Around a third of globally traded urea passes through the Strait of Hormuz, alongside roughly 30 per cent of ammonia. The recent geopolitical shock in the region therefore caused a shock to global fertilizer prices. This underlines a broader dependency: global food production relies heavily on fossil-fuel-based inputs, a dependency that both heightens exposure to these shocks and is itself a contributor to the climate pressures driving them.

The shock stabilized relatively quickly at the global level, as alternative sources of fertilizer were found and China reduced fertilizer export restrictions. However, the timing of fertilizer price rises directly coincided with the northern hemisphere planting season, causing an outsized impact due to its timing. Additionally, farm-gate prices remain elevated because transmission is partial, slow and country-specific (Hernández et al., 2026). This could cause global negative impacts on yields, including for vulnerable small-scale producers.

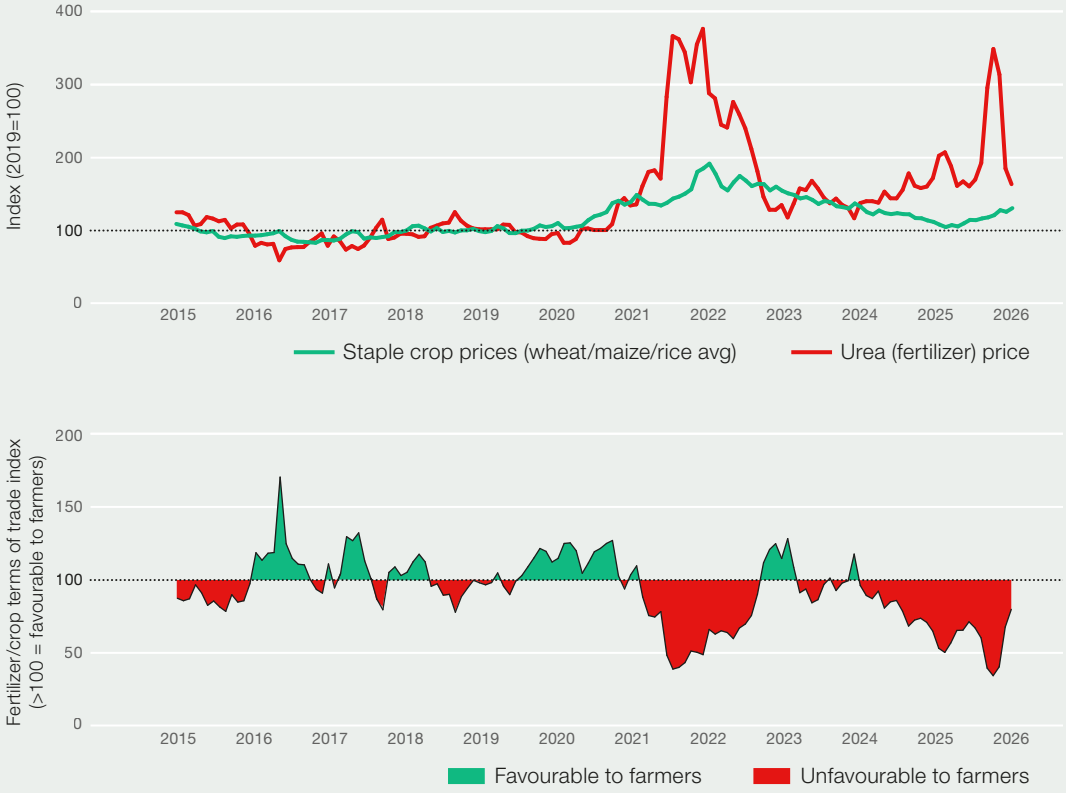
FIGURE 3 Urea and European natural gas prices, 2019–2026



Source: World Bank Commodity Markets Outlook.

THE REAL SQUEEZE ON SMALL-SCALE PRODUCERS IS IN TERMS OF TRADE

FIGURE 4 Staple crop and urea prices, and the fertilizer/crop terms-of-trade index, 2015–2026



The terms of trade index measures fertilizer costs relative to the price paid for staple crops: above 100 favours farmers, below 100 squeezes them. The index collapsed to about 49 in April 2022, recovered to above 100 by early 2023, then collapsed even further to about 35 during the April 2026 Iran/Hormuz spike.

The true deterioration for small-scale producers is likely worse still: they rarely receive global prices for their output, selling into local markets that moved far less than the global benchmark.

TERMS-OF-TRADE SQUEEZE: 2022 VS 2026

2022
+92%
Staple crop price rise cushioned increase in urea price

2026
+16%
Staple crop price rise while urea prices rose by around 70 per cent

Note: The windows are not matched in length. The 2019–2022 window spans 31 months against 8 months for 2025–2026, both defined according to the length of time between the most recent trough to the peak.

Source: World Bank Commodity Markets Outlook.

HIGHER-INCOME COUNTRIES CAN ABSORB COSTS, WHEREAS LOWER-INCOME COUNTRIES REDUCE APPLICATION

Globally, the volume of traded fertilizer barely moved, sitting between 78 and 84 million tonnes a year over the period 2019–2025, even as prices more than doubled. But this hides an uneven distribution. Many import-dependent lower-income countries – and the farmers within them – reduced fertilizer imports and use. The data for 2026 are not yet available, but the pattern points the same way, with cutbacks arriving at the height of the 2026 planting season.

FERTILIZER VOLUME CUTS

-3%
Median cut across all countries

-15%
Cut among low-income countries specifically

31%
Countries which cut volumes by more than 20%

50%
Low-income countries which cut by more than 20%

FIGURE 5

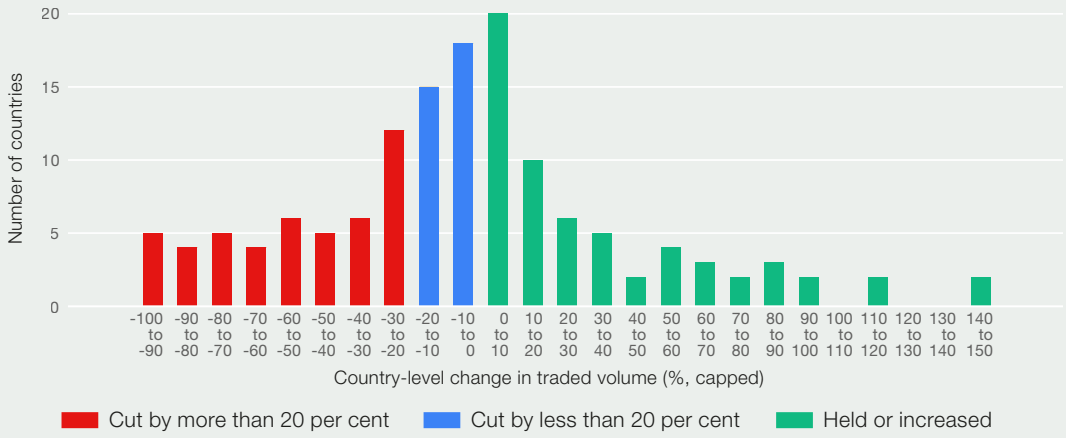
Aggregate trade: traded volume vs. implied price, 2019–2025
Nitrogenous fertilizer only, per calendar year, global panel



Sources: FAOSTAT; World Bank Commodity Markets Outlook.

FIGURE 6

Country-level change in nitrogen fertilizer import volume, 2021–2022



Source: FAOSTAT; World Bank Commodity Markets Outlook; United Nations Comtrade bilateral trade data.

FERTILIZER SUPPLY IS HIGHLY CONCENTRATED, SO A SHOCK IN ONE REGION CAN HAVE DIRECT AND STRONG IMPACTS GLOBALLY

Fertilizer production is heavily concentrated in just a handful of countries – just four countries produce 70 per cent of the world's phosphate rock, and four produce 76 per cent of its potash. Taken at the global level the median country relies on a single source for 85.1 per cent of its phosphate imports. This creates very high supply chain disruption risk.

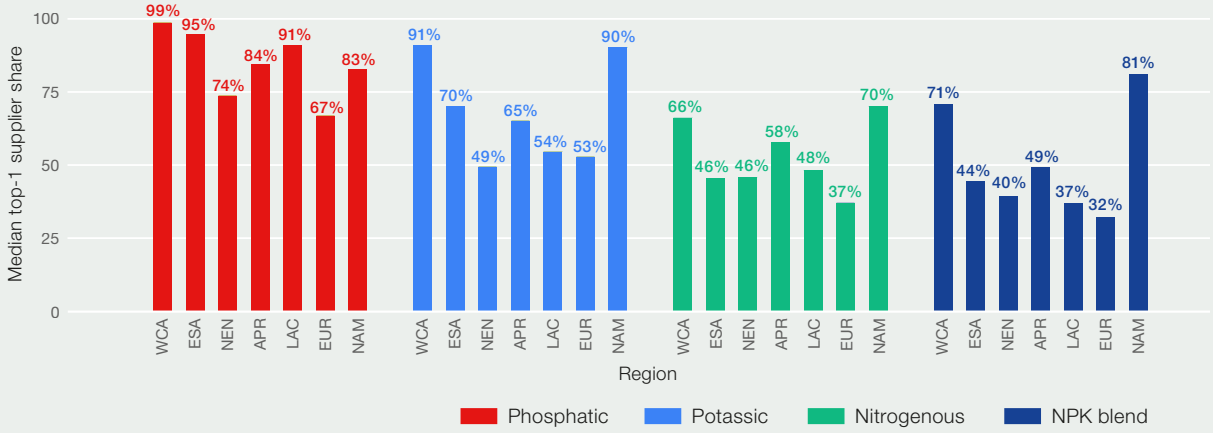
FERTILIZER SUPPLIER CONCENTRATION

85.1%
A typical country's phosphate imports come from one supplier

13%
Countries 90%+ reliant on one nitrogen supplier

4+4
Countries produce 70% of phosphate rock and 76% of potash

FIGURE 7 Fertilizer supplier concentration by nutrient and region: median top-1 supplier share of import value



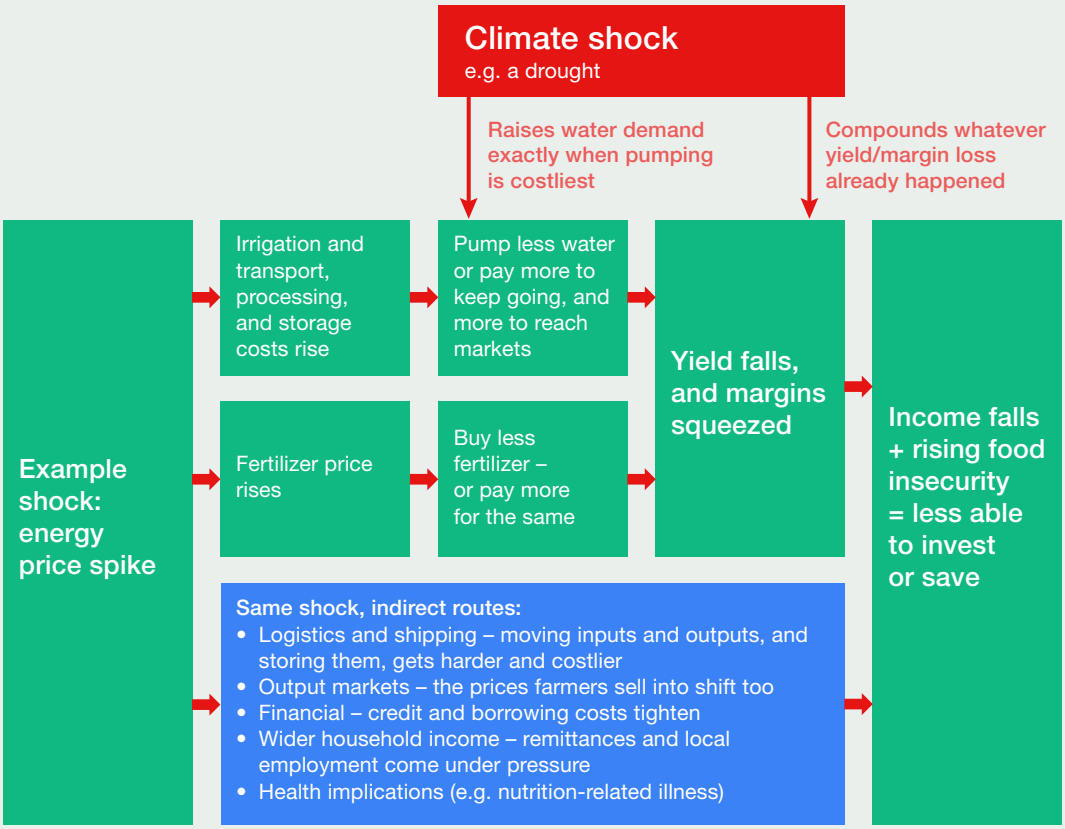
Notes: WCA = West and Central Africa; ESA = East and Southern Africa; NEN = Near East, North Africa, Europe and Central Asia; APR = Asia and the Pacific; LAC = Latin America and the Caribbean; EUR = Europe; NAM = North America. NPK = nitrogen (N), phosphorus (P), and potassium (K).

Sources: United Nations Comtrade bilateral trade data. Phosphate/potash production shares: United States Geological Survey Mineral Commodity Summaries, 2025–2026. The median is calculated across countries: it shows how many countries face this level of supplier concentration, not what share of people is affected.

INPUT SHOCKS SPREAD THROUGH MULTIPLE PATHWAYS, WHILE CLIMATE SHOCKS AMPLIFY THEIR EFFECTS

When climate shocks coincide with an input shock, direct on-farm losses increase. For example, when a drought coincides with an oil price increase, water demand rises just as pumping oil becomes more expensive. Indirect effects unfold at the same time: logistics and shipping costs increase, output markets shift, credit conditions may tighten and even remittance flows may decline. The scale of impacts depends less on any single pathway than on how these pressures interact. Climate resilience of small-scale producers and food systems is closely tied to input prices: where input and climate shocks compound, small-scale farmers face a high risk of crop failure, with strong implications for food and nutrition security.

FIGURE 8 The cascade: an energy price spike travels through direct and indirect pathways to squeeze margins and household income at once



Source: IFAD original analysis.



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02 THE COST OF COMPOUNDING SHOCKS, 2026-2027

In 2026, small-scale producers face a global energy and fertilizer price shock, compounding active droughts and a potentially record-strength El Niño all inside a single planting season

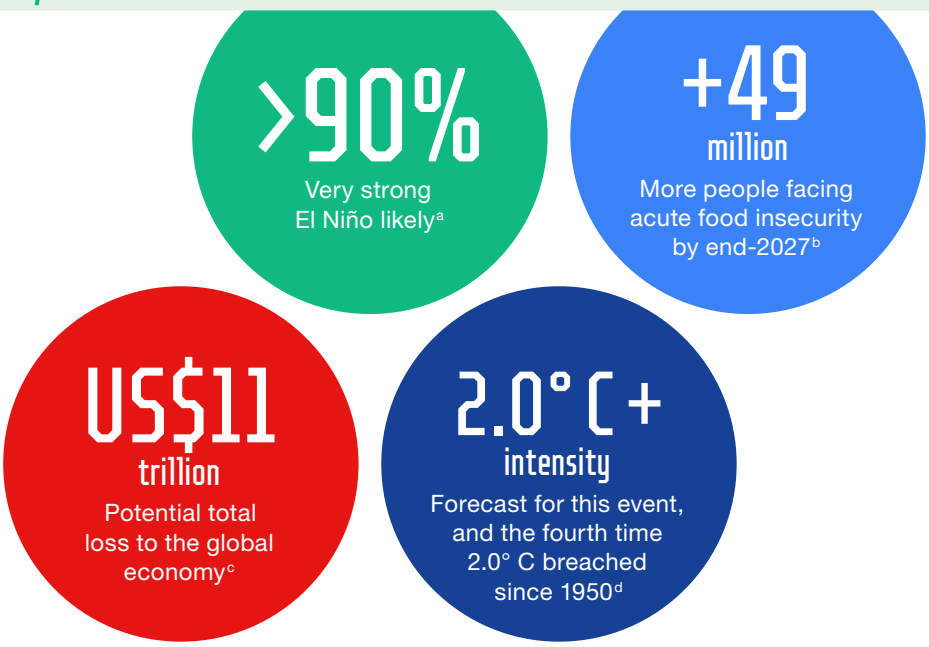
IFAD ANALYSIS SUGGESTS THIS EL NIÑO WILL HAVE SUBSTANTIAL AND LONG-LASTING ECONOMIC CONSEQUENCES, COSTING THE GLOBAL ECONOMY AN ESTIMATED US$11 TRILLION

El Niño is the warm phase of a natural Pacific cycle that shifts global rainfall and temperatures, raising drought risk in some regions and flood or storm risk in others. Events recur every two to seven years and usually last nine to twelve months, often spanning more than one growing season. The 2026/2027 event is expected to peak between October 2026 and January 2027, with impacts on producers likely to continue through 2027 and beyond.[2]

This event is especially concerning for three reasons: (i) it induces temperature increases to a planet that is already warming; (ii) it follows the 2026 Strait of Hormuz-driven energy price spike; and (iii) it lands most heavily on households already under climate stress. For example: while recovering, the Zambezi River basin remains in drought after weak 2024/2025 rains; while Zambia's bumper 3.7 million tonne maize harvest offers a buffer in one country, it does not do so across the basin (Zambia Ministry of Agriculture, May 2025); and continental Europe experienced one of its most severe droughts in recent decades, with France's 2026 maize crop its smallest in around 50 years (Copernicus/Joint Research Centre; General Association of Maize Producers [AGPM]/Reuters).

[2] As of September 2026.

2026/2027 EL NIÑO AT A GLANCE



Notes: [a] United States National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center, August 2026.
[b] World Food Programme (WFP).
[c] IFAD analysis. See Annex B for more details.
[d] joining 1982/1983, 1997/1998 and 2015/2016.

Source: IFAD analysis scaling published economic research on past El Niño events (Callahan and Mankin, 2023) using NOAA's central forecast for this event.

IFAD estimates that this El Niño event could cost the global economy US$11 trillion. The estimate combines the direct impacts on the agricultural economies affected, the impacts on infrastructure and wider economies, and the ripple effects as these compound around the world through food and commodity prices and cumulative impacts on demand and trade. See Annex B for more information on El Niño impacts and how this cost estimate was calculated.

EL NIÑO WILL REACH SMALL-SCALE PRODUCERS THROUGH MORE THAN FAILED RAINS, AND ITS SQUEEZE ON PRICES AND INCOMES WILL OUTLAST THE 2027 HARVEST

For a small-scale producer household, the damage arrives by several routes at once. For example, drought can cut yields while raising the need to irrigate just as hydropower falters: India's hydropower output fell 21 per cent as the June 2026 monsoon ran 40 per cent below normal (Bloomberg). Floods and storms affect the road to market for inputs and produce alike: the 2015/2016 event destroyed 4,793 km of roads and 433 bridges in Peru by late 2017 (World Bank). Reduced water levels in the Panama Canal have already led to a cap in transits in 2026, slowing international trade and continuing a pattern of pronounced El Niño impacts seen previously.

These shocks do not fall evenly within a household or a community. Women, who often have less secure land rights and less access to credit and farm-level support services, and young people, who are more likely to be landless or renting, typically have fewer resources to draw on when a shock hits. And other vulnerable groups can face compounding barriers to accessing the inputs, markets and finance that would otherwise help them recover. Even farms that have already diversified into both crops and livestock are not automatically protected, since both can be exposed to the same input-cost shock at once.

FIGURE 9 Expected impacts from El Niño



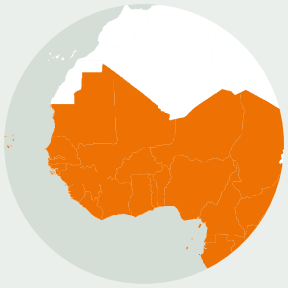
Horn of Africa

FORECAST

Below-normal rain June–September in the north and wetter short rains October–December in the south/east.

EXPECTED IMPACT

Drought stress hits the north first; southern rains raise flood and landslide risk even as they replenish pasture.



West Africa/Sahel

FORECAST

Agricultural drought, Senegal through Nigeria into Ethiopia and Sudan, on a lower-confidence forecast.

EXPECTED IMPACT

During major El Niño events, suppressed rains caused localized rainfall deficits of 20% to 35% across the Sahelian belt. This correlates directly with 15% to 30% yield reductions in key staple rainfed crops like millet, sorghum and maize.



Southern Africa

FORECAST

>50% probability of agricultural drought between October 2026 and March 2027 (Botswana, Namibia, South Africa, Zambia and Zimbabwe).

EXPECTED IMPACT

Maize yield losses; reduced pasture and water cut assets and food and nutrition security for pastoralists.



Central America

(Dry Corridor)

FORECAST

70% probability of below-normal rainfall region-wide, plus extreme heat.

EXPECTED IMPACT

Maize and bean yields cut up to 60% and 80% historically, the most exposed subregion in Latin America (+83.1% food insecurity projected by WFP).

South America

(hydro-exposed)

FORECAST

Mixed rainfall signal, but a likely cut to river and reservoir inflows.

EXPECTED IMPACT

Hydropower supplies 43.2% of regional electricity, the highest of any region, exposing both power and irrigation.



South and South-East Asia

FORECAST

Weakened summer monsoon: India's June 2026 rainfall ~40% below normal.

EXPECTED IMPACT

Rice most exposed: 2015/2016 cut regional output by 15 million tonnes, Philippines –11%; cotton, soybean and wheat also hit.



Australia and the Pacific

FORECAST

AUSTRALIA: raised odds of hotter, drier conditions in the east and north.

PACIFIC: drought across Micronesia and Melanesia vs. wetter signal in parts of Polynesia (Samoa and Tuvalu) and Kiribati.

EXPECTED IMPACT

2002–2003: wheat production fell from 24 million to 13.5 million tonnes, winter crops -40%; farm GDP falls ~13% in El Niño years on average.

PACIFIC: Vanuatu declared stage 1 drought July 2026 (336,000 people affected), Fiji in "very-high-concern" tier for October–December rainfall.

DURING THE 2015/2016 EVENT: Fiji sugarcane harvest –40% (~US$50 million loss); Papua New Guinea (PNG) drought/ frost affected 2.4 million people, 1.3 million severely.



Sources: World Meteorological Organization (WMO); Famine Early Warning Systems Network; FAO; WFP; World Bank; Bloomberg; National Australia Bank; International Federation of Red Cross and Red Crescent Societies/ PrepareCenter, August 2026; United Nations Office for the Coordination of Humanitarian Affairs–FAO–WFP–WMO Snapshot, 28 August 2026; FAO-PNG project brief.

The impact of El Niño varies substantially across regions globally. Most food-producing regions are geographically situated in areas forecast to be most heavily impacted by El Niño. **FIGURE 9** provides a global overview of typical climate shifts for regions and some indicative impacts.

Building resilience to El Niño and other global shocks calls for solutions across inputs, markets and finance alike.

On the inputs side, the starting point is preserving and making better use of the water already available, including through water-harvesting and conservation infrastructure, together with irrigation systems that can be programmed and timed in response to a reduced or less predictable rainy season. Where the risk runs the other way, towards excessive rain and flooding, the same logic points to water-control infrastructure instead: drainage, embankments and flood-tolerant seed, so a wetter season becomes manageable rather than destructive. Access to seasonal weather forecasts also shapes these choices directly: where farmers receive drought forecasts ahead of planting, they tend to shift towards drought-tolerant crops and make greater use of drought-tolerant seed than those without that information. Similarly, diversifying fertilizer sources, including organic and bio-fertilizer alternatives, limits exposure to current price shocks, and solar-powered irrigation is increasingly viable as a further, longer-term way to secure water access without adding to fuel costs that are already elevated.

Markets depend on access remaining open, despite flooding, snowfall and drought. Flood-resilient road design and flash-flood early warning systems let communities act before a market route is cut, giving them time to move goods, livestock or people ahead of the water rather than after it. Regional cooperation and diversified supply chains offer the same protection at a larger scale, reducing exposure to any single shipping route or corridor.

Finance underpins both. Savings tools, insurance and credit availability all matter here, alongside direct financing where buffers are thinnest. A growing body of cost-effectiveness evidence can guide investment towards interventions that deliver the strongest impact. Index insurance, in particular, has shown clear value: by paying out against a weather trigger rather than an assessed loss, it protects the investment a household has already made in seed, fertilizer or irrigation tools, so a bad season does not wipe out the following one's starting capital.



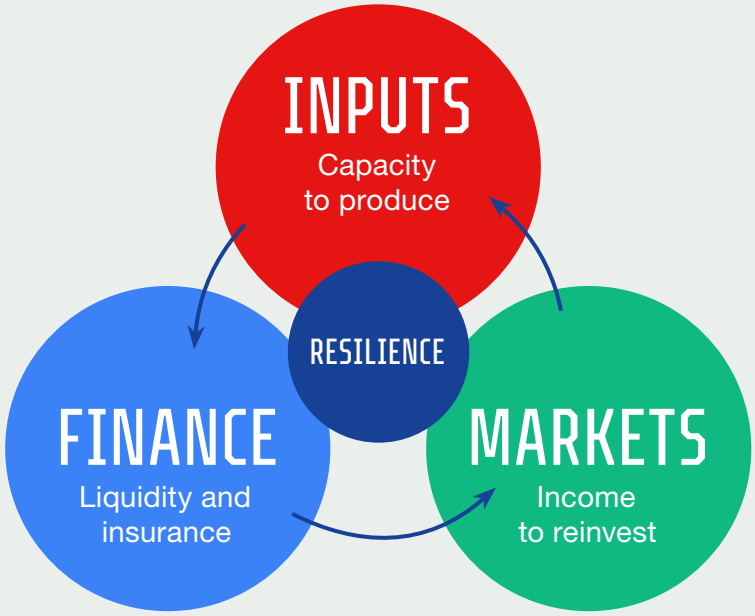
03 BUNDLED RESILIENCE, AN ANSWER TO MULTIPLE SHOCKS

A systemic shock needs a bundled response: inputs, markets and finance working together

Across food systems, resilience depends on three interlinked pillars working together (i.e. bundled), rather than on any one in isolation. This precondition matters more as shocks compound: while specific actions, such as drought-indexed insurance, solar-powered irrigation or local fertilizer production directly protect farmers, this can break down under multiple compounding shocks arriving at once. Ensuring that inputs, markets and finance are interlinked creates the conditions that limit the vulnerability of households. The pillars work on different parts of the problem, so their effects largely add together rather than overlap, and a household with all three is protected on more fronts at once. A small-scale producer with two pillars is better positioned than one with none, but remains more exposed to future shocks than a household supported by all three. Single-pillar or isolated interventions may raise incomes but often leave the underlying resilience gap unresolved.

Crucially, these pillars operate at local, national and international levels and it is essential they are supported by effective governance to ensure they connect across the food system to maximize impact.

FIGURE 10 Diagrammatic representation showing the relationship between inputs, markets and finance with resilience



INPUTS

The inputs pillar is not just about making more fertilizer, seed, energy or water available. It is about lowering exposure to concentrated and price-sensitive supply chains while keeping production capacity intact when shocks occur. This means combining efficient nutrient use, locally available organic and bio-based alternatives, stress-tolerant seed, water-smart technologies and advisory services that enable farmers to adjust before losses become irreversible.

Building local capacity to produce inputs such as fertilizer and bio-based alternatives reduces smallholders' exposure to global supply shocks directly, de-linking them from concentrated international markets rather than binding existing supply chains more tightly together. On its own, this pillar protects production; when bundled with markets and finance, it also becomes investable and commercially viable, closing the feedback loop.

FINANCE

The finance pillar gives small-scale producers the capacity to act before, during and after shocks. Credit, savings, insurance, grants and risk-sharing instruments help farmers invest in resilient production, avoid distress sales, recover more quickly and keep supplying markets when conditions deteriorate. Finance is most effective when it is tied to real production and market opportunities: loans are more useful when farmers can access both appropriate inputs for stronger yields and markets to capitalize on production. This in turn increases the power of savings mechanisms and reduces insurance premiums, increasing financial buffers for future cycles.

Bundled finance therefore converts resilience from a technical objective into a practical ability to invest, manage risk and remain commercially active through disruption. Reaching this potential requires attention to both sides of the market: strengthening the supply of rural financial services, and addressing the demand-side barriers, such as limited financial literacy, documentation and collateral, that often keep smallholders from accessing them.

MARKETS

The markets pillar turns production resilience into system resilience. Farmers can absorb shocks more effectively when they are connected to reliable buyers, storage, processing, transport and price information, and when value chains continue to function during disruption. Market access matters because resilience is not only about producing through a shock, but also about selling, storing and moving food in ways that protect incomes and local food economies.

In a bundled approach, market linkages create the demand and price signals that justify investment or transition to better sustainable inputs, while finance gives farmers and agribusinesses the liquidity to participate in those markets. Cooperatives and farmers' organizations are often central to this: aggregated purchasing, collective bargaining and shared storage or processing, as seen in Kenya's community-managed warehouses and Burkina Faso's value-chain organizations (see more below), give individual producers a stronger market position than they could reach alone.

Five IFAD-financed projects illustrate the same pattern: while specific interventions drive improved outcomes, bundling was the condition that led to resilience impact at scale.

KENYA: BUNDLING TRAINING WITH DROUGHT INSURANCE ENABLES FARMERS TO RECOVER FROM DROUGHTS

PROJECT

The **Kenya Cereal Enhancement Programme – Climate-Resilient Agricultural Livelihoods Window (KCEP-CRAL)** aimed to reduce rural poverty and food insecurity among smallholders in Kenya's arid and semi-arid lands by developing their economic potential, and improving their natural resource management capacity and resilience to climate change in an increasingly fragile ecosystem.



©IFAD/Manuel Casanova Crespo

PILLAR	MECHANISM
INPUTS	A graduated e-voucher co-payment scheme for seeds, fertilizer and bio-fertilizers was introduced: farmers started at 10 per cent of cost, rising to 40 per cent. The same 557 agro-dealers selling the inputs were accredited as merchants and/or bank agents for two financial institutions, putting input access and financial access at the same counter. Training in micro-dosing and agroforestry lifted the vegetation index, a measure of vegetation cover, from 62.2 per cent to 74.0 per cent.
FINANCE	The same e-voucher wallet carried parametric area yield index insurance (AYII), reaching 109,750 farmers alongside the mandatory seed and fertilizer wallets. Insurance later became optional while seeds and fertilizer stayed mandatory. A total of 59,110 farmers received a pay-out between 2020 and 2023, spanning Kenya's longest drought on record (2020–2022).
MARKETS	A total of 616 farmer clusters were formed and linked via memoranda of understanding to bulk grain buyers – millers, exporters and WFP – for collective marketing. Forty community warehouses were built or upgraded, of which only 11 were certified for the warehouse receipt system.

Source: IFAD, KCEP-CRAL project completion report (PCR), 2026.

How it was bundled. The specific driver was a single digital e-voucher platform, delivered through 557 accredited agro-dealers who doubled as bank agents, which let farmers access seeds, fertilizer and insurance pay-outs at the same counter. Bundling was the condition that made the platform work as intended: input subsidies and AYII insurance ran on the same wallet, so a pay-out could be converted into inputs immediately rather than routed through a separate financial step.

The result. Participants reached a resilience index score of 48.6 per cent, more than double the 23.2 per cent[3] recorded in the control group. Separately, 59,110 farmers received an AYII pay-out of US$1.32 million over 2020–2023, spanning the 2020–2022 drought, the country's longest on record.

[3] This is a composite index used in the programme's own monitoring framework, combining several dimensions such as asset ownership, income diversification and access to services into a single score. It is a programme-level measure, distinct from this report's own modelling.

BANGLADESH: MAKING CREDIT CONDITIONAL ON SOLAR IRRIGATION AND FOOD-SAFETY CERTIFICATION CONCURRENTLY CUT PRODUCTION COSTS AND OPENED UP PREMIUM MARKETS

PROJECT

The **Rural Microenterprise Transformation Project (RMTP)** aimed to sustainably grow selected rural value chains with real market potential, lifting the incomes, food security and nutrition of marginal and small-scale farmers, and the micro-entrepreneurs linked to them, through combined support to value-chain development, financial services and institutional strengthening.



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PILLAR	MECHANISM
INPUTS	Solar-powered irrigation replaced diesel pumps on off-grid char lands, cutting pumping-related energy consumption by 35 per cent. Vermicomposting training and agroecological methods such as multilayer cropping cut input costs 10 per cent and lifted yields 75 per cent for more than 45,000 farmers.
FINANCE	A total of 258,758 households accessed rural financial services through partner organizations. Average loan sizes rose 72 per cent, aimed at growth rather than mere survival.
MARKETS	A total of 1,796 producer organizations entered into formal partnerships with buyers. A certification developed by the Good Agricultural Practices for Bangladesh Livestock Sector and a national good agricultural practices-based livestock organization gave producers a structured route to food-safety compliance and market access, with supermarket chains offering premium pricing for certified products.

Source: IFAD, RMTP PCR, 2026.

How it was bundled. Solar power cut production costs by replacing diesel, and the bundling contribution was in connecting that saving to markets and finance: partner organizations linked the pillars through a single model, where non-financial services, training, advisory and market facilitation built a pipeline of viable borrowers, de-risking and strengthening lending, while certification opened separate premium-pricing routes to market rather than lowering costs further. The silage value chain shows this end-to-end: more than 16,000 maize farmers now supply over 45,000 livestock farmers through 186 commercial enterprises, with financing enabling the model to scale up.

The result. Sales grew 167 per cent and profits 41 per cent among project-financed microenterprises, against initial targets of 30 per cent and 20 per cent. Household incomes rose 49.9 per cent among RMTP participants over the project, against 22.4 per cent for a comparable control group, and participants were 32 per cent more likely than non-participants to recover from a shock.

INDONESIA: GROWING FARMERS' GROUPS BEFORE INTRODUCING SAVINGS AND CREDIT SCHEMES ENABLED INDONESIAN FARMERS TO CONVERT TRAINING INTO INCOME

PROJECT

The **Rural Empowerment and Agricultural Development Scaling-up Initiative (READSI)** worked to raise the prosperity of smallholder farming families by equipping rural households with the skills and resources to sustainably grow their farm and non-farm incomes.



©IFAD/Jefri Tarigan

PILLAR	MECHANISM
INPUTS	Farmer field schools trained 53,594 farmers in climate-resilient practices, including organic soil management, composting, drip irrigation, plastic mulching and diversified cocoa agroforestry. Bio-input training in compost and botanical pesticides reached 566 farmers, with at least eight groups scaling compost production for sale to others. Demonstration plots and high-quality seedling nurseries showed good practices in the field, while 17 community centres anchored organic fertilizer training.
FINANCE	READSI deliberately delayed partnering with financial literacy and savings and credit groups until farmers' groups were functioning well. Subsequently, savings and loan groups reached 8,269 individuals across about half of all farmers' groups, and machinery matching grants requiring a 30 per cent farmers' group contribution unlocked access to machinery.
MARKETS	Building on this technical base, a public–private partnership with Mars trained young farmers as paid "Cocoa Doctor" service providers through four weeks of agronomy and two of business training at the Mars Academy, with a digitized module and post-training mentoring. Partnerships with East-West, PT Sang Hyang Sri and PT Harmony strengthened horticultural and rice seed supply, while groups developed bulk marketing of members' produce.

Source: IFAD, READSI PCR, 2025.

How it was bundled. The sequencing was deliberate: farmers' groups formed and strengthened production training and market integration first, and only once they proved to be working well did READSI introduce savings and credit groups with matching grants for scaling through mechanization.

The result. Overall, 82.5 per cent of households met the rural-financial-services target and 75.3 per cent reported an income increase from project-supported crops. More broadly, 76.4 per cent of beneficiaries reported any income increase, against 10.95 per cent of non-participants. Organic composting also reduced dependence on chemical fertilizer, protecting farmers from some input price shocks.

TÜRKİYE: PAIRING MATCHING GRANTS WITH SOLAR-POWERED IRRIGATION CUT WATER AND ENERGY COSTS TOGETHER

PROJECT

The **Göksu-Taşeli Watershed Development Project (GTWDP)** aimed to reduce rural poverty in its target area through economic diversification, raising farmers' incomes from improved agricultural production and marketing while strengthening their resilience to climate shocks and promoting sustainable management of shared natural resources.



©IFAD/Ramazan Demir

PILLAR	MECHANISM
INPUTS	Solar-powered drip irrigation implementation and greenhouses and orchard establishment tackled water and energy costs together. Project participants reported their technology use rising 74.8 per cent and electricity costs falling 39.7 per cent for adopters, strengthening protection against future input-cost shocks.
FINANCE	Matching grants, cofinanced by farmers, funded the solar-drip systems and processing kit directly, tying finance tightly to inputs rather than offering it as a stand-alone product. Grant recipients were ten times more likely to own processing facilities than non-recipients (7.3 per cent vs 0.7 per cent), showing finance enabled adoption of the technology and infrastructure the wider package was built around.
MARKETS	A total of 21 producer organizations were formed, and 13 new market-related facilities built or upgraded now handle processing, storage and collection for members. Market infrastructure alone was not enough: producers still needed productive assets and finance to use it fully. Grant programmes lifted market access by 6.4 percentage points above where it would otherwise have been.

Source: IFAD, GTWDP PCR, 2026.

How it was bundled. Matching grants tied finance tightly to inputs. They closed the upfront capital-cost gap for solar-drip systems and processing kit. The underlying economics of switching from diesel to solar were already favourable, and the grant let farmers take that step sooner. That pairing worked, as technology adoption and incomes both rose sharply.

The result. A total of 24,807 households were reached. Self-reported average incomes rose 41 per cent and productivity rose 51 per cent, and grant recipients were also far more likely to sell directly in the market and own processing facilities than non-recipients. When measured against a matched control group, however, the income effect was smaller, at 32.8 per cent, and did not reach statistical significance.

BURKINA FASO: PAIRING BETTER INPUTS WITH STRONGER MARKET ACCESS DROVE LARGE YIELD AND INCOME GAINS

PROJECT

The **Agricultural Value Chains Promotion Project (PAPFA)** set out to improve food security and farm incomes in the rice, market-gardening, sesame and cowpea value chains, by easing access to inputs, equipment and extension advice, strengthening rural infrastructure, and helping producer organizations and rural microenterprises reach markets more easily.



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PILLAR	MECHANISM
INPUTS	Facilitated access to high-quality inputs, machinery and agricultural advice across the rice, market-gardening, sesame and cowpea sectors, alongside the rehabilitation and new development of 2,240 hectares (ha) of small-scale irrigation schemes. Yields rose across all four value chains (lowland rice from 1.5 to 3.7 tonnes/ha, rainfed rice from 0.9 to 2.7 tonnes/ha), and 98 per cent of households reported a production increase.
FINANCE	Enabled rural microenterprises to buy equipment and build working capital, and connected some producers to formal savings, credit and financial training schemes. A total of 2,672 microenterprises received business-development services, and 1,176 people in rural areas gained access to formal financial services.
MARKETS	Strengthened value-chain organizations and rural microenterprises, rehabilitated 97 kilometres of feeder roads, built or upgraded 99 storage warehouses, and supported the national agricultural market information system, which collects and disseminates prices across markets enabling farmers to compare them before selling. Processed and marketed output rose 49.5 per cent and 70 per cent of producer organizations signed formal market partnerships, creating 2,865 jobs.

Source: IFAD, PAPFA Project Completion Report (PCR) 2024

How it was bundled. Better inputs raised how much farmers could grow, but that surplus only became income once it could be stored, moved to market and sold at a known price. PAPFA invested in storage, roads and market information alongside the production, so the market side was ready to absorb the gains from the input side.

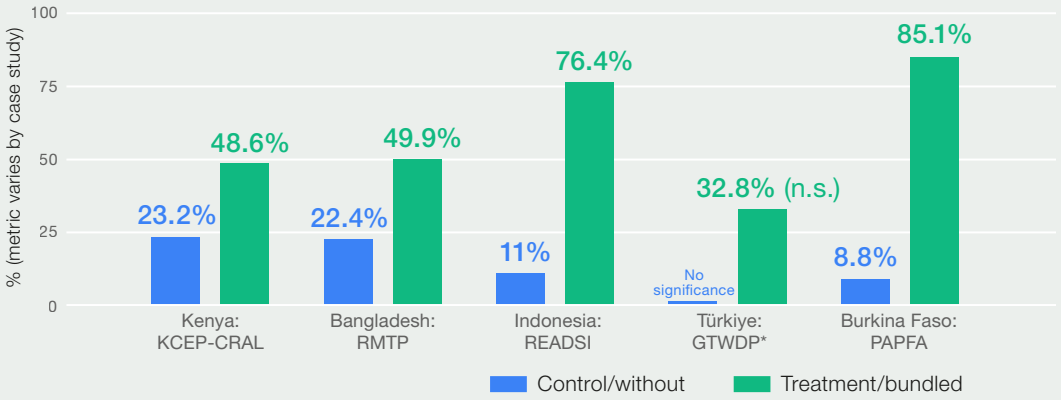
The result. Overall, 97.4 per cent of households reported an income increase, and 74 per cent[4] reported a rise of at least 30 per cent. Production and market access both improved substantially over the project (98 per cent of households reported higher production; 81 per cent reported better physical access to markets), consistent with the two reinforcing each other. 85.1 per cent of households adopted recommended climate-risk-management techniques, against 8.8 per cent in the non-intervention zone.

[4] This figure is drawn from the project's results framework (share of beneficiaries achieving at least a 30 per cent income increase), which differs from the household self-reported figure elsewhere in the PCR (60.7 per cent); both relate to the same underlying outcome but are measured differently.

WHAT CLOSING THE LOOP ACHIEVED

Closing the inputs–markets–finance loop generated substantial, measurable resilience gains across the case studies. **FIGURE 11** shows the scale of these gains. Although each case study uses a different outcome metric and comparator, the pattern is consistent: bundled intervention treatments produced markedly stronger resilience than controls.

FIGURE 11 Outcome without vs. with bundled inputs-markets-finance interventions for each case study



Note: Evaluation designs and rigour vary across projects. The figures reflect each project's own reported result, not a standardized comparison.
*Türkiye's figure is from a PSM-ATET (Propensity Score Matched) estimate against a no-intervention control and is insignificant.

Sources: IFAD project completion and impact assessment reports.



04 WHAT BUNDLING IS WORTH

IFAD modelling shows that bundling avoids 18.7 per cent of net farm income losses in a year of shocks, roughly twice the impact of the strongest single pillar approaches

To put a number on value addition of bundling, this report builds a stylized, illustrative model of a representative smallholder farm's response to a compounding 2026 shock. The Twelfth Replenishment of IFAD's Resources (IFAD12) Impact Assessment report found that all assessed projects with transformational income gains bundled finance or infrastructure with training and market linkages; the model below illustrates why the same logic holds under shock conditions.

The model uses literature-derived assumptions about how a representative smallholder farm, modelled using maize as an example crop, responds to price and cost changes: the farm pays for inputs and sells the resulting crop.

The shock is built up in stages:

- Fertilizer and energy prices spike – fertilizer prices had already been rising since May 2024 – reducing the inputs the farm can afford and raising its costs;
- This is then partly cushioned by higher global staple prices, though only part of that gain reaches the farm gate;
- A drought is then introduced on top of the price shock, cutting yields and amplifying the impact of the reduced input use. Droughts this severe do not hit every year, but when they coincide with a price shock, most of the resulting damage comes from the drought, not the price move.

The model is illustrative rather than a forecast: the same shock lands differently across farmers depending on scale, crop mix and existing exposure, so this model illustrates one representative case, not every farmer.

HOW SHOCKS CAN COMPOUND

-23%
A price shock alone would reduce net farm income by 23 per cent with no crop-price cushion

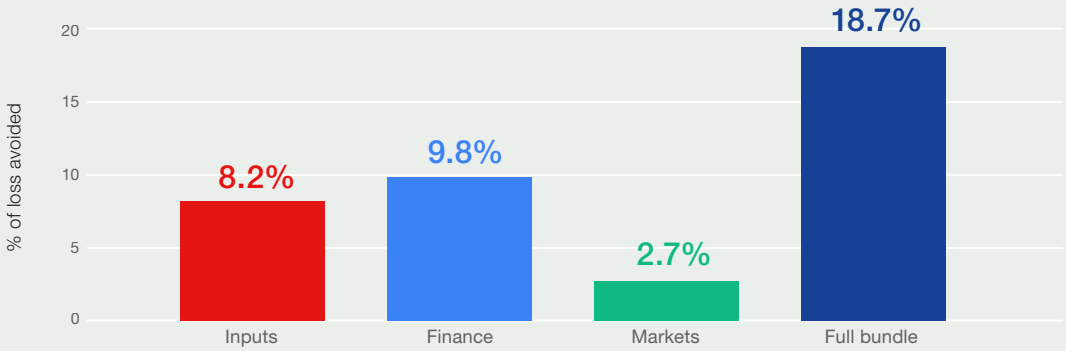
-9%
This is reduced to –9 per cent once this year's crop-price rise cushions the blow

-62%
However, it can drop to –62 per cent once a severe drought hits in the same year. This highlights the risk posed by El Niño.

Each lever acts on a different point in the chain from shock to net farm income.

FIGURE 12

Share of the no-intervention net farm income loss avoided, by lever and by the full bundle



Source: IFAD original analysis (the resilience model). Full methodology and parameters in the annexes.

Inputs. Inputs are the only lever that moves yield directly: they cut reliance on the imported fertilizer and energy that the price spike has hit. This reduces the yield loss from 24.8 per cent to 23.9 per cent, a modest but direct effect, avoiding 8.2 per cent of the income loss alone.

Finance. A real area yield index insurance product, with a coverage trigger, uptake rate and premium calibrated to Kenya's KCEP-CRAL, pays out on realized yield shortfalls. Finance is the strongest single lever: it avoids 9.8 per cent of the loss alone.

Markets. Markets move price, not yield: improved market access raises how much of a favourable global price move reaches the farm gate – Türkiye's own 6.4 percentage-point gap closure is an illustration of this.[5] Markets avoid a modest 2.7 per cent of the loss alone but add more when paired with Inputs and/or Finance.

Bundled interventions. Resilience only holds if all three levers stay connected. The full bundle avoids 18.7 per cent of net farm income losses, roughly double the best single lever. Each lever acts on a different point in the chain – Inputs on exposure, Markets on price pass-through, Finance on the realized shortfall – so the three effects largely add together, which is why bundling captures most of what each lever achieves alone. See Annex C for detailed breakdown of the modelling.

[5] The 6.4 percentage-point figure is a market-participation statistic from the GTWDP PCR (the share of grant-group households selling into the market, against none in the control group), used in the modelling exercise as a market-access closure parameter. Comparable market-access interventions elsewhere, for example in Indonesia with READSI, have shown larger effects, meaning the model's estimates of impact are conservative.



05 FROM EVIDENCE TO ACTION

The evidence in this report points to a simple conclusion: when shocks compound, responses must connect

Smallholders do not experience higher input costs, drought, constrained finance and disrupted markets as separate problems. These pressures interact, with one shock reducing their capacity to absorb the next. Development interventions designed around individual sectors or risks can therefore leave critical points of vulnerability exposed.

The five IFAD projects examined above show what a different approach can look like. Across diverse contexts, inputs, markets and finance reinforce one another when they are intentionally linked, whether through insurance connected to input systems in Kenya, finance tied to resilient technologies and market standards in Bangladesh, or production investments connected to storage, infrastructure and market access in Burkina Faso. This report's modelling reinforces this principle: the illustrative full bundle avoids 18.7 per cent of net farm income losses under the modelled compound shock, compared with 9.8 per cent for the strongest individual lever.

For development practitioners, this points to five priorities:

1 DESIGN FOR INTERACTING RISKS, NOT INDIVIDUAL SHOCKS

Assess how climate, input, energy, finance and market risks reinforce one another before selecting interventions.

2 BUNDLE AROUND THE CONSTRAINT FACING THE FARMER

Connect resilient inputs and technologies with the finance needed to adopt them and the markets needed to make investment worthwhile.

3 BUILD FLEXIBILITY INTO DELIVERY

Instruments should be capable of responding when shocks occur within a production cycle, rather than relying solely on predetermined sequences of support.

4 STRENGTHEN LOCAL RESILIENCE TO GLOBAL VOLATILITY

Prioritize efficient input use, locally available alternatives, water-smart technologies, functioning value chains and financial buffers that reduce exposure to concentrated and price-sensitive supply chains. As recent price shocks have shown, these are not only environmental priorities: they are also a matter of economic security for rural economies and the food systems that depend on them.

5 MEASURE THE BUNDLE, NOT ONLY ITS COMPONENTS

Evaluate whether interventions collectively protect production, incomes and the capacity to recover, rather than measuring each activity in isolation.

The practical challenge is therefore not simply to invest more in resilience interventions, but to connect investments more deliberately and increase impact from the limited resources available through bundling. This bundling is itself underpinned by governance at the community level, which shapes whether these connections hold in practice. This task is made harder by a wider financing environment in which official development assistance continues to decline, raising the stakes for mobilizing additional finance for every public dollar spent and deploying it towards resilience.

**As shocks become increasingly interconnected,
development practice must become interconnected too.**

ANNEX A: THE COUNTRY-LEVEL FERTILIZER AND DROUGHT EXPOSURE ANALYSIS

The underlying panel

The fertilizer and drought evidence in this report is built from a single country-year panel, combining fertilizer cost and trade data (FAOSTAT and United Nations Comtrade), commodity prices (World Bank Commodity Markets Outlook), drought exposure (the Food and Agriculture Organization of the United Nations [FAO] Agricultural Stress Index [ASI]), and national accounts data (World Bank), covering all countries with usable data across these sources.

Fertilizer cost-share exposure

The measure behind the compound-exposure evidence is each country's fertilizer cost as a share of the value of its crop production. This is calculated as a baseline pre-shock level, a 2017–2019 average, rather than from a single year or as a year-on-year change, so that the measure reflects a country's underlying structural exposure rather than one year's noise in survey-based fertilizer-use data or crop revenue. Fertilizer cost is priced using a single global reference price applied uniformly to every country, so cross-country differences in the measure come from how fertilizer-intensive a country's agriculture is relative to its crop revenue, not from differences in the price countries pay.

FERTILIZER COST-SHARE = FERTILIZER COST (GLOBAL REFERENCE PRICE) ÷ VALUE OF CROP PRODUCTION, 2017-2019 AVERAGE

- Countries where crop production is a negligible share of GDP (the bottom tenth of countries by this measure) are excluded, since the underlying ratio is unreliable where agriculture is economically marginal.
- The exposure measure is restricted to net fertilizer importers: a country that is a net exporter is not counted as price-shock exposed, even if its own cost-share happens to be high, since that reflects producer-side economics rather than importer vulnerability.

Double-exposed classification

A country is classified as double-exposed where it sits in the top third of the eligible population on both fertilizer cost-share and drought exposure (net fertilizer importers only).

Drought exposure is measured using the FAO-ASI.

DOUBLE-EXPOSED = TOP-TERCILE FERTILIZER COST-SHARE AND TOP-TERCILE DROUGHT EXPOSURE, AMONG GDP-ELIGIBLE NET FERTILIZER IMPORTERS

Fertilizer supplier concentration

The supplier-concentration evidence, the typical country's reliance on its single largest supplier for phosphate, nitrogen and potassium fertilizers, and the supplier-concentration chart broken down by nutrient and region, is built from United Nations Comtrade bilateral trade data. For each importing country and each nutrient category, the share of that country's import value coming from its single largest supplier is calculated; the chart shows the regional median of this figure, by nutrient, for the latest available year, while the headline figures cited in the main text (85.1 per cent for phosphate; 13 per cent of countries more than 90 per cent reliant on a single nitrogen supplier) are read from the same country-level figures directly, without the regional grouping. The separate production-concentration figure (four countries supplying 70 per cent of world phosphate rock output, and four supplying 76 per cent of potash output) comes from United States Geological Survey Mineral Commodity Summaries, to identify how much of world supply sits with the largest few producing countries.

SUPPLIER CONCENTRATION (COUNTRY, NUTRIENT) = VALUE OF IMPORTS FROM THE SINGLE LARGEST SUPPLIER ÷ TOTAL IMPORT VALUE

Distribution of the 2022 shock

The distribution evidence, how unevenly the 2022 fertilizer shock was absorbed across countries, uses FAOSTAT and United Nations Comtrade fertilizer trade volumes, comparing each country's import volume in 2022 against 2021. The typical country's percentage change, and the share of countries with a fall of more than 20 per cent, are both calculated across all countries with usable trade-volume data for both years, split out separately for low-income countries specifically. 2026 trade data are not yet available on the same basis, so the report treats the 2022 pattern as indicative rather than as a direct read on the current shock.

CHANGE IN IMPORT VOLUME = (2022 VOLUME − 2021 VOLUME) ÷ 2021 VOLUME

ANNEX B: THE EL NIÑO IMPACT

Using published estimates for past El Niño events and their economic impact, together with the National Oceanic and Atmospheric Administration (NOAA) August 2026 intensity outlook, a scaling exercise indicates that the 2026/2027 event could be associated with approximately US$11 trillion of lost global income in 2026 prices, measured over a core impact window running from the year of direct impact through the following five years. This is an order-of-magnitude scenario, not a forecast, and it excludes any separate allowance for the pre-existing Strait of Hormuz-related energy and fertilizer shock covered elsewhere in this report.

Method

The published research finds that the 1982/1983 and 1997–1998 El Niño events reduced global income by the amounts below, in 2017 United States dollars. These have been restated in Q2 2026 prices using the United States GDP implicit price deflator (2017 = 100; Q2 2026 = 133.805):

EVENT	PEAK INTENSITY	PUBLISHED LOSS (2017 US$)	RESTATED (2026 US$)
1982/1983	2.2° C	US$4.1 trillion	US$5.5 trillion
1997/1998	2.4° C	US$5.7 trillion	US$7.6 trillion
2023/2024*	2.1° C	US$3.0 trillion	US$4.0 trillion

* The 2023/2024 figure was an ex-ante projection associated with the earlier research, rather than a realized historical estimate.

An ordinary least squares regression fitted across these three data points, in 2026 prices, gives:

MULTI-YEAR GLOBAL INCOME LOSS (US$ TRILLION) = −20.8 + 11.9 × PEAK EL NIÑO INTENSITY (° C)

NOAA's August 2026 outlook gives a median peak intensity of 2.66° C for October to December 2026. Applying that value to the fitted relationship produces the illustrative estimate of US$10.8 trillion, rounded to US$11 trillion in the main report. NOAA's central 70 per cent intensity range, 2.37° C to 2.95° C, maps to an illustrative range of approximately US$7.4 trillion to US$14.2 trillion.

The five-year impact window follows the distributed-lag model used in the underlying research, which covers the event year and the following five years. For a late-2026/early-2027 event, the equivalent window runs from the first economic effects in 2026/2027 through to approximately 2031–2032.

Limitations

- The estimate rests on only three observations and assumes a linear relationship between event intensity and multi-year income loss.
- It applies the broad global pattern of impact observed in past events to today's world – a strong assumption, since the size, sectoral composition and geographic distribution of the global economy have changed, as have countries' trade links, debt positions and exposure to food and energy imports; the location and timing of climate impacts in 2026/2027 may also differ from previous events.
- The intensity of the 2026/2027 event remains uncertain. NOAA's central forecast is used here as a scenario input rather than a known outcome, so the illustrative range reflects forecast uncertainty in peak intensity but does not capture all of the underlying economic uncertainty.
- The historical inputs use NOAA's Oceanic Niño Index (ONI), while NOAA's current operational forecast uses a related but not identical measure, the Relative Oceanic Niño Index (RONI).
- The calculation does not separately quantify the Hormuz-related energy and fertilizer shock, which could increase and/or redistribute the losses estimated here.

ANNEX C: THE RESILIENCE MODEL

Bundling three resilience interventions (inputs, markets and finance) together protects a farm on more fronts than deploying any one alone:

- Net farm income: under a 2026-scale shock, an unsupported farm loses an estimated 62 per cent of a normal year's net income in a year when a drought also hits. Without the drought, a price shock alone – with no offsetting rise in crop prices – would cost around 23 per cent; this year's rising crop prices cushion that to around 9 per cent.
- Adding:
  - Inputs alone cuts the loss to 57 per cent, avoiding around 8 per cent of the loss.
  - Markets alone cuts it to 60 per cent, avoiding around 2.7 per cent of the loss on its own. It only has a shock to work against when there is a favourable global price move to capture.
  - Finance alone cuts it to 56 per cent, avoiding around 9.8 per cent of the loss on its own – the strongest single lever in the model – rising to 16 per cent paired with Inputs.
  - Combining all three completes the bundle, cutting the loss to 50 per cent, avoiding close to a fifth (18.7 per cent) of the loss altogether – nearly double what any single lever achieves on its own.
- Yield: Inputs support cuts the yield loss slightly, from an estimated 24.8 per cent to 23.9 per cent.
- Bundled interventions protect net farm income more than they protect yields, because farm margins are thin, so whatever protection is gained upstream is amplified into a much larger effect on net farm income.
  - That matters beyond this year alone: protecting net farm income protects a farm's ability to reinvest in next season's seeds, inputs and equipment, rather than eating into savings or assets just to get through the year.
  - Because many farms in a region under shock face the same squeeze at once, protecting net farm income at the farm level also protects the wider local economy: less distress-selling of assets, less pullback in local spending, and a faster recovery.

What this model shows

This model traces how fertilizer and energy price shocks reach an individual smallholder farm's profit, alongside a climate shock such as drought, and how much of the resulting damage is offset when different resilience interventions are in play, alone or bundled together. It is an illustrative tool built to show the shape and scale of what bundling adds, not a forecast of a precise number for any specific country or farmer. Real smallholder farms vary widely, so where a parameter is shown as a range, the central value represents a typical, middle-of-the-road farm within that variation, not a single precise estimate meant to fit every farm. Parameters are drawn from published economics research wherever an estimate exists; where none exists, the model uses a clearly flagged, evidence-informed assumption instead.

The model in brief

Farm profit is what is left after selling the harvest and paying cash costs:

$$\text{PROFIT} = \text{YIELD} \times \text{PRICE} - \text{COSTS}$$

"Profit" here means net farm income actually available to the household after costs, not a payout of any kind. Where finance, through credit or insurance, is modelled as protecting profit, that means it protects the household's overall net income position during the shock; an insurance payout itself is not counted as profit in the model, but the economic effect it has, cushioning the fall in net income, is what the finance parameter represents.

A price shock moves all three components of this equation at once. The model is built from three elasticities, each describing the percentage response of one variable to a percentage change in another:

- A price elasticity of demand: how much fertilizer or energy use falls for a given rise in its price.
- A yield elasticity: how much yield falls for a given cut in fertilizer or energy use.
- A margin elasticity: how a percentage shock to revenue, with costs held where they are, translates into a percentage shock to profit.

Netting the first two together, plus the change in the price a farm receives for its harvest, gives the shock to revenue minus costs. The margin elasticity is the largest of the three, and the step that turns a moderate commodity shock into a large profit shock:

$$\text{SHOCK TO PROFIT} \approx \text{MARGIN ELASTICITY} \times (\text{SHOCK TO REVENUE} - \text{SHOCK TO COSTS})$$

Profit is a residual, not a fixed share of revenue: because it is only a moderate share of revenue in smallholder cereal farming (around 40 per cent at this model's central parameters), the same percentage swing in revenue-minus-costs becomes a larger percentage swing in what is actually left over as profit once costs are netted off. On a farm earning 100 in revenue against 60 in costs – a profit of 40 – a 10 per cent fall in revenue, with costs unchanged, takes profit from 40 to roughly 30, a 25 per cent profit loss from a 10 per cent underlying shock: an elasticity of 2.5. Real farms range from higher-margin operations, with an elasticity closer to 1.5, to especially thin-margin ones, closer to 4.0. So 2.5 represents a typical, middle-of-the-road farm in between, consistent with the margin structures reported in the literature. Drought adds to this chain rather than sitting apart from it: it both cuts yield directly and makes the price shock's own yield effect worse.

Resilience intervention mechanisms

Each of the three resilience pillars works on a different elasticity, or a different point in the chain. They are designed as three separate, additive interventions, not three versions of the same lever.

- Inputs (e.g. solar-fed irrigation, locally blended fertilizer, etc.) shrink the price shock a farm is exposed to in the first place, by substituting towards inputs that are not priced on the volatile global market. Because this happens before the yield and cost effects are calculated, it reduces both together, automatically. Inputs act on the shock itself, upstream of everything else.
- Finance: area yield index insurance (AYII is a real insurance product, not an assumed offset. Farmers who hold a policy are covered once the area's yield falls more than 20 percentage points below what was expected (an 80 per cent coverage trigger); a shortfall beyond that point pays out in full, scaled by how many farmers actually hold a policy (52 per cent uptake), and a premium is paid regardless of whether a payout occurs. In Kenya, this is calibrated to the Cereal Enhancement Programme – Climate-Resilient Agricultural Livelihoods Window (KCEP-CRAL). Finance acts on the realized shortfall in yield, once it crosses the coverage threshold.
- Markets (e.g. buyer contracts, market information, storage and transport, etc.) raise how much of a favourable global output price move reaches the farm's own selling price. Local prices typically move by only a fraction of a global swing – roughly a third based on Food and Agriculture Organization of the United Nations (FAO) and World Bank price data – and market interventions close part of that gap. Markets act on price pass-through, and so only matter when there is a global price move to capture.

Because these three levers act on three different points in the chain, they do not cancel or crowd out what the others are already doing when combined. The combined effect is very slightly less than the sum of the three levers' individual effects – 18.7 per cent avoided from the full bundle against 20.7 per cent if the three levers were simply added up – a feature of how the shocks interact mathematically, not one lever cancelling another out. Inputs support carries extra weight in a drought year specifically because it shrinks the price shock a farm is exposed to before drought gets a chance to amplify it, so its value rises slightly whenever drought and a price shock coincide.

How drought compounds the shock

Drought does two separate things to a farm's yield, not one. First, it adds its own yield penalty, largely independent of prices: a bad rainy season cuts the harvest whether or not fertilizer is expensive that year. Second, it makes the price shock itself bite harder: a farm already under water stress cannot compensate for a fertilizer or energy cutback the way it could in a normal year, so the same price-driven reduction in input use costs more yield during a drought than it would otherwise.

The model's shocks

The model uses the scale of the actual 2026 shock on fertilizer, energy and food prices as its inputs, rather than an assumed figure. These are trough-to-peak increases over the run-up to the 2026 price spike: the fertilizer blend index rose 92.4 per cent from its trough in May 2024 to its peak in April 2026 (a conservative estimate of the scale of the shock, as urea rose 200.9 per cent over the same time period); the energy index rose 77 per cent from its trough in December 2025 to its peak in April 2026. At the farm gate, this model uses a central fertilizer price rise of 42 per cent and an energy price rise of 46 per cent, moderated down from the global commodity-price moves by an assumed farm-gate pass-through, with ranges of 18 per cent to 66 per cent and 20 per cent to 72 per cent respectively. Global staple crop prices are taken to rise 16 per cent over their own trough-to-peak window (August 2025 to April 2026), which is what softens the shock in the terms-of-trade scenario below.

RESULTS

SCENARIO 1: input costs and drought hit, and output prices stay flat. This isolates the cost-side and climate squeeze from any change in what a farm can sell its crop for, giving a clean read on what Inputs and Finance support are doing on their own.

SCENARIO	YIELD LOST	PROFIT LOST VS. A NORMAL YEAR	SHARE OF THE LOSS AVOIDED
No support	25%	75%	0% (reference case)
Inputs support only	24%	70%	7%
Finance support only	25%	69%	8%
Markets support only	25%	75%	0% (no price move to capture here)
Full bundle (all three)	24%	66%	13%
Price shock only, no drought (no support)	4%	23%	Not applicable

SCENARIO 2: input costs and drought hit, and global food prices also rise, as they have in 2026. This is the scenario the report leads with, since it reflects what farmers are actually facing this year.

SCENARIO	YIELD LOST	PROFIT LOST VS. A NORMAL YEAR	SHARE OF THE LOSS AVOIDED
No support	25%	62%	0% (reference case)
Inputs support only	24%	57%	8.2%
Finance support only	25%	56%	9.8%
Markets support only	25%	60%	2.7%
Full bundle (all three)	24%	50%	18.7%
Price shock only, no drought (no support)	4%	9%	Not applicable

These figures describe an illustrative farm rather than an observed one. Most of the parameters behind them are assumptions, set out with their ranges in the parameter table below.

How sensitive is the headline number?

The headline result, that the full bundle avoids 18.7 per cent of the loss against 20.7 per cent if the three levers were simply added up, was stress-tested by pushing every underlying assumption to the edge of its plausible range, one at a time and then all together. Pushed to the most cautious end across the board, the bundle still avoids 10.8 per cent of the loss; pushed the other way, it could avoid just over three-quarters, 76.2 per cent. One assumption barely moves the headline number at all: the 2.5 profit multiplier discussed above has essentially no effect on this figure across its full plausible range. It changes how large the loss looks in profit terms, but not how much of that loss the bundle avoids relative to no support at all, which is the number this report leads with.

ANNEX D: PARAMETERS, ESTIMATES AND SOURCES

Every parameter is either a coefficient taken from a specific published estimate, derived from project data via an explicit calculation, or a clearly flagged evidence-informed assumption where no direct estimate exists.

PARAMETER	WHAT IT IS	CENTRAL VALUE	HOW ESTIMATED
Fertilizer demand elasticity	How much fertilizer use falls for a 1% price rise	–0.40	Published estimate (Assefa, Berhane, Abate & Abay, 2025)
Energy demand elasticity	How much energy or irrigation use falls for a 1% price rise	–0.175	Midpoint of three published irrigation-price studies (China, India and Mexico)
Yield elasticity	How much yield falls for a 1% cut in fertilizer or energy use	0.15	Derived from published nitrogen response data (Assefa et al., 2025); the same elasticity is applied to energy-driven cuts as a modelling simplification, since no separate energy-specific yield-response estimate was available
Margin elasticity	How much profit moves for a 1% change in revenue minus costs	2.5	Standard farm-economics arithmetic (elasticity ≈ 1/profit margin) applied to a typical smallholder cereal farm's ~40% margin; real farms range from 1.5 (higher-margin) to 4 (thin-margin), so this is a middle-of-the-road figure rather than a directly estimated coefficient (Sheahan & Barrett, 2017; Burke, Snapp & Jayne, 2020). Margins on smallholder cereal farms vary widely and are often thinner than 40%; a thinner margin produces a larger loss.
Drought yield penalty	Added yield loss in a drought year, independent of prices	–20 percentage points	Evidence-informed, bracketed by a global drought-event average (Kim, Iizumi & Nishimori, 2019), a severe-drought synthesis (Daryanto et al., 2016), and anchored regionally by Letswamotse et al. (2024, South Africa)
Drought compounding factor	How much drought amplifies the price-driven yield loss	0.30	Evidence-informed: agronomic trials show water stress reduces the yield response to fertilizer, though no single study reports this exact figure
Fertilizer price shock	Rise in fertilizer prices reaching the farm gate	42%	World Bank Commodity Markets Outlook fertilizer blend index, trough (May 2024) to peak (April 2026), +92.4%, moderated by an assumed farm-gate pass-through; range 18%–66%
Energy price shock	Rise in energy prices reaching the farm gate	46%	World Bank Commodity Markets Outlook energy blend, trough (December 2025) to peak (April 2026), +77%, moderated by an assumed farm-gate pass-through; range 20%–72%
Global food price shock	Rise in global staple (wheat/maize/rice) prices	16%	World Bank Commodity Markets Outlook, trough (August 2025) to peak (April 2026), averaged across wheat, maize and rice; a shorter, more recent window than the 2019–2026 comparison, which understates the price move within this episode

PARAMETER	WHAT IT IS	CENTRAL VALUE	HOW ESTIMATED
Fertilizer cost share	Fertilizer cash cost as a share of baseline revenue	12%	Evidence-informed: Rice & Vos (2024, International Food Policy Research Institute [IFPRI]) give fertilizer at 10%–20% of maize production costs (Kenya), 30%–35% (South Africa); a typical, moderately commercialized farm at 20% of production costs converts to 12% of revenue
Energy cost share	Energy cash cost as a share of baseline revenue	6%	Stylized, weakly evidence-informed: no source gives a clean, denominator-matched direct-energy share for this reference farm; a typical farm is modelled as a blend of rainfed and part-irrigated (10% of variable costs), converting to 6% of revenue
Price pass-through	Share of a global output price move reaching the farm gate	34%	Food and Agriculture Organization of the United Nations (FAO) and World Bank price data, 2022 peak
Inputs' exposure reduction	How much inputs support shrinks exposure to the global price shock	20%	Stylized but evidence-informed: Van Asseldonk, Onumah & Lensink (2021, Zambia) and Berhane et al. (2020, Ethiopia)
Finance coverage trigger	Share of expected yield below which a payout is triggered	80%	Calibrated to Kenya's national area yield index insurance product design and the Kenya Cereal Enhancement Programme – Climate-Resilient Agricultural Livelihoods Window (KCEP-CRAL) project completion report (PCR) (IFAD)
Finance uptake rate	Share of farmers in the area holding an area yield index insurance (AYII) policy	52%	Calibrated to Kenya's national area yield index insurance product design and the KCEP-CRAL PCR (IFAD)
Finance premium rate	Premium paid per policy, regardless of whether a payout occurs	18%	Calibrated to Kenya's national area yield index insurance product design and the KCEP-CRAL PCR (IFAD)
Markets' pass-through gain	How much markets support closes the gap to full price pass-through	6.4%	Türkiye Göksu-Taşeli Watershed Development Project (GTWDP) project evidence: 6.4 percentage points of households in the grant group sold into the market, against none in the control group. This is a market-participation statistic used here as a market-access closure parameter, distinct from the price pass-through rate above. Comparable market-access interventions in Indonesia (Rural Empowerment and Agricultural Development Scaling-up Initiative (READSI)) and Uganda (Vargas Hill et al., 2020/2021, Agricultural and Resource Economics Review) show larger effects, corroborating the upper end of this parameter's range (up to 30 per cent) even though the central, directly sourced estimate here is conservative.

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