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El Niño - Understanding the World's Most Powerful Climate Phenomenon

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Abstract

El Niño, the most powerful interannual climate phenomenon, arises from warming of sea surface temperatures in the central and eastern Pacific, disrupting trade winds and atmospheric circulation through the Bjerknes feedback. This reorganisation of global weather leads to weakened monsoons and droughts in South Asia, floods in South America, bushfires in Australia, and altered storm tracks in Europe and North America. Historically, El Niño has caused devastating famines, notably the Great Famine of 1876–78 in India, with Telangana at its epicentre. Subsequent strong events in 1982–83, 1997–98, 2002, 2009, 2015–16, and 2023 repeatedly reduced crop yields and triggered food inflation. Forecasts for 2026 indicate belownormal monsoon rainfall, threatening kharif crops and rural livelihoods. Climate change intensifies El Niño's severity, compounding risks to food security. Preparedness measures and agronomic strategies such as droughttolerant varieties, contingency planning, conservation agriculture, and microirrigation are essential to safeguard agriculture and livelihoods.

1. Introduction: El Niño - A Climate Giant

Nearly 150 years ago, one of the deadliest events in human history unfolded silently: the Great Famine of 1876–78. Crops withered, rivers ran dry, and an estimated 55 lakh to 62 lakh people perished across India, from the Deccan Plateau to Telangana, within just two years. The culprit? A prolonged monsoon failure triggered by a powerful El Niño event. Today, as we enter 2026, scientists around the world are sounding the alarm again. The Super El Niño shadow is looming, and with it comes an uneasy question: are we prepared this time?

1.1. What is el niño?

El Niño is a naturally occurring climate pattern associated with warming of the tropical Pacific Ocean's surface temperatures. The name, meaning 'The Little Boy' or 'The Christ Child' in Spanish, was originally used by South American fishermen who noticed warm ocean waters arriving around Christmas. Today, it is recognised as one of the most powerful climate forces on Earth.

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1.2. Normal and el niño conditions

ENSO cycles through three phases: El Niño (warm), La Niña (cool), and Neutral. Each phase reshapes global weather across continents, making ENSO the most important inter-annual climate signal on Earth.

2. The Science Behind El Niño

2.1. Ocean-atmosphere feedback

El Niño arises from a self-reinforcing feedback between the Pacific Ocean and the atmosphere above it, which scientists call the 'Bjerknes feedback,' named after Norwegian meteorologist Jacob Bjerknes who first described the mechanism in the 1960s.

Table 1: Different scenarios of trade winds

Condition	Trade winds	Pacific SST	Asia/India monsoon	South America
Normal	Strong (East to West)	Warm West, Cool East	Normal to above-normal	Dry coast, cold upwelling
El Niño	Weak or Reversed	Warm East Pacific	Weakened, below-normal	Heavy rains, flooding
La Niña (opposite)	Stronger than normal	Cooler than normal	Enhanced, above-normal	Extreme drought

Here is how the cycle unfolds, step by step:

➢ Step 1-Warming Signal: Sea Surface Temperatures (SSTs) in the central-eastern Pacific begin to rise due to slight weakening of trade winds.

➢ Step 2-Wind Response: The warmer ocean surface warms the overlying air, reducing atmospheric pressure. This further weakens trade winds, creating a positive feedback loop.

➢ Step 3-Thermocline Deepens: As warm water spreads eastward, the boundary between warm surface water and cold deep water (the thermocline) sinks deeper, preventing cold water from upwelling.

➢ Step 4-Atmosphere Reorganises: The Walker Circulation, a massive east-west loop of rising and sinking air over the tropics, weakens and shifts. This ripples outward, affecting weather from California to Kenya to Telangana.

Key Metric — Niño 3.4 Index: Scientists monitor the average sea surface temperature anomaly in the Niño 3.4 region (5N-5S, 120W-170W). An El Niño is declared when this index exceeds +0.5 degrees Celsius for five consecutive overlapping three-month periods. Strong events exceed +1.5 degrees Celsius; Super El Niños exceed +2 degree C.

2.2. Global weather impacts

El Niño acts like a 'teleconnector'; events in the equatorial Pacific send shockwaves to weather systems thousands of kilometres away:

Table 2: El Niño Impact on different regions across the globe

Region	El Niño Impact
India & South Asia	Weakened Southwest Monsoon, drought, heatwaves, below-normal kharif rainfall
Australia	Severe drought, increased bushfire risk, reduced agricultural output
East Africa	Increased rainfall and flooding in some areas; drought in others
North America	Warmer winters in northern USA/Canada; wetter winters in southern USA
South America	Extreme rainfall and flooding in Peru/ Ecuador; drought in Amazon/Brazil
Southeast Asia	Drought and forest fires; reduced rice production in Thailand, Indonesia
Europe	Milder winters in parts of Northern Europe; altered storm tracks

2.3. El niño and climate change, an alarming nexus

While El Niño is a natural phenomenon documented for centuries, climate scientists have raised urgent concern about its interaction with human-caused global warming:

• NASA's GISTEMP data confirmed March 2026 as one of the hottest months ever recorded globally, approximately 1.27 degrees Celsius above the 1951-1980 baseline, a grim backdrop for an emerging El Niño.

• More frequent and intense El Niño events are projected under higher emissions scenarios, threatening global food security repeatedly.

• The 'compound risk', El Niño + climate change + fragile agricultural systems, is the defining food challenge of our era.

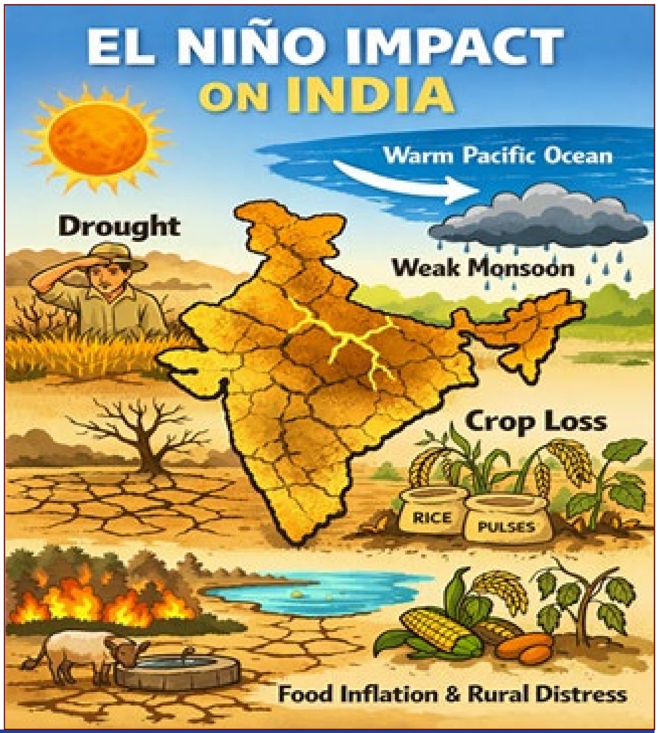

Figure 1: Image showing El Niño impact on India

3. Historical Impact: El Niño and India's Great Famines

3.1. The great famine of 1876-78, el niño's deadliest legacy

The 1877-78 El Niño event has been described by scientists as 'arguably the worst environmental disaster ever to befall humanity.' It was the strongest El Niño in recorded history - primed by an extended cool phase in the Pacific (1870-76) that stored enormous oceanic energy, then released catastrophically.

3.2. Telangana: at the epicentre of el niño famine

Present-day Telangana, then part of the Madras Presidency and the princely state of Hyderabad, bore the full brunt of the 1876-78 famine. Districts such as Nalgonda, Karimnagar, Warangal, and Nagarkurnool witnessed mass starvation, massive cattle deaths, and the collapse of irrigation tank systems that had sustained farming for generations.

• By 1877, the monsoon had failed two consecutive years over the Deccan Plateau, destroying rice, jowar, and pulse crops.

• Irrigation tanks and lakes like the Ramappa Lake helped buffer the famine's impact but could not sustain the scale of drought for multiple years.

Table 3: History of El Niño

Parameter	Details
El Niño Intensity	Strongest on record (1877-78)
Niño 3.4 Anomaly	Record-breaking; preceded by the strongest La Niña of 1875-76
Affected regions	India (Deccan, Madras, Bombay, Hyderabad), China, Brazil, Africa
Indian monsoon deficit	1876: -1.5 SD; 1877: -1.8 SD (all-India rainfall)
Famine deaths in India	5.6 to 9.6 million (estimates up to 10 million)
Global deaths	More than 50 million across Asia, Africa, and Latin America
Soil moisture deficit	48% of India experienced drought in September 1877

• Districts in Telangana received only 47.6 cm of rain by 1876, falling further to 44.4 cm in the peak famine year, nearly 46% below the long-period average of 37.02 cm recorded in 1877.

• Colonial British administrators were slow to act, and despite abundant grain stores, food continued to be exported, compounding suffering.

• Florence Nightingale wrote to London newspapers condemning the colonial government's neglect; harrowing photographs of skeletal survivors from the Madras Presidency and Bombay circulated internationally.

Telangana's Advantage Then and Now: Historical accounts note that Telangana's tank irrigation network — including large water bodies like the Ramappa Lake — helped soften the blow of famine compared to drier regions. Tribal and rural communities survived by subsisting on water, leaves, and wild dates for 11 days at a time. Today, Telangana's Mission Kakatiya and Mission Bhagiratha schemes restore this historical resilience.

3.3. Subsequent major el niño impact on india: a historical perspective

Historically, El Niño events have often been associated with weakened monsoon circulation and below-normal rainfall over India, although the relationship is not uniform for every event. The historical record shows that the intensity and regional impacts of El Niño depend strongly on other climate factors, particularly the Indian Ocean Dipole (IOD) and Indian Ocean sea-surface temperatures.

Table 4: El Niño impact on India

Year	El Niño Strength	India Monsoon Deficit	Key Impact
1982-83	Strong	-19% below normal	Drought in Maharashtra, AP; foodgrain output fell
1997-98	Super El Nino	-19% below normal	Severe drought, water crisis, crop failures
2002	Moderate-Strong	-19% below normal	Most severe drought since 1987, all crops hit
2009	Moderate	-23% below normal	Worst monsoon failure in 37 years; rice prices spiked
2015-16	Super El Nino	-14% (86% of LPA)	Drought-like conditions in 10 states; kharif damaged
2023	Strong	Uneven distribution	Rural income decline, food inflation rose to 8.66%

4. Current Scenario: The Emerging El Niño of 2026

4.1. Status as of June 2026

As of June 2026, ENSO has transitioned from a La Niña phase (2025-26) into a neutral phase, with rapidly rising subsurface ocean heat content in the equatorial central Pacific. The conditions are strongly reminiscent of the build-up phases that preceded major El Niño events.

NOAA Forecast (2026): NOAA's 2026 ENSO Diagnostic Discussion states a 61-70% probability of El Niño developing between June and August 2026, with the event persisting through year-end. IMD has already lowered its seasonal monsoon forecast and noted 'below-normal' rainfall expectations for India's 2026 kharif season.

4.2. India monsoon 2026, el niño's shadow

• Southwest Monsoon onset over Kerala was officially declared on 4 June 2026, three days delayed from the typical 1 June arrival.

• India experienced 60% below-normal rainfall in January-February 2026 combined with record heatwaves across Punjab, Haryana, Delhi, Rajasthan, UP, MP, Bihar, and Odisha.

• IMD lowered the 2026 Long Range Forecast for the southwest monsoon to below-normal due to the developing El Niño, with the Indian Ocean Dipole (IOD) expected to remain neutral, meaning no compensating positive IOD to soften the blow.

• The worst suppression of monsoon rainfall is typically expected in August and September, directly hitting standing Kharif crops before harvest, particularly in Central, Northwest, and Peninsular India.

• Telangana, Andhra Pradesh, Maharashtra, Karnataka, and Gujarat, the core monsoon zone, face the highest risk.

4.3. Agricultural impact: crops at risk

India's food system is uniquely vulnerable to c. Over 50% of the country's farmed land is rainfed. The summer monsoon (June-September) delivers 80% of total annual rainfall and coincides with the entire Kharif growing season. Agriculture contributes 18% of GDP and supports nearly half of India's workforce.

Historical data from ICRA and IMD estimates:

Table 5: Vulnerability of major crops to El Niño

Crop	Vulnerability	Key states at risk	Mechanism of impact
Rice	Very high	Telangana, AP, WB, Punjab	Transplanting delayed; tiller formation affected
Pulses (Tur, Moong)	Very high	Maharashtra, MP, Karnataka	Moisture stress at flowering stage
Oilseeds (Soybean, Groundnut)	High	MP, Rajasthan, Gujarat, AP	Moisture deficit at pod filling
Sugarcane	Moderate-high	UP, Maharashtra, Karnataka	Reduced ratoon yield; drought stress
Jowar/Bajra (Millets)	Moderate	Telangana, Rajasthan	Somewhat drought-tolerant but yield reduces
Cotton	Moderate	Telangana, Gujarat, AP	Boll formation affected under moisture stress

During the 2015-16 Super El Niño, rice production in India decreased by an average of 3.4 million tonnes (7%). El Niño causes yield reductions across 22-24% of global harvested area (Iizumi et al., 2014). If monsoon conditions remain weak in 2026, food inflation (CPI) may rise to 4.5-5.0% in FY27 (ICRA estimate).

4.4. Economic ripple effects

El Niño is not just a weather event; it is an economic crisis mechanism with multiple transmission channels:

◦ **Channel 1 - Heat Stress:** Long and punishing summers reduce outdoor working hours, cutting productivity for millions of daily wage workers, street vendors, construction workers, and agricultural labourers who depend on outdoor work.

◦ **Channel 2 - Price Shock:** Food prices are volatile and directly sensitive to climate. El Niño magnifies price spikes in rice, pulses, vegetables, and edible oils commodities that form the core of household budgets for India's 800 million poorer citizens.

◦ **Channel 3 - Rural Demand Collapse:** When crops fail and farmer incomes fall, rural demand for consumer goods, two-wheelers, tractors, and agrochemicals contracts sharply, affecting the entire economy from FMCG companies to automobile manufacturers.

◦ **Channel 4 - Global Commodity Prices:** Australia (wheat), Indonesia (rice, palm oil), and Brazil (coffee, soybeans) also suffer under El Niño, pushing up global commodity prices that India imports, worsening domestic inflation further.

5. Mitigation, Adaptation, and the Path Forward

5.1. Agronomic adaptation strategies

At the farm level, science offers practical solutions that can reduce El Niño vulnerability significantly:

• Shift to drought-tolerant varieties: Varieties like DRR Dhan 42 (rice), Pusa-22 (wheat), and ICPH 2671 (pigeonpea) show 15-20% better yields under moisture stress.

• Contingency crop planning: In regions where rainfall is expected to be deficient, replacing long-duration rice with DSR and aerobic rice cultivation saves 20% of water use and 10-15 days early maturity. Rice fields cannot simply be converted into dryland fields, as soil type, topography, irrigation infrastructure, and water-holding capacity differ.

• Conservation agriculture practices: Zero-tillage mulching is particularly effective during the *Rabi* season, and residue retention can improve soil moisture retention by 25-30%, extending the growing window during dry spells. Additional moisture conservation practices include broad-bed and furrow (BBF) systems, ridge-and-furrow planting, and rainwater harvesting, etc.

• Micro-irrigation expansion: Drip and sprinkler systems can reduce water consumption by 30-50% while maintaining near-normal yields even under 20-30% rainfall deficits.

• Carbon farming and soil health: Improving soil organic carbon (SOC) by 1% can increase the soil's water-holding capacity by approximately 3.7 litres per cubic metre, a critical El Niño buffer relevant to Telangana's black soils.

5.2. Policy recommendations

• Integrate ENSO forecasts into state-level crop planning calendars - farmers should receive advisories 6-8 weeks before sowing decisions.

• Expand the National Rainfed Area Authority (NRAA) mandate to develop district-level El Niño contingency plans for all 734 districts.

• Scale up Mission Kakatiya-type tank restoration programs nationally to restore traditional water harvesting resilience.

• Invest in real-time soil moisture monitoring networks; India needs at least 10,000 automated weather stations to support precision drought alerts.

• Establish a dedicated Climate Risk Insurance Pool that provides automatic payouts when IMD declares below-normal monsoon conditions, reducing delays in farmer compensation.

6. Conclusion

El Niño is not a distant curiosity but a recurring threat shaping India's agriculture, economy, and lives. From the Great Famine of 1876-78 to the Super El Niño of 2026. Today, science offers forecasts, droughttolerant crops, precision irrigation, and policy frameworks. What remains is the will to act at the farm, district, and national levels. For researchers, agronomists, and policymakers in rainfed regions like Telangana, understanding El Niño is not merely academic; it is vital to farmers' survival and resilience.

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