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El Niño–Southern Oscillation (ENSO): origins, evolution, global impacts and implications for the Indian monsoon, with an assessment of the 2026 event to 4 November 2026

A Narrative Review

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ABSTRACT

El Niño–Southern Oscillation (ENSO) is a coupled ocean–atmosphere mode of the tropical Pacific and the dominant source of seasonal-to-interannual climate predictability. This narrative review traces the historical recognition of El Niño, explains its onset, growth and decay through the Bjerknes feedback and delayed ocean-wave feedbacks, and synthesises its global teleconnections, effects on the Indian summer monsoon and tropical cyclones, benefits, destructive impacts and preparedness options. It also assesses the 2026 event using operational evidence available to 4 November 2026. In February 2026 NOAA's Climate Prediction Center (CPC) moved to the Relative Oceanic Niño Index (RONI) for official ENSO monitoring. CPC's 8 October 2026 discussion maintained an El Niño Advisory, reported September anomalies of +2.1 °C (Niño-3.4), +3.0 °C (Niño-3) and +3.9 °C (Niño-1+2), and assigned a greater than 83% chance to a strong-to-very strong event through January–March 2027 and an 83% chance that October–December RONI reaches +2.5 °C or more. India's southwest monsoon ended at 87% of the long-period average (759.4 mm against 868.6 mm), the lowest since 2015, within the range of IMD's seasonal forecasts (92 ± 5% in April; 90 ± 4% in May), with a pronounced regional contrast (about 74–76% in eastern/north-eastern India and the South Peninsula, against about 94% over the monsoon core zone). Two post-monsoon Bay of Bengal cyclones in late October–early November 2026 illustrate that El Niño modulates, but does not prevent, cyclones. ENSO is best treated as a probabilistic risk signal that supports region-specific early action rather than a deterministic prediction of any individual disaster.

Keywords: El Niño; La Niña; ENSO; Relative Oceanic Niño Index; Walker circulation; Indian summer monsoon; Indian Ocean Dipole; tropical cyclones; drought; climate risk.

Key points:

(i) NOAA's official ENSO index changed to RONI in February 2026.
(ii) The 2026 El Niño was strengthening rapidly at the evidence cut-off, with CPC giving an 83% chance of a record-strength Oct–Dec RONI.
(iii) India's 2026 monsoon was deficient (87% of LPA) but strongly heterogeneous in space and time.
(iv) Forecast probabilities are not certainties; impacts depend on local vulnerability.

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1. Introduction

The name El Niño (Spanish for "the boy child") originally described the warm coastal current that appears off Peru and Ecuador around Christmas. Modern usage refers to a basin-scale warming of the central and eastern equatorial Pacific coupled to atmospheric change [1,2]. El Niño is therefore not a storm, a cyclone or a single weather event; it is the warm phase of ENSO, a mode of variability that shifts the odds of seasonal rainfall, temperature and storm activity in distant regions.

The question of why ENSO matters in 2026 is practical as well as scientific. A rapidly strengthening event, a deficient Indian monsoon and an active post-monsoon cyclone season have coincided, and public communication has sometimes conflated forecast probability with certain outcome, or equated an El Niño with "the start of a cyclone". This review (i). summarises the history and physics of El Niño; (ii). describes global and Indian impacts, benefits and risks; (iii). documents the state of the 2026 event from official sources; and (iv). distils evidence-based preparedness measures. The objectives are explanatory; the review does not provide operational forecasts.

2. Review approach and sources

This is a narrative, not a systematic review and was not pre-registered. Foundational and review literature on ENSO dynamics, monsoon teleconnections and tropical-cyclone modulation was selected for conceptual importance and relevance to India. Current-state information was taken from primary operational sources: NOAA CPC, the World Meteorological Organization (WMO) and the India Meteorological Department (IMD). Where an IMD end-of-season figure could be located only in press reports of the IMD briefing, the report is cited and the figure is flagged for confirmation against IMD's final seasonal report. Each DOI listed in the reference list was cross-checked against publisher or indexing records in October–November 2026. Operational statements are time-stamped because they change quickly; CPC's next discussion has been scheduled for 12 November 2026, after the evidence cut-off [3].

3. ENSO: Definition, phases and monitoring indices

ENSO comprises linked variations in tropical Pacific sea-surface temperature (SST), sea-level pressure, trade winds, convection and ocean circulation. The pressure seesaw between the western and eastern tropical Pacific is the Southern Oscillation [4,5]. El Niño is the warm phase, La Niña the cold phase, and neutral conditions describe periods when neither is established (Table 1).

Table 1. Phases of ENSO and broad climatic tendencies.

Phase	Oceanic characteristics	Atmospheric characteristics	Broad tendencies
El Niño	Warmer-than-average central/eastern equatorial Pacific; thermocline deepens in the east; upwelling weakens	Easterly trade winds weaken; convection shifts east; Walker circulation weakens	Often drier Indonesia/Australia and weaker Indian monsoon tendency; wetter tendency in parts of the eastern Pacific/Americas
Neutral	No sustained basin-scale warm or cold event	Near-average Walker circulation	Other drivers and local weather dominate
La Niña	Cooler-than-average central/eastern equatorial Pacific; stronger eastern upwelling	Trade winds and Walker circulation strengthen	Often wetter Indonesia/Australia and stronger Indian monsoon tendency; regional exceptions

3.1 From ONI to the Relative Oceanic Niño Index

For decades NOAA classified events with the Oceanic Niño Index (ONI), the three-month running mean of Niño-3.4 SST anomalies (5°N–5°S, 170°W–120°W) relative to a periodically updated 30-year base period, with a requirement that the threshold be met for five overlapping seasons. Because the whole tropical ocean has warmed, the absolute Niño-3.4 anomaly overstates El Niño and understates La Niña relative to their atmospheric effects [6]. The relative Niño-3.4 index subtracts the tropical-mean (20°S–20°N) SST anomaly and rescales the result to the variance of the traditional index, which aligns it more closely with convection and rainfall [6,7]. CPC adopted the RONI for official monitoring, the ENSO Alert System and historical reclassification effective 1 February 2026, while continuing to publish the legacy Niño-3.4 and ONI files [8,9].

This change matters for interpretation. Figures quoted by different agencies (relative versus conventional Niño-3.4; different base periods) are not interchangeable, and historical comparisons are best made within a single index. Table 2 summarises the main indicators used to monitor ENSO.

Table 2. Principal ENSO monitoring indicators.

Indicator	What it measures	Use	Limitation
RONI / relative Niño-3.4	Niño-3.4 SST anomaly relative to the tropical-mean anomaly, rescaled	Official CPC classification and strength outlooks since Feb 2026 [8]	Single-region index; does not capture event diversity
ONI / conventional Niño-3.4	SST departure in central-eastern equatorial Pacific from a fixed-period climatology	Legacy index; long historical continuity	Warm bias in recent decades in a warming ocean [6]
Niño-1+2, Niño-3, Niño-4	SST anomalies in distinct Pacific sectors	Shows east–west structure and event diversity	Values not interchangeable
Southern Oscillation Index (SOI)	Standardised Tahiti–Darwin pressure difference	Tracks atmospheric pressure seesaw	Noisy on short time scales
Trade-wind and OLR anomalies	Low-level zonal wind; outgoing longwave radiation (convection)	Evidence of atmospheric coupling	Intraseasonal variability can obscure trend
Subsurface heat content	Upper-ocean temperature and thermocline depth	Precursor of growth/decay	Needs ocean observing system and model analysis

Oceanic indices should be read together with atmospheric indicators. Central-Pacific ("Modoki") and eastern-Pacific events of similar index value can drive different teleconnections [10,11].

4. Historical development and milestones

Coastal fishers in Peru and Ecuador recognised recurrent warm-water incursions long before modern meteorology; these episodes suppress nutrient-rich upwelling and disrupt fisheries. In the early twentieth century Gilbert Walker described the Southern Oscillation from pressure records. Jacob Bjerknes' 1969 paper provided the foundational explanation of how tropical Pacific SST, trade winds and atmospheric circulation reinforce one another, establishing the coupled ENSO concept [12]. Composite analyses of earlier events then defined the canonical life cycle [4], and the recharge-oscillator framework explained the delayed ocean feedbacks that make ENSO oscillate rather than saturate [13]. Reviews of theory and "ENSO complexity" document how this picture has been refined [5,14].

Table 3. Selected milestones in the recognition and monitoring of El Niño.

Period / event	Importance	Interpretive caution
1877–1878	Historically severe El Niño-related anomalies; prominent in drought and famine histories	Impacts were shaped by social vulnerability, colonial policy and food systems as well as climate
1920s–1960s	Walker's Southern Oscillation; growth of tropical meteorology; Bjerknes (1969) coupled framework [12]	Ocean observations were sparse
1982–1983	Major event; accelerated ocean observing and public awareness	Impacts differed across regions
1997–1998	Among the strongest instrument-era events; widespread floods, drought and ecosystem impacts	Not a universal template; a strong positive IOD coincided in India
2015–2016	Very strong event, intensively monitored; peak 3-month value of about +2.6 °C on the traditional index [15]	Regional responses differed from 1997–98
2023–2024	Strong El Niño followed by transition to neutral	RONI rates this event somewhat weaker than the legacy ONI did [16]
2026–early 2027	Strongly strengthening event in CPC's 8 October 2026 assessment [3]	Forecast probability is not certainty; bulletins update monthly

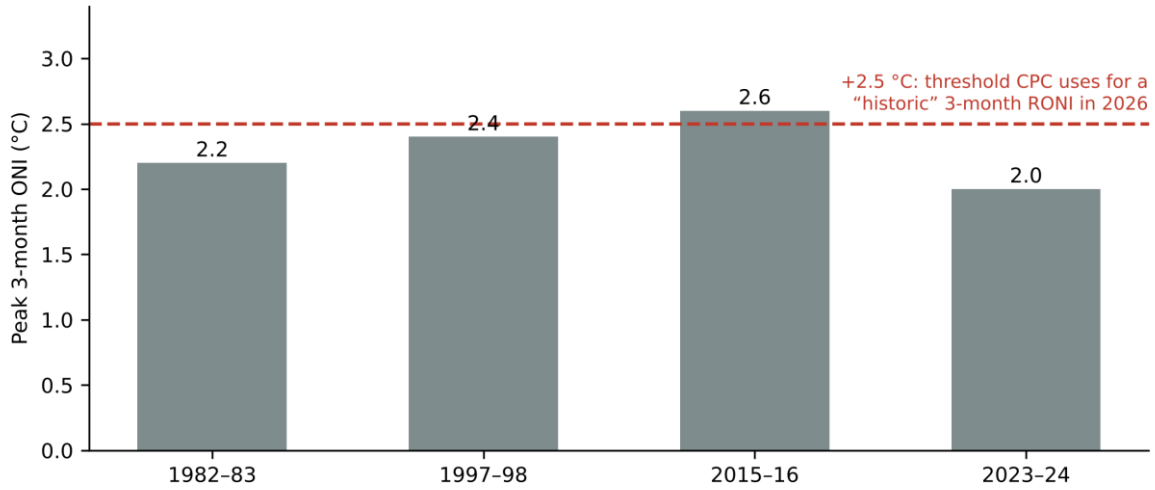


Figure 1. Peak three-month Oceanic Niño Index (traditional ONI) of four recent strong events, compared with the +2.5 °C relative-index threshold that CPC used to define a "historic" event in 2026. The threshold applies to RONI and the bars to ONI; the comparison is indicative only because the indices differ (Section 3.1). Values are rounded approximations of the traditional ONI peaks; the 2015–16 value is consistent with the record quoted in WMO's October 2026 update [15].

5. Physical mechanism: How El Niño begins, grows and ends

5.1 Normal conditions

Under normal conditions easterly trade winds push warm surface water westward, building a deep warm pool in the western Pacific. In the east the thermocline is shallow and cold, nutrient-rich water rises through equatorial and coastal upwelling. The east–west SST contrast maintains the Walker circulation, with rising air over the warm pool, eastward flow aloft, descent over the cooler east and westward return flow near the surface (Figure 2a).

5.2 Initiation and the Bjerknes feedback

Onset can be aided by westerly wind bursts, Madden–Julian Oscillation (MJO) activity, subtropical forcing and pre-existing subsurface heat [5,14]. As the trades weaken, warm water shifts east and the eastern thermocline deepens; upwelling becomes less effective and the surface warms; convection and rainfall shift east; the zonal pressure gradient weakens; and the trades weaken further. This reinforcing loop is the Bjerknes feedback [12] (Figure 3a).

5.3 Maturity, decay and transition

Many events peak near boreal winter, although onset, peak and duration vary. Equatorial Kelvin and Rossby waves, recharge–discharge of equatorial heat content, changing wind stress and the seasonal cycle supply delayed negative feedbacks that terminate the event [5,13]. The system may return to neutral or overshoot to La Niña (Figure 3b). Events recur irregularly, typically every two to seven years [14].

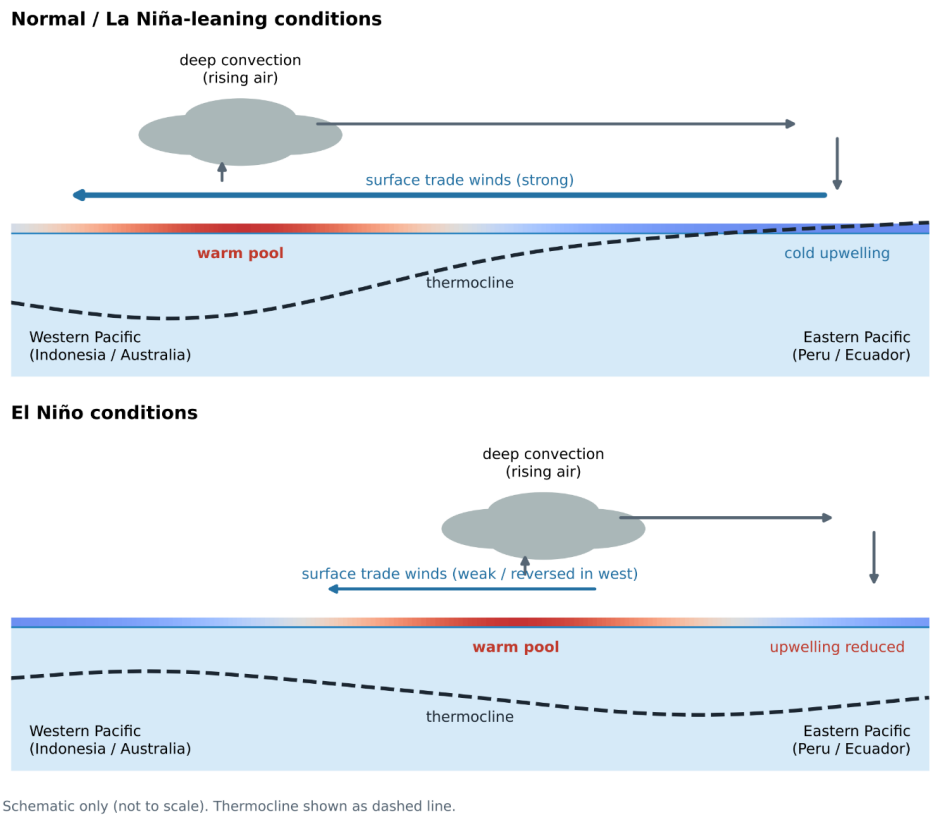


Figure 2. Simplified equatorial Pacific cross-sections for normal (upper) and El Niño (lower) conditions. Not to scale and not observed data.

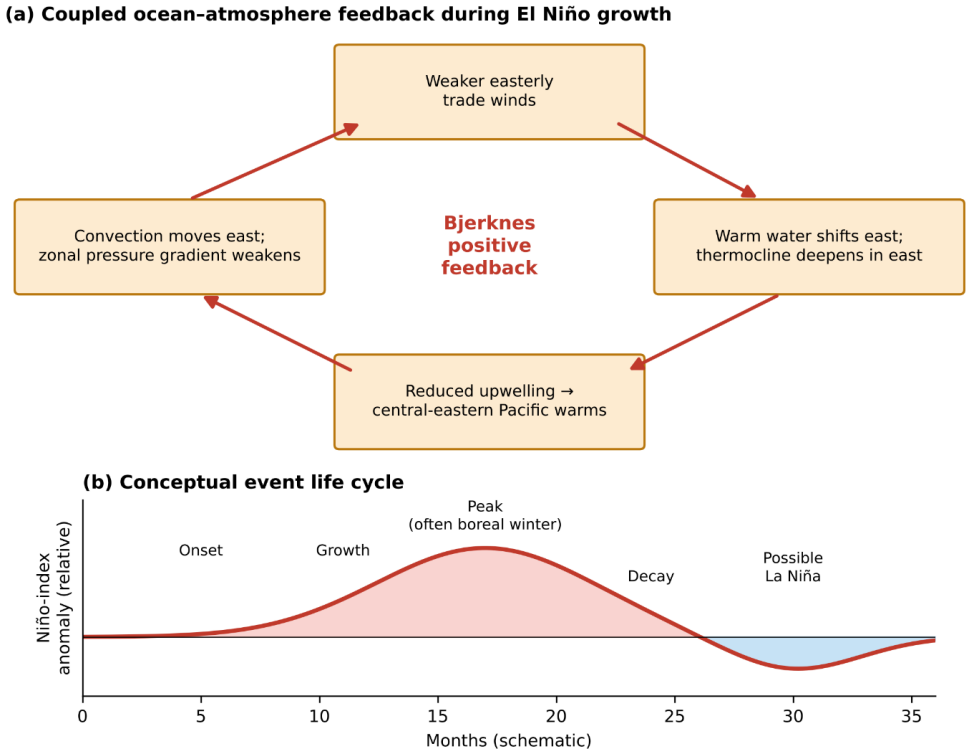


Figure 3. (a) The Bjerknes positive feedback that amplifies El Niño. (b) Conceptual life cycle of an event (onset, growth, peak, decay, possible La Niña overshoot). The curve is illustrative and is not an observed time series.

6. Global weather and climate impacts

Shifts in tropical convection alter the Walker circulation and excite planetary-scale atmospheric waves that modify jet streams, storm tracks and rainfall belts [1]. Sign and magnitude depend on season, event longitude, background climate and other modes such as the Indian Ocean Dipole (IOD) [17,18].

Table 4. Selected El Niño teleconnection tendencies and their qualifications.

Region / system	Common tendency during El Niño	Possible consequences	Qualification
Indonesia and Maritime Continent	Reduced rainfall in many events	Drought, fire weather, crop and water stress	Not every island or season is dry
Australia	Higher drought/heat risk in many seasons	Agricultural stress, bushfire weather, water shortage	IOD and local drivers modify outcomes
Peru–Ecuador coast	Warm coastal waters; heavier rain in some events	Floods, landslides, fisheries disruption	Coastal El Niño is related to, but distinct from, basin-wide ENSO
Southern USA / parts of South America	Some winters wetter or stormier	Flooding and erosion	Strongly seasonal and geographically variable
Southern Africa	Drought risk often elevated	Crop losses, livestock stress, food insecurity	Atlantic and Indian Ocean drivers matter
East African short rains	Can be enhanced	Floods, landslides, waterborne disease risk	IOD is an important co-driver [17]
Indian summer monsoon	Tendency to weaker all-India rainfall	Drought risk, kharif stress, reservoir deficits	Weakened and variable relationship; see Section 8
Global mean temperature	Temporary natural warming contribution	May lift annual global temperature records	Does not cause the long-term anthropogenic trend

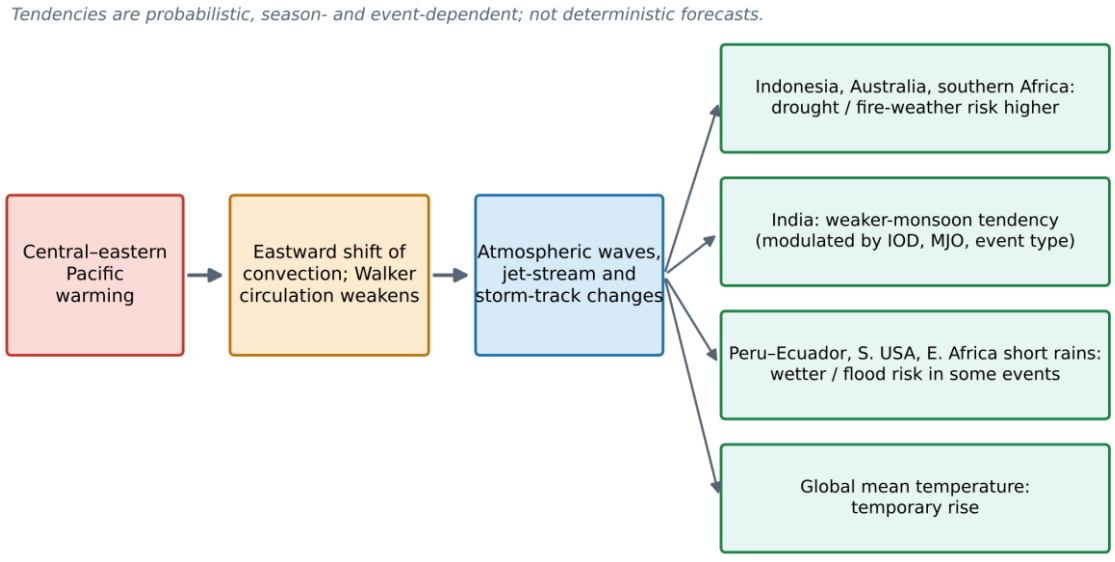


Figure 4. Conceptual teleconnection pathway from tropical Pacific warming to regional tendencies. Qualitative schematic; not a deterministic regional forecast.

7. The 2026 El Niño to 4 November 2026

CPC's ENSO Diagnostic Discussion of 8 October 2026, the latest available at the evidence cut-off, maintained an El Niño Advisory and reported that El Niño strengthened further during September. Niño-3.4, Niño-3 and Niño-1+2 reached +2.1 °C, +3.0 °C and +3.9 °C, with anomalies above +4.0 °C in parts of the eastern equatorial Pacific. The equatorial subsurface temperature index was well above average (a deeper-than-average thermocline), subsurface anomalies exceeded +10 °C at depth in the east, low-level westerly and upper-level easterly wind anomalies spanned the western to east-central Pacific, convection was enhanced from the central to eastern Pacific and suppressed over Indonesia, and the Southern Oscillation indices were significantly negative. CPC concluded that the coupled system reflected a strengthening El Niño [3].

CPC assessed a strong-to-very strong event as likely through January–March 2027 (remaining greater than an 83% chance) and gave chances of 54%, 83% and 70% that the three-month RONI reaches +2.5 °C or more (a historic event exceeding all events since 1950) in September–November, October–December and November–January, respectively [3] (Figure 5). CPC cautioned that impacts consistent with El Niño are more likely with an event of this magnitude, but not guaranteed. The WMO's 8 October update likewise forecast record central-eastern Pacific SSTs in October–December with a peak around December and persistence to about February 2027, noting a seasonal-mean Niño-3.4 anomaly near +3.7 °C; this refers to a different (conventional) index and base from CPC's relative index and should not be compared with it directly [15]. The WMO also expected a positive IOD to develop in August–October 2026, peaking about October [15,19]. IMD's end-of-season briefing expected El Niño to peak in November and weaken gradually from March 2027 [20]; such peak-timing statements differ among agencies and carry uncertainty.

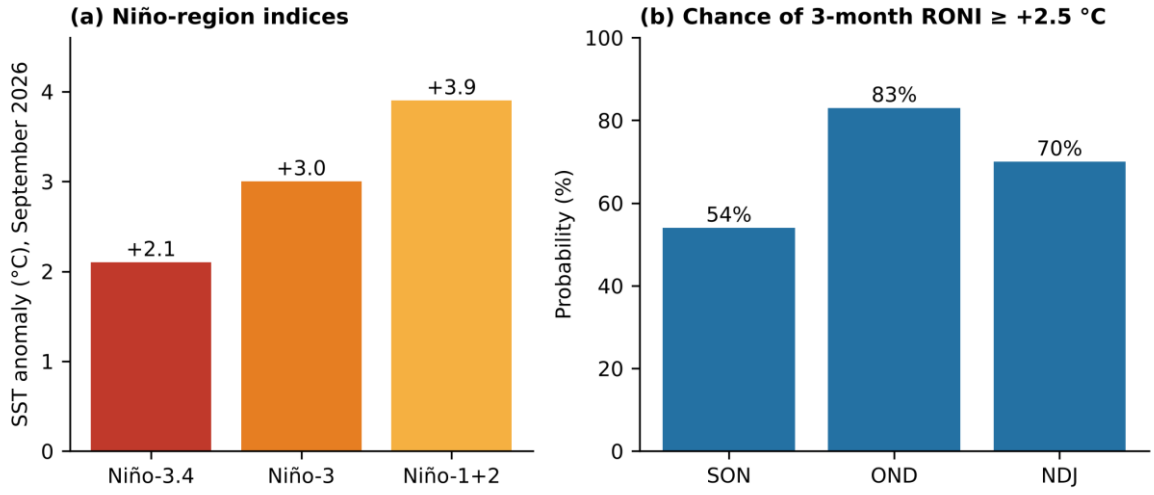


Figure 5. (a) Niño-region SST anomalies reported in NOAA CPC's 8 October 2026 discussion (September 2026 values). (b) CPC probabilities that the three-month RONI reaches +2.5 °C or more [3]. Values are transcribed from the cited source; regional indices differ and are not interchangeable.

The informal term "super El Niño" is widely used in media but is not an official category; a strong forecast should not be converted into a claim that every associated regional impact will occur.

8. El Niño and the Indian summer monsoon

8.1 Mechanisms and the evolving relationship

The Indian summer monsoon (June–September) depends on land–sea thermal contrast, cross-equatorial flow, moisture transport from the Arabian Sea and Bay of Bengal, the monsoon trough, low-pressure systems and active–break cycles [21]. During El Niño the eastward shift of convection and the weakened Walker circulation favour anomalous subsidence over parts of India, reducing convective rainfall, which explains the long-recognised tendency for weaker all-India rainfall in El Niño years [21,22].

The relationship is not absolute and has varied over time [23]. Some El Niño years have near-normal or above-normal rainfall because of the IOD, intra-seasonal oscillations, monsoon depressions, Eurasian snow and other factors [18,22]. A positive IOD can offset part of the El Niño effect, as in 1997, whereas a negative IOD can reinforce dryness [17,18]. The location of the Pacific warming also matters: events with warming further west (central Pacific) tend to be more damaging to the monsoon than classical Eastern-Pacific events [10,24]. Rainfall in the monsoon following an El Niño's decay can behave differently again [25]. National totals can mask severe regional extremes, and heavy-rain extremes have increased over central India even as seasonal means vary [26].

8.2 The 2026 season: Forecasts and observed outcome

IMD's first-stage forecast of 13 April 2026 projected seasonal all-India rainfall at 92% of the 1971–2020 long-period average (LPA; 87 cm) with a model error of ±5%, describing a transition from weak La Niña-like conditions towards neutral and then El Niño [27]. The 29 May update lowered the estimate to 90% of LPA (±4%), with below-normal rainfall expected over the monsoon core zone and over central and south-peninsular India [28]. The update assigned a 60% probability to deficient and 24% to below-normal rainfall, an 84% combined probability [29].

IMD reported that the season ended with all-India rainfall of 759.4 mm against an LPA of 868.6 mm, or 87% of LPA, the lowest since 2015, the fourth lowest since 2001 and the 13th lowest since 1901 [20]. IMD stated that the seasonal forecast was accurate and within its error limit, with an error of 2.6% [20]. Monthly rainfall was 65%, 101%, 84% and 92% of LPA in June, July, August and September. Seasonal rainfall was 76% of LPA over the South Peninsula and 74% over East and Northeast India (the latter the lowest since 1901), while the monsoon core zone received 94% [20]; press reports of the same IMD data gave about 94% for Northwest India and 97% for Central India [30]. Of 36 meteorological subdivisions, 18 (53% of area) were normal, 17 (42% of area) deficient and one (Odisha) excess; IMD noted that repeated low-pressure systems limited the impact in parts of eastern India, with 77 low-pressure-system days against a normal of 57 [20]. Southern-India reservoirs stood at about 50% of live storage on 24 September, against 79% nationally, and kharif sowing was only 1.2% below the previous year at 110.7 million hectares as of 25 September [20].

Table 5. IMD's 2026 southwest monsoon forecasts and observed outcome (all-India, June–September).

Item	Figure	Meaning
First-stage forecast, 13 April 2026	92% of LPA ±5% [27]	Forecast; below-normal category
Updated forecast, 29 May 2026	90% of LPA ±4%; 84% probability of below-normal or deficient [28,29]	Forecast; revised downward
Observed seasonal rainfall	759.4 mm, 87% of LPA [20]	Deficient category; lowest since 2015
LPA reference (1971–2020)	868.6 mm (≈87 cm) [20,27]	Climatological baseline used by IMD
Regional outcome	East & NE 74%; South Peninsula 76%; core zone 94% [20]	Strong spatial contrast
Monthly outcome	Jun 65%; Jul 101%; Aug 84%; Sep 92% [20]	Strong intraseasonal contrast

Observed figures are drawn from press coverage of IMD's 30 September 2026 briefing and should be confirmed against IMD's final seasonal report before journal submission.

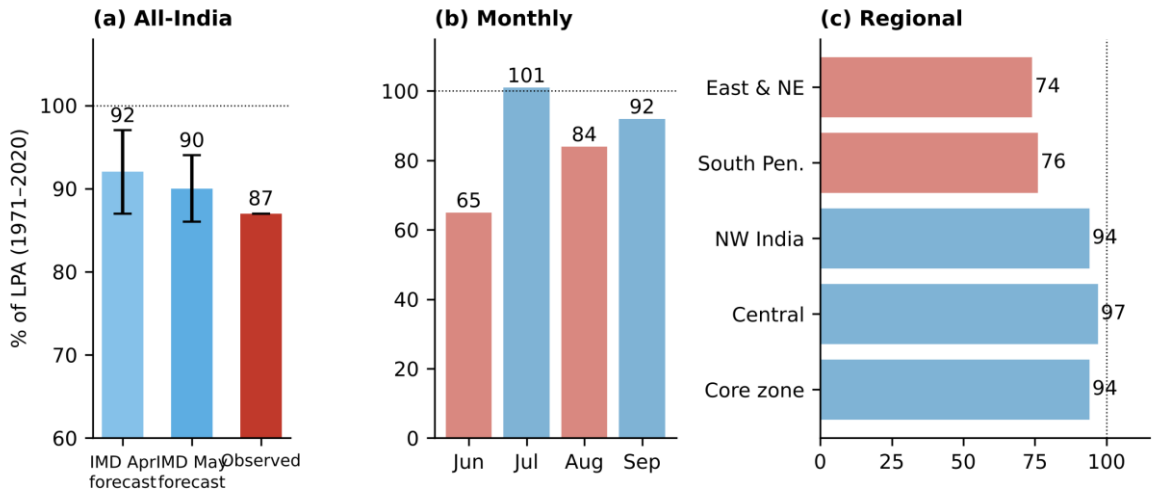


Figure 6. IMD forecasts and observed 2026 southwest monsoon rainfall as a percentage of LPA: (a). all-India forecasts (error bars show IMD's stated model error) versus observed; (b). monthly all-India rainfall; (c). regional rainfall (core zone = monsoon core zone). Values from [20,27,28,30]; dotted line = 100% of LPA.

The 2026 season is consistent with the El Niño-related tendency towards a weak monsoon, but it also demonstrates why the label alone is insufficient: July rainfall was near normal, June was very deficient, Odisha was in excess, and the monsoon core zone fared markedly better than the south and east. A positive IOD was only forecast to develop late in the season [19], so it was unavailable to offset the Pacific signal during the main monsoon months. Attribution of the seasonal deficit to ENSO alone is not warranted; interacting drivers act on every season [21,24].

9. El Niño and tropical cyclones

El Niño modifies cyclone environments by altering vertical wind shear, mid-level humidity, SST, upper-level outflow and steering flow. In the North Atlantic it tends to raise shear and suppress hurricanes; in the western North Pacific it shifts genesis eastward; Indian Ocean responses differ by basin and season [31,32]. An analysis of October–December Bay of Bengal cyclones over 44 years (1972–2015) found frequency, accumulated cyclone energy and power dissipation index negatively correlated with Niño-3.4 anomalies, with mean energy and dissipation about twice as high in La Niña as in El Niño years [32]. Earlier work also reported modulation of post-monsoon storm tracks in El Niño years [33]. These are statistical results for a defined basin, season and period; they do not mean that El Niño prevents cyclones.

The 2026 post-monsoon season illustrates the point. Cyclone Arnab was followed by Severe Cyclonic Storm Murasu, which made landfall near Ongole in Andhra Pradesh in the early hours of 3 November 2026 with IMD warning of storm surge of up to 1.5 m [34,35]. ENSO modulates the probability and environment of cyclone activity; it does not create an individual cyclone, and severe storms can occur during El Niño.

10. Potential benefits and favourable effects

El Niño is a natural climate mode, neither globally good nor bad; "benefit" is local and conditional.

- Some normally dry regions may receive useful rainfall, improving soil moisture and reservoir inflow, although excess rain can cause flooding.
- Some agricultural areas gain when rain arrives at the right time and temperatures remain within crop tolerance.
- Warmer winters in some mid-latitude regions may reduce heating demand and cold stress, offset by higher cooling demand elsewhere.
- Seasonal predictability supports crop planning, reservoir operation, food procurement, health preparedness and disaster risk reduction.
- After the event, restored upwelling and nutrient supply can support marine productivity and fisheries recovery, though recovery may be delayed.

11. Destructive impacts and societal risks

- **Drought and water scarcity:** lower reservoir storage, groundwater recharge and river flow affecting drinking water, irrigation, hydropower and industry.
- **Heat stress:** El Niño can raise temperatures in already warm regions, and superimposed on anthropogenic warming heat extremes become more dangerous.
- **Agricultural losses:** delayed sowing, reduced yields, fodder shortages, livestock stress and food-price volatility.
- **Wildfire:** hot, dry conditions raise fire weather in parts of Indonesia, Australia, Amazonia and southern Africa.
- **Floods and landslides:** enhanced rainfall elsewhere can cause flash floods, erosion, infrastructure damage and water contamination.
- **Marine ecosystem disruption:** weaker Eastern-Pacific upwelling reduces nutrient delivery, affecting plankton, anchovies, seabirds, marine mammals and fishing livelihoods.
- **Public health:** heat illness, dehydration, smoke exposure, food insecurity and water/sanitation disruption; vector-borne disease effects vary with local ecology and health-system capacity.
- **Economic and social disruption:** lost income, displacement, school disruption, insurance losses and unequal burdens on low-income households.

12. Sectoral impacts

12.1 Agriculture and food security

Rain-fed farming is especially exposed because sowing and crop development depend on monsoon onset, distribution and withdrawal. Seasonal totals can conceal long dry spells, intense downpours and heat stress. Adaptation includes drought-tolerant and short-duration cultivars, diversified cropping, adjusted sowing windows, soil-moisture conservation, farm ponds, efficient irrigation, fodder reserves, crop insurance and reliable district-level advisories. ENSO phase alone is not a farm-level decision tool.

12.2 Water resources and energy

Drought reduces reservoir inflow, recharge and hydropower; intense rainfall raises sedimentation, flood risk and dam-operation challenges. Integrated reservoir rules, demand management, leakage reduction, groundwater governance and floodplain protection are needed under both dry and wet scenarios.

12.3 Fisheries and marine ecosystems

In the eastern equatorial Pacific, El Niño weakens upwelling and nutrient supply, reducing primary productivity and shifting fish distributions. Management can use seasonal ocean forecasts, adaptive quotas, ecosystem monitoring and livelihood support.

12.4 Human health

Health effects are mediated by heat, water, food, air quality, infrastructure and disease ecology; the direction of vector-borne disease change is not universal. A 2025 systematic review of El Niño and positive-IOD impacts in Indo-Pacific low- and middle-income countries concluded that El Niño likely reduces agricultural production and productivity, found no clear consistent effect on disease incidence or market prices, found no evidence on migration, conflict and nutrition, and cautioned that the evidence has a generally high risk of bias [36].

13. ENSO and anthropogenic climate change

ENSO is natural internal variability, whereas greenhouse-gas-driven change is a forced long-term trend; the two interact. El Niño temporarily lifts global mean temperature above the underlying trend and La Niña tempers it. A warmer baseline means similar anomalies can do more harm, and the relative index exists precisely because background warming distorts raw anomalies [6]. Model studies project an increase in the frequency of extreme El Niño events under greenhouse warming [37] and of extreme positive IOD events [38], but projections remain sensitive to models, event definitions and emissions pathways [39]. It is incorrect to attribute every flood, drought, cyclone or heatwave in an El Niño year to ENSO alone.

14. Limitations and uncertainties

Table 6. Key limitations and uncertainties in ENSO science and its application.

Issue	Explanation
Spring predictability barrier	Forecast skill is reduced for forecasts issued around boreal spring as the coupled system passes through a season of low predictability [14].
Model spread	Models disagree on onset, peak strength, spatial pattern and decay timing [39].
Event diversity	Central- and eastern-Pacific events produce different teleconnections [10,11].
Competing drivers	IOD, MJO, monsoon intraseasonal oscillations, Eurasian snow, Atlantic variability and local conditions can offset or reinforce ENSO [18,24].
Non-stationarity	Changing background climate alters historical ENSO–rainfall relationships [23].
Index dependence	Event strength and ranking depend on index, base period and averaging window; RONI and ONI can differ [6,8].
Spatial averaging	All-India averages hide state-, district- and basin-scale extremes (e.g. 2026) [20,26].
Attribution limits	Association does not prove that ENSO caused a particular disaster.

15. Preparedness and risk reduction

Table 7. Priority actions by sector for El Niño preparedness.

Sector	Priority actions
Agriculture	Use district agrometeorological advisories; adjust sowing windows and crop mix; conserve soil moisture; maintain seed and fodder reserves.
Water	Review reservoir rule curves; reduce leakage; protect groundwater; prepare drought and flood operating plans.
Disaster management	Pre-position supplies; maintain heat action plans; map flood and landslide hotspots; strengthen early warning and last-mile communication, including for post-monsoon cyclones.
Health	Prepare heat-health responses; protect outdoor workers; ensure safe water and sanitation; monitor smoke and food insecurity.
Fisheries	Use ocean forecasts; monitor upwelling and fish distribution; adapt management; support coastal livelihoods.
Energy and industry	Stress-test hydropower and cooling demand; plan for water constraints; diversify supply and improve efficiency.
Communication	Explain probability, uncertainty and local relevance; avoid implying that ENSO guarantees a drought, flood or cyclone.

16. Discussion

ENSO links tropical ocean processes with distant atmospheric and societal outcomes, and is a major source of seasonal predictability, but its influence is neither uniform nor deterministic. Three lessons emerge from 2026. First, index definitions matter: the transition to RONI and the existence of multiple agencies' indices require care when comparing magnitudes. Second, a strong and well-forecast El Niño coincided with a deficient but heterogeneous monsoon, showing that national averages and ENSO labels are blunt instruments for local risk. Third, hazards such as post-monsoon cyclones are modulated rather than excluded by El Niño, so preparedness must remain multi-hazard. Operational information is most useful when translated into local action and refreshed as observations change. Limitations of this review include its narrative design, reliance on press reports for some IMD end-of-season details, and the rapid evolution of the 2026 event after the evidence cut-off.

17. Conclusions

El Niño is the warm phase of ENSO, historically recognised by coastal fishers and scientifically explained through the work of Walker, Bjerknes and later researchers. Onset involves weakening trade winds, eastward redistribution of warm water, reduced upwelling and positive ocean–atmosphere feedback, terminated by delayed ocean-wave and heat-content feedbacks. El Niño modifies seasonal rainfall, temperature, monsoon behaviour, cyclone environments, fisheries, agriculture, health and economies. As of 4 November 2026, CPC's latest diagnostic showed a strengthening event with a high probability of strong-to-very strong conditions through January–March 2027, and India's 2026 monsoon had ended deficient at 87% of LPA with marked regional contrast. The appropriate response is evidence-based preparedness, frequent bulletin updates and region-specific risk management.

Declarations

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Author contributions (CRediT): Conceptualisation, visualization, literature review, writing draft, reviewing, revising and editing.

Data availability. No new primary datasets were generated. All values analysed are published by NOAA CPC, WMO and IMD (see references). Figures 2–4 are conceptual schematics; Figures 1, 5 and 6 and the tables plot or transcribe values from the cited sources (Figure 1 uses rounded historical ONI peak values).

Ethics approval. Not applicable; the review did not involve human participants, animal subjects or personal data.

Use of generative AI. AI tools were used to assist with language editing, restructuring, figure drafting and reference checking. The author reviewed and takes responsibility for the content and verified all factual claims and citations against the cited sources.

Disclaimer. This review is not a substitute for operational weather warnings or for local agricultural, health and disaster-management advice.

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