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REVIEW

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El Niño in a Warming World: Understanding Intensifying Risks and Building Climate Resilience

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Abstract

El Niño–Southern Oscillation (ENSO) has long shaped global weather patterns, but in an era of accelerating climate change, the risks it carries are growing sharper and more consequential. The 2023–2024 El Niño event is one of the five strongest on record, and 2024 was the warmest year in the 175-year observational record, with a global mean near-surface temperature of 1.55 ± 0.13°C above the 1850–1900 average (World Meteorological Organization. 2025), which pushed global temperatures to unprecedented levels, intensified droughts and floods across multiple continents, disrupted food systems, and exposed the deepening vulnerability of developing nations. This short communication examines how a warming world amplifies the downstream consequences of El Niño events, with a particular focus on the socioeconomic risks facing nations such as India. It highlights that developing countries face an annual adaptation-finance requirement of US$310–365 billion by 2035, compared with only US$26 billion in international public adaptation finance in 2023 (United Nations Environment Programme. 2025). It further explores the immediate need for anticipatory, transformational climate resilience spanning early warning systems, adaptive agriculture, climate finance reform, and integrated governance. The paper argues that El Niño is no longer a periodic natural disruption to be managed reactively, but a compounding threat that demands structural, forward-looking adaptation at every level.

Keywords: El Niño; Climate Change; ENSO; Climate Resilience; Food Security; India; Adaptation Finance; Early Warning Systems

Introduction

El Niño, the warm phase of the El Niño–Southern Oscillation (ENSO) cycle, is one of the most powerful drivers of year-to-year climate variability on Earth. It originates in anomalous warming of sea surface temperatures in the central and eastern equatorial Pacific Ocean. El Niño disrupts the Walker Circulation, the atmospheric engine that governs rainfall and temperature patterns across the tropics and beyond. Every El Niño event brings with it a signature cascade which includes drought in South and Southeast Asia, Indonesia, and Australia; floods in equatorial Africa and parts of South America; and a global spike in surface temperatures. The intersection of El Niño with anthropogenic climate change is new, and demanding. The 2023–2024 El Niño, which ranked among the five strongest events in recorded history, coincided with a planet already supercharged by greenhouse gas emissions.

The impacts were unprecedented: 2024 was the warmest year on record, with the global average temperature reaching 1.60°C above the 1850–1900 pre-industrial baseline, while the three-year period from 2023 to 2025 exceeded 1.5°C above pre-industrial levels for the first time (Copernicus Climate Change Service. 2025). As a new El Niño is already developing in 2026, with the World Meteorological Organisation signalling likely El Niño conditions as early as May–July 2026 (World Meteorological Organization. 2026), the imperative to understand and respond to this compound risk has never been more pressing. ENSO cycles occur roughly every two to seven years, alternating between El Niño, La Niña (its cool-phase counterpart), and neutral conditions. Not all El Niño events are equal: strength is classified by how far central Pacific Sea surface temperatures rise above average, from weak (0.5–1.0°C) to very strong (above 2.0°C). The stronger the event, the more widespread and severe its downstream effects tend to be (Table 1) (Fig. 1).

Table 1. Major El Niño Events

Event	Peak SST Anomaly	Major Impacts
1982–83	≈2.1°C	Floods, economic losses
1997–98	≈2.3°C	Global damages, coral bleaching
2015–16	≈2.6°C	Extreme drought, food insecurity
2023–24	Top five strongest	Record global temperatures

This paper investigates how a warming world alters the risk profile of El Niño events, the sectoral and economic consequences for vulnerable nations, and the pathways available to build meaningful climate resilience.

Fig. 1. Compound impacts of El Niño in a warming world, illustrating intensified climate extremes, socioeconomic consequences, and integrated climate resilience strategies.

El Niño in a Warming World: A Compound Climate Threat

Historically, El Niño events have occurred irregularly, typically every two to seven years, with substantial variation in intensity and spatial footprint. Climate science has not established that global warming will simply increase the frequency of all ENSO events; however, evidence indicates that warming can alter ENSO variability and the characteristics of extreme events. Cai et al. (2023) found that observed post-1960 ENSO variability was higher than in the earlier twentieth century and that more than three quarters of the assessed climate models simulated an increase in ENSO amplitude under greenhouse warming. Kim et al. (2024) further showed that deep-ocean warming can shift ENSO eastward and increase the frequency of convective extreme El Niño events by 40–80% in their experiments. These changes are also supported by climate-model evidence under elevated greenhouse-gas concentrations. Chen et al. (2024) found that the predictability of central-Pacific ENSO can decrease under greenhouse warming, highlighting an additional risk for seasonal planning. The mechanism is straightforward but important: while El Niño adds heat to the Pacific climate system, climate change has already elevated the baseline temperature of both the ocean and the atmosphere. A warmer atmosphere can hold more moisture, while a warmer ocean provides additional energy to the climate system. Consequently, the same El Niño-related circulation anomalies can occur on a warmer background and intensify heatwaves, heavy rainfall, and drought impacts (World Meteorological Organization. 2025; Kim et al., 2024) (Fig. 2).

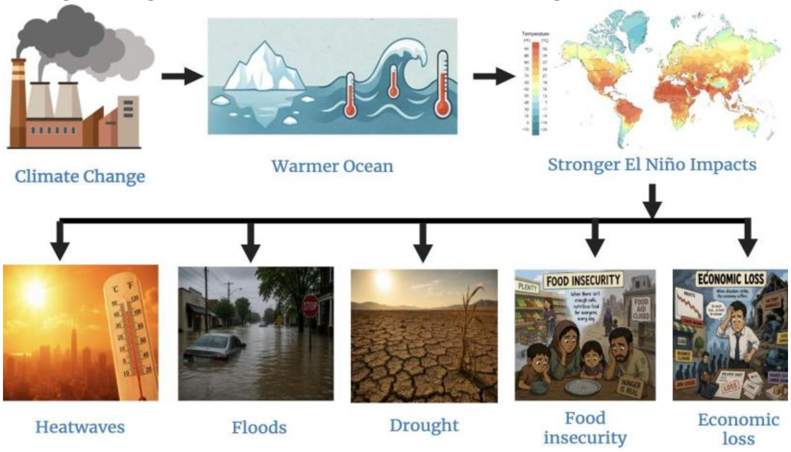

Fig. 2. El Niño in a warming world

The 2023–2024 event illustrated this interaction vividly. Regions vulnerable to record-high surface air temperatures included parts of the Bay of Bengal, the South China Sea, Alaska, the Caribbean, and the Amazon. In the Amazon, the combination of El Niño and anthropogenic warming contributed to severe heat and drought stress, increasing the risk of ecosystem carbon losses (Inside Climate News, 2026).

In short, El Niño is no longer merely a natural climate oscillation. In the context of anthropogenic climate change, it acts as a threat multiplier, amplifying existing environmental, social, and economic risks beyond the limits of historical experience. As a result, its impacts are becoming increasingly severe, widespread, and difficult to predict, underscoring the urgent need for effective adaptation and resilience strategies.

Intensifying Risks: Food, Economy, and Developing Nation Vulnerability

The consequences of El Niño events fall disproportionately on the Global South, nations that have contributed least to global greenhouse gas emissions yet bear the heaviest burden of climate disruption. Among these, India offers a particularly instructive case study.

India's economy and food system are deeply intertwined with the monsoon. Agriculture contributes approximately 15–20% of GDP, and roughly 40–60% of cultivated land depends on monsoon rainfall (Green Portfolio, 2023). Rain-fed irrigation accounts for half of India's net sown area and approximately 40% of total food production (Good Food Movement, 2023). When El Niño suppresses the South-West Monsoon as it typically does, the consequences ripple through the entire agricultural chain: delayed sowing cycles, reduced kharif crop yields, rising food prices, and rural income shocks.

Table 2. El Niño Impacts on India

Sector	Impact
Agriculture	Lower Kharif yield
Food Prices	Rice inflation 11.33%
GDP	Potential 4.5% loss
Water	Reduced monsoon rainfall
Energy	Higher cooling demand

During the 2023–2024 El Niño period, food-price pressures in India intensified, with rice inflation reported at 11.33%, above the Reserve Bank of India's 6% tolerance threshold (StockGro, 2023). India also imposed rice-export restrictions to support domestic availability, with implications for international food markets (JPMorgan, 2026). The Reserve Bank of India has projected that extreme heat and humidity could reduce India's GDP by up to 4.5% by 2030 through losses in labour productivity; El Niño-driven heat extremes can add to this risk (StockGro, 2023) (Table 2). Beyond India, the global ripple effects of a strong El Niño event extend to food supply chains, energy grids, public health, and maritime trade. Small Island Developing States (SIDS), which depend heavily on imports and maritime shipping, are projected to face consumer price increases and real GDP reductions disproportionately larger than the global average during El Niño-linked supply disruptions (ORF Middle East, 2026). Developing nations in the Horn of Africa, Southeast Asia, and Central America simultaneously experience either flooding or drought, leaving them caught between extremes with limited adaptive capacity (Table 3).

Table 3. Regional Effects of El Niño

Region	Typical Effect
India	Weak monsoon
Australia	Drought
Indonesia	Wildfires
Peru	Flooding
East Africa	Heavy rainfall
Southern USA	Wet winter
Amazon	Drought and forest fires

The scale of the adaptation finance gap makes this vulnerability more acute. The UNEP's 2025 Adaptation Gap Report found that international public adaptation finance actually fell slightly to $26 billion in 2023, even as the costs of climate impacts escalated sharply. Developing countries will require between $310 billion and $365 billion annually by 2035 to adequately prepare for climate extremes, yet current commitments amount to less than one-tenth of what is needed (United Nations Environment Programme. 2025) (Fig. 3) (Table 4).

Building Climate Resilience: From Reactive Response to Anticipatory Action

The pattern of responding to El Niño only after its impacts arrive is no longer sustainable. The UNEP's 2025 Adaptation Gap Report makes this explicit: adaptation can no longer rely on reactive, incremental projects, but must become anticipatory, strategic, and transformational, fundamentally redesigning water systems, cities, agriculture, and infrastructure for a future climate unlike anything in recorded history (United Nations Environment Programme. 2025). Several interconnected pillars underpin this shift.

Table 4. Adaptation Finance Gap

Indicator	Value
Finance available (2023)	US$26 billion
Required annually by 2035	US$310–365 billion
Funding gap	Nearly 90%

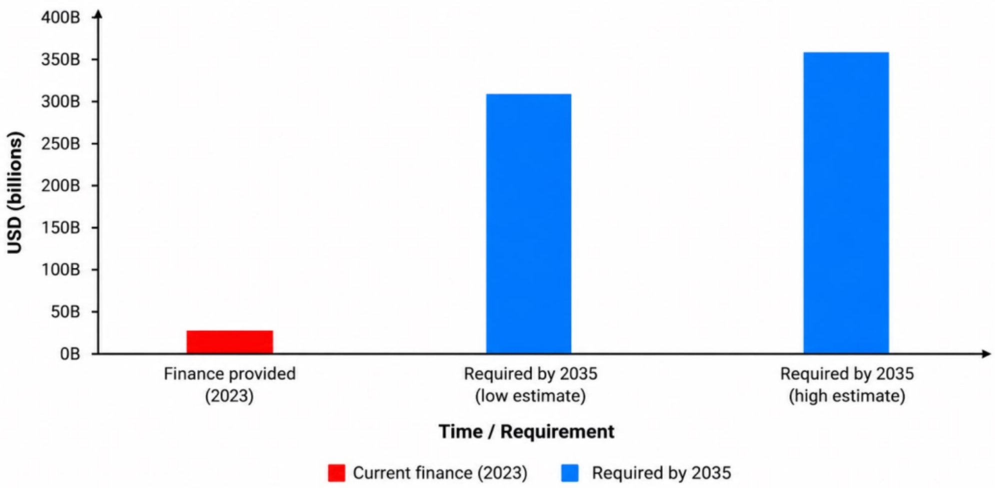

Fig. 3. Comparison of international public adaptation finance provided in 2023 ($26 billion) with the projected annual finance requirement for developing countries by 2035 ($310–365 billion) (United Nations Environment Programme, 2025).

The first and most immediate pillar is the expansion of early warning systems (EWS). The United Nations' Early Warnings for All (EW4All) initiative has set a target of extending early warning coverage to 100% of the global population by 2027, a goal that requires substantial investment in meteorological infrastructure, data sharing networks, and community-level communication systems (United Nations Office for Disaster Risk Reduction. 2023). The UN has repeatedly demonstrated that early warning systems deliver extraordinary returns: every dollar invested in disaster preparedness saves between four and ten dollars in post-disaster recovery costs (United Nations Department of Economic and Social Affairs. 2016). Crucially, early warning must be coupled with early action by translating seasonal El Niño forecasts into pre-positioned food reserves, pre-deployed medical supplies, and pre-approved agricultural support programmes.

The second pillar is climate-resilient agriculture. For nations like India, this means accelerating the development and deployment of drought-resistant and heat-tolerant crop varieties, expanding micro-irrigation to reduce dependence on monsoon rainfall, diversifying crop portfolios, and establishing weather-indexed crop insurance programmes that provide timely income support without requiring post-disaster damage assessments. Agricultural extension services need to incorporate seasonal climate forecasts as a standard tool for farmer advisory, enabling planting and harvesting decisions that account for El Niño risk (Down to Earth, 2026) (Fig. 4).

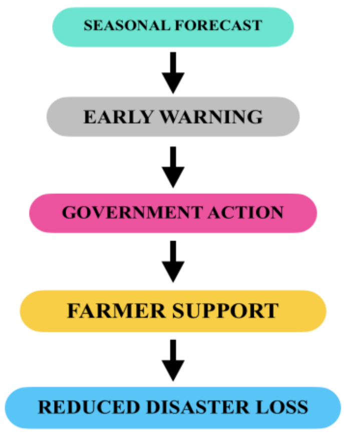

Fig. 4. Climate resilience

The third pillar is structural reform of climate finance. The current system, weighted towards post-disaster relief rather than pre-emptive adaptation, is fundamentally misaligned with the nature of El Niño risk, which is foreseeable weeks to months in advance. Multilateral development banks and climate funds including the Green Climate Fund, the Climate Risk and Early Warning Systems (CREWS) Fund, and the Adaptation Fund must rapidly scale pre-arranged contingency financing instruments that can be disbursed before, not after, a declared disaster (United Nations Office for Disaster Risk Reduction. 2023). For developing countries, this also requires that adaptation finance be delivered as grants rather than loans, avoiding the perverse outcome of countries accumulating debt as a result of climate impacts they did not cause.

The fourth pillar is integrated governance and regional cooperation. El Niño is by definition a transboundary phenomenon; its management demands transboundary solutions. Regional platforms for data sharing, joint seasonal forecasting, and coordinated humanitarian pre-positioning, especially across South Asia and Southeast Asia, can dramatically reduce the response lag that historically has cost lives and livelihoods. At the national level, El Niño risk must be mainstreamed into economic planning, not treated as an external shock. India's national budget, agricultural policy, and urban infrastructure planning should all reflect explicit El Niño scenarios as part of a coherent climate risk framework (Table 5).

Table 5. Summary of El Niño Impacts

Sector	Key Impact	Adaptation
Agriculture	Crop loss	Climate-smart farming
Economy	GDP decline	Adaptation finance
Health	Disease outbreaks	Early warning
Water	Drought	Water conservation
Infrastructure	Flood damage	Resilient planning
Environment	Coral bleaching	Conservation

Conclusion

El Niño has always been one of nature's most powerful climate engines. In a warming world, it has become something more: a recurring test of whether nations, especially those least responsible for climate change, can survive and adapt to the intensifying shocks it delivers. The 2023–2024 event shattered temperature records, disrupted food systems across three continents, and demonstrated with painful clarity that the compounding of El Niño and greenhouse warming is not a future risk, it is a present reality. With a new El Niño already forming in 2026, the window for action is not distant; it is now. Building climate resilience in this context is not a technical aspiration, it is a moral and economic imperative. Early warning systems that actually trigger early action, agriculture that can survive the monsoon's failure, and a global finance architecture that delivers adaptation funding before disasters rather than relief after them: these are the building blocks of a world in which El Niño remains a manageable challenge rather than an existential one. Nations like India, which stand at the intersection of high climate vulnerability, dynamic economic growth, and deep agricultural dependence, have the most to gain from getting this architecture right and the most to lose if they do not.

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