

El Nino Effect: A Threat to Achieving the Sustainable Development Goals

Dr. R. Kalirajan¹, Dr. R. Alagesan², Dr. S. Vigneswaran³

¹Assistant Professor and Head Postgraduate Department of Economics Ayya Nadar Janaki Ammal College, Sivakasi.

²Assistant Professor and Head Department of Economics Mannar Thirumalai Naicker College, Madurai.

³Assistant Professor, Department of Economics, Mannar Thirumalai Naicker College, Madurai.

Abstract- El Nino is one of the most influential forms of natural climate variability, with consequences that can extend well beyond the tropical Pacific Ocean. Through changes in atmospheric circulation, rainfall and temperature, El Nino episodes can affect agriculture, water resources, food prices, public health, livelihoods and ecosystems. These effects are directly relevant to the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), SDG 13 (Climate Action) and SDG 15 (Life on Land). This review paper examines the ways in which El Nino can slow progress towards the SDGs, with particular attention to India. It brings together international evidence, United Nations assessments, climate literature and Indian research on monsoon rainfall and agriculture. The paper argues that El Nino should not be understood simply as a temporary weather disturbance. Its consequences depend on the vulnerability of food, water, economic and social systems, and these vulnerabilities can be intensified by a warming climate. The paper discusses the food–water–climate nexus, the implications for India's agricultural and rural economy, and the importance of early warning, climate-resilient agriculture, water conservation, crop diversification and anticipatory social protection. The review concludes that strengthening resilience to El Nino is not separate from sustainable development; it is an important part of protecting development gains and keeping the SDGs within reach.

Keywords- El Nino, Sustainable Development Goals and Climate Resilience

I. Introduction

The 2030 Agenda for Sustainable Development presents 17 interconnected goals covering poverty, food security, health, water, energy, employment, environmental protection and climate action. The United Nations emphasises that these goals are interconnected and that progress in one area can depend on progress in others. Climate-related shocks therefore have implications far beyond the environment itself. El Nino–Southern Oscillation (ENSO) is a recurring climate phenomenon involving changes in sea-surface temperatures and atmospheric circulation in the tropical Pacific. El Nino represents the warm phase of ENSO. Its influence is transmitted through large-scale atmospheric circulation and can change rainfall and temperature patterns in distant regions. The exact effects differ between events, so El Nino should be viewed as a major source of climate risk rather than as a simple cause of a particular local weather outcome.

The development implications become particularly important in countries where agriculture, water supply and rural livelihoods remain sensitive to rainfall variability. India is one such country. The southwest monsoon is central to agricultural production and water availability, and changes in monsoon behaviour can affect crop yields, reservoir levels, rural income and food prices.

Indian research illustrates this relationship. Dakhore, Kadam and Kumar (2020), using 36 years of rainfall observations from Parbhani, found that El Nino episodes negatively influenced southwest monsoon and annual rainfall and were associated with lower productivity for several crops. Their results also show that the response was not uniform across crops, which underlines the importance of local conditions and crop characteristics.

The issue is especially timely because the global SDG context remains fragile. The United Nations' 2026 SDG reporting notes that progress is uneven and insufficient and calls for a major acceleration before 2030. Its 2026 Goal 2 assessment identifies escalating weather extremes as one of the factors threatening progress towards zero hunger. This paper therefore examines El Nino as a threat to sustainable development rather than as an isolated meteorological phenomenon. The focus is on how climate variability can move through food, water, livelihood and environmental systems and potentially weaken progress towards the SDGs.

Objectives of the Study

1. To explain the relationship between El Nino and sustainable development.
2. To examine the major pathways through which El Nino can affect India.
3. To discuss the implications of El Nino for selected Sustainable Development Goals.
4. To review evidence on the effects of El Nino on Indian monsoon rainfall and agriculture.
5. To examine the interaction between El Nino, climate change and existing development vulnerabilities.
6. To identify policy measures that can strengthen resilience to El Nino-related shocks.

II. Understanding El Nino

El Nino is the warm phase of ENSO and is associated with abnormal warming of the central and eastern tropical Pacific. The associated atmospheric changes can alter circulation patterns and shift rainfall and temperature regimes in different parts of the world. Because teleconnections vary geographically and from one event to another, the consequences cannot be inferred from Pacific temperature alone.

This variability is important when considering sustainable development. A climate event becomes a development crisis only when it interacts with exposed populations, vulnerable economic sectors and limited coping capacity. An El Nino episode may therefore produce relatively modest effects in one region but serious agricultural, water or livelihood consequences in another. The IPCC's assessment of climate change provides an additional layer to this discussion. Human-induced warming is already affecting many climate extremes, and risks increase as warming increases. Thus, El

Nino events occur against a changing climatic background rather than in a stationary climate system (IPCC, 2021; IPCC, 2022).

III. El Nino and India

The Indian monsoon

India's agricultural calendar is closely linked to the southwest monsoon. The timing, amount and distribution of rainfall influence sowing, crop establishment, irrigation demand and water storage. El Nino has historically been associated with weaker monsoon conditions in India, although the relationship is neither perfect nor uniform. The Parbhani study by Dakhore et al. (2020) provides a useful regional example. The authors found a negative influence of El Nino on southwest monsoon and annual rainfall and reported negative effects on the productivity of several Kharif crops. Their results also show that rice responded differently from several other crops.

Such findings suggest that the development consequences of El Nino depend on crop type, irrigation, local rainfall patterns and the capacity of farmers to adapt. It would therefore be misleading to assume that every El Nino year will generate the same agricultural outcome throughout India.

Agriculture and rural livelihoods

Agriculture is one of the clearest pathways linking El Nino with SDG achievement. A rainfall deficit can reduce yields, affect sowing decisions and increase dependence on groundwater or irrigation. Lower output can then reduce farm income and employment. Smallholders and agricultural labourers may be particularly exposed because they have fewer resources to absorb temporary losses.

The consequences can continue beyond the farm. A reduction in food production can place upward pressure on prices, while a decline in farm income can weaken rural demand. The final impact therefore depends not only on the size of the production shock but also on food stocks, trade, procurement policies, market integration and social protection.

Water resources

Water is a central link between climate variability and sustainable development. El Nino-related rainfall changes can affect reservoirs, groundwater recharge, irrigation availability and drinking-water supplies. The United Nations describes water as fundamental to health, poverty reduction, food security, ecosystems and other SDGs. Current SDG 6 reporting also highlights persistent global water stress and the increasing challenge posed by rising temperatures.

For India, this means that an El Nino-related rainfall deficit can have effects that extend well beyond agriculture. Reduced surface-water availability may increase groundwater extraction, while competition between domestic, agricultural, industrial and ecological uses can become more intense.

Food prices and food security

The relationship between El Nino and food prices is indirect but important. When climate conditions reduce agricultural supply, prices of affected commodities may

increase. The size and duration of the price response depend on stocks, imports, substitution between commodities, government intervention and market conditions. This matters for SDG 2 because food security is not simply a question of total production. Affordability and access are also important. The 2026 UN assessment of SDG 2 notes that escalating weather extremes threaten progress towards zero hunger and calls for resilient, climate-smart food systems.

IV. El Nino and the Sustainable Development Goals

SDG	El Nino-related pathway	Potential threat
SDG 1 – No Poverty	Crop losses, reduced farm income and employment	Greater livelihood insecurity and rural poverty
SDG 2 – Zero Hunger	Lower production, food-price pressure and nutrition risks	Higher food insecurity and difficulty achieving resilient agriculture
SDG 3 – Good Health	Heat, water stress, floods and climate-sensitive disease	Greater pressure on health systems and vulnerable populations
SDG 6 – Clean Water	Rainfall variability, drought and groundwater pressure	Water scarcity and difficulty achieving sustainable water management
SDG 8 – Decent Work	Agricultural and rural economic disruption	Reduced employment and income opportunities
SDG 12 – Responsible Production	Resource stress and production losses	Greater pressure on efficient and sustainable resource use
SDG 13 – Climate Action	More complex and interacting climate risks	Higher adaptation requirements
SDG 15 – Life on Land	Drought, heat and ecosystem stress	Land degradation and biodiversity pressures

SDG 1: No Poverty

Climate shocks can increase poverty by reducing the income of households that depend directly or indirectly on agriculture. The effect may be particularly severe for households with limited savings, insurance or alternative employment. An El Nino event can therefore reverse short-term poverty-reduction gains if adequate support is not available.

SDG 2: Zero Hunger

SDG 2 is perhaps the most direct development concern. Reduced agricultural output can affect both the availability and affordability of food. The UN's 2026 assessment stresses that weather extremes are already threatening progress towards zero hunger and that resilient, climate-smart food systems are needed.

SDG 3: Good Health and Well-being

Health impacts can arise through several routes. Heat and dehydration can increase health risks, while flooding or water-quality problems can increase exposure to water-related disease. Food-price shocks can also affect nutrition among poorer households. The health effect is therefore not limited to a single disease pathway.

SDG 6: Clean Water and Sanitation

Water security is fundamental to sustainable development. Current UN reporting notes that billions of people still lack safely managed drinking water and sanitation and that climate change is making water availability more uncertain. In an El Nino year, drought conditions can reduce water availability, while in other locations altered rainfall can increase flood risks. Sustainable water management therefore needs to account for both scarcity and excess water.

SDG 8: Decent Work and Economic Growth

Agricultural losses can affect employment not only on farms but also in transport, processing, trading and other rural activities. For regions with limited economic diversification, this can turn a seasonal climate shock into a wider local economic slowdown.

SDG 12: Responsible Consumption and Production

Climate shocks can make production less predictable and increase pressure on scarce resources. In agriculture, inefficient responses to water scarcity may increase groundwater depletion. Sustainable production therefore requires adaptation measures that improve resource efficiency rather than simply increasing extraction.

SDG 13: Climate Action

SDG 13 is closely connected to the El Nino question because climate action includes adaptation to climate-related hazards. El Nino cannot be prevented through mitigation policy, but the damage caused by its impacts can be reduced through preparedness, resilient infrastructure, climate information and adaptive institutions.

SDG 15: Life on Land

Drought and heat can place stress on forests, grasslands, soil and biodiversity. Where vegetation cover is already degraded, climate stress may accelerate land degradation. Protecting ecosystems can therefore serve as an adaptation measure as well as a biodiversity objective.

SDG 13 and SDG 15: A Combined Climate–Ecosystem Risk

The review indicates that climate adaptation and ecosystem protection should be treated as complementary responses. El Nino-related drought and heat can increase stress on land, vegetation and water systems, while degraded ecosystems reduce the capacity of communities to absorb climatic shocks. Thus, progress under SDG 13 and SDG 15 can influence the resilience of the food, water and livelihood systems associated with other SDGs.

V. Methodology and Analytical Framework

This study adopts a non-empirical, narrative review approach. The analysis is based on secondary literature and documentary sources relating to El Nino/ENSO, sustainable development, climate risk, Indian monsoon variability, agriculture, food security and water resources. The principal sources reviewed include publications of the United Nations, IPCC, World Meteorological Organization and peer-reviewed Indian studies cited in the reference list.

The review followed four broad stages. First, the major development systems exposed to El Nino were identified: agriculture, water, food markets, livelihoods, health and ecosystems. Second, these systems were mapped to the Sustainable Development Goals that are most directly affected. Third, the available Indian evidence was examined to identify pathways linking El Nino, monsoon variability and agricultural outcomes. Finally, the evidence was synthesised into a conceptual results framework that explains how a climate disturbance may translate into development risks.

Because the paper is a review study, the term “results” is used to refer to findings emerging from the synthesis of the reviewed literature rather than to statistically estimated primary or secondary survey results. The study therefore does not claim causal estimates beyond the evidence available in the cited sources. This approach is appropriate for identifying major pathways, recurring vulnerabilities and policy implications across interconnected SDG domains.

VI. Results and Discussion

The synthesis of the reviewed literature produces five principal findings.

Result 1: El Nino is best understood as a systemic development risk rather than a purely meteorological event. The literature reviewed in this paper consistently shows that changes in rainfall and temperature become development problems when they interact with exposure and vulnerability. The same El Nino episode may therefore have different consequences across regions, crops and social groups.

Result 2: Agriculture and water are the principal transmission channels in the Indian context. The reviewed evidence on monsoon variability and crop productivity, including the Parbhani study, indicates that El Nino conditions can be associated with weaker southwest monsoon and annual rainfall and with reduced productivity for several crops. However, the response is not uniform, indicating that local rainfall patterns, crop characteristics and irrigation matter.

Result 3: The consequences can spread through a food–water–livelihood chain. A rainfall deficit may reduce water availability and agricultural output; lower output may affect farm income and employment and place upward pressure on food prices. These effects can subsequently influence poverty, nutrition, health and local economic activity.

Result 4: The greatest risks arise where climatic exposure is combined with weak coping capacity. Rainfed agriculture, groundwater stress, limited irrigation, low

household savings, weak market access and inadequate climate information increase the probability that a temporary climate shock will produce wider development losses.

Result 5: Resilience measures have cross-SDG benefits. Early warning, climate-resilient agriculture, efficient water management, food-system preparedness, ecosystem protection and anticipatory social protection can reduce exposure and vulnerability simultaneously. The review therefore suggests that resilience investment should be treated as an integral component of SDG implementation.

Table 2. Summary of Synthesised Results and Development Implications

Finding	Evidence synthesised	Development implication
El Nino affects development through multiple systems	International climate and SDG literature	Requires cross-sector policy coordination
Monsoon and agricultural impacts vary spatially and by crop	Indian rainfall and crop studies	Localised planning is essential
Water stress can transmit climate shocks beyond agriculture	SDG 6 and climate-risk literature	Water policy is central to SDG resilience
Food security depends on both production and affordability	SDG 2 literature	Production shocks need market and social-policy responses
Vulnerability determines the severity of outcomes	Climate adaptation literature	Focus should be on exposed groups and low coping capacity
Resilience investments support several goals simultaneously	Review synthesis	Adaptation should be integrated into SDG planning

Discussion

The findings confirm the central argument of this paper: El Nino threatens sustainable development primarily through interconnected vulnerabilities. The significance of the phenomenon for India lies not simply in the possibility of a weak monsoon, but in the way rainfall and temperature disturbances can cascade through water systems, agriculture, food markets and household livelihoods.

The first major discussion point concerns the non-uniformity of El Nino impacts. The reviewed Indian evidence does not support a simplistic conclusion that every El Nino event produces identical drought or crop losses across the country. This is important for policy. A national climate forecast must be translated into district- and sector-specific risk information. The effectiveness of adaptation will depend on local irrigation, crop choice, reservoir conditions, groundwater dependence and the socio-economic capacity of households.

Second, the review demonstrates that SDG risks are interconnected. SDG 2 is directly exposed through agricultural production and food affordability, but a food shock can also affect SDG 1 through income losses, SDG 3 through nutrition and health, and SDG

8 through employment and rural economic activity. Similarly, water stress under SDG 6 can intensify agricultural and health risks. This supports a nexus approach rather than separate sectoral responses.

Third, vulnerability is the key factor that converts climate variability into a development crisis. Two districts experiencing similar rainfall conditions may have very different outcomes if one has reliable irrigation, diversified livelihoods, effective social protection and access to climate information while the other depends heavily on rainfed agriculture and depleted groundwater. The results therefore shift attention from the climate event alone to the resilience of social and economic systems.

Fourth, climate change increases the policy importance of preparedness. El Nino is a natural mode of climate variability and should not be equated with anthropogenic climate change. Nevertheless, higher background temperatures and changing extremes may intensify water demand, heat stress and the consequences of rainfall deficits. Adaptation planning must therefore consider both recurring climate variability and long-term climatic change.

Finally, the review identifies resilience as a development investment rather than an emergency cost. Investments in water conservation, crop diversification, climate information, ecosystem restoration and anticipatory social protection can generate benefits even in normal years and reduce losses during climate shocks. This makes resilience-building consistent with the broader objective of sustainable development.

VII. Key Contributions of the Study

The study makes four contributions. First, it brings together climate variability and SDG analysis through an integrated development perspective. Second, it places India's monsoon, agriculture and water systems at the centre of the El Nino–SDG relationship. Third, it presents a synthesised results framework suitable for a non-empirical review paper. Fourth, it translates the reviewed evidence into policy directions focused on district-level preparedness and resilience.

Limitations of the Study

This paper is based on secondary sources and does not estimate the magnitude of El Nino effects using an original statistical model. The conclusions should therefore be interpreted as a synthesis of the reviewed evidence. In addition, ENSO impacts vary across events and locations, and the availability of comparable district-level evidence remains limited. Future empirical research can address these limitations by combining climate indicators with district-level data on rainfall, crop yields, water availability, food prices and household welfare.

The Food–Water–Climate Nexus

El Nino demonstrates why the SDGs should not be treated as separate policy compartments. Agriculture requires water; food production affects prices and livelihoods; water scarcity affects health and ecosystems; and climate action influences the capacity of societies to absorb shocks.

El Nino → Rainfall and temperature variability → Water availability → Agriculture → Food prices and livelihoods → Health and poverty → SDG progress

This chain is not automatic. Its strength depends on irrigation, reservoir storage, crop diversification, markets, government policy, social protection and local adaptive capacity. A resilient system can absorb part of a climate shock without suffering major development losses.

El Nino, Climate Change and Vulnerability

El Nino is a natural component of the climate system, whereas current global warming is primarily driven by human activities. The two should not be treated as the same phenomenon. However, their effects can interact. Higher background temperatures can increase heat stress and evaporative demand, making some drought conditions more damaging.

The important policy issue is therefore vulnerability. An El Nino event is an external shock, but the scale of its consequences is influenced by the resilience of agricultural, water, health and social systems. The same climatic disturbance can have very different outcomes in two regions because their infrastructure, institutions and coping capacity differ.

Lessons from Previous El Nino Events

The 2015–16 El Nino episode attracted substantial international attention because of its effects on food security, health, livelihoods and displacement. The United Nations highlighted the need for stronger early-warning systems and long-term resilience rather than relying only on emergency response. The Indian evidence also shows why event-specific analysis is necessary. Dakhore et al. (2020) found that different crops responded differently to El Nino conditions at Parbhani, demonstrating that vulnerability is shaped by local agricultural characteristics.

These lessons suggest that a national response should combine climate forecasts with local information about crops, water availability, household vulnerability and market conditions.

Challenges to Sustainable Development in India

- High dependence on monsoon rainfall in many agricultural areas.
- Unequal access to irrigation and climate-resilient technologies.
- Groundwater depletion in several agricultural regions.
- Limited capacity of vulnerable households to absorb income shocks.
- Food-price volatility following supply disturbances.
- Uneven access to reliable climate information and early-warning services.
- Pressure on ecosystems and natural resources during drought and heat.
- Coordination challenges between agricultural, water, disaster-management and social-protection policies.

VIII. Strategies for Building El Nino Resilience

Strengthen early-warning systems

Climate forecasts become valuable when they lead to decisions. Seasonal ENSO information should be translated into practical advisories for farmers, water managers,

local governments and vulnerable households. Early warning should be connected to early action rather than treated simply as information dissemination.

Promote climate-resilient agriculture

Crop diversification, drought-tolerant varieties, soil-moisture conservation, micro-irrigation, improved agronomic practices and weather-based advisories can reduce agricultural exposure. The appropriate combination will differ by region and crop.

Improve water management

Water security requires attention to both supply and demand. Rainwater harvesting, watershed restoration, efficient irrigation, groundwater regulation and better reservoir management can reduce vulnerability to rainfall deficits.

Strengthen food-system resilience

Adequate public stocks, efficient procurement, diversified food supply chains and timely market interventions can reduce the effect of climate-related production shocks on consumers. Nutrition programmes are particularly important for vulnerable groups.

Expand anticipatory social protection

Social-protection systems can be designed to respond before a forecast climate shock produces its full economic effect. Temporary employment support, cash transfers, food assistance and livelihood protection can help households avoid distress sales of assets.

Integrate SDG and climate-risk planning

Climate-risk information should be incorporated into SDG monitoring. Progress should be assessed not only by current outcomes but also by the resilience of systems to foreseeable climate variability.

Policy Implications for India

India's response to El Nino should be based on preparedness rather than on a single emergency measure. The most useful approach is likely to combine climate forecasting with district-level vulnerability assessment. A district experiencing an El Nino-related rainfall deficit, low reservoir storage and a high share of rainfed agriculture should receive a different policy response from a district with reliable irrigation and adequate water reserves.

The food, water and climate sectors also need stronger coordination. Agricultural policy that increases water demand can become counterproductive during drought conditions, while water policy that ignores food-security needs can create other risks. A nexus-based approach can help policymakers manage these trade-offs. The broader lesson is that resilience is itself a development investment. Spending on water efficiency, climate information, resilient seeds, ecosystem restoration and social protection may reduce losses when climate shocks occur and can also support development in normal years.

IX. Research Gaps and Future Directions

The existing literature provides useful evidence but leaves several areas for further investigation. First, the relationship between ENSO and Indian rainfall varies across regions and events. Second, agricultural impacts differ substantially by crop and

irrigation status. Third, more work is needed on the transmission from climate shocks to food prices and household welfare. Fourth, the interaction between El Nino and other climate drivers deserves greater attention. Future research could also examine district-level vulnerability, the role of groundwater, gendered livelihood effects, migration, nutrition outcomes and the effectiveness of anticipatory social protection. Such work would complement the conceptual and review-based analysis presented here.

X. Conclusion

El Nino is a natural climate phenomenon, but its consequences can become a serious development challenge when they interact with vulnerable food, water, economic and social systems. In India, the link between El Nino, monsoon variability and agriculture makes the issue particularly important. The effects can extend from crop production to food prices, farm income, water availability, health and local employment.

The implications for the SDGs are therefore broad. SDG 2 may be affected through food production and affordability; SDG 6 through water availability; SDG 1 and SDG 8 through livelihoods; SDG 3 through health risks; SDG 13 through the need for adaptation; and SDG 15 through ecosystem stress. The interconnected nature of these impacts reinforces the need for integrated policy.

El Nino cannot be prevented, but its development consequences can be reduced. Early warning, climate-resilient agriculture, diversified crops, efficient water management, resilient food systems, ecosystem protection and anticipatory social protection can strengthen India's capacity to withstand ENSO-related shocks. In this sense, building El Nino resilience is not a separate climate programme. It is part of the wider effort to protect and accelerate progress towards sustainable development.

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