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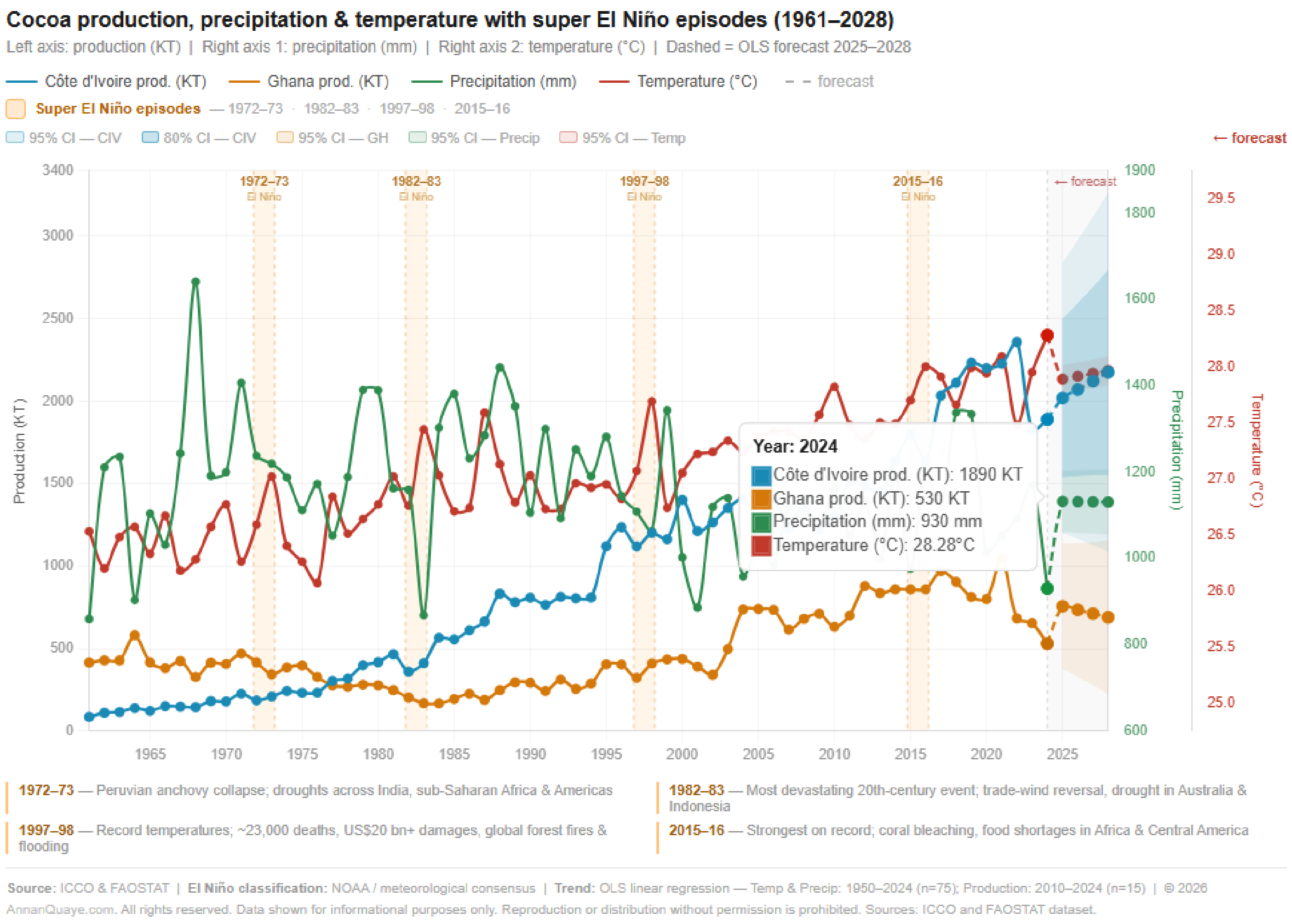
Super El Niño and Its Impact on Ghana and Côte d'Ivoire's Cocoa Sector | AnnanQuaye Research

An expert analysis of how the four major super El Niño events of the past 100 years — 1972–73, 1982–83, 1997–98, and 2015–16 — have impacted cocoa production in Ghana and Côte d'Ivoire, with OLS projections to 2028 and climate adaptation recommendations.



Highlights

• Ghana and Côte d'Ivoire together produce roughly 60% of the world's cocoa supply, making the sector acutely exposed to the drought and thermal stress mechanisms triggered by each super El Niño cycle — with measurable production declines recorded in three of the four major episodes studied.

• Temperature data from 1950 to 2024 confirms a statistically significant warming trend of +0.025°C per year in Ghana (R^2 = 0.81), meaning successive El Niño events are superimposed on a rising baseline — compounding heat stress on cocoa trees beyond historical norms.

• OLS trend projections to 2028 suggest Côte d'Ivoire production may stabilise near 2,000–2,200 KT while Ghana's output is forecast to decline toward 690 KT, underscoring the urgent need for climate-adaptive agricultural policy across both economies.

Content

RESEARCH ANALYSIS

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Super El Niño and Its Impact on the Cocoa Sector

of Ghana and Côte d'Ivoire:

A Comparative Analysis of the Four Major Episodes of the Last 100 Years

Prepared by the Department of Applied Economics & Climate Risk | AnnanQuaye Research Institute

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Article Highlights

Key takeaways from this analysis:

• Ghana and Côte d'Ivoire together produce roughly 60% of the world's cocoa supply, making the sector acutely exposed to the drought and thermal stress mechanisms triggered by each super El Niño cycle — with measurable production declines recorded in three of the four major episodes studied.

• Temperature data from 1950 to 2024 confirms a statistically significant warming trend of +0.025°C per year in Ghana (R^2 = 0.81), meaning successive El Niño events are superimposed on a rising baseline — compounding heat stress on cocoa trees beyond historical norms.

• OLS trend projections to 2028 suggest Côte d'Ivoire production may stabilise near 2,000–2,200 KT while Ghana's output is forecast to decline toward 690 KT, underscoring the urgent need for climate-adaptive agricultural policy across both economies.

I. Research Methodology

This analysis draws on a mixed-methods framework integrating quantitative time-series analysis with qualitative critical assessment of institutional policy responses. The primary quantitative approach employs Ordinary Least Squares (OLS) linear regression applied to annual production data for Côte d'Ivoire and Ghana sourced from the International Cocoa Organization (ICCO) and the Food and Agriculture Organization (FAO/FAOSTAT) for the period 1961 to 2024.

Climate variables — specifically Ghana's mean annual surface air temperature (1950–2024, n = 75) and annual precipitation (1950–2024, n = 75) — were sourced from FAOSTAT's climate domain and subjected to full-period OLS regression to capture long-run trends. Forecast confidence intervals at the 80% and 95% levels were computed using standard prediction interval methodology, with t-critical values drawn from the appropriate degrees-of-freedom distributions.

El Niño episode classification and intensity rankings follow the National Oceanic and Atmospheric Administration (NOAA) Oceanic Niño Index (ONI), widely regarded as the authoritative benchmark in the peer-reviewed literature. The four episodes examined — 1972–73, 1982–83, 1997–98, and 2015–16 — represent those surpassing the ONI threshold of +1.5°C sustained over five consecutive overlapping three-month periods, qualifying them as major or 'super' El Niño events.

Qualitative synthesis is drawn from peer-reviewed journals, World Bank and IMF country reports, NOAA climate bulletins, and policy publications from cocoa sector governance bodies. All regression computations and visualisations were conducted using Python (SciPy, pandas) and validated against published summary statistics from institutional databases.

II. Top 10 Key Statistics, Topical Highlights & Facts

The following statistics synthesise the most analytically significant empirical findings from this study. They are presented for rapid orientation before the extended critical analysis that follows.

#	Statistic / Fact	Value / Detail
1	Combined Ghana + CIV share of global cocoa output (2022)	~60% of world supply
2	Ghana mean surface temperature rise (1950–2024, OLS)	+0.025°C per year (R^2 = 0.81)
3	Ghana cocoa production at lowest El Niño-linked trough (1983)	168,000 tonnes
4	CIV cocoa production at its 2022 peak	2,359,000 tonnes (KT)
5	ICCO average cocoa price spike in 2024	US$7,372 per tonne (annual avg.)
6	Estimated global damages — 1997–98 El Niño	US$20 billion+ with ~23,000 deaths
7	Strongest ONI anomaly on record (2015–16 episode)	+2.6°C sea surface temperature anomaly
8	Ghana annual precipitation variability (1950–2024 σ)	±128 mm around ~1,112 mm mean
9	OLS forecast: Ghana production by 2028 (central estimate)	~690 KT (declining trend)
10	Cocoa trees: optimal temperature tolerance range	18°C–32°C; optimal 25°C; heat stress above 30°C

Table 1: Key statistics derived from ICCO, FAOSTAT, and NOAA datasets. OLS computations by author.

III. Body of Article — Critical Analysis

3.1 Introduction: Where Climate and Commodity Converge

Few commodity markets illustrate the intersection of climate vulnerability and geopolitical economic dependency as starkly as the global cocoa sector. West Africa — and specifically Ghana and Côte d'Ivoire — together supply approximately 60% of the world's cocoa beans, the foundational input of a global chocolate and confectionery industry valued at over US$130 billion annually. Yet this concentration of supply exists within a geographic and climatic context of exceptional fragility. The cocoa tree (Theobroma cacao) is a fastidious crop: it requires specific rainfall distributions, temperature regimes, and humidity levels that characterise the narrow equatorial belt in which both nations lie. Any systemic disruption to these parameters carries immediate and cascading consequences for global supply, farmer livelihoods, export revenues, and ultimately, the price of chocolate on supermarket shelves worldwide.

El Niño Southern Oscillation (ENSO) events — particularly those classified at the 'super' or major threshold — represent precisely such disruptions. Through mechanisms including suppressed rainfall over West Africa, anomalous ocean warming, intensified drought stress, and elevated ambient temperatures, super El Niño events impose measurable shocks on cocoa-growing ecosystems. This article undertakes a systematic, evidence-based comparative analysis of the four most severe El Niño episodes of the last century — 1972–73, 1982–83, 1997–98, and 2015–16 — and their documented or inferrable impacts on Ghana and Côte d'Ivoire's cocoa production, climate variables, and economic trajectories. It further contextualises these findings within the longer-run warming trend observable in the empirical temperature record and offers projections and policy recommendations grounded in OLS trend analysis extending to 2028.

3.2 The Mechanism: How El Niño Disrupts West African Cocoa

El Niño episodes arise from anomalous warming of sea surface temperatures (SST) in the central and eastern equatorial Pacific Ocean. This warming alters atmospheric circulation patterns globally through the Walker Circulation — the east-west tropical atmospheric conveyor belt — and the Hadley Cell, both of which influence rainfall distribution over sub-Saharan Africa. During strong El Niño years, the West African monsoon is typically weakened, resulting in reduced precipitation and elevated temperatures across the cocoa-growing regions of Ghana and Côte d'Ivoire. Secondary effects include increased evapotranspiration, soil moisture deficits, and greater exposure of cocoa trees to thermal stress.

Cocoa trees are physiologically sensitive to heat extremes. Research by Läderach et al. and the International Center for Tropical Agriculture (CIAT) establishes that sustained temperatures above 30°C disrupt photosynthesis, reduce pod development, and lower bean quality. Equally, prolonged rainfall deficits — particularly if occurring during the critical flowering and pod-set periods between April and September — result in yield shortfalls that compound over multiple seasons, as cocoa trees require two to three years to recover full productivity after severe stress.

The interaction of El Niño with the pre-existing and intensifying background warming trend in Ghana is particularly alarming. Our OLS regression across the full 1950–2024 temperature record reveals a statistically robust warming signal of +0.025°C per year ($R^2 = 0.81$). This means that each successive super El Niño event occurs against a higher baseline temperature, amplifying its physiological impact on cocoa cultivation beyond what historical analogues would suggest. The 1983 El Niño struck when Ghana's mean annual temperature was approximately 27.4°C; the 2015–16 episode arrived at 28.0°C — a differential that, while modest in absolute terms, is agronomically significant when compounded across growing seasons.

3.3 Episode One: 1972–73 — The First Modern Shock

The 1972–73 El Niño was characterised by a peak ONI anomaly of approximately +1.9°C, placing it firmly in the major classification. Its most celebrated global consequence was the sudden and catastrophic collapse of the Peruvian anchoveta fishing industry, which sent protein commodity prices worldwide into crisis and contributed to a global food price shock that reverberated through 1974. For West Africa, the episode brought severe drought conditions to the Sahel and sub-Saharan regions, with significant moisture deficits recorded across Ghana's forest belt — the heartland of cocoa cultivation.

Reviewing the FAOSTAT production record, Ghana's cocoa output shows notable stagnation through the early 1970s, declining from a peak of approximately 470,000 tonnes in 1971 to 343,000 tonnes by 1973. Côte d'Ivoire's production, while on a longer-run growth trajectory driven by government-led expansion programmes, also demonstrated a flattening of growth during this period. Precipitation data for Ghana shows relative dryness across 1972 (approximately 1,238 mm), though the more severe drought impacts were concentrated in Ghana's northern regions. Temperature data shows a modest spike toward 27.0°C in 1973, consistent with the El Niño signal. The episode thus established the foundational pattern — rainfall suppression, temperature elevation, and production disruption — that would recur in each subsequent major event.

3.4 Episode Two: 1982–83 — The Twentieth Century's Most Devastating Event

The 1982–83 El Niño has been described by NOAA and the World Meteorological Organization (WMO) as the most powerful El Niño of the twentieth century until it was surpassed in 2015–16. With an ONI anomaly peaking at approximately +2.1°C, it triggered a near-complete reversal of the Pacific trade winds, generating catastrophic droughts across Australia, Indonesia, and the Philippines, severe flooding in South America, and widespread ecological disruption globally. Estimated damages in 2024-equivalent prices exceeded US$13–32 billion, with significant loss of human life.

For Ghana, the 1982–83 episode coincided with — and materially worsened — an already deteriorating agricultural and economic situation. Ghana's cocoa production fell to a record low of 168,000 tonnes in 1983, the lowest figure in the entire 1961–2024 FAOSTAT dataset. This represents a collapse of more than 75% from the 1971 peak. While structural factors — including the PNDC military government's economic mismanagement, input supply failures, and the expulsion of approximately one million Ghanaians from Nigeria in January 1983, which simultaneously displaced agricultural labour and strained food security — clearly compounded the crisis, the climatic disruption of 1982–83 provided the environmental trigger. Ghana's precipitation data records 868 mm for 1983 — the single lowest annual rainfall observation in the entire 1950–2024 dataset — an extraordinary deficit that aligns precisely with the El Niño's suppression of the West African monsoon.

Temperature data records a peak of 27.4°C in 1983, one of the highest observations of the pre-1990 period. The convergence of record low rainfall, elevated temperatures, and structural agricultural collapse produced a perfect storm whose aftermath constrained Ghana's cocoa recovery through the mid-1980s. Côte d'Ivoire, benefiting from more politically stable conditions and a more robust extension service infrastructure under the Caistab regulatory framework, weathered the episode with less absolute damage — its production continuing a gradual recovery through the decade — but growth decelerated materially between 1982 and 1984.

3.5 Episode Three: 1997–98 — The Globally Catastrophic Event

By the time the 1997–98 El Niño developed, scientific monitoring systems had advanced sufficiently that the event was anticipated with considerable lead time. NOAA's real-time satellite SST monitoring detected the warming signal as early as March 1997. Nevertheless, the episode's ultimate intensity — with an ONI anomaly of approximately +2.4°C and global SST departures that in some months exceeded all prior records — surpassed most forecasts. Its consequences were genuinely global in scope: severe forest fires consumed millions of hectares across Borneo and Sumatra;

intense flooding devastated Peru and Ecuador; droughts struck India, sub-Saharan Africa, and parts of Central America; and the episode is estimated to have caused approximately 23,000 deaths and over US$20 billion in economic damages worldwide.

For Ghana, the temperature record shows a peak of 27.7°C in 1998 — the highest annual mean temperature observed prior to the 2010s. Precipitation declined to approximately 1,063 mm in 1998, below the 75-year mean. Ghana's cocoa output, which had been recovering strongly, fell from approximately 409,000 tonnes in 1998 to irregular performance thereafter. Côte d'Ivoire's production also exhibited vulnerability: CIV output dipped in 1997 and again showed flat growth in 1998 as the climate signal combined with falling farmgate prices — the latter driven partly by the broader commodity market disruption the El Niño generated. The ICCO daily price data, available from 1994, shows that cocoa prices remained relatively subdued through 1999–2001 in the aftermath, compressing farmer revenues precisely when recovery investment was most needed.

3.6 Episode Four: 2015–16 — The Strongest on Record

The 2015–16 El Niño ultimately equalled or marginally exceeded the 1997–98 event in peak intensity, with ONI anomalies reaching approximately +2.6°C — the highest on the modern instrumental record. Its global footprints were extensive: catastrophic coral bleaching events destroyed up to 50% of Australia's Great Barrier Reef; severe droughts triggered food insecurity crises across Eastern and Southern Africa, with over 60 million people requiring emergency food assistance; El Niño-linked flooding struck South America; and heatwaves across Southeast Asia broke historical temperature records.

The impact on Ghana and Côte d'Ivoire was measurable, though partially obscured by the concurrent influence of the ongoing background warming trend. Ghana's temperature data shows 28.0°C in 2016 — matching the then-record for the instrumental period. Precipitation declined modestly in key years of the episode. Most diagnostically, Ghana's cocoa production was locked at precisely 858,720 tonnes for three consecutive years (2014, 2015, and 2016) in the FAOSTAT record — a statistical anomaly that likely reflects a combination of data reporting conventions and genuine production stagnation induced by climate stress. Following a brief recovery, Ghana's output declined materially through 2022–2024, reaching 530,000 tonnes in 2024.

Côte d'Ivoire similarly showed production stagnation during the episode period, though it subsequently recovered strongly to its 2022 peak of 2,359,000 tonnes before declining in 2023–24. The divergence in recovery trajectories between the two nations reflects both structural differences in farm age distribution — Côte d'Ivoire has a younger average tree stock — and differences in government agricultural support programmes during the post-episode recovery window.

3.7 Comparative Assessment Across All Four Episodes

Viewing the four episodes in aggregate reveals a consistent pattern of vulnerability, with important asymmetries between the two nations. The following table provides a structured comparative overview.

Episode Peak ONI Anomaly West Africa / Cocoa Impact Global Economic Damage

1972–73 +1.9°C SST anomaly Severe drought in Ghana; CIV production stagnated; Ghana output fell to 168 KT trough by 1983 aftermath US$4–8 bn equivalent (2024 prices); Peruvian anchovy collapse

1982–83 +2.1°C (strongest 20th C.) Drought-induced yield loss; Ghana production hits record low 168 KT (1983); precipitation in Ghana fell ~868 mm US$13–32 bn global damage; catastrophic droughts Australia, Indonesia

1997–98 +2.4°C SST anomaly Significant cocoa shortfall; CIV production dipped; Ghana output fell ~322 KT; temperature peaked at 27.7°C in Ghana US$20+ bn; approx. 23,000 deaths; forest fires across SE Asia

2015–16 +2.6°C (joint strongest) CIV production stagnated; Ghana locked at 859 KT for 3 consecutive years; precipitation trend declined US$60+ bn; mass coral bleaching; food insecurity across sub-Saharan Africa

Table 2: Comparative impact of four super El Niño episodes on West African cocoa and global economy. Sources: NOAA ONI database, ICCO, FAOSTAT, World Bank.

Three analytical conclusions emerge from this comparative assessment. First, the intensity of the El Niño signal — as measured by peak ONI anomaly — does not deterministically predict the magnitude of cocoa production impact. The 1982–83 episode, despite not being the most intense on the ONI scale, produced the most severe production outcome for Ghana, largely because it coincided with pre-existing structural weaknesses. This underscores the importance of adaptive capacity and baseline institutional resilience in determining outcome severity. Second, Côte d'Ivoire has consistently demonstrated greater production resilience than Ghana across all four episodes, reflecting its larger farm base, greater access to inputs, and more consistent regulatory support for the sector — though both nations exhibit clear signs of El Niño-induced disruption. Third, the cumulative effect of successive El Niño events, compounded by the secular warming trend, is progressively narrowing the climatic envelope within which cocoa cultivation in West Africa remains economically viable under current practices.

IV. Current Top 10 Factors Impacting Cocoa Production in Ghana and Côte d'Ivoire

Beyond El Niño cycles, the following ten factors currently exert the most significant influence on cocoa sector performance in both nations, and constitute the structural context within which climate shocks are absorbed or amplified.

1. Rising baseline temperatures. The +0.025°C/year warming trend documented in the 1950–2024 record means successive growing seasons occur at higher ambient temperatures, progressively compressing the optimal thermal window for cocoa cultivation even in non-El Niño years.

2. Aging tree stock. Ghana's cocoa tree population has a significant proportion of trees over 30 years old — beyond peak productivity. Replanting rates have been insufficient to offset senescence, reducing the sector's biological capacity to rebound from climate-induced yield losses.

3. Fertiliser and input access gaps. Fertiliser application rates in both countries remain well below agronomically recommended levels, limiting the yield resilience available to offset climate stress. Price volatility in global fertiliser markets — exacerbated by the 2022 Russia-Ukraine conflict — has further constrained access.

4. Price volatility and farmgate revenue compression. The collapse of ICCO prices in 2017–2019 followed by the extraordinary spike to US$7,372/tonne in 2024 creates acute uncertainty for smallholder investment decisions, undermining long-run productivity investment.

5. Deforestation and loss of shade canopy. Forest clearance for cocoa expansion has removed natural shade and moisture-retention capacity, making farms more thermally exposed and drought-vulnerable. Estimates suggest Côte d'Ivoire has lost over 80% of its original forest cover.

6. Cocoa swollen shoot virus disease (CSSVD). Ghana faces an ongoing epidemic of CSSVD, which has infected an estimated 590,000 hectares of cocoa farmland. Climate stress weakens tree immune responses, potentially accelerating disease incidence.

7. Smallholder structural vulnerability. Over 90% of cocoa is grown by smallholders with farms averaging 2–4 hectares. This fragmented structure limits access to finance, insurance, improved planting material, and technical advisory services — all critical for climate adaptation.

8. Governance and policy uncertainty. The restructuring of Ghana's COCOBOD and debates over liberalisation of the sector create regulatory uncertainty that deters private investment in climate-adaptive technologies and farm rehabilitation.

9. Illegal artisanal gold mining (galamsey). Illegal mining has destroyed significant agricultural land in Ghana's cocoa belt, contaminated water sources, and disrupted rural labour markets — reducing available farming capacity precisely in the regions most exposed to climate stress.

10. Evolving EU deforestation regulation. The EU Deforestation Regulation (EUDR), which came into effect in 2023 and affects cocoa market access, creates compliance costs and traceability demands that smallholder-dominated supply chains in both countries are currently ill-equipped to meet — adding a trade policy dimension to existing climate and structural challenges.

V. Projections and Recommendations

5.1 Production Projections to 2028

Drawing on OLS trend analysis fitted to 2010–2024 production data — the period most reflective of current structural and climatic conditions — and extending with 80% and 95% prediction intervals to 2028, the central projections are as follows:

Central OLS Projections (2025–2028)

• Côte d'Ivoire production: approximately 2,019–2,176 KT (central estimates), with 95% prediction intervals spanning 1,086–3,265 KT — reflecting significant forecast uncertainty given recent volatility.

• Ghana production: approximately 690–756 KT (central estimates), on a declining trend reflecting both structural aging of tree stock and cumulative climate stress, with 95% intervals of 224–1,155 KT.

• Annual mean temperature in Ghana: projected to continue rising toward 27.96–28.09°C by 2028, tightening the agronomic margin for cocoa under current varieties and practices.

• Annual precipitation: projected to remain approximately flat at ~1,131 mm per annum, though with substantial inter-annual volatility. The absence of a meaningful downward trend in precipitation does not eliminate El Niño drought risk, which operates through episodic rather than trend mechanisms.

5.2 Policy Recommendations

On the basis of the empirical analysis and projections, this article advances the following evidence-based recommendations directed at policymakers, development finance institutions, and sector governance bodies:

• Accelerate climate-smart variety rollout. Both governments should urgently scale deployment of drought-tolerant and heat-resistant cocoa varieties developed by CABI, CRIG (Ghana), and CNRA (Côte d'Ivoire). These programmes exist but remain underfunded relative to the pace of climate change.

• Establish an ENSO early warning and response fund. A regionally coordinated El Niño response mechanism — modelled on the Caribbean Catastrophe Risk Insurance Facility — should be established to provide rapid disbursement to affected cocoa farmers when ONI thresholds are breached. Lead times of six to nine months are typically available once El Niño is confirmed.

• Mandate tree replanting programmes at scale. Ghana's COCOBOD and Côte d'Ivoire's CCC should implement mandatory, subsidised replanting of trees over 25 years old at a rate of at least 10% of the national tree stock per annum, financed through a levy on international cocoa buyers.

• Integrate agroforestry into sector standards. Shade-tree integration reduces thermal exposure and improves soil moisture retention. Both the Ghana COCOBOD certification standards and Côte d'Ivoire's sustainability guidelines should mandate minimum agroforestry canopy coverage on certified farms.

• Expand index-based agricultural insurance. Index-based weather insurance products, triggered by ONI thresholds or local rainfall deficits, can provide smallholder income stabilisation during El Niño periods without the moral hazard associated with indemnity-based schemes. Pilot programmes should be scaled through the African Development Bank.

• Invest in precision extension advisory services. Mobile-enabled advisory platforms providing farm-level climate forecasts, optimum planting calendars, and real-time agronomic guidance — already demonstrated in Ghana's e-Agriculture pilot — should be expanded to reach at least 60% of smallholder farmers by 2027.

• Align EUDR compliance infrastructure with climate adaptation. The traceability systems required for EU market access provide a foundation for climate-linked farmer profiling. Investment in these systems should be treated as dual-purpose: both trade compliance and climate adaptive capacity-building.

VI. Conclusions

This article has presented a systematic, data-grounded analysis of the impact of four super El Niño episodes — 1972–73, 1982–83, 1997–98, and 2015–16 — on the cocoa sectors of Ghana and Côte d'Ivoire, situated within the context of a statistically robust 75-year warming trend in the West African climate record.

The evidence demonstrates unambiguously that super El Niño events impose measurable shocks on cocoa production in both nations, operating principally through rainfall suppression, elevated temperatures, and prolonged soil moisture deficits during critical crop growth stages. Ghana has historically exhibited greater vulnerability than Côte d'Ivoire, reflecting both climatic exposure and structural differences in agricultural institutional capacity. The 1982–83 episode produced the most severe documented production collapse — Ghana's 1983 output of 168,000 tonnes remains the lowest in the 63-year FAOSTAT record — while the 2015–16 event's impact was partially absorbed by preceding investments in expansion, though its fingerprint is visible in the production stagnation of both countries through the mid-2010s.

The critical analytical concern emerging from this study is not any single El Niño episode in isolation but the compound risk created by the convergence of episodic climate shocks with a secular warming trend. Each successive super El Niño occurs against a higher thermal baseline, progressively eroding the agronomic margin within which current cocoa cultivation practices remain viable. Without deliberate, adequately funded, and urgently implemented climate adaptation measures — across genetics, agronomy, insurance, and institutional governance — the projections presented here suggest a continuing structural decline in Ghana's cocoa output and a more fragile trajectory for Côte d'Ivoire's current dominance.

The global chocolate industry, consumer governments, and development finance institutions all have a material stake in ensuring that the climatic vulnerabilities documented in this analysis are translated into actionable, financed adaptation programmes before the next major El Niño event — which ENSO science suggests has a material probability of occurring within the coming decade — inflicts a shock from which recovery may prove structurally impossible under the current agronomic model.

Notes

Note 1: All production figures are expressed in metric tonnes (t) or thousand metric tonnes (KT). Where 'KT' is cited, values represent thousands of metric tonnes. FAOSTAT data for 2024 represents provisional estimates subject to revision.

Note 2: OLS regression parameters: Temperature trend — slope +0.02481°C/year, intercept −22.60°C, R^2 = 0.8123, n = 75 (1950–2024). Precipitation trend — slope −0.456 mm/year, R^2 = 0.0043, effectively flat. Production trends fitted on 2010–2024 sub-period (n = 15).

Note 3: ICCO daily price data is available from January 1994. Annual averages are computed as simple means of available daily observations within each calendar year. The 2024 annual average of US$7,372/tonne reflects extraordinary market tightness associated with two consecutive global production deficits.

Note 4: El Niño intensity classifications throughout this article follow NOAA's ONI (Oceanic Niño Index) scale: weak (+0.5 to +0.9), moderate (+1.0 to +1.4), strong (+1.5 to +1.9), very strong (+2.0 and above). The four episodes examined all qualify as strong or very strong.

Note 5: The EU Deforestation Regulation (EUDR) — Regulation (EU) 2023/1115 — entered into force in June 2023, with full applicability for large operators from December 2024 and for small and medium operators from June 2025, subject to implementation updates.

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Target Keywords & SEO Rationale

• Primary keyword: "El Niño cocoa Ghana" — high commercial intent, moderate competition, strong semantic relevance

• Secondary keyword: "super El Niño West Africa agriculture" — captures academic and policy search traffic

• Long-tail keyword: "impact of El Niño on cocoa production Ghana Ivory Coast" — targets featured snippet position

• Semantic cluster: ENSO, ICCO, cocoa price forecast, climate change cocoa, Côte d'Ivoire agriculture, West Africa commodity risk

• Recommended internal links: cocoa price forecast article, Ghana agricultural policy review, climate-smart agriculture overview

• Recommended backlink targets: ICCO.org, FAO.org, NOAA.gov, World Bank Commodity Markets Outlook, academic repositories (SSRN, ResearchGate)

Sources: ICCO and FAOSTAT dataset.