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A STUDY ON GROWTH RATE OF COCOA IN INDIA WITH SPECIAL REFERENCE TO SUPPLY RESPONSE IN ANDHRA PRADESH

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ABSTRACT
India's production of cocoa (Theobroma cacao L.) has increased significantly over the previous 20 years, but it is still marked by price instability, stagnating productivity, and area-led growth. This study uses the Nerlovian partial adjustment framework to analyze the supply response of cocoa to price and non-price determinants in Andhra Pradesh and predicts the compound annual growth rate (CAGR) of yield, area, and production throughout key producing states. At the national level, yield growth has either plateaued or decreased despite significant increases in area and production, suggesting a structural productivity difference. The area and production CAGRs for Andhra Pradesh were 7.91% and 11.72%, respectively. The necessity for regionally tailored policy interventions was highlighted by the much higher price responsiveness of East Godavari compared to Eluru (short-run: 4.06 vs. 0.68; long-run: 8.74 vs. 1.23). Productivity-focused extension, price stabilization through procurement infrastructure, and district-specific policy design are recommended to strengthen cocoa supply response and close the productivity gap.

KEYWORDS: Area response; Cocoa; Compound Annual Growth Rate; Nerlovian adjustment model; Price elasticity

INTRODUCTION

In the nineteenth century, cocoa (Theobroma cacao L.), a member of the Malvaceae family, was brought to the Indian subcontinent from the tropical rainforests of South America. Commercial production began in the early 1970s, mostly as an intercrop on arecanut and coconut farms. This intercropping strategy still dominates the industry, making for over two thirds of the country's total cocoa acreage (George & Raju, 2021). Andhra Pradesh, Kerala, Tamil Nadu, and Karnataka are the four southern states that produce the majority of India's cocoa. Cocoa is a commodity of great economic and geopolitical importance on a global scale. The International Cocoa Organization (2025) estimated that 4.8 to 5.0 million tons of cocoa would be produced worldwide in 2025, with 65 to 70 percent coming from West Africa, led by Ghana and Côte d'Ivoire. Over 90% of the global supply is generated from smallholder farms, making the global cocoa supply chain extremely susceptible to input limitations, price signals, and weather shocks (Andres et al., 2016).

Due to the developing confectionery and chocolate processing industries in China, Japan, and Southeast Asia, the cocoa market in Asia is expanding. Continental production is dominated by Indonesia and Malaysia, but India is well-positioned for substantial growth because to its agroclimatic advantages and growing domestic chocolate consumption. India procured more than 29,947 metric tonnes of cocoa in 2024–2025, while producing 30.39 thousand metric tonnes on 111.04 thousand hectares in 2024. This shows a persistent gap between supply and demand (DCCD, 2024). India's cocoa production has historically been concentrated in the coastal districts of East Godavari and Eluru; in 2023–2024, Andhra Pradesh alone was responsible for 41% of the nation's overall output. Despite dominating in area and production, India's average cocoa yields are still well below the global average, indicating a structural productivity gap that cannot be closed by expanding area alone.

Supply response analysis is necessary to comprehend how agricultural producers alter their production choices in response both financial and non-financial incentives. The Nerlovian partial adjustment model, first developed by Nerlove in 1958, is the most widely used framework for estimating the short-term and long-term price elasticities of

agricultural supply. Bateman (1965), who developed fundamental elasticity estimates for perennial crops with intrinsic adjustment lags, used it to cocoa for the first time in Ghana. Later studies have applied this method to a range of commodities and geographical areas: It was used to arecanut in Karnataka by Patil et al. (2012), chickpea acreage response in India by Ghosh et al. (2025), and maize South Africa's supply response by Shoko et al. (2016). When Sundariya et al. (2022) calculated growth rates and supply response for cocoa in the districts of Coimbatore and Thanjavur, Tamil Nadu, they found that price responsiveness varied greatly between sites. The structural dynamics of cocoa planting within the Indian cocoa industry were documented by George & Raju (2021). Parvathidevi and Ravichandran (2014) showed similar varied supply responses for groundnuts throughout Andhra Pradesh districts, emphasizing that price elasticities are region-specific and should not be generalized. The effects of the market integration levels and policy distortions on the transmission of price signals to farmers' acreage decisions was further highlighted by Jeyalakshmi (2010) and Jaweriah et al. (2020). Despite this corpus of research, there are still no rigid district-level supply response estimates for cocoa in Andhra Pradesh, the state that produces the most cocoa in India.
The existing literature on Indian cocoa has two major gaps. First, major differences in productivity trends and instability at the district level have been obscured by growth rate evaluations that have seldom broken down below the state level. Second, Andhra Pradesh, which accounts for 40% of the nation's cocoa area and 41% of its production, lacks a specialized econometric study because supply response studies for cocoa have primarily focused on Tamil Nadu. This discrepancy is important because farm-level price responsiveness determines the effectiveness of price regulation, procurement measures, and extension activities. Against this backdrop, the present study was undertaken with the following objectives: (i) to compute the compound annual growth rate of cocoa production, productivity, and area and area in India and Andhra Pradesh; (ii) to evaluate the supply response of cocoa to price and non-price factors in Andhra Pradesh; and (iii) to compute short-run and long-run price elasticities and the coefficient of adjustment for cocoa in the districts of East Godavari and Eluru.

MATERIALS AND METHODS

All of the data used in the study are secondary. The Directorate of Cashewnut and Cocoa Development, Kochi, provided state-level data on the cocoa productivity, production and area for India, Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh. The data included the twenty-year period from 2004-05 to 2023-24, which includes the main stages of the country's cocoa sector development. The Directorate of Economics and Statistics, Government of Andhra Pradesh, provided district-level data on area, production, yield, yearly rainfall, and farm harvest prices for the districts of East Godavari and Eluru from 2009-10 to 2023-24. The state statistics directorate collected rainfall data for each district from the Indian Meteorological Department.

Compound Annual Growth Rate

The log-linear (exponential) growth function, which is more suitable than a linear trend model for variables that expand multiplicatively over time, was used to predict production, productivity, and area growth rates (Boyce & Fernandes, 2020). The model is described as follows:

$\ln(Yt) = \alpha + \beta t + \varepsilon t$ ... (1)

where εt is the stochastic error term, the intercept is α, and the slope is β coefficient that represents the instantaneous growth rate, and Yt is the value of the variable (area, production, or yield) in year t. The percentage annual growth rate, or CAGR, was calculated as follows:

CAGR (%) = $(e\beta - 1) \times 100$ … (2)

To evaluate production instability, the standard deviation divided by the mean was used to compute the coefficient of variation (CV), given as a percentage (Cuddy & Della Valle, 1978).

Nerlovian Supply Response Model

The Nerlovian Lagged Adjustment Model was employed to measure the responsiveness of the cocoa supply in two chosen districts, East Godavari and Eluru (Braulke, 1982). In order to assess how sensitively cocoa farmers respond in terms of supply and how they make decisions about the distribution of land under cocoa production, this methodology was applied using three econometric specifications. Cocoa growers' supply decisions are impacted by a variety of non-price related and price related factors, like current replacement crop pricing and precipitation levels. Developing successful plans for cocoa acreage planning and output management in the selected districts would require a thorough grasp of the responsiveness of the cocoa supply to these factors as well as the implications of pertinent policies.
The following is an expression for the three estimated model specifications:

$\log At = \log a0 + a1 \log Pt\text{-}1 + a2 \log Rt + a3 \log At\text{-}1 + et$ (3)

$\log Qt = \log a0 + a1 \log Pt\text{-}1 + a2 \log Rt + a3 \log Qt\text{-}1 + et$ (4)

$\log Yt = \log a0 + a1 \log Pt\text{-}1 + a2 \log Rt + a3 \log Yt\text{-}1 + et$ (5)

where Pt-1 is the cocoa farm harvest price lagged by one year (Rs quintal-1); Rt is the current year's total yearly rainfall in (mm); At-1, Qt-1, and Yt-1 are lagged values of area (ha), production (MT), and yield (MT/ha), respectively; and et is the random error term. In the loglinear specification the coefficient a1 directly represents the price elasticity of supply in short run. The adjustment coefficient is divided by the short-run elasticity ($\lambda = 1 - a3$) yielding the long-run price elasticity. The Durbin-Watson statistic was employed to check for autocorrelation in the residuals and the number of years (N) to achieve 95 per cent of the total price adjustment effect was calculated using the formula: $N = \ln(0.05) / \ln(1 - \lambda)$. In the R statistical computing environment, ordinary least squares (OLS) were used to estimate each model.

RESULTS AND DISCUSSION

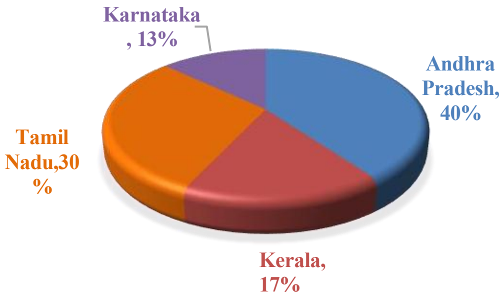
State-wise Production Share of Cocoa in India

The distribution of cocoa planting over the four major chocolate producing states of India indicates a preponderance of land and output in Andhra Pradesh but the pattern has shifted dramatically over the previous two decades. Table 1 presents the area and production by state as of 2023-24.

Table 1. Area and production share of cocoa state-wise in India (2023-24)

Sl. No.	State	Area (000' ha)	Percentage share	Production (000' MT)	Percentage share
1	Andhra Pradesh	44.99	40%	12.38	41%
2	Kerala	18.66	17%	10.75	35%
3	Tamil Nadu	32.98	30%	3.12	10%
4	Karnataka	14.41	13%	4.14	14%
	Total	111.04	100%	30.39	100%

Source: Data from the DCCD (2024) was compiled by the authors.



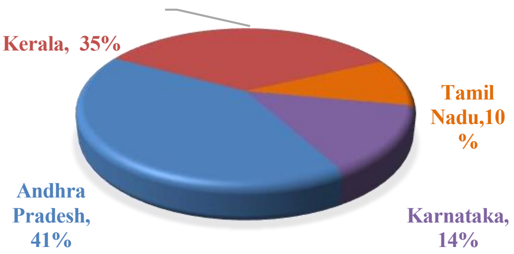


Figure 1. Cocoa's proportionate share of area (A) and production (B) in India, 2023-24

Source: Authors' calculation based on Table 1 data.

With almost 40% of the entire acreage and 41% of the overall production, Andhra Pradesh solidified its status as India's top producer of cocoa (DCCD, 2024). Kerala came in second with 35% of the overall output in terms of production from just 17% of the land. This indicates relatively greater productivity levels, which may be related to more intensive management techniques and better-endowed agroclimatic conditions in domestic gardens. Despite its recent large area expansion, Tamil Nadu only provided 10% of the overall production, which is indicative of reduced productivity associated with early planting maturity and climatic setbacks in important areas (Sundariya et al., 2022). At 14% of production from 13% of land, Karnataka's contribution was small.

Growth Rate Analysis – India

The CAGR estimates for area, production, and yield of cocoa across primary states that produce and at the all-India level for the period 2004-05 to 2023-24 are demonstrated in Table 2.

Table 2. Cocoa's acreage, production, and yield compound annual growth rate (CAGR) of major states of India (2004-05 to 2023-24)

State	Area CAGR (%)	Area CV (%)	Prod. CAGR (%)	Prod. CV (%)	Yield CAGR (%)	Yield CV (%)
Andhra Pradesh	8.29*** (40.59)	46.06	17.06*** (14.17)	65.72	8.18*** (6.56)	35.97
Karnataka	5.19*** (11.44)	28.17	1.86** (2.11)	23.43	-2.90** (-2.45)	34.30
Kerala	3.79*** (23.67)	21.91	3.11*** (6.92)	22.08	-0.50 (-1.02)	12.25
Tamil Nadu	18.93*** (6.66)	58.36	16.25*** (11.39)	71.58	-2.12 (-0.67)	46.19
India	8.12*** (15.77)	40.70	6.77*** (24.43)	39.18	-1.21* (-1.91)	17.75

Note: t-values are shown in parenthesis; Significance at the 1%, 5%, and 10% levels is represented by the symbols ***, **, and *. Source: The authors' computation using data from DCCD (2024).

Cocoa production increased at a rate of 6.77 percent and cocoa area grew at a CAGR of 8.12 percent at the national level, both of which were statistically significant at the one percent level. However, as growth has continued onto less suited or poorly managed lands, yield has decreased at a rate of -1.21 percent annually, indicating a growing productivity gap. This pattern is in line with an area-led growth paradigm, in which horizontal expansion rather than intensification is the main factor driving output improvements (George and Raju, 2021).

Tamil Nadu had the highest area growth rate (18.93%) and output CAGR (16.25%) as a result of significant government-sponsored expansion through the Mission for Integrated Development of Horticulture (MIDH). Despite this impressive rise in area, yield growth was negative at -2.12 percent, and instability as determined by the CV was remarkably high at 58.36 percent for area and 71.58 percent for production, illustrating the volatility of a quickly growing but agronomically immature industry. These outcomes are consistent with those of Sundariya et al. (2022), who saw a significant rise in the Coimbatore district and a decline in Tamil Nadu production.

At the one percent level, Andhra Pradesh showed a more balanced trend, with an area CAGR of 8.29 percent, production CAGR of 17.06%, and yield CAGR of 8.18%. Andhra Pradesh stands out from the other main producing states because to its positive yield growth, which indicates that production intensification has coincided with area development.

The maturation of older plantings and more deliberate management may be the cause of this. Kerala and Karnataka demonstrated more moderate but statistically significant expansion in area and production, whereas yield growth was either negligible or negative, according to the study on aging cocoa plantations in these states (DCCD, 2024).

Growth Rate Analysis – Andhra Pradesh

Disaggregated growth rate estimates for East Godavari, Eluru, and Andhra Pradesh as a whole are presented in Table 3.

Table 3. Cocoa's acreage, production, and yield compound annual growth rate (CAGR) of Andhra Pradesh (2009-10 to 2023-24)

Region	Area CAGR (%)	Area CV (%)	Prod. CAGR (%)	Prod. CV (%)	Yield CAGR (%)	Yield CV (%)

East Godavari	13.61*** (6.6)	91.59	7.65** (2.25)	90.49	-5.25*** (-3.66)	30.01
Eluru	9.88*** (14.06)	42.21	10.98*** (4.8)	47.29	1.01 (0.52)	24.49
Andhra Pradesh	7.91*** (24.57)	34.41	11.72*** (15.32)	43.57	3.54*** (4.09)	18.43

Note: t-values are shown in parenthesis; Significance at the 1%, 5%, and 10% levels is represented by the symbols ***, **, and *. Source: Data from the Andhra Pradesh government's Directorate of Economics and Statistics was used in the authors' computation.

Both the output growth of 7.65% and the area growth of 13.61% were statistically significant in East Godavari. However, there was severe instability, with both area CV and output CV exceeding 90%, and yield fell precipitously at -5.25% annually. The frequency of climatic shocks, especially cyclonic disturbances in Andhra Pradesh's coastal regions, which periodically destroy established cocoa gardens and result in dramatic year-over-year variations in area and yield, is probably the reason of this exceptional degree of unpredictability. With a notable area CAGR of 9.88% and production CAGR of 10.98%, as well as a positive but statistically insignificant yield growth of 1.01%, Eluru district performed more steadily. Compared to East Godavari, Eluru's instability measurements (area CV: 42.21%; production CV: 47.29%) were significantly lower, indicating more favorable agroclimatic and market conditions.

Andhra Pradesh saw notable increases in area (7.91%), production (11.72%), and yield (3.54%) at the state level, with significantly less variability because aggregation tends to mitigate district-level volatility. In contrast to the negative productivity trends seen in Tamil Nadu and Karnataka, the state-level positive yield CAGR is encouraging from the perspective of longterm competitiveness.

Nerlovian Model for Supply Response Analysis

Table 4 displays the findings of the Nerlovian partial adjustment models for area, production, and yield response in the districts of Eluru and East Godavari.

Table 4. Cocoa's area, production, and yield response in East Godavari and Eluru districts

Variable	EG Area	EG Prod.	EG Yield	Eluru Area	Eluru Prod.	Eluru Yield
Intercept	-44.711 (5.806)	-61.784 (54.141)	-10.853 (7.636)	-4.692 (14.211)	4.600 (4.623)	12.096 (2.918)
log(Pt-1)	4.056*** (0.579)	5.881* (5.169)	1.490 (0.664)	0.681 (1.490)	-0.303 (0.434)	-0.674 (0.439)
log(Rt)	-0.087 (0.177)	-0.705 (0.852)	-0.529 (0.349)	0.235 (0.263)	0.537* (0.169)	0.320* (0.061)
log(At-1)	0.536*** (0.060)	—	—	0.446 (0.564)	—	—
log(Qt-1)	—	0.416 (0.292)	—	—	0.479*** (0.121)	—
log(Yt-1)	—	—	0.470 (0.262)	—	—	0.065 (0.577)
R^2	0.705	0.527	0.571	0.709	0.677	0.204
DW Stat.	2.608	2.501	2.263	2.626	1.932	1.610

Note: EG = East Godavari; Standard errors are shown in parenthesis; Significance at the 1% and 10% levels is represented by the symbols *** and *. Source: Data from the Andhra Pradesh government's Directorate of Economics and Statistics was used in the authors' computation.

Area Response

The area response model for East Godavari produced an R2 of 0.705, meaning that almost 71% of the disparity in the current-year cocoa area could be outlined by the chosen explanatory variables. The lagged price coefficient was positive and highly significant ($\beta = 4.056$; $p < 0.01$), indicating that when it comes to allocating acreage, farmers in East Godavari are extremely responsive to price incentives obtained in the prior year. The lagged area coefficient ($\beta = 0.536$; $p < 0.01$) was likewise positive and significant, indicating the intrinsic inertia of perennial crop cultivation: once farmers commit to cocoa, the established plantation structure causes considerable path dependency in acreage decisions (Braulke, 1982). In this region, where natural shade and moisture retention are provided by coconut and arecanut-based intercropping, rainfall was negatively correlated with area but statistically insignificant, indicating that moisture availability is not a constraining constraint for area allocation.

The area response model explained 70.9% of the current-year area variance in the Eluru district. Eluru's area allocation decisions are less susceptible to price signals than those of East Godavari, as seen by the lagged price coefficient being positive but statistically insignificant (β = 0.681). This may be because a larger proportion of cocoa is grown as an established intercrop in established coconut gardens, where decisions about removal or replanting have longer time horizons and higher switching costs. According to (Parvathidevi & Ravichandran, 2014) findings for groundnuts in Andhra Pradesh, rainfall in Eluru had a positive but insignificant effect on area.

Production and Yield Response

The production response model explained 52.7% of the variation in current-year output for East Godavari. Higher prices in the previous year encourage more investment in crop management and harvesting effort, improving production even in the absence of immediate area expansion, according to the lagged price coefficient, which was positive and marginally significant at the ten percent level (β = 5.881). In East Godavari, the lagged production coefficient was positive but not significant (β = 0.416), whereas rainfall exhibited a negative but inconsequential connection with output. The production model accounted for 67.7% of the variance in Eluru. According to (Ghosh et al., 2025) on chickpeas, the delayed production coefficient was extremely significant (β = 0.479; $p < 0.01$), suggesting that farmers' decisions about production in the current year are heavily influenced by previous output levels, exhibiting production inertia. In Eluru, rainfall was positively and significantly correlated with production (β = 0.537; $p < 0.10$), indicating that sufficient moisture enhances bean set and pod fill.

Given that yield is influenced by a variety of agronomic and biological factors that are not entirely captured by price and rainfall variables alone, it is not unexpected that yield response models produced lower explanatory power ($R^2 = 0.571$ for East Godavari and 0.204 for Eluru). In both districts, the lagged yield coefficient was positive but not statistically significant. Rainfall was positively and significantly correlated with yield in Eluru, but negatively and insignificantly correlated with yield in East Godavari, indicating differing moisture-yield correlations in the two districts. Although statistically insignificant, Eluru's negative price-yield association (β = -0.674) warrants consideration because it may represent farmers' propensity to harvest immature pods when prices are high, which lowers per-unit dry bean yield. This phenomenon has been reported by (Lass et al., 1990) in other cocoa-producing regions.

Price Elasticities and Coefficient of Adjustment

The long run and short run price elasticities identified from the Nerlovian model, together with the coefficient of adjustment and the adjustment period, are displayed in Table 5.

Table 5. Price elasticities and coefficient of adjustment for cocoa area and yield in Andhra Pradesh

Particulars	EG Area	EG Yield	Eluru Area	Eluru Yield
Short-run Elasticity	4.056	1.490	0.681	-0.674
Long-run Elasticity	8.736	2.812	1.229	-0.720
Coefficient of Adjustment (λ)	0.464	0.530	0.554	0.935
Years to 95% Adjustment (N)	4.799	3.970	3.708	1.096

Note: EG = East Godavari; λ = coefficient of adjustment; N = years to realise 95% of price effect. Source: The authors' computation using the estimates in Table 4.

East Godavari's price elasticity of area was 8.736 in the long run and 4.056 in the short run, suggesting a very elastic supply response to price in this district. According to (Sundariya et al., 2022), short-run area elasticities for cocoa in Tamil Nadu were negative in Coimbatore and minor and positive in Thanjavur. These values significantly surpass these findings, indicating that East Godavari farmers are among the most price-responsive cocoa growers in India. As farmers gradually interplant more cocoa seedlings inside their current plantation systems or spread the crop onto other plots, the cumulative effect of continuous price incentives over several seasons is reflected in the huge size of the long-run elasticity.

In comparison to East Godavari, Eluru district's short-run area elasticity of 0.681 and long-run elasticity of 1.229 show a more inelastic supply response. The region's lesser price responsiveness may be caused by Eluru's lower price transmission efficiency, higher market intermediation costs, or the preponderance of subsistence-oriented intercropping systems that are less sensitive to shifts in commodity prices (Jaweriah et al., 2020).

The coefficient of adjustment for area in East Godavari was 0.464, which indicates that farmers correct around 46% of the disparity between the intended and actual area in any given year. Eluru's adjustment coefficient was slightly higher at 0.554, indicating a somewhat faster rate of convergence. The corresponding adjustment periods of approximately 4.8 years in East Godavari and 3.7 years in Eluru are generally consistent with the biological realities of cocoa cultivation, where newly planted trees take 3-5 years to reach full bearing capacity, even though they are longer than those estimated for cocoa in Tamil Nadu (Sundariya et al., 2022).These results also support the general claim made by (Shoko et al., 2016) that, in comparison to annual crops, the rate of adjustment in perennial crop production is intrinsically slower.

Due to essentially different farm management reactions to price in the two districts, In Eluru, the yield elasticity in relation to price was negative. (short-run: -0.674; long-run: -0.720) but positive in East Godavari (short-run: 1.49; long-run: 2.81). Higher prices seem to encourage investment in yield-enhancing management techniques in East Godavari, whereas in Eluru, price impacts on yield are either nonexistent or detrimental, maybe as a result of early harvesting.

CONCLUSIONS

India’s cocoa production from 2004-05 to 2023-24 exemplifies an area-led growth paradigm characterized by strong expansion in area and output but declining yield performance at the national level. Andhra Pradesh stands out among major producing states by recording positive growth across all three dimensions, whereas Tamil Nadu’s rapid area expansion has been accompanied by a sharp decline in productivity. There is substantial inter-district heterogeneity in Andhra Pradesh, according to the Nerlovian supply response analysis. While Eluru's response is still rather modest (short-run: 0.68; long-run: 1.23), East Godavari shows extremely elastic price responsiveness (short-run elasticity: 4.06; long-run: 8.74). It takes four to five years for both districts to realize 95% of the long-run pricing effect, according to the delayed adjustment dynamics of perennial crops. There are obvious policy ramifications to these findings. The Directorate of Cashewnut and Cocoa Development and state horticulture departments must implement productivity-focused programs, especially in light of districtlevel yield inequalities. In East Godavari, price stabilization through procurement centers, advance contracts, and market connections handled by Farmer Producer Organizations is particularly important. To achieve latent productivity improvements for Eluru, it is advised to maintain technical extension and enhance input availability.

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Conflict of interests

The authors declare no conflict of interest.

REFERENCES

1. Andres, C., Bhullar, G. S., & Bhullar, N. K. (2016). Sustainable intensification of tropical agro-ecosystems: Need and potentials. Environments, 3(1), 1–3. https://doi.org/10.3389/fenvs.2016.00005
2. Bateman, M. J. (1965). Aggregate and regional supply functions for Ghanaian cocoa, 1946–1962. Journal of Farm Economics, 47(2), 384–401. https://doi.org/10.2307/1236584
3. Boyce, J. K., & Fernandes, E. C. M. (2020). Understanding tropical agriculture: Growth and productivity. Annual Review of Resource Economics, 12, 443–464. https://doi.org/10.1146/annurev-resource-110319-114949
4. Braulke, M. (1982). A note on the Nerlove model of agricultural supply response. International Economic Review, 23(1), 241–244. https://doi.org/10.2307/2526474
5. Cuddy, J. D. A., & Della Valle, P. A. (1978). Measuring the instability of time series data. Oxford Bulletin of Economics and Statistics, 40(1), 79–85. https://doi.org/10.1111/j.1468-0084.1978.mp40001006.x
6. Directorate of Cashewnut and Cocoa Development. (2024). Annual report 2023-24. Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India. https://dccd.gov.in
7. George, A., & Raju, K. V. (2021). An empirical analysis of the dynamics of cocoa cultivation in India. Agricultural Situation in India, 78(8), 27–34.
8. Ghosh, S., Gupta, S., & Neogi, A. (2025). An analysis of acreage response of chickpea (gram) in India: Based on the Nerlovian approach. Cogent Economics & Finance, 13(1), 2511125. https://doi.org/10.1080/23311932.2025.2511125
9. International Cocoa Organization. (2025). Quarterly bulletin of cocoa statistics. ICCO. https://www.icco.org/statistics/
10.Jaweriah, H., Avinash, K., & Devesh, R. (2020, July 26–28). Supply response of staple food crops in the presence of policy distortions: Some evidence from India [Paper presentation]. Agricultural and Applied Economics Association Annual Meeting, Kansas City, MO, United States.
11.Jeyalakshmi, N. (2010). Growth, instability and acreage response of sugarcane in Tamil Nadu [Doctoral dissertation, Madurai Kamaraj University]. Shodhganga. https://shodhganga.inflibnet.ac.in
12.Lass, R. A., Reilly, J. J., & Jonfia-Essien, W. A. (1990). Supply response and market structure in Ghanaian cocoa production (Cocoa Research Unit Bulletin, pp. 12–29). University of Reading.
13.Nerlove, M. (1958). The dynamics of supply: Estimation of farmers' response to price. Johns Hopkins University Press.
14.Parvathidevi, R., & Ravichandran, S. (2014). A study on supply response of groundnut in Chitoor district, Andhra Pradesh. Research Journal of Agricultural Sciences, 5(6), 1258–1260.
15.Patil, K. R., Patil, B. L., Basavaraja, H., Kunnal, L. B., Sonnad, J. S., & Havaldar, Y. N. (2012). Supply response of arecanut in Karnataka state. Karnataka Journal of Agricultural Sciences, 25(3), 437–440.
16.Shoko, R. R., Chaminuka, P., & Belete, A. (2016). Estimating the supply response of maize in South Africa: A Nerlovian partial adjustment model approach. Agrekon, 55(3), 237–253. https://doi.org/10.1080/03031853.2016.1203802
17.Sundariya, M., Banumathy, V., & Ravichandran, S. (2022). Analysis of growth rate and supply response of cocoa in Tamil Nadu, India: Nerlovian adjustment model. Journal of Plantation Crops, 50(3), 162–168. https://doi.org/10.25081/jpc.2022.v50.i3.7890