



RESEARCH ARTICLE

An empirical study on forecasting the price of groundnut in Tamil Nadu

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Abstract

Groundnut (*Arachis hypogaea* L.) or more popularly referred to as peanut, occupies a central role amongst the globe's leading oilseed crops and India is one of the main producers. This research investigates the trends of groundnut farming, area, production and productivity in India and Tamil Nadu from 2005 to 2024. The purpose is to assess the volatility in groundnut farming and patterns of prices using statistical analysis like Cuddy-Della Valle Instability Index (CDVI), seasonal price index and Auto-Regressive Integrated Moving Average (ARIMA) model for forecasting prices. The findings indicate that the area under groundnut cultivation in India has decreased slightly, while production has remained steady and productivity has increased. This steadiness has factors like better seed varieties, improved agronomic methods and government support. In Tamil Nadu, though there was some reduction in area on account of drought and water shortages in certain places, such as Villupuram and Thiruvannamalai, there was an increase in production as a result of improved irrigation and cultivation methods. The time series and descriptive methods are employed to determine evident trends in production and price fluctuations. The Compound Annual Growth Rate (CAGR) methodology illustrates a moderate increase in production in spite of the decline in area, while the CDVI detects some instability at the times of droughts. The seasonal price index indicates that the prices go through a typical pattern, peaking in December due to a shortage of supply before the new harvest. ARIMA forecasting models demonstrate a satisfactory level of accuracy for the selected markets, which is a reliable tool for price prediction. The results reveal a valuable insight for farmers, traders and policymakers to take informed decisions regarding the production planning, strategies of storage and interventions in the market for the sustainable groundnut cultivation and to enhance the efficiency.

Keywords: compound annual growth rate; Cuddy Della Valle Index; groundnut; price forecasting; seasonal price index

Introduction

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops globally, ranking third worldwide and second in India in terms of production (1). Commonly called the "King" of oilseeds or peanut, this crop originated from Brazil and is now widely cultivated in tropical, subtropical and warm temperate regions (2). Over the past decade, global demand for groundnuts and related confectionery has increased substantially (3).

India is among the top producers of groundnut, with approximately 4.8 million hectares dedicated to its cultivation and annual production ranging from 8.6 to 10.4 million tonnes. Key producing states include Gujarat (Saurashtra region leading with 5.2 million tonnes), Rajasthan, Madhya Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu (around 700000 tonnes), Telangana, Odisha, Uttar Pradesh and Maharashtra (4). Within Tamil Nadu, groundnut is cultivated across several districts, with Pudukkottai having the largest area (44000 ha) primarily under rainfed conditions but comparatively low productivity (~1,589

kg/ha). Districts such as Villupuram and Thiruvannamalai exhibit higher productivity (~3,883 kg/ha and notable production figures), benefiting from irrigation and advanced cultivation methods. Other regions contribute under mixed cropping or dryland agriculture (5).

Besides its culinary uses, groundnut oil is utilised in soaps, cosmetics, lubricants, vanaspati ghee and as a preservative in food products. The crop also contributes to various value-added products like sweets and medicines. Moreover, groundnut by-products such as shells and cake have significant commercial and agricultural value (6). It is known as the wonder nut or poor man's cashew. The crop holds considerable ecological and economic importance, not only domestically but also in international trade. India exports various groundnut products and imports some selected kernels, signifying the crop's role in global markets. Groundnuts enrich soil fertility through nitrogen fixation, making them vital in crop rotation (4, 7).

Despite Tamil Nadu's significant contribution to national groundnut production, limited research exists on region-specific price dynamics and forecasting that consider the unique climatic, agricultural and market conditions of this state. The pricing mechanisms of such a major agricultural commodity are influenced by distinct regional production patterns, volatility and complex market interactions affecting producers and consumers alike (5, 8). Price forecasting in agricultural commodities, especially pulses like groundnut, is crucial for policy formulation and market stabilisation (9). While various econometric and machine learning models have been explored for price prediction, the ARIMA model remains a widely accepted and effective statistical tool due to its capability to handle time series data and forecast price movements reliably (10). However, most prior studies focus on national-level or broad crop price trends with little emphasis on Tamil Nadu's regional market or the impact of seasonality and climatic variables inherent to that geography.

This study fills the gap by leveraging an extensive 20-year dataset (2005–2024) specific to India and Tamil Nadu. It employs a combination of statistical methods—the Cuddy-Della Valle Instability Index (CDVI) to assess volatility, the seasonal price index to capture intra-annual price behaviour and ARIMA modelling for forecasting grounded in regional market realities. Moreover, the study integrates price transmission and market efficiency analyses across Tamil Nadu's wholesale markets, offering novel insights into local price behaviour and enabling more targeted policy and market interventions (11, 12). The present study was undertaken to examine the historical trends of groundnut area, production and productivity across India and Tamil Nadu and to assess the variability in these indicators using the CDVI. In addition, the study analyses the seasonality in groundnut prices in selected markets and provides price forecasts using the ARIMA modelling approach.

Materials and Methods

The study was conducted for the period 2005–2025. The study relies entirely on secondary data, sourced from official government publications and databases. Possible concerns include missing values, reporting errors and market anomalies. These were addressed by cross-verification with official records and applying consistency checks.

Analytical framework (Step-wise)

1. Data collection
2. Cleaning and validation
3. Descriptive statistics
4. CAGR and CDVI computation
5. Seasonal Index analysis
6. ARIMA modelling
7. Forecast evaluation

Alternative models such as SARIMA, ARCH/GARCH and machine learning approaches were considered. However, given the short time series (monthly data, 2005–2025) and focus on interpretability for policy, ARIMA provided an optimal balance of simplicity and accuracy.

Trend analysis - compound annual growth rate (CAGR)

CAGR was used to examine the groundnut's growth trend, which helps to know the average annual rate of change in variables like area, production, productivity and price. The Compound annual growth rate calculation follows a model called the exponential growth model.

$$Y_t = a \times b^t \times U_t \quad (\text{Eqn. 1})$$

Where,

Y_t – dependent variable for t (dependent variable – Area, production, productivity or the price)

a – the starting value or the intercept

b – growth multiplier or base of the exponential growth

t – the time period (years 1,2,3..... n)

U_t – the error term for year t

Equation (1) is converted to logarithmic form to facilitate the statistical estimation.

$$\log Y_t = \log a + \log b + \log U_t \quad (\text{Eqn. 2})$$

This equation (2) enables the use of the ordinary least squares regression technique for estimating the parameters. This provides estimates for the intercept ($\log a$) and the ($t \log b$) slope coefficient.

After the regression parameters are obtained, the CAGR is calculated by the following formula:

$$g = (b-1) \times 100 \quad (\text{Eqn. 3})$$

Where,

g – annual compound growth rate expressed in percentage

b – antilog of $\log b$

Instability index

Cuddy Della Valle Index (CDVI)

Coefficient of Variation (CV) is the simplest indicator of instability, it is an over-estimation of the instability for time series data exemplifying long-term trends (9). CV is applied to look at instability in the groundnut area, productivity and production variability over time.

$$CV = \text{Standard deviation} / \text{Mean} \times 100 \quad (\text{Eqn. 4})$$

The instability direction is shown by the Cuddy Della Valle Index de-trends.

$$CDVI = \text{Standard deviation} / \text{Mean} \times 100 * (1-R^2)^{1/2} \quad (\text{Eqn. 5})$$

Where,

CV - Coefficient of Variation in percentage

R^2 - time trend regression's coefficient of determination.

The ranges of CDVI are: Low instability - 0 to 15, Medium instability - 15 to 30, High instability - 30 and above.

Construction of seasonal index

This tool is used to quantify and measure the regular seasonal patterns in the movement of prices throughout the year. When prices rise or fall below the annual average for a season or specific months, it provides insights into the predictable behaviour of the market. Each month's average price is divided by the overall annual average price and multiplied by 100.

Seasonal index = (Monthly Average Price / Annual Average Price) × 100 (Eqn. 6)

The seasonal index expresses the ratio of each month's price compared to the yearly average price, with a base value of 100. Throughout the year, this method helps to identify the peak price periods and lean price seasons.

Price forecasting

Auto-regressive integrated moving average model (ARIMA)

ARIMA is a price forecasting model applied to a wide range of contexts. The model is used for analysing time series data and to forecast future values by analysing the patterns in past prices and accounting for the random market functions (13, 14). It's an extrapolation model that requires only the historical time series data.

Structure of the ARIMA model

It combines their key components represented by the notation ARIMA (p, d, q), where each has a specific meaning:

p - Number of autoregressive terms

d - Number of differencing operations needed to make the data stationary

q - Number of moving average terms

Component models

Autoregressive (AR) component

Uses the previous values of the variable to predict the current values. It's expressed as Equation 7.

$$Y_t - \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \alpha_3 Y_{t-3} + \dots + \alpha_p Y_{t-p} + \varepsilon_t \quad (\text{Eqn. 7})$$

Where the current price depends on the previous period's prices, with each period having a specific coefficient in the prediction.

Moving average (MA) component

Used to correct previous forecast errors to improve the current predictions. It's expressed as Equation 8.

$$Y_t = \mu + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} \quad (\text{Eqn. 8})$$

Where the current values are adjusted based on the wrong previous forecasts

Combined ARIMA Model

Both the autoregressive and moving average components are used here together (p,q),

$$Y_T = \Psi_0 + \Psi_1 y_{t-1} + \Psi_2 y_{t-2} + \Psi_3 y_{t-3} + \dots + \Psi_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} \quad (\text{Eqn. 9})$$

It combines the influence of past values and errors of the past to make it more accurate prediction.

Integration (I) component

Involves differencing the data to remove the trends and makes the series stationary, which means the statistical properties remain constant over time. The first step is stationarity testing, where the price data is tested for its stationarity using the autocorrelation function (ACF) plots. Then non-stationary data is differentiated until the statistical properties become constant over time and it is determined as the parameter d. The second step is model identification, analysing the ACF and Partial Autocorrelation Function (PACF) plots to identify appropriate 'p'

– autoregressive terms and 'q' – moving average terms which are the parameters of the ARIMA (p,d,q) Model. The third step is parameter estimation-the coefficients of the model are estimated using maximum likelihood estimation to find the parameter values that serves best in the historical price data.

The fourth step is model validation, the residuals are examined to ensure they are randomly distributed and normally distributed. The identification process is repeated with different parameters if the pattern exists. The fifth step is model selection, the best model is selected by using the criteria, like Akaike information criterion (AIC), Schwarz-Bayesian criterion (SBC), Root mean square error (RMSE) and Mean absolute percentage error (MAPE). The MAPE is used as a relative measure for comparing the forecasts of the same series across different models.

$$\text{MAPE} = \frac{\sum_{t=1}^n \left| \frac{y_t - \hat{y}_t}{y_t} \right|}{n} \times 100 \quad (\text{Eqn. 10})$$

Where,

y - Actual value at time (t)

\hat{y}_t - Predicted value at time (t)

n – Number of observations

The final step is forecasted for simple statistics and the confidence intervals to determine the validity of the forecast and to track the model performance for detecting the control situation. SPSS 16 was used in this study for estimating and forecasting the ARIMA model and the standard procedure was used (14). With the lower values, the better model is indicated. The last step is forecasting, where the selected model generates and forecasts the future price with intervals by providing reliable predictions and measures of the forecast accuracy for making decisions.

Results and Discussion

Trend analysis of area, production and productivity of Groundnut in India and Tamil Nadu

The collected data was analysed to get meaningful outcomes, shown in the following figures and tables. The different trends of groundnut cultivation from 2005 to 2024 in India and Tamil Nadu in terms of area, production and productivity were analysed. Table 1 shows groundnut cultivation trends in India during the period 2005-2024, a complex but revealing scenario. Although the area under cultivation decreased marginally (-0.20 % CAGR), production has a moderate growth (+0.23 % CAGR), led by a consistent increase in productivity (+0.54 % CAGR). This presents a structural transformation in Indian agriculture from area-based to efficiency and technology-based growth in groundnut cultivation.

Table 1. Trend in area, production and productivity of groundnut in India

	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Period I	-0.268	0.501	0.956
Period II	-0.017	0.391	0.492
Overall	-0.209	0.237	0.543

The reduction in area can be accounted for by reasons like unpredictable monsoons, frequent droughts (particularly during 2009, 2015–16 and 2016–17), a change towards high-value or low-risk crops, urbanisation and market volatility. Most of the conventional groundnut-growing regions, particularly in Andhra Pradesh and Telangana, as well as Tamil Nadu, experienced lower sowing because of inadequate rainfall and unfavourable post-harvest price realisation.

However, the decline in area was compensated by yield improvements, supported by high-yielding drought-tolerant varieties, improved agronomic practices and interventions through government schemes like National Food Security Mission (NFSM)-Oilseeds and Pradhan Mantri Fasal Bima Yojana (PMFBY). States like Gujarat and Rajasthan lead by better water-use practices and improved mechanisation. On the other hand, the increased global demand for hand-picked and selected (HPS) groundnut and oilcake exports also encouraged production in some years. But frequent price crashes and poor procurement support heads to instability, discouraging consistent expansion of groundnut cultivation.

Table 2 depicts groundnut cultivation in Tamil Nadu for the period 2005–2024, indicating a shift due to climatic, economic and technological factors. The general decline in area (-0.55 % CAGR) indicates farmers shifted away from groundnut farming because of repeated droughts, groundwater overexploitation, urbanisation and adverse price realisation - particularly in rainfed areas such as Pudukkottai, Theni and Dindigul. Notwithstanding this, output expanded (+0.89 % CAGR), increased in productivity (+0.34 % CAGR) by performing better in districts like Villupuram, Thiruvannamalai and parts of the delta.

During Period I (2005–2014), the area fell drastically (-1.09 %) and production reflected stagnation, with small increments in productivity. Shortage of water, low returns from markets and low confidence among farmers were the reasons for this period. In contrast, Period II (2015–2024) was one of reversal: although area remained stable (-0.06 %), production increased (+2.03 %), signalling growth in high-yielding areas, probably helped by better seed varieties (e.g. VRI 8, TMV 7), official support (NFSM, PMFBY) and Rabi expansion in irrigated areas.

Table 3 shows the instability trend over the years 2005–2024 of groundnut farming in India. The area (11.27 %), production (10.84 %) and productivity (2.26 %) show low overall instability. In the Period I (2005–2014), the fluctuation was low due to favourable conditions and factors which caused states like Gujarat and Rajasthan to lead across the seasons, consistent yield and output. Due to irregular rainfall and recurrent droughts,

Table 2. Trend in area, production and productivity of groundnut in Tamil Nadu

	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Period I	-1.091	-0.149	0.743
Period II	-0.061	2.030	-0.030
Overall	-0.547	0.892	0.344

Table 3. Instability (in %) of the All-India area, production and productivity of groundnut

	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Period I	0.72	2.72	2.88
Period II	15.88	14.72	1.99
Overall	11.26	10.83	2.26

there was medium instability in the area (CDVI 15.89) during Period II (2015–2024), especially in areas of southern and central India. Farmers started switching to different crops because they were either more profitable or more suited to the fluctuating weather. Production instability also remained within manageable limits (CDVI 14.73), indicating that yield gains were able to offset the reduction in cultivated area. The high-quality seeds, better irrigation techniques and assistance from agricultural extension services led to productivity consistency (CDVI 2.00).

The instability percentage of Tamil Nadu's groundnut farming from 2005 to 2024 is shown in Table 4. In terms of area, production and productivity, Period I was quite stable. But in Period II, unpredictable rainfall, frequent droughts and farmers' migration to more profitable or climate-resilient crops like cotton and pulses caused considerable volatility in both area (CDVI 24.93) and production (23.18). However, government programs, better irrigation techniques and new crop types helped to keep productivity relatively steady (CDVI 1.73). Overall, yield consistency lowered the impact of the more unpredictable cultivation.

Seasonal variation in groundnut price

The data were analysed using the seasonal index, and the results are presented in Table 5. The seasonal price index analysis reveals distinct pricing patterns for groundnut in the Thiruvannamalai market.

Table 5 represents the seasonal index for groundnut in Thiruvannamalai, revealing a rising trend, with prices being low in January (15.4 %) and progressively increasing until they reach a peak during December (184.6 %). These extreme fluctuations may be linked to festival-driven demand in December and reduced arrivals in January. However, they could also reflect data outliers, which warrants caution in interpretation and this indicates that groundnut prices are comparatively lower at the start of the year and continue to rise as supply tightens. The steep increase during December is an indication of a shortage before the upcoming harvest and the prices are highest when supply is tight. The trend is a classic seasonal fluctuation in which prices rise towards the end of the year as a result of a shortage.

Table 4. Instability (in %) of the Tamil Nadu area, production and productivity of groundnut

	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg/ha)
Period I	0.75	10.95	2.41
Period II	24.92	23.18	1.72
Overall	16.41	18.07	2.32

Table 5. Seasonal price index for groundnut in Thiruvannamalai

Month	Seasonal index for groundnut in Thiruvannamalai
January	15.4
February	30.8
March	46.2
April	61.5
May	76.9
June	92.3
July	107.7
August	123.1
September	138.5
October	153.8
November	169.2
December	184.6

ARIMA model

This requires analysing autocorrelation patterns through the visual representation. Across different time periods, the autocorrelation measures demonstrates the relationship between the time series and its previous values. ‘Correlograms’ are typically used in graphical displays. It shows the strength of correlation between the present and past data points in various intervals. This visualisation is called the autocorrelation function, which serves as a fundamental tool in the ARIMA model.

ARIMA analysis for groundnut in Thiruvannamalai market (Tamil Nadu)

Fig. 1 & 2 shows stationarity assessment by autocorrelation analysis, showing that it is rapidly declining ACF values, which indicates the stable time series behaviour. The groundnut price series in the Thiruvannamalai market displays a slow exponential decay in the autocorrelation coefficient, also indicating the non-stationary characteristics that require transformation through differencing for achieving stationary ARIMA modelling. Significant correlation values are at early lags with gradual diminishing patterns, revealed in the ACF plot. The PACF analysis illustrates a single statistically significant positive correlation in

the first lag, with all other subsequent lags falling within the confidence intervals. These combined patterns indicate the presence of autoregressive components, suggesting an AR (1) process in the price series.

Auto correlation and partial auto correlation plot of residuals of the selected ARIMA (111) model

The residual ACF and PACF plots are in the Fig. 3, confirming that the residuals behave as white noise, where no significant autocorrelation patterns remain. This validates that the model works well and can be trusted for making future predictions.

Forecasted Price using different models

The price forecast under various ARIMA models is shown in Table 5. Under various models, it shows the predicted price. The ARIMA (111) model forecasts the highest price from June to December 2025 consistently, peaking at December ₹8274.4. It predicts stronger price growth compared to other models, indicating a more optimistic trend. Forecasting was performed using the monthly price data for groundnut from January 2005 to May 2025 and the projections were made for the months June – December 2025, as shown in Table 6.

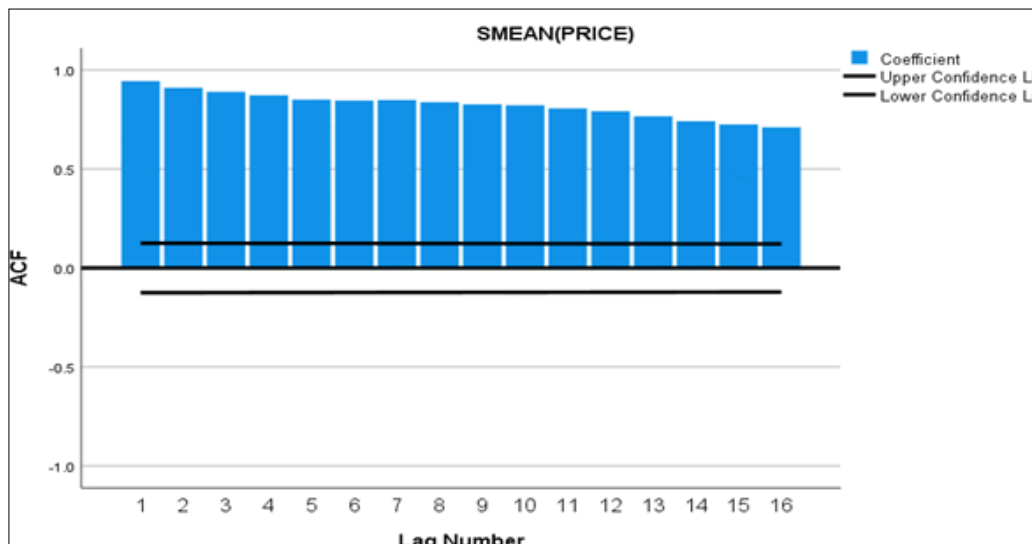


Fig. 1. Auto-correlation plot of groundnut price series in the Thiruvannamalai market.

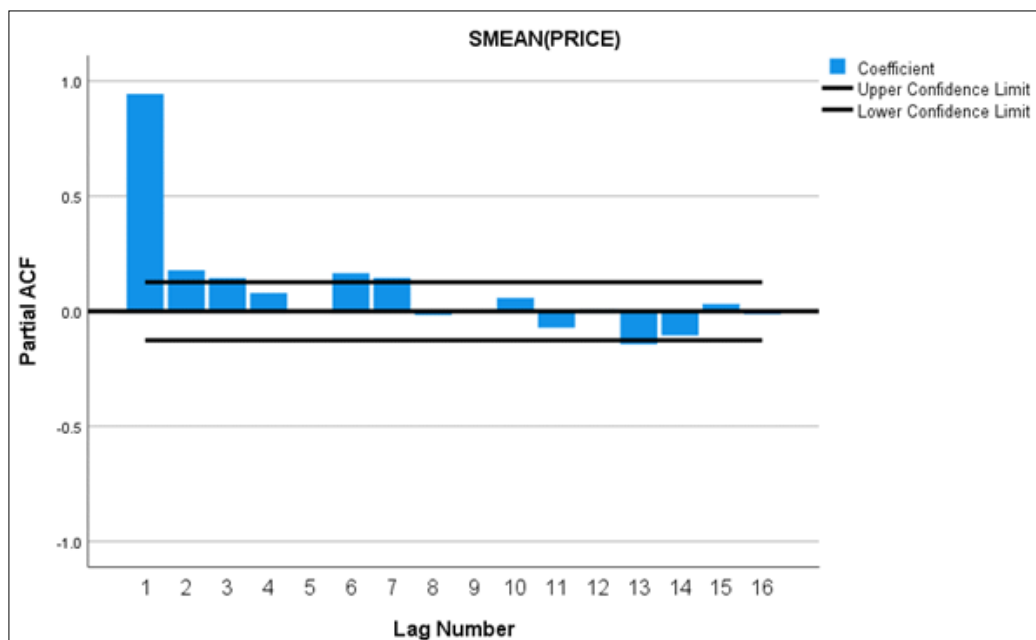


Fig. 2. Partial autocorrelation plot of groundnut price series in Thiruvannamalai market.

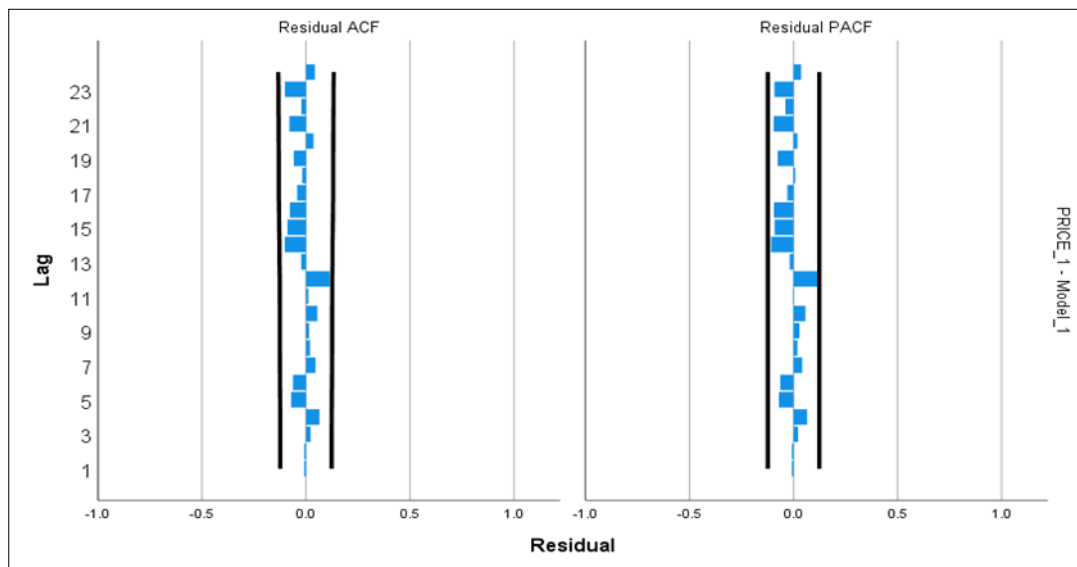


Fig. 3. The ACF and PACF for the selected ARIMA (111) model.

Table 6. The forecasted price of different models

ARIMA Model	June, 2025	July, 2025	August, 2025	September, 2025	October, 2025	November, 2025	December, 2025
100	6558.6	6507.3	6458.8	6412.8	6369.2	6327.9	6288.8
110	7041.8	7059.2	7076.6	7094	7111.4	7128.8	7146.2
111	8122.1	8155.5	8183.1	8207.7	8230.7	8252.8	8274.4
101	6775.5	6745.8	6716.7	6688.3	6660.5	6633.3	6606.8
011	7116.8	7134.7	7152.6	7170.6	7188.5	7206.4	7224.3

Accuracy performance measures of the forecast

The accuracy of the models is measured using the mean absolute percentage error. The results are illustrated in Table 7.

Table 7. MAPE under various models of ARIMA

Model	MAPE
100	10.482
110	10.343
111	9.706
101	9.877
011	9.934

Conclusion

The research analysed groundnut yield and price projections for Tamil Nadu between 2005 and 2024 and identified significant trends in area, production, productivity and markets. Groundnut production was found to be relatively variable due to changes in cropping patterns and climatic uncertainties, particularly during the second phase (2015-2024), as measured using the CDVI. Seasonal price trends revealed volatility, with prices peaking sharply in December due to reduced arrivals and anticipation of the new harvest. The ARIMA model demonstrated strong predictive performance, accurately capturing market tendencies. Forecast results indicate a continued increase in groundnut prices, with the highest level expected in December 2025.

These reliable forecasts provide actionable guidance for stakeholders and the following policy implications are recommended: Strengthen storage and marketing infrastructure to minimise losses and stabilise seasonal price fluctuations. Revise crop insurance schemes to incorporate forecasted price and yield instabilities, ensuring better farmer protection. Guide farmers on optimal sowing and harvesting windows based on forecast insights to improve production planning. Develop state-

level market intelligence systems to provide real-time information for policymakers, traders and producers. By implementing these measures, the findings can contribute to improved farmer incomes, reduced market risks and more resilient agricultural value chains in Tamil Nadu.

Authors' contributions

AR conceptualized the study, conducted formal analysis, prepared the original draft, performed visualization and contributed to reviewing and editing the manuscript. MD contributed to conceptualization, methodology development and validation of the study. RA participated in formal analysis and validation. PDR carried out formal analysis and validation. VBM assisted in formal analysis and validation. All authors read and approved the final version of the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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