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Study on Predicting the Price of Coconut in Tamil Nadu Market

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study aims to comprehensively analyze coconut cultivation trends in Tamil Nadu, covering area, production, yield, and market prices. Through data analysis, it seeks to reveal historical shifts in cultivation practices. The study also strives to develop precise price forecasting models for Coimbatore and Pollachi markets, enhancing insights into agricultural dynamics and enabling accurate price predictions.

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Study Design: Exploratory research design.
Place and Duration of Study: The present study was conducted in the year 2023 during July and August
Methodology: Secondary data was used for the present study. Secondary Data on area , production and productivity of coconut in Tamil Nadu was collected from 2000 to 2022 and price of coconut from 2012 to 2023 in selected market was collected. The research utilizes Compound Annual Growth Rate (CAGR) Analysis to identify the past trends in the area, production, and productivity of coconut in Tamil Nadu. Additionally, the Autoregressive Integrated Moving Average (ARIMA) models are employed to forecast the future trens in coconut price in Coimbatore and Pollachi market.
Results: Area, Production and Productivity of coconut in Tamilnadu has shown a positive trend. Coconut cultivation is growing steadily with a 1.56% increase in cultivation area and a 2.089% rise in production, while productivity is also improving by 1.19% annually, indicating positive growth. ARIMA (1, 1, 1) for Coconut in the Coimbatore market and ARIMA (1, 1, 1) for coconut in the Pollachi market was found to provide the best fit for predicting the price of coconut in both markets.
Conclusion: Increase in trend in area, production and productivity was observed in Tamil Nadu. ARIMA (1, 1, 1) was found to provide the best fit for predicting the price of coconut in both markets. The model predicted declining price in the forthcoming months (August – September, 2023). Increased area under cultivation and increased production of coconut in all the major growing States are the major reasons for declining prices. Efforts have to be made to increase the consumption of coconut value added products to sustain the price of coconut in the coming years.

Keywords: Coconut, coconut products; compound annual growth rate (CAGR); auto regressive integrated moving average (ARIMA) model; growth rate.

1. INTRODUCTION

Coconut holds a prominent position in the agricultural landscape of Tamil Nadu, India, being a major source of livelihood and cultural significance. Tamil Nadu is a leading coconut producer globally, with a robust industry encompassing cultivation, processing, and trade. The state's versatile coconut products, including oil, water, and desiccated coconut, are widely consumed within the region, across India, and internationally. Fluctuations in coconut prices can impact farmers, traders, and the regional economy. India ranks high in global coconut production, cultivating it across 19 states and 3 Union Territories, with an impressive average productivity of 8,303 nuts per hectare.

Traditional coconut cultivation in India is concentrated in states like Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh, while non-traditional areas include Assam, Gujarat, and more. Southern states (Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh) contribute over 90% of the country's production, with Kerala leading. In Tamil Nadu, coconut farming thrives on a favorable tropical climate, especially in coastal districts like Cuddalore, Thanjavur, and Kanyakumari. The state's production is about 4.3 lakh hectares, yielding 4515 million nuts, with a productivity of 10484 nuts per hectare. Various coconut varieties, like "Tall" and "Dwarf," are cultivated, each having distinct traits and uses.

One study conducted in Karnataka utilized ARIMA models, revealing that prices of coconut, copra, and coconut oil were non-stationary and influenced by factors such as demand, supply, weather, input costs, and government policies [1]. In Andhra Pradesh, researchers found an upward price trend for coconut products over time and significant seasonality, with higher prices during pre-monsoon months [2]. A study focused on production and productivity growth rates, showing positive annual changes in production but negative growth rates in productivity [3].

In the context of Kenya, forecasting pulses production was undertaken using the ARIMA model, with a determined best-fit model for prediction [4]. In Kerala, the assessment of tender coconut prices revealed an increasing trend over time and pronounced seasonality, with peak prices during winter months [5]. A study in Ghana employed the ARIMA model to analyze annual coconut production, identifying the best-fit model for the study [6]. A study on forecasting techniques of onion price and concluded that the ANN model was the best fit ARIMA model for better accuracy of onion market in Bangalore. They also suggested that the present study would help the stakeholders in the value chain to take suitable decisions [7] .A study of coconut farmers showed 58.33% medium, 21.67% low, and 20% high marketing behavior levels. Farmers mainly sold locally using middlemen. Planners need to enhance marketing strategies for better prices.A study of coconut farmers showed 58.33% medium, 21.67% low, and 20% high marketing behavior levels. Farmers mainly sold locally using middlemen. Planners need to enhance marketing strategies for better prices [8]. Malaysia's coconut sector saw economic challenges. EU's palm oil stance created coconut potential. Review studied production hurdles and supply chain. Factors categorized: severe, tech, political, socio eco, environmental. Need policies like subsidies, research, and extension to enhance production [9].

1.1 Theoretical Framework

Compound annual growth rate of coconut was worked out to examine the tendency of variable to increase, decrease or stagnant over a period of time. Compound annual growth rates of area, production and productivity of coconut are estimated by using the exponential growth function of the form:

$$Yt = a\ btUt \qquad (1)$$

Where,

Yt = Dependent variable for which growth rate of coconut was estimated
a = Intercept
b = Regression coefficient
t = Year which takes values of (1, 2, 3,…n)
Ut= Disturbance term in year 't'.

The equation (1) will be transformed in to loglinear and written as:

$$\text{Log } Yt = \log a + t \log b + \log Ut \qquad (2)$$

Equation (2) will be estimated by using Ordinary Least Square (OLS) technique.

The compound growth rate (g) will be then estimated by the identity given in equation (3)

$$g = (b-1) \times 100 \qquad (3)$$

Where,

g = Estimated compound growth rate per annum in percentage.
b = Antilog of log b

1.2 Auto-Regressive Integrated Moving Average (ARIMA) Model

A brief description of Auto Regressive Integrated Moving Average (ARIMA) processes are given in the following sections as described by Gujarati (2003). "The popularity of ARIMA model is due to its statistical properties as well as use of wellknown Box-Jenkins methodology in the model building process" (Jha and Sinha, 2013).

"The ARIMA is an extrapolation method, which requires historical time series data of underlying variable. The methodology refers to the set of procedures for identifying, fitting, and checking ARIMA models with time series data" [10-12].

Average (ARIMA) model, time series variable is assumed to be a linear function of the previous actual values and random shocks. In general, an ARIMA model is characterized by the notation ARIMA (p, d, q), where p, d and q denote orders of Auto-Regression (AR), Integration (differencing) and Moving Average (MA), respectively.

A pth –Order Auto-Regressive model: AR (p), which has the general form

$$\psi_\tau = \alpha_0 + \alpha_1 \psi_{\tau-1} + \alpha_2 \psi_{\tau-2} + \alpha_3 \psi_{\tau-} \ldots\ldots\ldots\ldots + \alpha_\pi \psi_{\tau-\pi} + \varepsilon_\tau{}^{--1}$$

y_t = Coconut price time t

y_{t-1} , y_{t-2} , y_{t-3} …..y_{t-p} = Coconut price at time lags t-1, t-2,……, t-p, respectively

α_0 , α_1 , α_2 ,….., α_p = coefficients to be estimated,

ε_t= Error term at time t

A qth-order Moving Average model: MA (q), which has the general form:

$$y_t = \mu + \varepsilon_t - \phi_1 \varepsilon_{t-1} - \phi_2 \varepsilon_{t-2} - \ldots\ldots \phi_q \varepsilon_{t-q} \text{---------}2$$

y = Coconut price

μ = constant mean

$\phi_1, \phi_2 \ldots\ldots \phi_q$ = Coefficients to be estimated

ε_t = Error term at time t

$\varepsilon_{t-1}, \varepsilon_{t-2}, \varepsilon_{t-q}$ = Errors in previous time periods that are incorporated in Yt

Auto Regressive Moving Average Model: ARMA (p, q), which has a general form:

$y = \alpha_0+\alpha_1 y_{t-1}+\alpha_2 y_{t-2}+\alpha_3 y_{t-3}\ldots\ldots\ldots+\alpha_p y_{t-p}+\varepsilon-\phi_1\varepsilon_{t-1}-\phi_2\varepsilon_{t-2}-\ldots\ldots\phi_q\varepsilon_{t-q}$ -------- 3

y_t= Coconut price

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \ldots, \alpha_p, \phi_1, \phi_2, \phi_q$= Coefficients to be estimated

ε_t = Error term at time t

$\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots, \varepsilon_{t-q}$ = Errors in previous time periods that are incorporated in Yt

The first step in the process of ARIMA modelling is to identify the model using Auto Correlation Functions (ACFs) and Partial Auto Correlation Functions (PACFs) to achieve stationary and tentatively identify patterns and model components. A series is regarded as stationary if its statistical characteristics such as the mean and the autocorrelation structures are constant over time. Determine whether the series is stationary or not by considering the graph of ACF. If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series values should be considered stationary. If the original series is stationary, d = 0 and the ARIMA models reduce to the ARMA models [13-15]. However, many economic time series are non-stationary, that is, they are integrated. If a time series is integrated with an order of 1, it implies that the first difference of the price is effective and it is denoted as I (0). This implies that mean and covariance have attained stationarity. In general, if a time series is integrated as I (d), after differencing it d times we obtain a stationary I (0) series. If a price series is nonstationary it is differentiated'd' times to make it stationary using ARIMA (p, d, q) model. The stochastic trend of the series is removed by differencing, and multiple ARMA models are chosen on the basis of Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF) that closely fit the data.

The second step involves determining the coefficients and estimation through maximum likelihood approach such that the overall measure of errors is minimized or the likelihood function is maximized. The third step involves diagnostics checking using ACFs and PACFs of residuals to verify whether the model is valid. In this step, model must be checked for adequacy by considering the properties of the residuals whether the residuals from an ARIMA model must has a normal distribution and should be random. Otherwise repeat the steps of identification, estimation and diagnostics. The most suitable ARIMA model is selected using the smallest Akaike Information Criterion (AIC) or Schwarz-Bayesian Criterion (SBC) value and root mean square error and lowest Mean Absolute Percentage Error (MAPE) criterion. The MAPE calculates the forecast error as a percentage of actual value. MAPE is used as relative measure to compare forecasts for the same series across different models.
The MAPE is calculated using the following:

$$\text{MAPE} = \frac{\sum_{t=1}^{n}\left|\frac{y_t-\hat{y}_t}{y_t}\right|}{n} * 100$$

yt = Actual value at time t
*yˆ*t = Predicted value at time t
n = Number of observations

The procedure for these tests is drawn from Makridokis and Wheelright (1978). The final step is forecasting simple statistics and confidence intervals to determine the validity of the forecast and track model performance to detect out of control situation. In this study, all estimations and forecasting of ARIMA model have been done using SPSS 26. The ARIMA model was used for predicting the price of coconut in the Coimbatore and Pollachi markets.

2. METHODOLOGY

Secondary data was used for the present study. Secondary Data on area, production and productivity of coconut in Tamil Nadu was collected from 2000 to 2022 and price of coconut from 2012 to 2023 in selected market was collected from the published sources of coconut Development Board.

3. RESULTS AND DISCUSSION

3.1 Trend in Area, Production and Productivity of Coconut in Tamil Nadu

It is inferred from Table 1 that the area under cultivation is expanding by 1.56% annually, potentially driven by increased demand and improved farming techniques. Concurrently, coconut production is growing at a rate of 2.089% per year, likely due to advancements in agriculture, disease management, and expanded cultivated land. Moreover, the productivity growth rate of 1.19% signifies that more coconuts are being harvested per unit of effort or land. The results of the trend in area , production and productivity of coconut in Tamil Nadu has recorded a positive and significant growth.

Table 1. Compound annual growth rate (CAGR) in area, production and productivity coconut in Tamil Nadu (2000-2022)

S. No.	Variables	Growth rate (percentage)
1	Area	1.56
2	Production	2.089
3	Productivity	1.19

3.2 ARIMA Model Outcomes

The first step in building ARIMA model is the identification stage. This identification is done through plotting the autocorrelation values. Autocorrelations are numerical values that indicate how a data series is related to itself overtime. These measures are most often evaluated through graphical plots called "correlograms". A correlogram plots the auto-correlation values fora given series at different lags. This is referred to as the "autocorrelation function" and is very important in the ARIMA method. The results are depicted in the Figs.1 and 2.

If a graph of ACF of the time series values either cuts off fairly quickly or dies down fairly quickly, then the time series values should be considered stationary. In our graph since the values are not dies down quickly it could be considered for non stationarity of the series. Hence differencing could be done to make the series stationary. The model will be ARIMA.

In order to arrive the best fit model, different ARIMA models (p, d, q) were compared. The best fit model from the Table 1 was examined as (1,1, 1) for coconut in Coimbatore Market and for Pollachi Market was (1, 1, 1) with lowest MAPE values. The MAPE values of the former were 6.017 for the latter were 6.237.

The Residual ACF and PACF of the selected ARIMA (1, 1, 1) model is presented in the Figs. 1 & 2. It could be inferred that the residuals are white noise and the fitted model ARIMA (111) was valid, therefore one of the values are used for forecasting.

Fig. 1 displays the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) plots for coconut data in Coimbatore market. These plots help identify patterns and relationships in the time series data. ACF shows correlation between the data and its past values, while PACF reveals direct relationships between data points and their lagged versions. These plots assist in selecting the right parameters for building an accurate predictive model like ARIMA, essential for understanding and forecasting coconut prices or related trends in Coimbatore market.

Fig. 2 displays Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) plots for coconut data in the Pollachi market. These plots help detect patterns in the time series. ACF shows correlations between the data and its past values, while PACF reveals direct relationships between data points and their lagged versions. These plots are crucial for selecting appropriate parameters in models like ARIMA, essential for predicting coconut prices or trends accurately in the Pollachi market.

Table 2 presents the accuracy performance measures of forecasting coconut data, specifically the Mean Absolute Percentage Error (MAPE) values, in both the Coimbatore and Pollachi markets. MAPE is a widely used metric in forecasting and represents the average percentage difference between the predicted values and the actual observed values.

3.3 Forecasted Price by Using Different ARIMA Models

Based on MAPE value and residual ACF and PACF ARIMA (111) model was the best fit model for predicting the area and production of Coconut in India. The results of forecasts of various ARIMA models are presented in the Tables 3 and 4.

Fig. 3 displays the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) plots of the residuals from a selected ARIMA (1, 1, 1) model for coconut data in the Coimbatore market. Residuals are the differences between the actual observed values and the predicted values obtained from the ARIMA model.

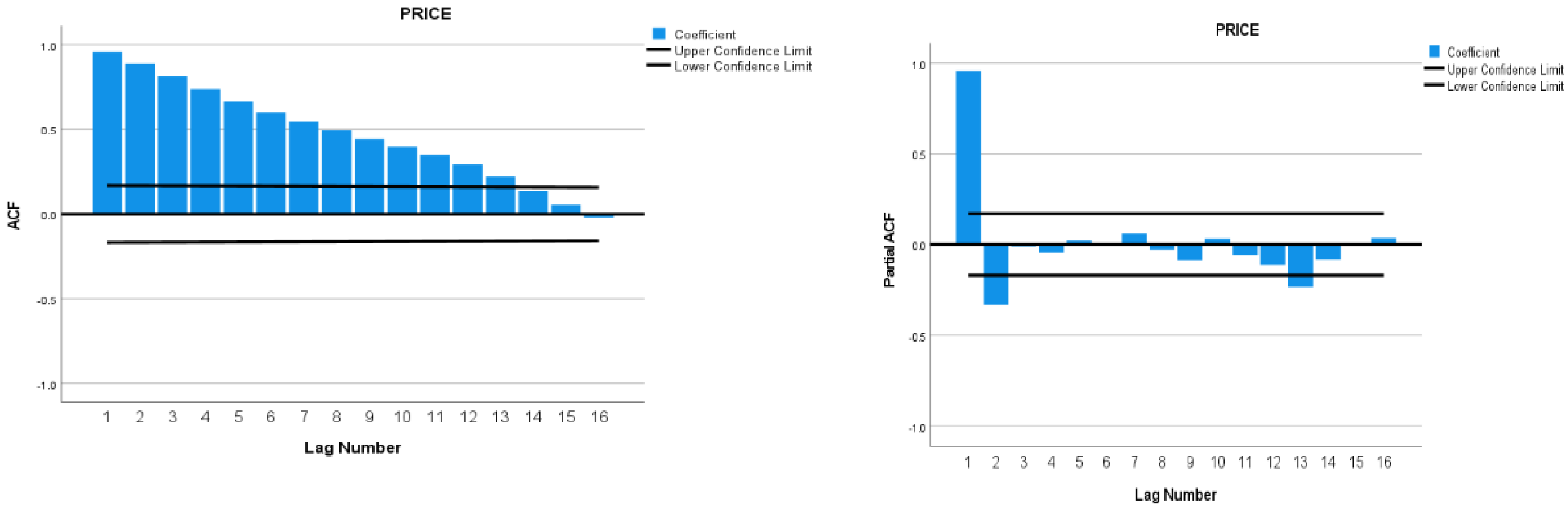

Fig. 1. Auto correlation and partial auto correlation of coconut in coimbatore market

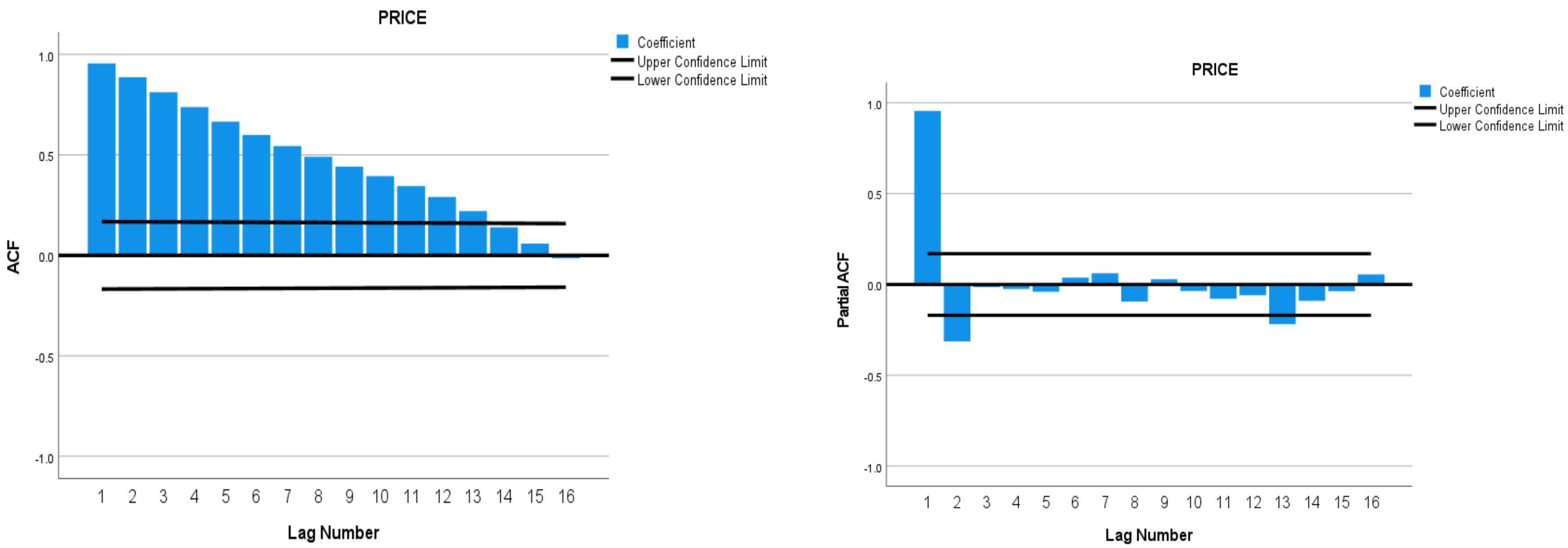

Fig. 2. Auto correlation and partial auto correlation of coconut in pollachi market

Table 2. Accuracy performance measures of Forecast

Model	MAPE values of Coconut(Coimbatore market)
110	6.026
011	6.037
100	7.045
101	6.507
111	**6.017**
Model	**MAPE values of Coconut (Pollachi market)**
110	6.404
011	6.262
100	7.091
101	6.789
111	**6.237**

Table 3. Forecasted Price of Coconut (Coimbatore market)

Model	Forecasted Price of Coconut (Rs/Ton) (Coimbatore market)				
	AUG	SEP	OCT	NOV	DEC
110	19049.73	19062.79	19091.11	19124.81	19160.39
011	19297.75	19338.69	19379.64	19420.59	19461.53
100	19167.91	19252.82	19334.82	194141.01	19490.49
101	19414.97	19581.34	19738.45	19886.80	20026.90
111	**19124.24**	**19136.66**	**192022.08**	**19240.17**	**19278.17**

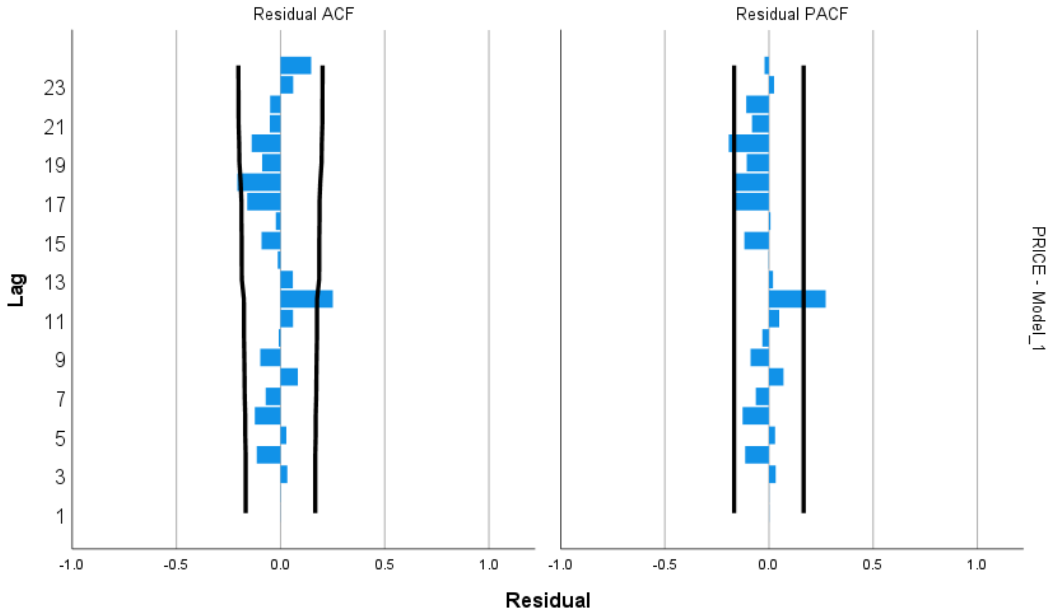

Fig. 3. Auto correlation and partial auto correlation plot of residuals of selected ARIMA (1, 1, 1) model of Coconut in Coimbatore Market

Fig. 4 displays the Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) plots of the residuals from a chosen ARIMA (1, 1, 1) model for coconut data in the Pollachi market. Residuals represent the differences between actual observed values and predictions generated by the ARIMA model.

The Table 3 presents forecasted coconut prices in the Coimbatore market for various months, with each row representing a distinct model configuration. The table showcases the forecasted prices in terms of Rs per ton for AUG, SEP, OCT, NOV, and DEC.

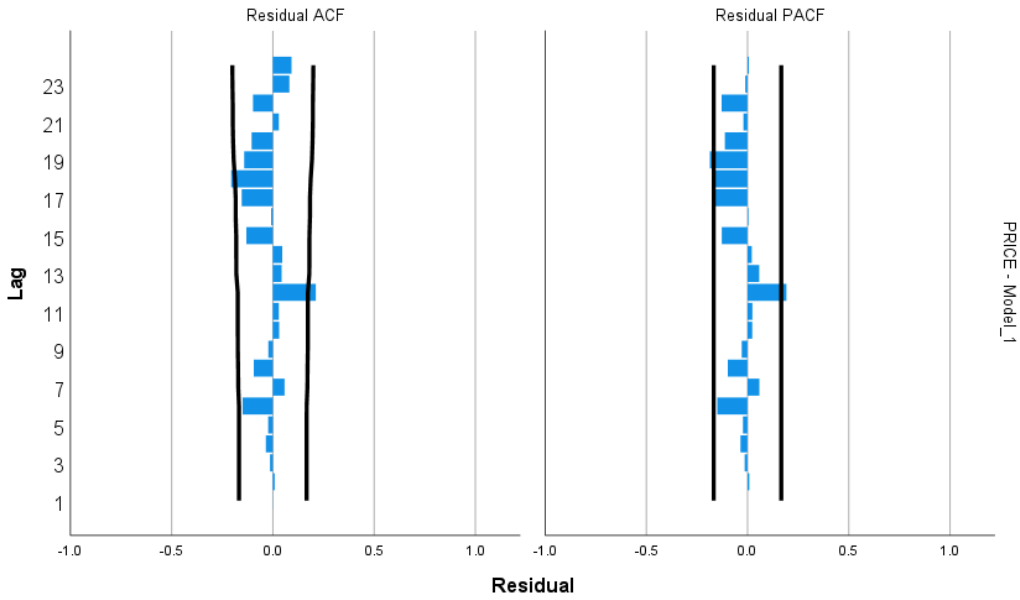

Fig. 4. Auto correlation and partial auto correlation plot of residuals of selected ARIMA (1, 1, 1) model of Coconut in Pollachi Market

Table 4. Forecasted Price of Coconut (Pollachi market)

Model	Forecasted Price of Coconut (Rs/Ton) (Pollachi market)				
	AUG	SEP	OCT	NOV	DEC
110	19873.18	19910.00	19949.92	19990.83	20032.06
011	20077.00	20121.93	20166.87	20211.80	2056.74
100	19935.01	20020.66	20103.20	20182.76	20259.45
101	20189.28	20346.31	20494.56	20634.52	20766.67
111	**19893.77**	**19937.22**	**19979.45**	**20021.32**	**20063.08**

The Table 4 displays forecasted coconut prices in the Pollachi market for various months, with each row representing a different model configuration. The forecasted prices are given in terms of Rs per ton for the months of AUG, SEP, OCT, NOV, and DEC.

4. CONCLUSION

In conclusion, the analysis of the Area, Production, and Productivity of coconut cultivation in Tamil Nadu reveals a positive trajectory. Notably, there has been a consistent and encouraging growth of 1.56 percent in the cultivation area and a 2.09 percent rise in production. Concurrently, productivity is also on an upward trend, improving by 1.19 percent annually. This collective data points towards a favorable environment for the coconut cultivation sector in the region. Furthermore, employing ARIMA (1, 1, 1) models for predicting coconut prices in both the Coimbatore and Pollachi markets has yielded the most accurate results. The forecasted trend for the upcoming months, specifically August to September 2023, suggests a potential decline in coconut prices. This projection can be attributed to the substantial increase in cultivation area and production across major coconut-growing states, which has led to an excess supply. To counteract this decline and maintain stable prices, there is a pressing need to stimulate the consumption of value-added coconut products. By diversifying the utilization of coconuts and boosting demand for these products, the coconut industry can work towards sustaining the price levels of coconuts in the forthcoming years. This could help strike a balance between supply and demand, ensuring the continued growth and stability of the coconut market.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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